Digitally Enabled Design & Manufacture of Designer Products for Circular Economies

Future Fashion Factory

Future Fashion Factory researches and develops advanced digital and textile technologies to transform the industry's agility in the luxury fashion design process, and ability to shift to circular economies.

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Director's Statement

In 2018, the Creative Industries Clusters Programme (CICP) presented an exciting opportunity for us to forge a major programme of industry-led collaborative R&D in fashion and textiles, working together with other Universities.

Building on these existing relationships, we were keen to develop a strategic plan of engagement that would address industry needs and innovation gaps, by harnessing academic expertise and high-quality research facilities. Importantly, we also harnessed relationships with the leading national sector bodies.

As a result of this initiative by the Arts and Humanities Research Council (AHRC) and the Industrial Strategy Challenge Fund (ISCF) it was possible to enable a new collaborative structure with industry, in which there was the opportunity to strategically plan for long-term impact.

Industry-academic engagement was built into every facet of our planning. Industry's voice was heard loud and clear at initial consultation meetings and then embedded across all our research activities. Both the FFF Steering Group and the FFF Programme Management Group included multiple industrial representatives, including engagement with the CEO of the UK Fashion and Textile Association (UKFT), both on the Steering Group and as Chair of FFF's Responsive R&D Investment Committee. These multiple points of contact with industry were designed to keep FFF delivery focused on what would make a significant difference to the UK fashion and textile sector. Despite some initial scepticism on how much real advantage would accrue to industry partners through collaborative University research, FFF's model of collaboration resulted in strong endorsement, not least at FFF's Spring EXPO event (May 2024) where it was concluded:

"Whichever way you look at FFF it has been an outstanding success" "FFF has driven a horse and cart through the idea that universities do not work to support industry" – CEO, UKFT

In addition to embedding on-going dialogue with industry, a conscious decision was made to make FFF easy to engage with and to disseminate programme activities and findings as widely as possible, via a range of channels. FFF originally targeted a network of 600 firms, but over the delivery period this was greatly exceeded. Engagement recorded in mid-2024, via newsletter subscription (1,060) LinkedIn (6,407) and Instagram (2,078), was strong and still growing. The extended network membership attracted micro-businesses, SMEs and PLCs from across the whole fashion and textile design supply chain, from selection of raw materials, through to finished garments. Companies involved in the end-of-life management of textile products, as well as those focused on digital technologies, AI and games also came onboard.

In 2020 something happened to disrupt programme delivery which could never have been anticipated in our risk management planning. Despite the major challenges it presented to our industry, the COVID-19 pandemic stimulated creative thinking, an even greater focus on innovation and skills development, as well as exploitation of digital technologies. FFF managed to pivot effectively, utilising digital platforms to host 'creative lab' events rather than usual in-person activities and developed new approaches to collaboration.

"As a consortium we went into the FFF programme knowing that fashion and textile businesses find established grant funding opportunities difficult to access. With this in mind FFF designed both a light touch process which was easy to use, and provided brokerage support to assist companies with developing innovation proposals."

Adam Mansell,
CEO, UK Fashion & Textile Association Chair.
FFF Steering Group and Investment Committee.

One example was the collaborative initiative of our Co-Director, Suzy Shepherd, working with RCA design graduates and Yorkshire mills during Wool Week 2020. An immersive, digital showcase of unique garments, produced by these emerging designers and using luxury fabrics designed, manufactured and supplied by Yorkshire mills was presented. Colleagues also developed a Zero Waste Fashion Competition in 2020, the winner of which delivered a workshop event to FFF network members where some of the 360-degree product photography received as part of the competition prize was premiered. Innovation for enhanced supply chain transparency was also targeted in a UKFT-led project involving University of Leeds FFF researchers, which included input from major retail brands (Next, Cos, N Brown, New Look) with technical support from IBM and Tech Data. Given the vibrant ecosystem that was created during the FFF programme, it was pleasing that targets were greatly exceeded in terms of innovation concept development (294%), collaborative project submission (145%), joint ventures (200%), skills/course development (280%) and match funding targets (367%).

Early in delivery of the FFF programme it was clear that the original industry network had the potential to develop further. With the support of key industrial stakeholders and the University of Leeds, an independent Strategic Impact Assessment was commissioned, which highlighted the innovation capacity of the Yorkshire region's fashion and textile cluster. Later, building on the approaches to industrial engagement pioneered by FFF, and following a major financial co-investment by the Clothworkers' Company and the University of Leeds, the Leeds Institute of Textiles and Colour (LITAC) came into being in September 2021, hosted by the School of Design. LITAC provides a gateway for all textile, colour and fashion research activity within the University. The mission is to be the academic partner of choice for collaborative, industry-led R&D across all areas of fashion, textiles and colour, with a goal to identify unmet industry needs, and to act as a convener and trusted partner for significant sectoral research challenges that are too large for any one company to tackle alone.

Looking to the future, we will continue to innovate, support sustainable development of the industry, and focus on real-world outcomes. It has been a real pleasure to be the Director of the Future Fashion Factory, and I know the LITAC team is looking forward to supporting the industry for years to come.

The Challenge

“The programme has been a success because from the start the University of Leeds consulted businesses about their requirements and involved the industry in programme design and delivery at every stage.”

Paul Johnson,
Managing Director, W.T. Johnson & Sons (Huddersfield) Ltd Chair. LITAC Advisory Board.

A shared vision to create the world's first designer-led, digitally enabled, creative design and technical innovation platform for high value, luxury products.

Future Fashion Factory (FFF) became part of the Creative Industries Clusters Programme (CICP), alongside eight other programmes in October 2018. The research challenge defined by FFF was the result of extensive industry consultation and it was key to the programme's development, maximising from the outset the value and impact of this collaborative R&D initiative. Engagement with national sector bodies including the UK Fashion and Textile Association (UKFT) and the British Fashion Council (BFC), alongside regional industrial and local government partners helped us to develop a coherent vision that all partners could get behind:

"A shared vision to create the world's first designer-led, digitally enabled creative design and technical innovation platform for high value, luxury products."

At the time of FFF's creation, the UK's fashion industry was cited as contributing £28bn (directly) and £50bn (indirectly) to the economy making it a significant contributor to GDP. Factors such as long lead times, including for product development, across geographically distributed supply chains, issues of textile waste and major skills gaps were identified by UK design and manufacturing businesses as key challenges to productivity. In response, FFF proposed a targeted programme of collaborative R&D that would address specific industry-led challenges, by harnessing academic research expertise from multiple UK Universities, to co-develop innovative processes and products to support long-term sustainable development. Simply stated, the overall purpose of the collaborative initiative was about:

"Transforming the UK's agility and capacity for new product innovation through the convergence of digital and textile technologies"

Four main objectives were agreed, the first sought to improve competitiveness by shortening 'creative product development cycles and lead times to increase agility'. Increased flexibility across interconnected supply chains, by creative use of emerging digital technologies and data to inform design and manufacturing processes had the potential to transform operations. Design of the 'right product, for the right customer at the right time', emerged as a second objective. This included exploration of new business models including 'made to order' rather than 'made for stock' approaches to consumer engagement to increase product personalisation, and so the emotional durability of garments, whilst at the same time significantly decreasing waste.

The 'shift from linear to circular economies, reducing waste and creating new business models' was identified as a third objective relevant to both SMEs and larger businesses. Evaluation of new design approaches, materials and innovative process developments, including those relating to waste minimisation, as well as recycling and reuse with a view to improving margins and establishing circular economies, were majorareas of unmet need. Alongside the development of data-driven design and digitally driven manufacturing processes, a strong skills agenda emerged that questioned traditional approaches to teaching fashion design. The final objective thereby emerged: 'Create a new generation of STEAM-based fashion designers capable of exploiting new textile and digital technologies as part of the creative design process'. Blending of traditional design skills with a deeper understanding of science and technology was needed for fashion design graduates, as well as those pursuing apprenticeship training, to support creative development of new products and enable the UK's fashion and textile industry to remain competitive.

Supported by a dedicated Programme Manager and a Communications and Digital Engagement Officer, FFF developed and grew the industry network, and encouraged businesses to come forward with tightly defined R&D challenges that required academic support and expertise to deliver. A responsive R&D co-funding mechanism was established in which businesses and FFF partner Universities could collaborate and co-develop innovative processes and products aligned with FFF's overall programme objectives. For many of the SMEs involved, this enabled collaborative R&D partnerships to be created with universities for the first time, that would otherwise not have been possible. Meanwhile, communication and dissemination channels were developed that forged further growth of FFF's network of fashion and textile businesses.

Six years after FFF's original research challenge was developed with industry, the world has moved on. During the FFF programme, COVID lockdowns created major disruption and challenges for industry, but also accelerated creative developments in digitalisation across various parts of the supply chain. A sharper focus on reducing environmental impacts also emerged, including demand for reduced energy and resource utilisation, improved waste minimisation and the development of new business models. This was reflected in FFF's later responsive R&D calls, where sustainable development and circular economies gained even greater prominence, alongside skills. This was also driven in part by growing regulatory pressure associated with reducing the sector's environmental impacts.

Whilst FFF's original research challenge remains valid, the vision for change has now evolved to embrace Net Zero drivers such as the UK's Net Zero Strategy: Build Back Greener and the European Union's Green Deal. FFF's academic team is now part of a wider collaboration involved in the delivery of UKRI's Network Plus for Circular Fashion & Textiles, a three subnetwork multi-partner programme. In this Network Plus programme, three key areas of research are required to support the sustainable development of the sector:

- Improvement of data collation, analysis and assessment.
- Start to establish research-validated baselines.
- Environmental impact and circularity.

As with the FFF, which formed part of the Creative Industries Clusters Programme, a collaborative approach involving a multidisciplinary group of academic partners from different universities, working together with a large industry network of SMEs and larger businesses, is fundamental to the delivery of the Network Plus initiative.

"Repeated surveys have shown that our sector has lagged behind others in the adoption of digital technologies and sustainable production processes. This reflects the fact that many companies in the sector have lacked the capacity to innovate in these areas and many have struggled to secure external expertise and support as the challenges they face have not aligned to the requirements of the region's universities and research centres. The Future Fashion Factory has demonstrated how the business and academic agendas can be brought together for mutual benefit. The programme has been a success because from the start the University of Leeds consulted businesses about their requirements and involved the industry in programme design and delivery at every stage, including management, promotion, project development and appraisal. Central to success has been the programme's brokerage activity which has matched individual company requirements with the skills of the research faculty, delivering activity within timescales relevant to businesses without excessive bureaucracy. We now have a model that works."

Paul Johnson,
Managing Director, W.T. Johnson & Sons (Huddersfield) Ltd.

Meet the Team

"Team. Coming together is a beginning. Keeping together is progress. Working together is success."

Henry Ford

Core Team

Prof. Stephen Russell

FFF Director

Steve is Professor of Textile Materials and Technology in the School of Design at the University of Leeds. His main areas of expertise are in textile engineering, textile design and manufacture. In addition to academic research, he has fifteen years product development and Company Director experience in the textile industry.

In September 2021, Steve became the founding Director of Leeds Institute of Textiles and Colour (LITAC) and has been pivotal in bringing together world-leading research capabilities in design, science and engineering.

Suzy Shepherd

FFF Co-Director

Suzy's expertise is in fashion, retail and marketing. She is a Co-Founder and Director of Leeds Fashion Works and also Yorkshire Textiles Ltd. Suzy is passionate about the imbued excellence, the quality of the products and specialist skills that have led to the utilisation of Yorkshire's textiles by global brands.

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Sue Rainton

FFF Programme Manager

Sue joined Future Fashion Factory in January 2019 bringing a wealth of project and programme management experience to the team. She has worked variously within Local Government, Regional Agencies, the Higher Education Sector and SMEs, this background giving her a broad understanding of the needs and drivers of FFF partners.

In November 2021 Sue was appointed as LITAC's Associate Director, managing operational activity for the new Institute. FFF evolved within the new LITAC operational framework, becoming a central pillar of activity Fashion@LITAC.

Giorgio Grande

FFF Communications and Digital Engagement Officer

Giorgio has a range of marketing and content writing experience, with a focus on the fashion and literary industry. In Future Fashion Factory, he is responsible for marketing communications, digital engagement, member co-ordinating and events planning. In 2023, Giorgio was appointed as the Communications and Events Officer for LITAC.

Research Leads

Parik Goswami

Professor Goswami is the Director for Research, Innovation and Knowledge Exchange at the University of Huddersfield. Previously he was the Head of the Department for Fashion and Textiles and then of Music and Design Arts at the University of Huddersfield. He is also the Director of the Technical Textiles Research Centre.

Before joining the University of Huddersfield, Professor Goswami was the Director of Research and Innovation at the School of Design, University of Leeds and led the Fibre and Fabric Functionalisation research group at Leeds. In his research, since joining the University of Huddersfield, Professor Goswami has proactively developed the research profile and activities in Technical Textiles.

Susan Postlethwaite

Susan Postlethwaite is Professor of Fashion Technologies at the Fashion Institute, Manchester Metropolitan University, and Director of the Robotics Living Lab (RoLL). She is an alumna of the prestigious Policy Fellowship programme at the Royal Academy of Engineering and is a Network Expert for the NERC-funded ‘Back to Baselines in Circular Fashion and Textiles’ project.

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Kevin Almond

Dr. Kevin Almond is an Associate Professor at the University of Leeds. He holds a BA (Hons) Fashion and Textiles, and is a Master’s Graduate from the Royal College of Art. He gained his PhD from the University of Huddersfield in 2012, entitled ‘Suffering in Fashion’. Kevin is a Fellow of the Higher Education Academy.

Dr. Almond has significant experience within the fashion industry, both as a designer and freelance designer. He has published widely in a variety of books and academic journals. Kevin serves on the advisory board of the Journal of Fashion History, International Journal of Sustainable Fashion and Texiles, and the Journal of Fashion, Style and Popular Culture.

Dawn Ellams

Dawn Ellams is a Research Fellow at the Royal College of Art. Dawn’s background in sustainable design and circular systems development uses design research as a catalyst for innovation within multi-disciplinary and complex industry collaborations. Her current research explores R&D activities within UK fashion and textiles supply chains, focussing on the impact that materials, systems and manufacturing innovations can have on current and future sustainable practices and places.

Ningtao Mao

Ningtao is Professor of Fibre and Textile Technology at the University of Leeds. His research interests are focused on functional fabrics and clothing, including creating functional fibres for technical textiles and protective clothing. He is particularly interested in the engineering design of fibrous assemblies for technical applications, including characterisation and modelling of liquid wetting and wicking, fluid-fibre-particle interactions, as well as fluid transport and heat transfer in fibrous materials.

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Stephen Westland

Stephen Westland is Professor of Colour Science at the University of Leeds, where he is Chair of Colour Science and Technology. He has published about 200 peer-reviewed papers, book chapters and books in the areas of colour science, colour imaging and colour design.

Stephen's research tends to use two specific experimental techniques: psychophysics and machine learning. Psychophysics is a process of quantifying human perceptual response (often colour-or vision-related) to physical stimuli. Machine learning is a computational technique that usually uses data to develop computer-based predictive models.

Core Research Themes

Working closely with industry partners FFF co-developed five Core Research Themes which served to focus research activity across the programme.

Digital Communication

Some aesthetic properties of fabrics and garments, such as handle, drape and fit, are difficult to communicate objectively. As a result, fabric swatches, sample garments and finished products are transported around fashion supply chains, while customers often return products purchased online.

Naturally, by conveying more accurately what businesses and consumers can expect from designers, significant reductions in the resources required to create, manufacture and transport surplus fabrics and finished garments can be achieved.

Put simply, by harnessing digital technology to reduce dependency on the manual assessment of textile products during product development, and by new modelling and simulation tools, more accurate communication of visual and tactile properties is possible. This includes in some situations a shift towards a new AR/VR immersive product development environment, capable of speeding up decision making in the supply chain and reducing lead times associated with design and product development.

Professor Ningtao Mao (University of Leeds) led this Core Research Theme, applying his expertise in functional fabrics and clothing to explore innovative digital methods to more accurately convey information about how fabrics look and feel.

The development of an objective descriptor that could accurately and quickly communicate luxury fabric appearance and tactile properties between designers, fabric/garment manufacturers, buyers, retailers and consumers underpinned much of the research associated with this theme.

By working with the programme's academic and industry partners, and by using new technology capable of accurately representing fabric handle as data, much of this CRT's R&D output focused on integrating these objective descriptors into (Computer-Aided Design) CAD, (Augmented Reality) AR and (Virtual Reality) VR platforms.

The implementation of these platforms was facilitated by various digital systems partners, allowing for business-critical information about fabric handle and aesthetics to be accurately and rapidly communicated directly to remote customers. These technologies have also been used as the basis for embedding realism in virtual catwalks (British Fashion Council) and digital fashion archives that sought to convey the intricacies of historical garments with greater graphical fidelity.

Late-Stage Customisation

As demand has grown among consumers for more personalised products and experiences, there has been equal demand placed upon the fashion and textile industry to offer new digital and textile finishing technologies, as well as to design and produce small volume, customised products – all while cutting lead times and waste.

Core Research Themes

"Future Fashion Factory has innovated not only in the wider industry, but in the very processes and manufacturing models used by the diverse member businesses that inform its dynamic network - a network that is energised by the same collaborative spark that has resulted in such pivotal innovation."

Suzy Shepherd,
FFF Co-Director.

However, to produce bespoke products that meet this demand, particularly in a manner that is cost effective for businesses, disrupting manufacturing processes with minimal impact, necessitated a high pedigree of innovation and ingenuity.

Professor Parik Goswami (University of Huddersfield) oversaw some of the groundbreaking work taking place across the programme.

Underpinning this CRT were research projects centred on digitally connected design and customisation processes. Specifically, through creative use of 2D and 3D weaving technologies including rapid changeovers on a common warp beam, as well as additive 3D deposition techniques that produce novel surface textures on fabrics, we supported methods that directly integrated customisation into various design phases. Further innovations looked at new uses of digital jet printing technologies for applying novel sensorial inks, and resist-plasma treatments, enabling the innovative, late-stage modification of fabric surface texture and aesthetics. Similarly, an exploration of make-on-demand production models helped to drive opportunities for designer-led, small volume, rapid product customisation processes, all with shorter lead times.

Data-Driven Design and Artificial Intelligence

Whether combatting over-production, providing new assistive tools for fashion designers or optimising low-waste manufacturing, data-driven design plays an important role in producing the right product for the right customer at the right time – all the while, doing so sustainably and profitably.

Trend forecasting is a critical mechanism to achieve streamlined production methods, not only because components of aesthetics, such as colour predictions, rely solely on the anticipation of consumer acceptance, but because poor accuracy leads to significant wastage of resource and materials. This includes designing and making products that do not sell as originally intended.

Therefore, to improve forecasting accuracy for international markets, notably critical to the success of final product ranges, this CRT prioritised a focus on innovative forecasting and decision-making mechanisms across its focussed research outputs.

The CRT also prioritised innovative data analytical methods to greatly increase the speed and accuracy of business-critical design and forecasting decisions in terms of international colour prediction and consumer design preferences, based on factors such as demographics and location.

Professor Stephen Westland (University of Leeds) led Future Fashion Factory's data-driven design research, exploring how AI, machine learning and big data analytical techniques could be developed and expanded throughout the Programme. Across varied research projects, consumer data analytics experts identified and implemented appropriate methods of analysing large datasets to address design decision-making questions, from consumer preferences in relation to fabric aesthetics, colour, style or fit to industrial-scale logistical optimisation.

Skills and Education

It is no understatement to say that the fashion industry has been changing rapidly, often at a pace incommensurate with the ability to align education activity with its changing demands and requirements.

Industry 4.0, digital design tools, the impact of environmental regulation, and widening skills gaps in key sectors are all placing new demands on education and training providers. In addition, an aging workforce, endemic skills shortage and the need to integrate future skills across disciplines, especially digital channels, have represented barriers to growth for fashion and textiles businesses in the UK.

The Skills and Education CRT addressed the demand for a workforce in which fashion designers are capable of bridging artistic and scientific disciplines in digital and textile technologies.

Dr. Kevin Almond (University of Leeds) and Bill Macbeth OBE (Textile Centre of Excellence) led Future Fashion Factory's research in training and skills for the future.

Diverse training modules that integrated creative design principles and new technologies buoyed up several of this CRT's research projects, breaking down traditional fashion design and technology silos to produce designers capable of becoming future industry leaders. Industry-academic collaboration was built into all FFF Responsive R&D projects, a key element in upskilling academic staff, developing researcher understanding of commercial drivers and requirements for impactful applied research.

With an aim to ensure the long-term growth and sustainability of the cluster and wider UK industry, numerous project partners supported the delivery of youth-focused apprenticeship schemes, while also implementing their own innovative training systems as part of company workflow.

Sustainability and Circular Economies

The fashion and textile sector faces significant challenges to address sustainability and circular economy agendas and transition to Net Zero by 2050. The COVID-19 pandemic and post-Brexit landscape exposed the UK industry's reliance on long, global supply chains, as well as restricted access to R&D activities necessary to enable innovation for sustainability and circularity.

The Sustainability and Circular Economies CRT focused on the interdisciplinary and sector-wide collaboration required to drive innovation at every stage of the product life cycle from design, manufacturing, to end of life waste management. Reducing waste and extending the life of products through new processes, technologies and business models has become essential.

Professor Susan Postlethwaite (Manchester Metropolitan University) and Dr. Dawn Ellams (Royal College of Art) led this CRT, applying their expertise in Fashion Technologies, Processes and Materials within Circular Systems to explore collaborative and scalable innovation to support the sector's transition to more sustainable and circular practices.

Underpinning the work within the CRT was the aim to ensure the SME and Micro firms, that make up most of the UK sector, were engaged with and able to access R&D activities and resulting innovations.

"Future Fashion Factory has exceeded all my hopes in how big industry has responded to the call to connect with independent creators and businesses. Creative, complex responses to needs for development within fashion and textile supply chains have underpinned the work throughout the programme, introducing a radically new way of working that has driven collaboration between heritage brands, universities and industry in the region.

Future Fashion Factory has innovated not only in the wider industry, but in the very processes and manufacturing models used by the diverse member businesses that inform its dynamic network - a network that is energised by the same collaborative spark that has resulted insuch pivotal innovation.

Prior to Future Fashion Factory, in my role as a Founder and Director of Yorkshire Textiles, I have placed emphasis on the importance of collaboration and engagement between every agent on the fashion and textile supply chain; it is this same lifeblood that has helped Future Fashion Factory develop a brand identity that has outlived the original funded project, and is evident in the ongoing interest and relationships that continue to flourish under its umbrella."

Suzy Shepherd,
FFF Co-Director.

Research Team

Dr. Alessia Grassi

Dr. Alessia Grassi took up her new role at the University of Leeds as Lecturer in Fashion Marketing in February 2021. With a background in business and economics before specialising in the fashion industry, Alessia brings a wide range of knowledge to her research on physical retail and the relationship between luxury fashion and other forms of culture.

After a bachelor's degree in economics and accounting and a master's in business consulting in her native Italy, Alessia came to the UK to pursue another master's degree in fashion management at the University of Huddersfield.

Bringing these areas of interest together, she went on to pursue a PhD at Huddersfield, focusing on how luxury brands develop immersive experiences that build trust with consumers through art and museums.

"Some of the biggest brands have set up foundations that invest in, collect, curate and exhibit art, because the opportunity to gain knowledge is a positive experience with deep personal impact," she explains.

"There is a crossover in the minds of customers between seeing luxury fashion and seeing pieces of art, so the research took in psychology, sociology, museum studies, public engagement and a range of different approaches to understand how brands use this to deepen their relationships with consumers."

Using art and cultural experiences as a part of brand strategy is a practice that stems from physical retail when luxury brands started placing pieces of art in flagship stores. Louis Vuitton, for example, transformed the top floor of the Champs Elysées flagship into dedicated exhibition space before eventually opening the Fondation Louis Vuitton building in Paris.

For Alessia this sparked an interest in the reinvention of physical retail spaces. Having taught strategic retailing during her time as a lecturer at the University of Huddersfield, she has collaborated with a colleague in Milan to explore how brands can implement cultural hubs in physical spaces to offer new in-person experiences.

"I'm excited about retail and about brand communication – and crucially, how retail is a form of communication in and of itself," Alessia says. "The experience of interacting with a brand tells us about its values; how it makes us feel determines whether we align ourselves with it. That offers a huge opportunity for companies who want to build and maintain relationships with customers."

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Research Team

Dr. Hye-Won Lim

Consistent and predictable sizing is a priority for many consumers but continues to be a real challenge for the entire fashion industry. Dr Hye-Won Lim, Lecturer in Fashion Design at the University of Leeds, is committed to finding new ways to achieve the right size and fit for brands and customers alike.

Hye-Won returned to Leeds, where she completed her MA and PhD, after spending three years in the fashion team at Birmingham City University. Originally from Korea, she came to Leeds to develop her research in adapting pattern cutting methods to account for different body types.

From there her PhD took her to researching body size and sizing systems by analysing and comparing data from childrenswear in the UK and Korean markets.

"As children grow up, their body sizes change with different growth intervals while body shape and proportions are also changing irregularly. The physical growth rates and body proportion changes across gender and ethnicity between children in the two countries make them interesting to compare," Hye-Won explains.

The last national sizing survey for UK adults took place in 2001. Although SizeUK was extremely valuable, Hye-Won says, it's clear that the industry needs more recent information on which to base decisions about sizing and fit. This is an important part of her current research, making use of technologies that have become commonplace in the past two decades.

"We need data from several thousand people to get a statistically relevant result, but people can now measure themselves at home with their smartphones," she says. "Some 3D body scanning technologies are available through mobile apps, so we have the potential to generate lots of useful information."

As well as understanding how the average size of UK consumers has changed, the data could be used by brands to adapt their products to their target audiences. If certain body shape changes can be seen between different demographics, for example, businesses can adjust pattern grading intervals to get the best fit for their market.

Sizing is far from an exact science, and Hye-Won also investigates the psycho-physiological factors that impact how we choose size and fit. Some people prefer a tighter or looser fit, while individuals' perceptions of fit can vary with their mood.

"It's absolutely about psycho-physiological comfort as well as physical comfort from a consumer perspective," she adds, "But that is also useful information for brands. Inconsistent sizing can be a real source of stress and discomfort for shoppers that impacts on what they buy and where they shop."

With so many variables to consider, Hye-Won is interested in understanding how digital garment technologies need to be adapted for customised clothing, where these individual needs and preferences are especially important. She works to apply these technologies to inclusive design, plus size and maternity clothing, and even sportswear, where patterns could be adapted to make specific movements more comfortable.

Digital pattern software and 3D simulation technology offer fresh scope to explore these ideas without generating sampling waste. Hye-Won says this could be particularly exciting for smaller brands and manufacturers.

"I would be really interested to see how these new systems impact on efficiency and how much freedom they offer designers," she adds. "Trailing them with new businesses, making use of the facilities we have here in the School of Design, could offer lots of potential."

Dr. Tim Smith

Dr. Tim Smith took up his post as a Research Fellow at the University of Huddersfield in 2019. With a background in chemistry, he brought his technical knowledge to projects focussed on changing the functionality of textiles.

Tim completed his PhD at the University of Cardiff in 2013, focusing on synthetic chemistry for contrast agents in medical imaging.

At the time he says textiles were not on his radar at all, but a six-month research project at the University of Leeds offered an opportunity to apply his knowledge in developing medical textile products for blood filtration.

This new interest led Tim to pursue a further 5 years of industry focused research within technical textiles.

From there he moved to the Technical Textiles Research Centre at the University of Huddersfield, where he is using his chemistry background in a variety of collaborative projects with manufacturers and designers.

“I’ve benefited from so many great opportunities to bridge the gap between technical and creative expertise,” says Tim. “I’m learning all the time, swapping my knowledge for the creative insights of our partners and hearing from industry about how new techniques and processes could be scaled up or taken into commercial production.”

Working with Future Fashion Factory, Tim’s focus has been on how plasma treatment can be used to modify fibres and fabrics to add or improve their functionality, from making fabrics reactive to improving durability and strength. One project has investigated how plasma treatment can temporarily change the surface of wool to develop a one-step process for adding creative designs.

“If we use specially designed techniques to make sure some parts of the surface don’t absorb specific dyes, we could develop a system where the pattern emerges on the fabric during the dyeing process,” he explains.

“That would be a quick form of late-stage customisation that could be particularly helpful for small businesses, because it doesn’t have to be done on a huge scale.”

The project team has tested a range of options to achieve different patterns and results using this process, including using more dyes and mixing colours. This raised the question of whether the process could take place a step earlier – by modifying the yarn before weaving, so the pattern emerges as a fabric is batch dyed.

Each research question leads to commercial benefit for fashion and textile businesses, a key concern for Tim since he has moved to Yorkshire. Surrounded by the region’s textile heritage and working with partners across the supply chain, he says he has realised just how many opportunities exist in the sector.

“I didn’t appreciate how big and dynamic the industry is, especially in Yorkshire, but now that I live here I know there is so much to shout about,” he adds. “I’m keen to support local companies through research and innovation. There are so many new and interesting possibilities, and we have a lot to offer them.”

Future Fashion Factory

Dr. Boshuo Guo

Consumer data is one of the fashion industry’s most valuable commodities, supporting decisions from the colour and style of each new collection to the influencers chosen by different brands and their wider digital strategies.

Analysing this data and turning it into useful business information is at the heart of Dr. Boshuo Guo’s research. As Lecturer in Digital Fashion Marketing at the University of Leeds, Boshuo specialises in using data to provide insight into consumer behaviour, enabling businesses to make better strategic decisions.

Some of the most significant sources of data come from digital services. Since completing her PhD in management research at Imperial College London, Boshuo has worked extensively with clickstream data – everything that comes from a customer’s interactions with a website, from the time spent on each page to their navigation decisions.

“Social media is a powerful tool. Ultimately it is about people talking, but we can use techniques such as hashtag analysis and natural language processing to generate quantitative data on topics like consumer sentiment and the wider interests of target customers,” Boshuo explains.

For businesses that have an existing product line, much of this data will already be available. But for brands that are launching new product lines or moving into completely new categories, it can be difficult to identify the target customer. Boshuo has brought to Future Fashion Factory her wider research and analysis skills to identify the target market for new products.

More broadly, Boshuo has been excited to engage with different sources of data, from alternative social networks such as Instagram to in-store smart technology and app data. Combining these sources offers a real opportunity to understand the full customer journey both on and offline. New forms of digital retail have also offered exciting possibilities.

“Luxury brands have started driving sales through live-streaming events, using influencers and experts to demonstrate products and enabling purchasing in real time,” adds Boshuo. “That is a very rich source of information that brands will need to mine effectively.

Dr. Lindsey Waterton Taylor

Experience in the design sector, composites, textile technology and production led to Dr. Lindsey Waterton Taylor securing the role of Lecturer in Weaving Technologies and Design at the University of Leeds, as well as becoming the academic lead for the 3D Weaving Innovation Centre (3D WIC) in the School of Design.

Originally graduating in design and woven textiles, Lindsey specialised in 3D weaving during PhD research at the University of Manchester Institute of Science and Technology (UMIST).

Her PhD project, funded by EPSRC and co-sponsored by a small composites company in Lancashire, researched the potential of 2D-to-3D wovens for the composites sector and gave her a wealth of experience in collaborative industry-led research.

The PhD entailed using conventional weaving technology and production principles to develop fully integrated woven textile truss configurations known as the 3D Woven Nodal Structure (3D WNS).

The range of configurations for these structures, combined with high performance yarns and considered weave architectures for technical applications, produces a lightweight woven preform for composite applications.

“I’ve always loved translating my technical knowledge into something practical businesses can use,” Lindsey says. “One of the benefits of being sponsored by a small business was that throughout my PhD I had to keep linking my research to its commercial applications.”

Lindsey has taught weaving for nearly two decades, drawing on her commercial experience to equip students to work collaboratively and creatively in diverse roles across the industry. At the same time, she continued her research in 3D weaving of complex 3D structures.

The success of a 3D woven preform/shape and surface comes from translating 3D geometries into a 2D-folded folded form on the loom, similar to paper engineering. Once the woven 2D form is removed from the loom it can then be turned from a 2D into a 3D woven structure.

The scope of 3D-to-2D-to-3D weaving allows new multilayer woven structures that can be developed and produced to combine aesthetics and functionality.

In the fashion and textile sectors, one of the key areas for development is seamless woven forms, from apparel to interiors.

Lindsey came to the University of Leeds in 2016 to lead the 3D WIC in the School of Design, which formally opened in May 2018.

“I’d visited the trade show ITMA, Milan in 2015, and seen the latest innovations in both weaving machinery and jacquard technology exhibited by two different engineering companies,” Lindsey explains.

“That began the vision for a multi-shuttle weaving machine combined with a single end warp control jacquard system with variable shedding geometries. A conversation led to these two businesses forming the only multi-shuttle jacquard weaving machine in a UK Higher Education Institute.”

Supported initially by the European Regional Development Fund, Leeds City Regional Fund and University of Leeds, the 3D WIC began working with small and medium-sized enterprises (SMEs) to identify opportunities to use 3D weaving in product design and manufacturing.

Now, Lindsey is keen to continue working with businesses to explore the possibilities of 3D weaving for industry and develop equipment and software to drive this technology forward.

“I think 3D weaving is a perfect example of how creativity and technology are completely inseparable,” says Lindsey. “Without the design expertise and the supporting software, it’s impossible to get the results you need from the loom. Fashion is all about having the right technical tools to bring your creative vision to life and 3D weaving opens up lots of new possibilities for designers.”

Future Fashion Factory

Research Team

Dr. Sohel Rana

Dr. Sohel Rana took up his role as Lecturer in Technical Textiles at the University of Huddersfield in 2018. With experience in his native India as well as Portugal and West Yorkshire, Sohel has been developing his research in some of the world’s best-known textile manufacturing regions for over a decade.

After completing his PhD on Fibre Science and Technology at the Indian Institute of Technology (IIT, Delhi), Sohel worked across a wide range of projects at the University of Minho in Portugal, collaborating with industry partners to deliver innovation with real commercial impact.

Since joining the University of Huddersfield, he has built on this combination of research and manufacturing expertise as part of the Technical Textiles Research Centre, founded by Professor Parikshit Goswami.

“I want to bridge the gap between research and industry – finding new solutions and making them useable and commercial,” Sohel says.

“It’s also about using technical knowledge to support creative ideas. For example, if you want a knitted fabric that can expand in all directions when it’s stretched – an auxetic structure – or to develop a textile that can change shape, an understanding of advanced textile structures could help make that a reality.”

Sohel’s wide-ranging research includes nano-functionalisation of textiles – giving fibres and fabrics different properties, such as making them conductive, anti-microbial or flame-retardant – and advanced textile structures, which could relate to woven, knitted, or braided fabrics. He is also working on textile composite materials, with a focus on finding new uses for biological materials such as cellulose and wool.

“I am personally motivated to work more with natural materials wherever possible,” Sohel adds. “Bio-composites are more sustainable, and I want to help maximise the value of biological waste.”

Future Fashion Factory brings together the technical aspects of textile research with the creative potential of the fashion industry. Among Sohel’s projects, he has worked with Conductive Transfers Ltd. to develop 3D-zoned heaters that can be transferred onto garments – an innovation funded in FFF’s second funding call that will lead into the next generation of comfortable, effective wearables.

Sohel is keen to hear from businesses who could benefit from his expertise, from using sustainable and natural waste materials to speciality fibres, high-tech applications such as sensing and harvesting energy from textiles and adding new functional properties to fabrics.

Dr. Sahar Arshi

Dr. Sahar Arshi became a research fellow in the School of Design at the University of Leeds in 2019, having studied and researched across the UK as well as in her native Iran.

Alongside Professor Ningtao Mao, Sahar worked on one of Future Fashion Factory's core research themes: developing new technologies that communicate the look and feel of a fabric without the need to send a physical sample.

The project started with Leeds University Fabric Handle Evaluation System (LUFHES), a patented technology created by Professor Mao. LUFHES evaluates and quantifies fabric tactile properties to indicate how people perceive the fabric's look, feel, and drape. Using this system and other techniques, fabric tactile properties can be characterised and reproduced with specialist haptic technologies.

Drawing on her expertise in combining arts with computer sciences, Sahar has also worked on a data-driven system to determine how fabric tactile properties can be communicated with subjective touch feel of fabrics of specific group of users.

By reducing the need to send fabric swatches between buyers and suppliers worldwide, the project outcomes can lead to shortened product lead times and cut waste in the product development process. It also carries impact for e-commerce solutions, by giving online shoppers the chance to 'feel' a garment before placing an order.

With expertise and skills in artificial intelligence, mathematical modelling, and data mining, Sahar has worked on collaborative projects relating to data-driven design and digital communication of fabric touch feel and aesthetics. As a musician whose PhD thesis focused on creating new Persian music using artificial intelligence tools, she is excited by working in the interface between technology and creativity.

Future Fashion Factory

Dr. Claire Evans

Graduating with a BA(Hons) Fashion/Textiles, Claire became a fashion designer and garment production specialist then set-up and managed a successful fashion design label for over ten years, producing, retailing and wholesaling globally. She moved into academia and working at the University of Leeds launched, as Course Leader, BA (Hons) Fashion Communication and Marketing.

Moving to the University of Huddersfield she became Course Leader for the Fashion Design suite of courses, a position she has held for over 12 years. She has held roles such as external validator, external examiner, Course Franchise lead (Hong Kong), written courses and modules and taught across subjects including fashion design, pattern cutting, grading, garment production, marketing, dissertation and pattern design software.

Claire leads research on fashion production waste efficiencies. Her PhD investigated the effective use and repurposing of fashion production waste for new garment solutions. As Principal Investigator she was successfully in gaining two Future Fashion Factory R&D projects to working with UK manufacturers exploring product development possibilities for more streamlined production development and improving client interaction when shopping online with the use of 3D technology.

Dr. Andrew Hewitt

Dr. Andrew Hewitt joined the University of Huddersfield as Lecturer in Textiles in March 2018. Though new to academia, Andrew was no stranger to textile research, with 24 years of commercial textile R&D experience. Before joining the university he worked at a university spin-out company for over 12 years, conducting confidential textile R&D for industrial clients across the globe.

Andrew was drawn to the University of Huddersfield by the vision of Future Fashion Factory co-investigator Professor Parik Goswami, aiming to re-establish the town and region as a world leader in textiles by harnessing novel technologies and manufacturing techniques. Huddersfield's heritage as a major centre for the chemical industry was another catalyst for the formation of the Technical Textiles Research Centre in 2019.

On arrival at Huddersfield, Andrew's first project was to help prepare the funding application for what is now the Future Fashion Factory programme.

"One of the things about my job that excites me most is the ability to make real differences to businesses, to society and to our planet," he explains.

"I get a thrill from innovation that results in new products and processes that are adopted commercially. Listening to businesses and consumers is key. I enjoy hearing about the technical challenges they face and working to develop innovative solutions to overcome them."

Andrew has worked on a variety of FFF projects, one of which involved analysis of how woven cloth can be modified whilst retaining the same warp beam, using tailored online treatments to the warp and/or weft threads during production.

At the same time, he has been involved with a systematic study of wool fibres from different UK sheep breeds, establishing new applications and develop new finishing techniques to broaden their range of useful properties. A further project examined the benefits of waterless plasma treatments and other novel finishing technologies on textile coloration.

Andrew is also passionate about producing the next generation of textile researchers. Inspired by conversations with industrial partners that highlighted a shortfall in high quality graduates, Andrew and his colleagues at the Technical Textiles Research Centre have developed a master's course called 'Product Innovation with Textiles,' which centres on an understanding of textiles, but also on design management for innovation and how to plan and conduct successful research projects.

Dr. Raheleh Jafari

Dr. Raheleh Jafari took up her post at the University of Leeds as a University Academic Fellow in AI Technology in Fashion Design in 2019. Having studied and researched around the world – including her native Iran, as well as Mexico and Norway – Raheleh has come to Leeds to develop her research on using artificial intelligence (AI) to develop new tools and analytical techniques for the fashion and textile industry.

Key to Raheleh's research is developing the next generation of retail bots, using machine learning and AI to bring these tools closer to reaching the tone and complexity of human conversation. Bots that can cope with sudden changes in conversation topic, for example, will be able to provide more personalised services to meet customer needs more effectively.

Data-driven design has represented one of Future Fashion Factory's core research themes, making better use of AI and big data analytics to understand, forecast and interpret consumer preferences across different markets and demographics. With fresh insights into how consumers shop and what they buy, brands will be better equipped to produce the right products for the right customers at the right time, driving sales and ultimately supporting growth.

Investment Mechanisms

Central to the Creative Industries Clusters Programme was a ‘commissioned R&D’ funding mechanism enabling collaborative projects to be co-created and developed by academia and industry in response to periodic calls for proposals. Such R&D projects were designed to be industry-facing and focused on making a real-world difference to the areas being targeted.

For Future Fashion Factory (FFF), this meant collaborating with multiple fashion and textile businesses (mainly SMEs), as well as other academic partners to ensure that funds were directed to the most impactful projects, aligned with the overall objectives of the FFF programme.

Within FFF, the commissioned R&D was referred to as ‘Responsive R&D’, the name change reinforcing the industry-led, targeted and responsive-mode nature of the awards. This change was also reflective of the fact that there had been significant industry consultation prior to launching the first call in January 2019, and the structure of the funding on offer had been co-developed, aligned with stated industry needs.

This initial consultation also defined FFF’s five Core Research Themes (CRTs) and, to keep programme activity aligned with industry need, a decision was made to use CRT alignment as gateway criteria for the Responsive R&D funding awards. Three funding streams were defined (Table 1) depending on the purpose of the specific proposal, all of which required co-funding.

Funding Stream	Total Project Value	Maximum Grant Value	Purpose	Funding Breakdown
Proof of Market (PoM)	Up to £10k	£9k	To evaluate a market opportunity; identify existing IP/conduct freedom to operate; explore further funding options; carry out small-scale R&D activity.	10% minimum match-funding requirement. 90% Intervention rate
Proof of Concept (PoC)	Up to £50k	£37.5k	To carry out interventions that progress proven methods and knowledge into validated technologies for a defined application.	25% minimum match-funding requirement Up to 75% Intervention rate Varies depending on company size & project
Innovation Challenge Project (ICP)	Up to £100k	£60k	Funding for innovations in partnership with industry to demonstrate and begin to scale up new technologies in a commercial setting. Such projects should be near to market (TRL 7-8, see table on page 6)	40% minimum match-funding requirement Up to 60% Intervention rate Varies depending on company size & project

Table 1: Overview of FFF Responsive R&D structure showing the three levels of funding available.

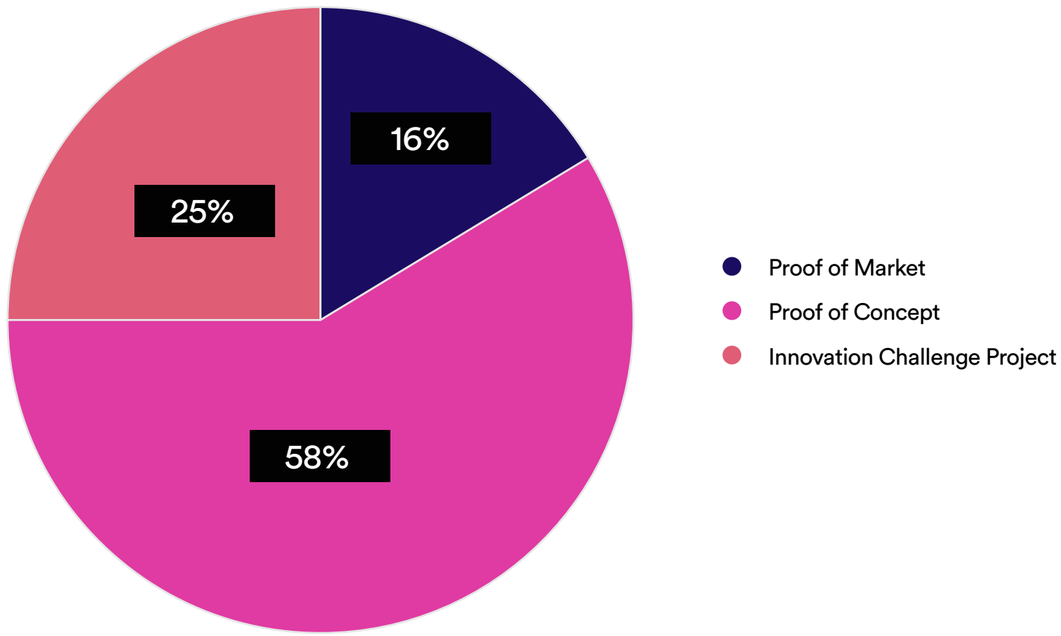


Figure 1: Distribution of Types of Funding Stream in all FFF supported Projects.

All six calls launched by FFF (Table 2) were structured to provide industrial applicants with as much flexibility as possible, leaving the decision on the level of funding sought and how much academic input was required entirely in their hands. A formal investment committee involving industry and experienced research and innovation professionals, considered all proposals against clearly defined criteria.

Throughout the FFF programme, the team reported on progress to both operational (Programme Management Group) and strategic (Steering Board) advisory meetings, which included individual industry member and sector body input. There was also on-going, ad hoc learning from applicant feedback and engagement events.

	Launch Date	Call Type	Projects Awarded	Project Types
Call 1	Friday 25th January 2019	Single Stage, all CRTs	9	2 ICP, 5 PoC, 2 PoM
Call 2	Tuesday 3rd September 2019	Single Stage, all CRTs	10	4 ICP, 4 PoC, 2 PoM
Call 3	Thursday 30th April 2020	Two Stage, all CRTs	13	2 ICP, 7 PoC, 4 PoM
Call 4	Monday 12th April 2021	Two Stage, all CRTs	12	4 ICP, 7 PoC, 1 PoM
Call 5	Monday 19th July 2021	Two Stage, all CRTs	5	3 ICP, 2 PoC
Call 6	Monday 10th January 2022	One Stage, single CRT focus	6	6 PoC

Table 2: FFF Calls – launch dates, number and distribution of awards, call type

Although the initial FFF application process was designed to be more streamlined than for example a standard Innovate UK SMART competition, industry feedback suggested that SMEs still found the detail required for Full Applications to be onerous and difficult to complete. Calls 1 and 2 effectively piloted a detailed, single stage application process which was then, in direct response to industry feedback, reviewed to become a two-stage application process; this consisted of an initial Expression of Interest (and feedback) stage, followed by an invited Full Application, for Calls 3 to 5. The Call 6 process reverted to a single stage mechanism but with a tighter focus on sustainability / circularity and with just one project type (Proof of Concept) available. This ensured that the FFF calls were agile enough to reflect current industry priorities, with a view to maximising impact.

Initial plans, for six open funding calls distributed equitably across the FFF delivery period, were amended due to COVID-19 challenges, which affected both industry partners working conditions and University lab availability (to varying degrees) from March 2020 to Summer 2022. The initial COVID lockdown resulted in a delay between the launch of Calls 3 and 4 with knock-on impacts on contracting, facilities access and recruitment for a further period. The time industry partners had during COVID lockdowns, to reflect on their business strategies and focus on research priorities, influenced the structure of the single CRT focused Call 6.

The fact that the fashion and textile sector responded so positively to FFF funding calls throughout the lifetime of the programme is a testament to the strength of the FFF ecosystem and the passion of industrial partners for high impact innovation. An overview of the types of FFF responsive R&D funding awarded across the various calls is given in Figures 1-3.

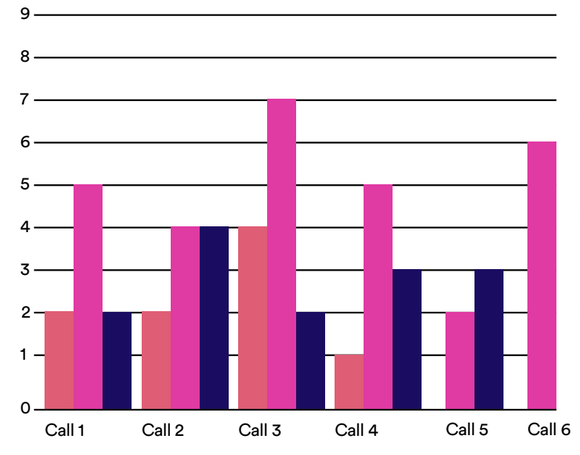


Figure 2: Number of Types of Funding Streams in each FFF Call.

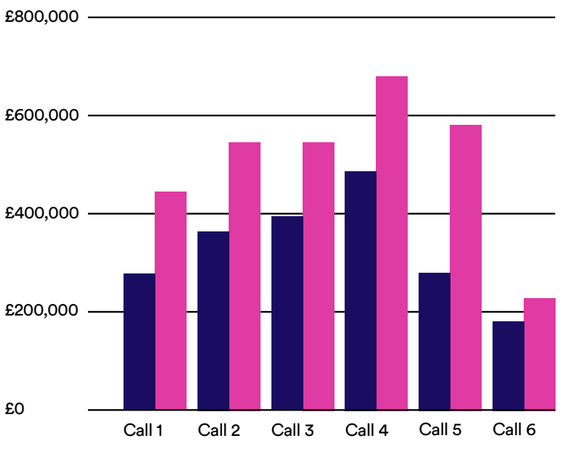
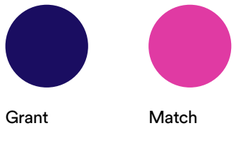


Figure 3: Comparison of Grant Award vs. Match Funding for each FFF call.



R&D Case Studies.

This support saw a large number of proposals submitted to FFF which in turn led to many fantastic projects being funded. These projects not only helped the companies themselves but also importantly benefitted the wider sector.”

Adam Mansell,
CEO, UK Fashion and Textile Association.
Chair, FFF Steering Group and Investment Committee.

Colour Measurement of Blended Fibres

With 30 years in the textile industry Mick Dixon, Dyehouse Manager at Abraham Moon & Son, has developed a broad and deep knowledge of the dyeing process. At the Moon mill in Guiseley, West Yorkshire – the town where the company has been based since it was founded in 1837 – his team ensures consistency in the colour of each luxury Moon fabric and accessory.

"Without this project we absolutely never would have looked at the issue from this perspective. I would absolutely do it again."

Mick's process typically starts with the blend number (e.g. 106d) and works backwards, breaking it down into the specific dye colours needed to achieve the right effect. It is a complex and creative process, done almost entirely by eye in a lightbox – and as wool can vary from year to year and even from sheep to sheep, Mick draws on his skills and experience to make subtle adjustments that maintain a consistent shade.

For quality control and audit purposes the mill uses a spectrophotometer, a specialist colour measurement tool that allows for accurate matching and allows the team to keep a record of readings for future reference. Ultimately the process relies on the unique expertiseof experienced dyers.

"A lot of this process is trial, and error and our experience allows for a good level of accuracy," Mick explains. "At Moon, we started considering how we could make the colour-matching process more efficient with digital technology."

Collaborating with Professor Stephen Westland and research assistant Keith Findlater at the University of Leeds, the project had two distinct parts: to analyse the colour measurement process and understand the available data; and to explore how this data could feed into a predictive model determining the colour requirements for blended fibres.

As Professor of Colour Science and Technology, Stephen has worked with numerous industry partners and published around 200 papers, book chapters and books on colour science, design and imaging. With his expertise in machine learning and analysis, he also leads Future Fashion Factory's core research theme on data-driven design.

The first phase of the project saw Stephen and Keith meeting with the production team at Moon to examine how samples are prepared and presented, while Keith also took standard blends and pads from the mill for further analysis.

They looked at how existing technology could enhance the process, for example, whether VeriVide's DigiEye tool could scan a sample and immediately identify the necessary adjustments.

"That was when we realised that the issue wasn't with prediction – it had been in measurement all along," Mick says.

"Samples are prepared slightly differently by each person, so we need to standardise the whole process and guarantee more consistent data for our existing colour measurement tools. We invested in a new padding machine to solve this problem, so the pad will be the same even when different teams are working."

The padding machine represents a capital investment of just over £31,000, a direct result of the original project, and has already been used for its first few jobs.

By decreasing the waste produced in manufacturing and minimising product sold at a discount due to quality issues, improved colour consistency will protect Moon's margins and reduce its environmental impact.

In addition, the company has started investigating new equipment such as a specialist carding lab for quality testing and sampling, which would allow for further gains in productivity and efficiency and relieve the pressure on production staff to manage the process by eye.

"This new approach doesn't negate our knowledge, creativity and skill, but it does make our jobs much easier," he adds. "We've been doing this for years but we can't keep doing the same thing forever."

Fabric Evaluation System

Roaches©

No two people will describe how a fabric looks and feels in the same way. The lack of a common language to describe fabric aesthetics poses challenges for communicating across the complex global fashion and textile supply chain.

In a project funded by Future Fashion Factory, Roaches International has worked with University of Leeds researchers to commercialise research on fabric evaluation and analysis, creating a fabric evaluation system that removes subjectivity and ensures consistency in measuring fabric tactile properties.

Without any standard language to quantitatively describe a fabric's tactile properties, it is difficult to ensure consistently high quality in fashion products, leading to higher levels of waste and environmental impacts.

The team at Roaches International partnered with Professor Ningtao Mao at the University of Leeds, who leads the development of the Leeds University Fabric Handle Evaluation System (LUFHES), and with W.T. Johnson & Sons (Huddersfield) Ltd.

"We are aware of the long-term challenge which exists in communicating touch-feel of fabrics within textile, fashion and retailing industries. The LUFHES technology is intended to define fabric tactile properties in a haptic spatial system, similar to how colour charts have been digitally defined for colour palettes, and Tog value defined for warmness/ coolness," said Professor Mao.

Fabric samples are placed into LUFHES that then runs a series of tests to generate quantitative fabric tactile property data akin to a fingerprint for the fabric, which can then be compared against other samples and communicated digitally to partners in different locations.

Working closely with Professor Mao and potential end users, Roaches International led a collaborative innovation project to develop LUFHES' technology into a commercial product. Supported in Future Fashion Factory's first funding call, it focused on refining the sampling method, the fabric evaluation system itself, and user-operated software.

Reliable and consistent sampling is crucial to ensure the quality of the generated data. Roaches International created a device that would automate the process, ultimately building a more efficient system for business use. The fabric evaluation system consisted of two parts – the automated measuring device itself, with a casing suitable for industrial settings based on commercially available materials, and software to control the system and algorithm for data processing. Professor Mao has worked on-site at Roaches International to support the project, as well as being in frequent contact with the software developer.

Roaches International is working with clients to either access their fabric archive to generate valuable data for their fabric designs, or to help their technical team to gauge the customised touch feel of their fabric finishes.

From there, Roaches International can focus on testing the system with partners in the fashion and textile supply chain, evaluating how well the data obtained can be used to help the communication of the fabric qualities of their fashion products in a different location. To achieve this the company will build additional units.

"From our first introduction to LUFHES we could see the possibilities for this technology to impact the supply chain in a similar way the spectrophotometer did for the communication of colour," said Sean O'Neill, Roaches International Managing Director.

"LUFHES is an ideal addition to Roaches International offering, and fits perfectly with our ambitions to designing and supplying apparatus with a higher level of technology."

The product will have significant benefits for Roaches International's clients, shortening lead times, ensuring the consistency and quality of products as well as developing fabrics having a customised touch-feel for specific fashion products. By reducing waste in the supply chain, generated when products do not meet performance requirements and quality standards, it will also contribute to the long-term sustainability of the fashion industry.

The company is even considering the system's applications in e-commerce, working with brands and retailers to improve the online customer experience – a host of tangible commercial benefits born from this ground breaking research.

New Heritage©

Historic Inspiration for Designer-Led Bespoke Short Run Fabric

Short runs of bespoke fabric provide independent fashion designers with a new way of stamping their identity on their collections. In a project funded by Future Fashion Factory, historic woollen mill AW Hainsworth collaborated with Yorkshire Textiles to create a unique ‘New Heritage’ cloth, bringing designers into the manufacturing process as part of a new service. AW Hainsworth has been in the same family on the same site in Leeds since 1783. It continues to produce luxury cloth for prestigious global fashion brands and forges close relationships with emerging designers.

“Fashion designers want to stamp their own identity on their collection, but with smaller ranges it is often difficult to meet the minimum order quantities for most fabric suppliers,” says Julie Roberts, Marketing Manager at AW Hainsworth. “We’ve been offering bespoke colourways for several years, but we needed to go a step further to support these fashion startups. At Hainsworth we started thinking about a service where we could offer short runs of bespoke fabric designs.”

Working with Suzy Shepherd, founder of Yorkshire Textiles and Co-Director of Future Fashion Factory, the mill’s team developed a plan to test the potential service for the luxury fashion market. Through the non-profit Yorkshire Textiles, Suzy was looking for opportunities to bringdesigners into the manufacturing process, giving them an insight into how their fabric is made and highlighting the unique history and pedigree of Yorkshire’s mills. She suggested using some of the earliest innovations of the Industrial Revolution, taking heritage patterns from punch cards used in historic jacquard looms as the inspiration for a unique fabric design.

Independent fashion and home interior brands based at the AW Hainsworth site would have creative input at each stage, using the finished short run fabric in their own products. The project was funded by Future Fashion Factory and weaver Rebecca Ough was tasked with working backwards from the punch cards to uncover the designs, eventually translating them into modern design software. With ongoing support from the designers at the mill, a wide range of samples were created and whittled down to three designs that went into production.

The finished product – a short run of bespoke ‘New Heritage’ cloth – was on display at Future Fashion Factory’s Year 1 Showcase in October 2019. Unique accessories and home interiors by designers including Future Fashion Factory members, *The Odd Bobbin* and Charlotte Luisa were all on show. Garments were also created by the fashion team at the University of Leeds, based on a student project using pieces from the Yorkshire Fashion Archive. The New Heritage cloth has continued to bring designers closer to their fabric: fashion students from the University of Leeds visited AW Hainsworth, where they watched a new short run being woven in red and black. For Yorkshire Textiles, this is part of equipping tomorrow’s fashion designers with the skills to work more collaboratively across the industry.

Dr. Kevin Almond, University of Leeds Fashion Lecturer said “The project was an exciting opportunity for the students to observe the weaving of the jacquard fabric and utilise this fabric in creative and innovative ways in the design and production of a fashion collection. Seeing how the jacquard coding process brought historic designs to life has been inspirational for the students & will enhance their creative understanding of the use of textiles within the fashion design process.”

“Understanding the manufacturing process opens up opportunities, creatively and commercially,” Suzy says. “Knowing where your cloth came from and being able to engage with the process can be a source of inspiration and can enrich the story of your brand.”

At AW Hainsworth, the success of the project demonstrated that a short run bespoke fabric service was both possible and viable. Shorter runs that meet the designer’s needs also reduce waste, a point which AW Hainsworth reported in their 2020 Sustainability Report. The mill has started offering the service to specific designers, and new collaborations are in the pipeline as a result.

Innovative Mattress Design to Reduce Textile Waste

Deluxe Beds©

Of the seven million mattresses that were disposed of in the UK in 2017, 40% were sent to landfill and a similar proportion were incinerated. The industry faces a significant challenge when it comes to managing waste as well as demand for new virgin textile materials. Just 19% of all mattresses are being recycled into new products - a figure which the National Bed Federation (NBF) has pledged to increase to 75% by 2025.

Across the sector, businesses are looking for new solutions to mitigate the environmental impact of used mattresses.

A modular design composed of different blocks that could be arranged, removed, and added separately, could add years to the life of the product and retain valuable materials, as well as offering some unique benefits for consumers.

Working with Dr. Sohel Rana, Lecturer at the Technical Textiles Research Centre, and a group of researchers at the University of Huddersfield, the team at Deluxe Beds in Huddersfield led a project to develop a new approach to mattress design that enabled individual components to be replaced over time.

Deluxe Beds had already started work on a three-layer mattress that was recognised as a finalist in the 'Innovation of the Year' category at the 2019 NBF Awards. The Future Fashion Factory project took a different approach, building on Deluxe Bed's prior work before exploring whether the product could be sectioned vertically as well as horizontally, therefore creating smaller sections that allowed greater flexibility in design. Keeping sustainability at the heart of the project, the adhesive used to connect the product sections also needed to be biodegradable or recyclable, as did the other fibres and fabrics used in the entire construction.

Although many existing mattresses use natural fibres such as wool, and recycled textile fibre in combination with steel springs or other materials, polyester is commonly used as a protective barrier between the different layers. The new modular mattress design eliminates polyester completely – replacing an oil-based, non-biodegradable synthetic material with eco-friendly alternatives that will either biodegrade or can be recycled.

Deluxe Beds is now well positioned to take forward modular products, which can be completely personalised to each consumer while reducing the amount of waste created during end-of-life disposal.

By using entirely natural and renewable materials, the design will also cut global demand for synthetic polyester and ensure that the remaining waste is either recyclable or biodegradable.

"This project really helped to fast-track our product development," says James Appleyard, Sales Director at Deluxe Beds. "By closing down dead ends, identifying leads and giving us a clear direction of travel, collaborating with Future Fashion Factory has helped speed us toward a solution capable of driving major global change."

Recycling Cashmere

Joshua Ellis©

In over 250 years, Joshua Ellis & Co. Ltd has been owned by just three families. At the heart of Yorkshire's textile industry since it opened in 1767, the company specialises in luxury cashmere fabric and accessories which are exported around the world.

While proud of its heritage the business is also investing in its future, developing partnerships with some of the world's biggest brands – Alexander McQueen brought Kate Moss to the mill in Batley to shoot their Autumn/Winter 2019 campaign – and building new initiatives to ensure the business is sustainable for the next 250 years.

"We began to discuss the idea that by recycling cashmere from other products when they reached the end of their lives, we could potentially open ourselves up to new more price-conscious markets and customers without compromising our commitment to quality and sustainability," says Oliver Platts, former Managing Director of Joshua Ellis.

The company needed to understand whether there was a market for accessories that used recycled cashmere, and how much of the product should be recycled. Previous tests had suggested that the finish on the product changed with more than 25% recycled fibre in the mix.

For Joshua Ellis, this suggested the choice was to produce either a 100% recycled cashmere product, or an item made largely with virgin fibre and a small proportion of recycled material.

While the team worked with Oliver on developing his full application, we also identified researchers whose interests aligned with the project and introduced Joshua Ellis to Dr. Alice Dallabona at the University of Leeds.

Alice researches the luxury fashion industry, as well as fashion marketing and the relationship between fashion and identity. She collaborated with the team at Joshua Ellis to shape their key research questions, speaking to both Oliver and the company's sales director to understand the concerns expressed by the company's customers.

Building on existing research by academics and industry, and with the support of research assistant Camilla Bandera, Alice set up focus groups with luxury fashion consumers where they were asked about their interest in sustainability and how it affects their +buying decisions.

While most respondents said that they were aware of issues around sustainability and environmental impacts, they were more likely to act on these concerns when it came to food or energy consumption than with fashion.

Combining existing research with the results of the focus groups, the analysis showed that luxury customers are interested in the sustainability of brands. However, the environmental impacts of a luxury product are not a significant priority: positive environmental messages are often seen as an "extra" on top of a product the consumer would buy anyway.

Rather than confirming Oliver's theory, Alice's report gave a new perspective on what sustainability really means for a luxury brand like Joshua Ellis, as well as for the 24 other textile businesses owned by SIL Holdings – a family-owned group based in Bradford. After the report was shared at group level, SIL decided to recruit a sustainability director to focus on this question and to champion sustainable practices across all 25 of the group's companies.

In addition to fulfilling the brand's pledge to eliminate single-use plastics, Oliver said that the company is thinking more broadly about its supply chain and manufacturing processes, from reducing water usage to supporting high standards of animal husbandry.

"We want to ensure sustainability is at the heart of everything we do," Oliver said, "and this project has made it clear that we need to focus our efforts on a variety of different initiatives throughout our supply chain and manufacturing."

Immersive Textile Training

Laxtons is a name that has been synonymous with the spinning of fancy and worsted yarns for over a century, with roots dating back to 1907. Enjoying a long-standing reputation of being innovators in the sector, the fancy and worsted spinner specialists make a natural fit for collaborative partners in one of Future Fashion Factory's earliest R&D projects.

"We are really excited about the outcomes of this project which will enable us to take our training and multi-skilling to the next level, not only improving productivity but also improving staff engagement in the whole process. On top of which we have now secured the skills for life, which is a huge issue within the industry as more skills are lost due to retirement"

James Laxton, Managing Director

Today, Laxtons offers a premium yarn product that prioritises not only quality and traceability but is customisable upon request. Achieving this balance requires a high level of expertise amongst its workforce, where staff-members are tasked to not only produce bespoke yarns but to do so at pace with ever high demand.

Typically, it has taken between 6-8 months to fully train a staff member from induction to the point where they can independently manage a spinning machine. Higher education courses rarely provide the necessary structure and rigorous training to prepare graduates to take on roles in the textile manufacturing sector as it functions today.

To best train and retain a skilled staff member, Laxtons has produced an immersive bespoke training tool to not only upskill its existing workforce, but to aid in the training of new employees. The tool has been built to reduce the time it takes to ensure proficiency in every area of operations, providing a comprehensive digital training record for all its users.

The collaborative project, which brought together Laxtons with the University of Leeds' Professor Muhammad Tausif (Professor in Sustainable Textile Manufacturing), focussed on the ways in which harnessing new augmented reality (AR) techniques could develop exciting new immersive training packages for Laxton's staff.

This allowed them to gain virtual hands-on experience of complex production processes, cutting average learning times, as well as providing unrivalled access to high quality training provision.

To enable the delivery of this tool, Laxtons produced a data pool that consists of video, audio, and AR/VR components. This utilises digital devices (such as tablets) during the setup process for each spinning machine. As a result, the bespoke tool is not only useful for Laxton's own training purposes, but is scalable, and could potentially be picked up by other industrial players.

An additional use of the data pool could be utilised by fashion & design students or implemented for educational use with buyers & designers who are direct clients of industrial spinners. This would mean that these groups would be better supported in understanding what they are buying. This would mean that sales teams for spinners, weavers and textile manufacturers would be able to spend less time explaining their products, their manufacturing processes and lead times, thus freeing them to have the capacity to follow up more sales leads and enable these businesses to grow.

Critically, the tool could help secure the relevant skills for life, which could help address the current skills gap in the UK textile industry and thus help provide a new generation of textile technologists.

Analytics to Enter New Markets

Whiteford Felts & Fabrics©

Whiteford Felt & Fillings Ltd has been producing thermally bonded waddings and needled felt fillings for more than three decades. As the company expands into new markets with its own range of luxury outerwear, it requires a wide range of information to help reach an entirely new customer base. In partnership with Future Fashion Factory, the company has harnessed big data analytics to generate insights that will inform the next phase of its growth.

Driven by founding director David Edge Sr., Whiteford has enjoyed sustained success in its core business and remains at the forefront of the textile fillings industry. In the next stage of the company's growth, David was keen to diversify the business with the 'Flagship Collection': incorporating the use of natural fibres in a premium line of wool-insulated coats and gilets, aimed at luxury car lovers.

The company's core business has seen growth through recommendations from customers, establishing strong relationships from word-of-mouth, while not necessarily having invested in marketing. Apparel is completely new territory in which additional support is required for the company to gain a foothold: entering a new market would have been challenging without a bank of customer data that could have informed market research. To acquire this data and generate insights into the target market, Whiteford collaborated with Dr. Boshuo Guo, a researcher at the University of Leeds who specialises in data-driven marketing techniques.

Initially, the project was set to focus on unstructured interviews with prospective customers among the membership of a luxury car club, but the impact of the pandemic led to a radical shift in approach. As e-commerce exploded and customers spent virtually all their time at home, social media represented a more promising methodology.

"Although we couldn't get direct feedback from people, Twitter generates huge volumes of data that we could work with," Boshuo explains. "This data set can tell us a lot about customers' interests, how they find and access information, and even the other kinds of brands they engage with. That gives you a starting point from which you can build a product marketing strategy."

Using big data analytics techniques, Boshuo studied random selections from over 20,000 tweets to turn data into meaningful information a brand can use, such as who the target customers are and what kinds of information influence them.

Popular images can inspire the aesthetic of a product photoshoot, while frequently used words can be incorporated into marketing content. The findings even highlighted key brands in areas such as vintage fashion and luxury childrenswear that are popular with the target customer: studying the success of their campaigns will offer insights into how to drive sales.

Digital Analysis of Fabric Finishing Processes

Every piece of luxury fabric goes through multiple stages of manufacturing before it reaches the hands of a fashion designer. From raw materials to spinning and weaving, creating premium cloth is a highly creative and complex process.

Finishing is the final piece of the puzzle, which can transform a piece of woven fabric by adding shine, changing how it feels, and even adding functionality like stain-resistance. WT Johnson & Sons, a family-owned business in Huddersfield, has been finishing luxury woollen fabric since 1910.

“Basically, we make fabric special,” smiles Alan Dolley, the company’s Technical Manager.

Alan has worked for the company since he was a teenager, accumulating the wealth of specialist knowledge that makes him what he calls the “first-aid man”.

“When a customer comments on the drape or lustre of the fabric, I’m already mentally making adjustments to the processes we’ve used to give them exactly what they’re looking for,” he explains. “We find that being able to feel a fabric and tell someone what that means in technical terms is a valuable skill.”

Even so, evaluating the finish of a fabric is a subjective process carried out by individuals. This poses challenges for a business like WT Johnson, which balances bulk orders for household name retailers with small volumes of luxury and bespoke cloth for international brands. Achieving consistency between seasons and across large volumes of cloth is the key to the business’ success.

“We are very good at this with our experience and creative judgment, but anything that might increase our accuracy is worth exploring,” Alan says.

“We send samples all over the world to our customers’ international suppliers, and if you could quantify handle, you could sell products globally without physical samples that can go to waste.”

Working with Professor Ningtao Mao at the University of Leeds, WT Johnson led a collaborative project to explore the potential of Leeds University Fabric Handle Evaluation System (LUFHES) in finishing. LUFHES performs a variety of different tests on fabric and translates the results into quantitative data: effectively, a digital ‘fingerprint’.

By connecting this data to samples from WT Johnson’s own archive, the project set out to develop a digital system that links the characteristics of a fabric with the finishing techniques used to achieve them. In turn, this new way of quantifying fabric handle could become useful to ensure consistency in the final product, and even to predict the right techniques to achieve a desired finish.

Ningtao and his team members, Dr. Sahar Arshi and Dr. Verity Hardy, digitised a variety of fabrics from WT Johnson through LUFHES, and integrated the data into an intelligent system. Based on machine learning models to allow fabric handles to be connected with finish processes and the properties of raw fabrics, the system will learn from new data as it is added.

WT Johnson was able to trial and evaluate the new software, comparing the data with the subjective experience of fabric handle that the business knows so well.

“This system is incredibly clever, and now it needs to be evaluated against our conventional human experience of fabric handle,” Alan explained. “We absolutely see potential for further work to test and refine it, and it will only become more accurate as the sample size grows and the system learns.”

A predictive system that enables WT Johnson to guarantee right-first-time finishing could drive big improvements in efficiency, as well as reducing the environmental impacts of repeating or adding new processes to fabric. With a quantitative point of reference, the company could immediately identify and reproduce specific finishes that customers prefer.

Ultimately, the system is an example of innovation supporting the creativity and skill of the company’s staff to continue making luxury fabric special for the thousands of fashion designers worldwide using Yorkshire wool in their collections.

“We would never have gone down this road without Future Fashion Factory,” Alan says. “We treasure the subjective experience of fabric handle, but technology that can help us guarantee that accuracy and consistency is particularly valuable.”

Developing a Digital Archive

Abraham Moon & Sons©

Like many of the high-quality woollen and worsted manufacturers in the West Yorkshire region, Abraham Moon & Sons have amassed a considerable amount of physical material and technical production data in their design archive. So much so that maximising the massive potential this could have for the business is extremely difficult and, as a result, the resource is massively underused.

In a R&D project supported by Future Fashion Factory, Moon were able to work with researchers from the School of Design at the University of Leeds to build a digital archive of these assets. To hold the different forms of data that Moon staff needed to access, the archive pioneered the development of a new digital software tool that successfully curates, manages and analyses the historic designs in parallel with the company's new creations. To kickstart this process, the project required high-resolution imaging to capture the aesthetic of each design, as well as detailed information on the manufacturing specification.

This digital solution has enabled Moon to adeptly manage and curate the historical archive in an innovative digital platform, providing a tool that will develop an easily accessible resource to support decision-making, enable rapid optimisation of processes and reduce lead times.

"Established in 1837, we are immensely proud of our heritage with a rich archive of designs and fabric qualities created over decades in our vertical woollen mill. The archive is vast and the work is ongoing, and of course the archive will be forever be growing as long as we continue to create new collections!" says Judith Coates, Design Director at Moon.

As well as supporting future design decisions, the data will enable the company to optimise its manufacturing processes for new products, reducing lead times. Moon are already able to search design and fabric types easily and access technical information without physically searching for the fabric swatches. The software also serves as an invaluable marketing tool which demonstrates the rich design heritage to customers. Critically, the tool will support the reduction in fabric development time and cost through easy access to historical designs and design data.


Camira©

Rapid Application of Functional Finishes

Camira Fabrics supplies high-end interior fabrics for everything from homeware to public transport, meaning flame-retardant finishes are a top priority. Collaborating with Future Fashion Factory, the company has moved toward a new finish that meets the same performance standards with a much smaller environmental impact: reducing water, energy and chemical usage for more efficient and sustainable manufacturing.

Camira produces fabrics at scale to meet large orders from around the world. Flame retardance is one of the most popular properties for these customers and needs to be imparted through a finishing process after the fabric has already been dyed and woven. Every stage of the manufacturing process adds time, energy, water or chemicals – as well as room for costly mistakes.

“Existing treatments can change the shade of the fabric, so the results may not be repeatable from batch to batch,” says Mick Coll, Senior Innovator at Camira. “There is a high margin for error, so the process needs to be supervised by experienced staff. If something goes wrong a lot of resources are wasted.”

As well as the time, risk and complexity associated with current methods, changing regulatory standards pose an entirely new challenge which limits business opportunities.

Camira’s wool / bast fibre fabrics have a natural inherent flame retardancy offering a sustainable solution for some sectors, but for other wool fabrics, which require chemical flame-retardant treatments, the industry needs a more sustainable solution.

“Some fire-retardant finishes are being outlawed in markets which then become closed to us,” explains Colin, Technical Development Manager. “As national and international standards change, we want to futureproof the company with a natural alternative to traditional methods.”

To investigate natural flame-retardant finishes, Camira collaborated with Professor Parik Goswamiat the University of Huddersfield. For Parik, the opportunity aligned perfectly with Huddersfield’s commitment to the Textiles 2030 initiative, which aims to accelerate the shift towards sustainability and circularity in the UK.

“We’re focused on using chemistry from the natural environment to support the region’s businesses to become more sustainable,” says Parik. “It’s exciting to harness natural resources to give Yorkshire companies the cutting edge when facing tomorrow’s challenges.”

Parik and his team in the Technical Textiles Research Centre undertook lab testing of new natural chemical alternatives, supported by Colin and Mick’s commercial insight to develop solutions that would meet industry standards.

The result was a promising set of findings which shed light on the potential performance of a natural flame-retardant finish. Even more exciting, the new solution could be added to the fabric in the dye bath as part of a one-step dyeing and finishing process.

Removing an entire stage of the manufacturing process would massively reduce the energy, water and chemical resources needed to produce Camira’s fabrics – and by simplifying the process and reducing the margin of error, it would enable more consistent results to satisfy customers’ quality specifications.

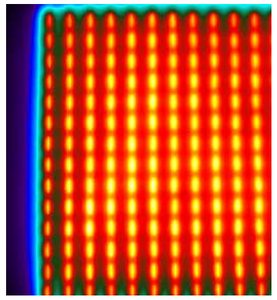
Camira is currently investigating commercial sources of natural chemicals which will enable them to scale up and commercialise the new technique. The novel approach could be applicable in markets that are still closed to the company, creating new opportunities worldwide. Bringing an innovative solution to market could even give Camira a new revenue stream.

“The market is saying that we need to become sustainable, but nobody actually has a solution to address this challenge,” Colin explains. “If we’re the first, the market potential is huge.”

Personalised 3D-Zoned Textile Heaters

Conductive Transfers©

Conductive Transfers Ltd has developed a new process for screen-printing circuits with a high level of durability. This ground-breaking approach eliminated the wires and plastic substrates that are commonly found in contemporary wearables, all while preserving the benefits of printing onto a plastic sheet.



The innovative method has embedded new features into the printing process, allowing for the incorporation of sensors, heaters, and surface mount components when working with existing garment designs. Another aspect of this approach centres on subjecting the technology to stress tests, to fully validate various performance metrics across deployable environments. Critically, intelligent textiles solutions continue to draw significant interest from a range of sectors, from fashion, medical textiles, sports goods, home textiles and the automotive industry.

Working with Future Fashion Factory, Conductive Transfers Ltd collaborated with Dr. Sohel Rana and Dr. Shama Parveen at the University of Huddersfield to successfully develop an innovative and cost-effective nano-ink for 3D zoned heaters to replace the expensive silver inks that are used in today's printed heaters.

The zoned heaters allow for highly regulated increases and decreases in power output for each applied heating zone. This aligns with a more controlled and energy efficient technology when heating fabrics. The new approach has been achieved by heat pressing printed heaters onto textile material which uses the new nano-ink and printed temperature sensors in each heating zone. In addition, the approach allows for additional heating elements that can be included to meet product requirements.

The heaters can also contain complimentary printed insulation technology for enhanced thermal efficiency, (such as a graphene ink, bubble ink or reflective ink layer for example). This novel technology will help to tackle the problems with existing textile heaters based on conductive yarns (which are complicated and expensive) or printed on plastics (which are uncomfortable and environmentally unfriendly).

The project has produced a bespoke heating system which is highly efficient, cost effective, light weight, thin with a soft feel, and that is also plastic free, recyclable, and durable.

It is expected that the development of the new nano-ink for 3D zoned textile heaters can significantly improve the competitiveness of Conductive Transfers Ltd within the e-textiles market, both in the UK and globally.

A Second Life for Automotive Leather

On average, eight cow hides are used to produce a single luxury car interior, but there is no established model for utilising the waste product tied to this process. Further waste risks are also possible, for example, a small error in the stitching can mean that the produced seat is not fitted into a vehicle and is discarded. Fine leather seats in end-of-life vehicles also end up in the landfill. While the automotive sector produces a luxury resource, for which it does not have another use, yet a different manufacturer may be able to maximise its value.

To find a new life for these resources, HSSMI adopted a cross-industry methodology.

The project, funded by Future Fashion Factory, brought together sustainable engineering experts Miretur, a global car seat manufacturer, and the wealth of fashion and design expertise at luxury fashion house Burberry. Supply chain researchers Dr. Samir Dani and Dr. Nicoleta Tipi from the University of Huddersfield completed the project team.

Working at The Textiles Research Centre at The University of Huddersfield, one of the three Future Fashion Factory research centres, the partners were tasked with identifying different use cases for luxury leather from the automotive sector in high-value fashion products.

Tristan Coats, Project Lead and Technical Specialist at HSSMI, said that the project was designed to understand the challenge from a variety of different angles.

“In the first phase of the project, we asked participants about the characteristics that are useful for different products and put together a use case matrix, which gave us insight into the product line to compare against existing automotive industry by-products,” he explains.

“It completely changed our assumptions about leather as a material and the processes it goes through. It was vital in giving us a real, physical understanding of the challenge at hand.”

Equipped with this information, each project participant received a variety of automotive leather samples.

Despite working from home and often with limited equipment, the project partners set to work on the creative challenge of making a new product prototype from the leather they were given as part of the project Hackathon. Originally the Hackathon was meant to bring partners together to work collaboratively on physical samples in person. Despite the travel restrictions that made this impossible, the act of engaging creatively with the challenge enabled each participant to gain a new understanding of the problem and bring these perspectives to a virtual workshop where they presented their new product prototypes.

Coin purses, pick cases, jigsaws, and decorative features were all among their creations, while others had even tried weaving together strips of leather to make larger pieces. With physical prototypes of fashion products at their fingertips, the participants demonstrated the cross-industry potential to find a new life for automotive leather.

“It was fantastic to share so many ideas and find common ground,” adds Nicoleta Tipi. “Understanding the full potential for re-using leather from perspectives in design, the supply chain and even disposal and end-of-life really demonstrated the potential of collaborative, cross-sector research.”

From this consensus, the conversation has evolved to explore numerous avenues for further research and development, addressing questions such as how to maximise the value of luxury materials through design, as well as applications for re-use.

Miretur is pursuing a project to bring a new re-use product to market in partnership with a car manufacturer, a fashion house and their suppliers. At the same time, other partners have been inspired to consider new ways of designing for manufacture across industries.

“At the moment, there is no established process for collaborative design, which would allow us all to benefit from shared resources,” explains Francesco Pianca, Senior Manager (Sustainable Manufacturing) at Burberry. “If you could co-design products, for example a car seat and a coin purse, the cutting process could achieve a greater yield and minimise the waste from every hide.”

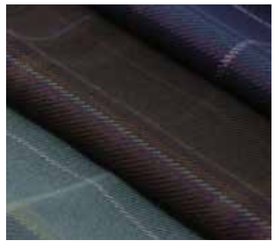
For HSSMI, the project highlighted the benefits of working across sectors to drive the shift toward a circular economy.

“It has been an incredible stepping-stone for us,” adds Tristan. “Having a dedicated circular economy team means we can transfer our knowledge and skills across industries, and we are keen to develop more projects that support UK manufacturers in creating a more sustainable fashion industry.”

Novel Finishing Techniques for Fluorocarbon-Free School Wear

Marton Mills©

Marton Mills Co Ltd is a is a celebrated traditional family-owned weaving mill based in the textile homeland of West Yorkshire. Stocking ranges of pure wool tartans and Shetland tweeds, along with a variety of blends which are used to create a various industry leading fabrics, it is no understatement to say that pedigree and quality are the hallmarks of their product ranges.



When producing heritage textiles for a continuously evolving marketplace, a particular challenge can arise - how to best adopt innovative technologies so that product ranges can retain high standards, while also adapting to the ever-shifting technologies of an increasingly dynamic sector.

It is with this tension in mind that Marton Mills embarked on a collaborative R&D case study with Future Fashion Factory. Consistent quality and exemplary service has led to Marton Mills being the largest supplier of school wear and kilt fabrics in the UK. As such, the collaborative project was designed to address technical concerns around fluorocarbons and certain chemicals used in contemporary finishing techniques for school wear. New methods for finishing fabrics designed for school wear were explored, as well as a focus on retaining their signature anti-pilling properties.

Bringing together a collaborative team of technicians at Marton Mills, Professor Parik Goswami, and researchers at the University of Huddersfield, the project was centred on identifying safer and more sustainable methods for finishing cloth used in the production of school uniforms. The aim was to seek an alternative to fluorocarbons, which are typically used as a chemical finish but have environmental concerns and will soon be removed from the market.

Existing clients of the mill have relied on the high level of consistency and performance of the products provided, and so the challenge centred on maintaining a high-performance while negating these concerns. The project launched a comprehensive literature review and market analysis as their basis for formulating a new solution. The team then employed rigorous laboratory trials to test this formulation, ensuring that it could overcome any potential issues without compromising comfort and other performance characteristics.

Performance of the finished fabrics were then assessed, and an optimisation of the finishing formulation was carried out to maximise the performance while ensuring utmost safety. To achieve this, the project had scope for iterative testing based on client feedback, wherein Marton Mill worked with their existing client base to gather feedback from clients on the new finish. This led to the identification and ultimate adoption of a new gold-standard for provision of school uniforms.

It goes without saying that reducing the quantity of fluorocarbons utilised within the fabric finish will help better protect the environment. The outcome could also potentially be used for any application where sustainable, durable fabrics are required including outer wear, corporate wear, and highland wear.

Professor Parikshit Goswami, Associate Dean Research Innovation and Knowledge Exchange, School of Arts and Humanities, at the University of Huddersfield explains:

‘This project is a perfect example of how a traditional family-owned weaving mill in the heart of Yorkshire works together with the academic infrastructure and research capabilities to solve contemporary technical challenges. Collaborations such as these will keep our businesses world-leading, and the rich heritage of Yorkshire-made fabric will grow even further.’

Nomad©

Innovative Digital Applications for Independent Fashion Brands

"People think that universities, colleges and businesses are all separate, but we need to collaborate to find these kinds of solution. As an independent brand we can learn from them, and they can learn from us."

Naturally, Covid-19 accelerated shifts in consumer shopping habits, as a lack of opportunities for physical retail therapy led to an explosion in e-commerce. Nomad Atelier was already reconsidering its online offering before the pandemic took hold, but the independent brand's hand was forced when the national lockdown led to the closure of its store and studio in Barnsley.

Making better use of customer data has enabled the company to grow and consolidate its client base, while digital platforms, such as Zoom or by providing styling advice over WhatsApp helped to maintain the personal relationships that have proven key to Nomad's success.

For Rita Britton, Nomad's founder, the past year has demonstrated the importance of innovation for independent brands.

"If you stand still, you're going backwards," she says. "I have clients who have been with me for more than 40 years, but you need to keep finding new ones and building lasting relationships with them.

"We spotted an opportunity because our collections matched people's new lifestyles once they were spending more time at home. To make the most of it, especially to draw in new clients who wouldn't be able to travel to the store after reopening, I knew we had to make the online experience as slick as instore."

To explore this prospect, Nomad collaborated with researchers at the University of Huddersfield led by Claire Evans, senior lecturer in fashion. The three-month project focused on researching the landscape of 3D and digital offerings across the fashion industry, before testing different platforms for showcasing products digitally to come up with some recommendations for Nomad's digital growth.

Competitor analysis and benchmarking were crucial to this first phase. Claire's research highlighted a variety of approaches being used by large and small companies, giving Rita a starting point to consider what would work in the context of her independent luxury brand. The feedback enabled Claire to refine her approach to the second phase.

Ideas generated in this early stage of the project supported the development of 'Perfect', the new brand Rita has recently launched under the Nomad umbrella. Physical samples will be available in-store but Perfect pieces can only be purchased online, meaning a smooth customer experience on the website is crucial. Rita says the insights gained from the project fed into Perfect's approach to e-commerce.

"It helped us learn what we want to do, but it was just as useful to see what we didn't want to do," Rita explains. "What works for a big fast fashion label won't necessarily be right for us, so we were able to combine Claire's industry insight with my knowledge of my clients and brand."

As the project progressed, the research team moved on to explore the potential for showcasing Nomad products using digital technologies, reducing the need for physical samples and modelling.

The researchers tested a wide range of 3D design applications for as a means of presenting garments to customers, demonstrating that digital technologies can be used to communicate the fit and drape of luxury garments – even incorporating movement to do this in a dynamic way.

Balancing the quality of the results against the commercial viability of each solution for an independent design brand was vital in finding the right approach.

"This has been an iterative process, using the feedback and collaborating to find a realistic solution that works for a small business," explains Claire.

"There is no miracle answer that doesn't involve time and investment, but we've been able to identify a range of different options that keep creativity and skills at the centre while allowing a brand to demonstrate its unique style in new ways."

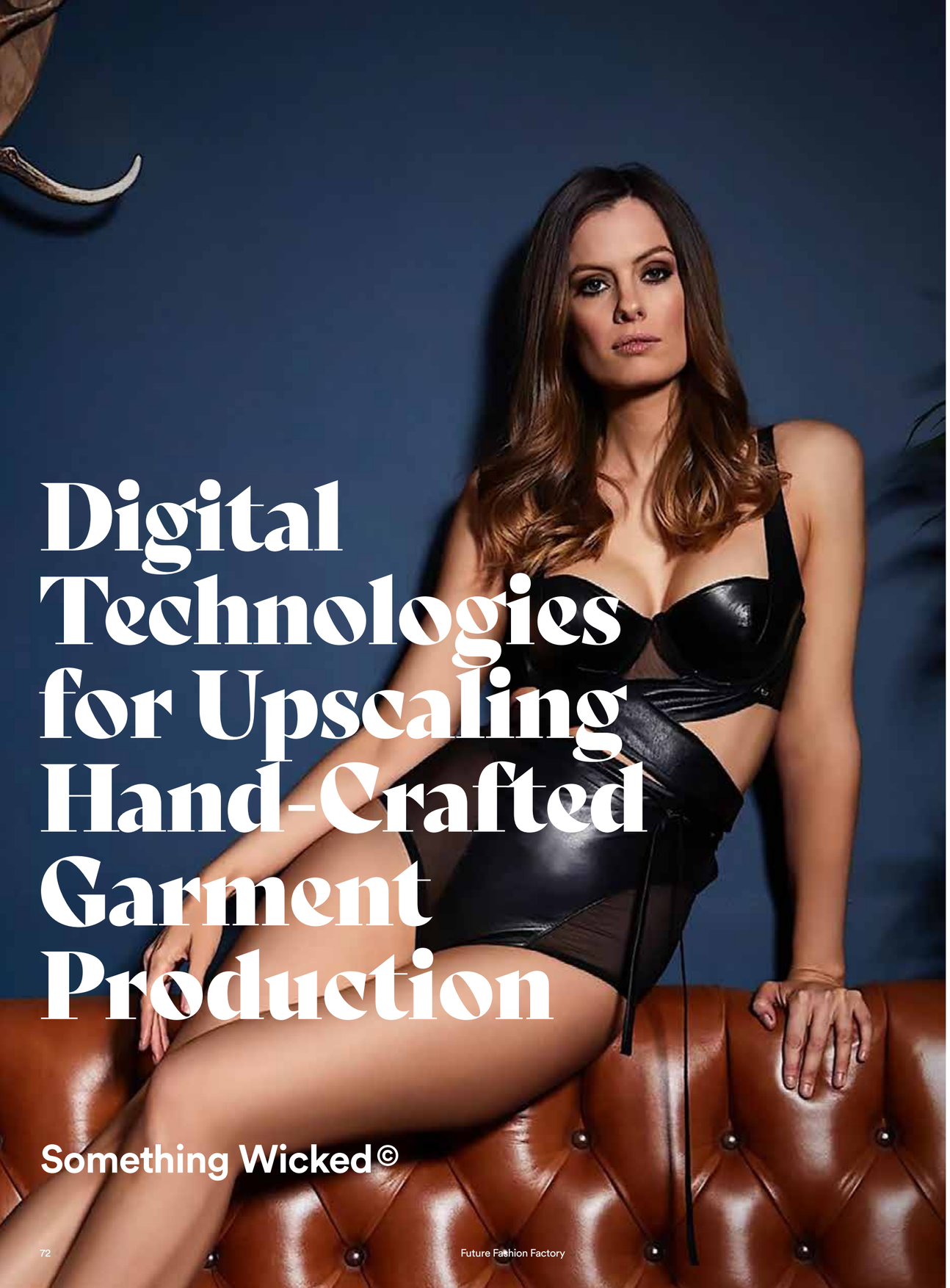
Taking existing Nomad garments as their starting point, Claire's team developed examples of digital rendering using software platform Clo 3D. The results, which were also displayed as part of Future Fashion Factory's Virtual Showcase in April 2021, showed how the technology could simulate the drape and fit as the wearer moves around.

Nomad Atelier garments rendered in Clo 3D, presented at the Virtual Showcase.

Rita says Nomad is "definitely exploring" the project's recommendations and sees digital product showcasing as an exciting part of the brand's future marketing.

Enabling Nomad to market products and gauge interest in them before investing in materials and manufacturing, as well as reducing the cost of models, stylists, hair and makeup for physical photoshoots, could help to lower overheads as well as driving new sales. It could even pave the way for a bespoke personalised shopping service which would transform the customer experience.

"The investment will be worthwhile in the longer term," Rita adds. "We have a way forward now because we have worked together.



Digital Technologies for Upscaling Hand-Crafted Garment Production

Something Wicked©

Something Wicked has been producing luxury hand-crafted lingerie at its base in Leeds since 2016. Each garment is made by a single member of staff from start to finish, working with materials from local suppliers as part of an entirely UK supply chain.

Harnessing the skills of talented local makers has been at the heart of the company's strategy: supporting the talent pipeline in the region, the company also welcomes placement students from the University of Huddersfield's fashion and costume programmes.

"Local, traceable manufacturing is a vital part of our story," explains Steff McGrath, Managing Director at Something Wicked. "The appetite for UK-made luxury products is growing, and that presents us with a lot of opportunities."

With plans to extend the brand's reach in e-commerce and increasing numbers of enquiries, it became clear Something Wicked would need to upscale its production capacity to meet demand.

The challenge was how to do this while keeping the creative skills of individuals, so integral to the company's ethos, at the heart of the process. Collaborating with Claire Evans, Senior Lecturer at the University of Huddersfield, the brand developed an innovative human-centred design process - identifying digital tools and technologies that streamline manufacturing not by reducing human input, but by supporting the individuals that drive the process.

"We focused on bringing in digital tools in a natural way – designing processes that enabled creative staff to work more efficiently," Claire says.

"We invested time being absorbed into the company, getting real insights by speaking to staff about their pain points and priorities. All of this impacts the final product so it's important feedback to gather."

The project identified how digital equipment could empower staff at each stage of the production process. Machines that cut thread automatically or can be used for more than one process make a number of small time savings that add up to a shorter product lead time. Similarly, machines with voice functions that repeat back user commands made a real difference to staff when checking their own work.

"If you can save a bit of time here and there it eventually adds up to a big change," Steff says. "The new equipment gives us so much more room for improvement and consistency."

"The feedback from staff during the trial period was really positive," Claire adds, "and sometimes quite unexpected. For creative people who build relationships with their work, having a machine that said hello in the morning made a big difference. Taking in information using different senses, such as hearing commands back rather than having to visually check everything, also worked well for them."

Digital tools were also identified to support patternmaking and grading. Most Something Wicked garments were produced from physical card patterns kept on site, but over time these had started to degrade. Small defects in the pattern being cut can add up to overall issues with inconsistency and fit – especially as patterns have been created and graded by different people over time.

Using specialist pattern and grading software, the project team digitised the existing cards. Not only did this ensure that every pattern is now held in a consistent format, but it also enables new templates to be cut from rigid plastic which will retain its shape. The company can now use this as the basis for a digital pattern archive, adding new designs with every collection.

"Everyone works a little bit differently, so a system that allows for consistency across the board is vital to get our product right," Steff says. "It gives us a solid basis to bring in more staff in future, working with an established system."

At the point of the project's completion and with production capacity increased, Something Wicked – which usually has around 8 freelancers, employees and interns – was planning to create two new jobs. For Steff, the project offered time and space to look at the big picture, exploring how the company can grow and offer more opportunities for creatives while keeping their skills as the brand's driving force.

"We're never going to be a production line. That's not our story," she adds. "We want to have efficient equipment and tools to support talented people, and this project has been brilliant.

"Our facilities are in a former mill, built for manufacturing in the community. Eventually we'd love to reclaim some more of the space for that purpose."

Mycelium Eco-Leather

OSMOSE©

Derived from the roots of mushrooms, mycelium is one of the innovative materials offering a plant-based alternative to leather. To produce mycelium on a commercial scale, new equipment is needed that ensures the consistency and quality of the product at larger volumes. In a collaborative project funded by Future Fashion Factory, OSMOSE Studio, formerly known by ‘Mykkö developed an effective production line for a mycelium alternative to leather and identifying new routes to market.

An example of the mycelium leather grown through vertical farming.

Founder Aurélie Fontan is a biodesigner, working with organic materials and dyes across each of her fashion collections. When she met her partner Ashley Granter, a product designer who was already working with mycelium, the pair began to develop prototype products that demonstrated the potential of the material for fashion and other applications. Soon they had relocated to the East Midlands and won awards including the Lord Mayor’s Award and the Innovate UK Sustainable Innovation Fund.

“Growing mycelium uses less water than many other materials on the market, and because it is grown on an organic substrate it’s completely renewable,” Aurélie explains. “About 70% of our raw material is hemp which we source nearby in Yorkshire, keeping carbon emissions from our supply chain low. The potential for mycelium as a sustainable, low-waste, plant-based alternative to leather is great if it works at scale.”

OSMOSE led an ambitious research and development (R&D) project in collaboration with Future Fashion Factory researchers to develop a full production line for mycelium, including a prototype machine that can ensure consistency across higher volumes of material, testing and characterising the performance of the products, and formulating a route to market. As they moved closer to their minimum viable product (MVP), Aurélie and Ashley also benefited from the support and experience they needed to prepare for their next phase of growth.

Underpinning the process was the need to understand the performance of OSMOSE’s mycelium products, highlighting how they could be refined and ensuring that the production line can meet the right product specifications.

Dr. Sohel Rana and Dr. Shama Parveen at the University of Huddersfield tested material samples for properties such as tensile strength and flex resistance, giving the company a solid baseline and highlighting how the mycelium could be refined.

At the same time, Aurélie and Ashley continued to develop the prototype machine and researchers at the Royal College of Art, led by Dr. Dawn Ellams, researched the wider landscape in which OSMOSE’s new mycelium production line would sit.

In workshops with potential end users, the researchers identified their requirements and highlighted questions that needed to be answered to form a viable route to market.

“Customers needed a very clear understanding of the offering and how it would fit within their wider systems and processes,” Dawn explains. “They asked questions about the durability and performance of the material, which the technical testing will help OSMOSE answer – and it even got us thinking about whether a repair and re-manufacturing service model would be a viable revenue stream.”

With a prototype machine nearly finished and testing about to begin on the wet systems at the heart of the manufacturing line, Aurélie says the project has given her a much stronger sense of how the business could grow in the future through developing its product and service offerings.

It has also armed her with the experience and confidence to take mycelium alternatives to leather to the next level, as they grow their new relationships with materials science and footwear companies interested in the next phase of user testing.

“Future Fashion Factory enabled the kind of core R&D that startups don’t normally have when they’re creating an MVP,” Aurélie says. “And because Sohel and Dawn were so supportive we learned a lot about the technical side of materials development and the fashion manufacturing system. It gives us a knowledge base and experience that has prepared us to work with bigger industry partners and investors.”

Intelligent Detection of Weft Misalignment

WT Johnson & Sons©

WT Johnson & Sons has built on its relationships with Future Fashion Factory researchers, the historic company developed an enriched system to spot weft misalignment as it happens, giving the skilled team opportunities to correct the issue, ensure consistency, and minimise waste during a key manufacturing process.

One of the key criteria that buyers assess is the straightness of the weft – the yarns that are woven horizontally through the fabric. Any imbalance in tension across the fabric as it goes through machines during finishing can lead to the weft being distorted: if it is not completely straight and at a right angle to the vertical yarns (the warp), the whole batch of fabric can fail a quality assessment.

Although WT Johnson's skilled team monitor the fabric closely as it enters each machine, there is still a margin for error. On inspection as much as 1.5% of the company's production is stopped because of weft misalignment, which then requires significant time, energy and cost to fix.

"Getting weft alignment right first time is the biggest day-to-day problem we face," explains Alan Dolley, Technical Manager at WT Johnson.

"Every dyer and finisher in the world has this problem and re-processing fabric can be disastrous: it causes production delays and uses energy, water and chemicals. There is a big market opportunity for an effective solution."

Collaborating with sensing expert Dr. Zhiqiang Zhang from the university's School of Electrical Engineering and textile technologist Professor Ningtao Mao, the team developed a prototype system to detect the misalignment as it occurs.

Zhiqiang has worked extensively on wearable sensing and signal processing, particularly for medical applications. He says the same principles of data processing apply to working with textiles, though working closely with the WT Johnson team during site visits was crucial to gain an understanding of their specific needs and challenges.

"The only difference is in the image data itself," he says, "But it is processed in a similar way. We realised that the first step was to have a system that could 'see' the fast-moving misalignment in the production line and alert the machine operator to the problem."

The team developed a system that colour-codes images from a camera on the production line in real time. As the machine operator monitors this footage, they can immediately see when the weft is falling out of alignment as the colour shifts from green to orange to red – giving them time to stop the machine and correct the error.

Alan, Zhiqiang and Professor Ningtao Mao from the University of Leeds hoped to use this proof of concept as a stepping stone to a more efficient solution which could stop the machine automatically, or even be connected to a new system that would automatically correct the error. By giving the team the chance to prevent distortion before they need to re-process the fabric, the new system will help to minimise waste in the process, reducing the amount of water, energy and chemicals used to give fabrics the perfect finish.

"This is a very real challenge that we would never solve without academic support, and which academics couldn't tackle without the benefit of our industry experience," says Alan.

"A whole sector of the textile industry is dedicated to weft straightening and nobody is doing it this way. The principle is great: now we need to take it further."

Frameworks for Sustainable Careers in Digital Design

Digital fashion has exploded in gaming over recent years. With major brands launching entire runway shows on gaming platforms and users paying for outfits from designer brands for their characters, the potential exists for a new revenue stream for designers – provided that the economic model both protects and compensates them fairly.

In a collaborative project funded by Future Fashion Factory, game developer Lockwood Publishing worked with fashion researchers at the Royal College of Art to understand and build new frameworks around the technical, legal and economic challenges involved in a new business model for digital fashion in gaming.

Lockwood Publishing, the developer of the immersive 3D social world Avakin Life, has an in-house fashion team that launches 100 items a week for an audience of almost 1,000,000 daily users. Oliver Kern, Chief Commercial Officer, says the company also aspires to become a platform of choice for creatives looking to collaborate and design in-game or to bring their own collections to market.

"Avakin is an opportunity to democratise how fashion is created, giving opportunities to up and coming designers," says Oliver. "We're interested in a value chain in which everyone can participate and benefit, but to do that we need to understand more about how that chain currently operates."

Seeking to understand how Avakin could create new opportunities for designers raised a number of questions about how designers can thrive in the digital sphere. The company found the right match of expertise in Zowie Broach, Head of Fashion, and Dr Dawn Ellams at the Royal College of Art, for whom working with Lockwood offered an exciting opportunity to advocate for designers, putting them at the centre of a cross-industry conversation.

Zowie has been interested in the convergence of fashion and gaming since the late 1990s and has seen the industry evolve to be able to exploit the potential of new technologies.

"Digital design tools are now natural choices for fashion students, while the shift to digital-first design in the fashion industry has been accelerated by the pandemic," Zowie explains. "There is a new space opening up in the digital sphere with a need for aesthetic and technical skills, and the idea of an economic base that is not in the real is intriguing for emerging designers."

As creative designs spring from individuals to be created and sold on gaming platforms, intellectual property is being created and shared – but with a relatively untested model for IP ownership and sharing, this is often low on the agenda of businesses. The project attracted the expertise of media and entertainment law firm Sheridans to identify possible solutions to the legal challenges that emerged.

"Fashion designers often don't understand IP and its value, and often independent brands have much less experience in licensing than bigger companies," explains Andrew Bravin, associate at Sheridans. "Developers and designers often don't even consider that they have valuable and protectable assets, so opportunities to exploit those assets go unexplored."

Combining the partners' technical, design, commercial and legal expertise, the RCA team led the research with the aim to understand how designers currently engage with gaming platforms and how this emerging business model can support them to succeed.

Drawing insights from interviews with stakeholders and a variety of other methods, the RCA research sought to develop a set of recommendations and frameworks for revenue models, licensing agreements, technical developments and more.

The project culminated in a report that brought together all these insights. Not only did it confirm the importance of several key issues and provided an evidence base for future development, but it raised a host of complex, interconnected questions that set the direction for future research.

"This collaborative R&D project has enabled RCA researchers to link insights from cross-sector experts," says Dawn. "We have used these to inform the report's recommendations on the skills, tools, IP and revenue frameworks required to enable fashion designers to work as part of this emerging digital value chain."

Access to digital tools for emerging designers was a key theme of the research identified by the RCA team. With such a wide range of tools on the market – most of which are incompatible with each other and come with their own costs – the lack of a common language for digital designs is a significant barrier. For Lockwood, this highlighted a market opportunity for tools that allow users to import between different systems, creating more efficient workflows and opening up collaborative and creative possibilities.

"We've had a clear realisation of what we need to do to become easier for designers to work with," Oliver says. "This evidence base gives us a much stronger starting point for future development that we can build on with further research."

At the same time, the project highlighted how many grey areas exist around how and even whether digital assets might be protected and owned. These questions could even lead to a shift in the business model and roles fulfilled by fashion designers.

> "There's scope for so much work on the new roles that will exist in this sphere, and ultimately it's about protecting designers and ensuring they have revenue streams," Dawn adds. "The technical and aesthetic abilities are there and now we need to identify their route into industry. The question is, what skills and tools do designers need to be able to create in this digital space?"

While providing evidence to support decisions about larger-scale research and development, the project laid the foundations for research into the world of work for digital creatives, technical developments, and industry standards for owning, protecting and managing digital assets.

"This is about understanding what the market is and whether it is sustainable to be a digital-only fashion designer," Andrew adds. "We've made an important first step to answering some very big questions."


Amphico©

Recyclable Alternatives to Waterproof Breathable Textiles

Waterproof breathable textiles (WBTs) are ubiquitous in the outdoor apparel sector. They offer high levels of performance so consumers can spend hours facing the elements, but they are also very difficult to recycle and use chemicals with negative environmental impacts. Working with Future Fashion Factory researchers, Amphico (formerly Amphibio) is developing a fully recyclable, sustainable alternative to existing WBTs.

Customers look for WBTs to keep them dry and comfortable regardless of weather conditions. To do this the materials usually consist of at least a woven layer bonded together with a membrane, so that the fabric repels the water whilst the membrane lets sweat pass through.

The challenge is that the layers are usually made from different materials. To recycle a garment using one of these WBTs means having to separate each layer – a time-consuming, resource-intensive process which often makes it very costly to turn used outerwear into new products.

When recycling is prohibitively expensive or technically impossible, used WBTs contribute to the huge quantities of waste textiles sent to landfill or incineration every year. Given that existing products are usually made with chemicals such as PFCs which release harmful chemicals into the air when incinerated, this leads to significant impacts on the environment.

Amphico was founded by RCA graduate Jun Kamei to solve this challenge by developing a WBT where both layers were made of the same novel material, offering a fully recyclable alternative to existing options. To take the startup's original fibre and turn it into a viable product, Amphico collaborated with Professor Stephen Russell, Dr. Mark Taylor and Dr. Ioana Taylor at the University of Leeds.

"My background is in materials and in water-repellency, but we really needed that input on the fibre and woven side," says Jun. "This project gave us access to the knowledge, technical capabilities and support from the experts to fill that gap."

The researchers worked with Amphico to refine the fibre and explore ways of optimising the manufacturing process to improve its performance, ensuring the new product could match the same high-quality standards as existing materials. This in turn laid the groundwork for a new prototype of the company's three-layer WBT, *Amphitex*.

Brands can now use the prototype to test and trial *Amphitex* for their own collections, but Amphico has also started to demonstrate how the material can be used in a range of outerwear pieces. Leeds-based manufacturer Reshore Apparel consulted with the team on the construction of prototype garments.

"Seeing how the *Amphitex* thread moves through the material showed us where we can refine the product," Jun explains. "We can measure individual components to make sure we're a market leader in performance as well as sustainability."

With Amphico on the verge of bringing a new recyclable WBT to market, the project partners are still collaborating. For now, the priorities are on upscaling production to meet demand from large brands, as well as trialling end-of-life technologies to identify how recycled Amphitex can be used in new products.

"We're now ready to be interesting to brands and get some initial trials going," Jun adds. "It's amazing that in a year we've gone from that fibre to something that actually looks like sportswear!"

New digital system for 3D-woven fashion design

Twelve Oaks Software©

3D weaving is an increasingly common production method in industries from aerospace to automotive. It also has potential to introduce innovative and sustainable new ways of working to the fashion industry – from low-waste manufacturing to seamless garments.

Working with Future Fashion Factory researchers, York-based developer Twelve Oaks Software investigated user needs and requirements for a software solution that could broaden creative and commercial opportunities for fashion designers.

Through collaborating with other members in the Future Fashion Factory network, Paul Jervis, Managing Director of Twelve Oaks, identified a market opportunity among the specialist software used in 3D weaving.

“I had a series of conversations with other members who identified a technology gap,” he explains. “From design to manufacturing a product can go through five or six different 2D and 3D tools that all use different software, so files are changing constantly.

“I wondered about the demand for a bridge that could automate those conversions, or even a one-size-fits-all solution that meant a fashion designer would only have to learn to use one interface.”

Twelve Oaks led a collaborative project to explore how the process could be streamlined with new software, making 3D weaving more accessible to designers as a result. The project drew on the expertise of Dr. Lindsey Waterton Taylor, who leads the 3D Weaving Innovation Centre (3D WIC) at the University of Leeds, as well as Professor Susan Postlethwaite, Senior Tutor (Research) at the Royal College of Art.

“3D weaving offers designers a sustainable approach as well as cost savings,” says Susan. “It reduces waste and even opens new possibilities for making on demand. Developing that potential will require user-friendly interfaces that allow designers to control the process without learning lots of new specialist skills.”

Bringing together the perspectives of weave experts and companies who already work with 3D weaving, mills, textile and fashion designers, 3D experts and virtual textile researchers, demanded a multi-faceted approach.

In addition to extensive desktop research to understand the commercial landscape, Research Associate, Eva Lili Bartha, combined in-depth interviews with collaborative online workshops to build a strong evidence base.

Travel restrictions meant the workshops had to take place online – as did Lili’s first experience with a 3D loom, as Lindsey demonstrated the specialist equipment at Leeds over Zoom.

This and the differing skills, knowledge and experience of stakeholders highlighted the importance of communicating about the technology in the most accessible way to expand opportunities to non-specialists.

Identifying common observations across varying perspectives was vital to the project’s end goal: a set of recommendations for software that would offer designers a simpler and more streamlined experience.

“We found a demand for workflows that don’t exist yet, as well as areas where user needs are and are not being met,” Lili says. “Workshops are a great opportunity to spot patterns and gaps, agreements and divergence between participants, which you can then combine with more detailed findings from interviews. Together they provide rich insights into the needs of end users.”

The project is a natural complement to Susan and Lindsey’s ongoing research applying 3D weaving to contemporary fashion design, offering new creative and commercial possibilities using agile, sustainable practices. For Paul, it demonstrates the potential for a new solution that offers a more efficient way of working and a better user experience. The next step is to investigate the market thoroughly to determine the commercial viability of the product.

“Price point will be a key issue because prototyping and building new software takes a lot of investment,” he adds. “This project has been a great starting point to understand where we go next.”

An AI-driven planning system for producing luxury fabrics

Abraham Moon & Sons©

In its near 200 years of operations, Abraham Moon & Sons has developed a reputation for producing fabrics of the utmost quality and cutting-edge design. To stay ahead of the curve when it comes to textile manufacturing innovation, they set out to work with Future Fashion Factory on a further R&D project, scoping the feasibility of Artificial Intelligence software across all areas of operations within a textile mill.

Working with Professor Ningtao Mao at the University of Leeds, Abraham Moon examined the usability of software that would allow the user to define performance requirements, whether this be machine efficiency, customer service levels or a blend of both.

Using the results of these studies, the mill was then able to create a production schedule with critical path timings that could result in achievement of the performance requirements. The software could then ideally integrate into existing enterprise resource planning software so that live data is used, and manual input is limited.

It stands true that the variety of ways in which AI could be implemented within a fully vertical mill reflects the seemingly infinite number of permutations that a business of Moon's scale can have when planning the production of its own raw materials and processes.

Traditional software used in mill operational management does not typically could schedule production, relying instead on a variety of spreadsheets and reports to make decisions around what to produce, by when and in what volumes. This in turn carries an obvious risk when it comes to minimising efficiency and waste.

Following a full-scale investigation into the many pathways going forward in which AI could streamline the mill's operations, the project was able to take its findings and help inform decisions around a new production planning system. While AI certainly carries the potential to produce an optimise production schedule, the project's findings directed Moon down an alternate route – to introduce SAP Advanced Planning and Scheduling software (APS) as a standard feature.

APS is especially well-suited to environments where simpler planning methods cannot adequately address complex trade-offs between competing priorities – this can certainly be said of a vertical mill. As opposed to AI's use of machine learning, APS uses complex mathematical algorithms to achieve its results: to scope demand, to plan and schedule production within specified constraints, and to derive optimal source and product-mix solutions.

Notable to APS in the context of production scheduling is a 'heuristic approach' or rule-of-thumb method, nevertheless sufficient for reaching an immediate, short-term goal or approximation – and critically, without requiring the huge datasets that are needed for machine learning. By the same token, the increased adoption of Artificial and Machine learning has only benefited APS systems, where new algorithms have been adopted to solve even more complex planning problems.

Customisable British wool face coverings with defined filter performance

British Wool©

The British Wool Face Coverings project focussed on the design and manufacture of personalised, reusable face coverings as fashion accessories, able to provide excellent thermo-physical comfort.

To embark on this project, British Wool and FFF worked together to find new use-cases for some of the coarser British wool varieties that were otherwise unsuitable for apparel and accessories, and in doing so, could also helped to develop new manufacturing supply chains in the UK.

“We are delighted to be working with the Universities of Leeds and Huddersfield on this innovative project looking for brand new uses of British wool,” Haldi Kranich-Wood, Product Manager at British Wool.

The huge demand for cheap, synthetic, single use facemasks, exacerbated by the Covid-19 pandemic has already caused major fibre repurposing issues worldwide. Traditional sheep farmers positioned in northern regions of the UK, where arable land is scarce, have reared hardy animals that are able to thrive in such a landscape. Naturally, these sheep produce wool that is unsuitable for facemasks. Where there is undeniably scope for more research in the technical applications for coarse wool, this project was able to address that gap.

By exploring the prototyping of new fabrics, academic lead Professor Parikshit Goswami, alongside a team of researchers at the University of Huddersfield, and Professor Stephen Russell and the University of Leeds, collectively worked to produce a nonwoven variant of the woollen fibre, one that has the required porosity needed for fashion use-cases.

“This project demonstrates how underutilised British resources could be used for manufacturing value-added products and create valuable innovation ecosystems with British farmers as primary stakeholders. This project also critically looks at a framework of how Life-Cycle assessment could be utilised to inform impact-driven material research,” Professor Parikshit Goswami, University of Huddersfield.

The University of Huddersfield research team has also taken varieties of nonwoven fabrics produced by The University of Leeds and have made them viable by way of nano functionalisation techniques.

This project carries the natural advantage of helping to support traditional sheep farmers positioned in northern regions of the UK where arable land is scarce and the optimal usage of the land is to raise traditionally hardy animals adapted to thrive in harsher environments.

Traditional Piece Dyeing with Modern Control Systems

DP Dyers©

DP Dyers, a commission piece dyeing business, has matched its skills, accumulated over 100 years in industry with the newest technologies available, allowing them to control dyeing variables and improve shade matching and continuity.

It is in the spirit of continuous innovation that DP Dyers have collaborated with Future Fashion Factory, led by the University of Leeds' Professor Stephen Westland, on a R&D project that introduces modern control systems that can significantly reduce some of the challenges experienced in the dyehouses of today. Dyeing, while a highly technical process, can still be considered one of the more traditonal and therefore practical methods used in fabric manufacturing. By applying modern control systems to traditional dyeing techniques, this project was able to reduce lead times and provide increased confidence in the piece dye option.

"The project has allowed DP Dyers to identify and look at the critical variables in a way they could never have done without the academic help from the university. By improving the control of a number of these variables and by improving dyeing protocols they have made gains in shade matching, quality and efficiency. In turn, this will undoubtedly help their customers better compete in a large global market," Alan Dolley, Technical Director at DP Dyers and WT Johnson and Sons.

Commercial piece dyeing is a useful way to produce plain solid shades, whereby woven lengths of white fabric are dyed to a specific colour. This is done by creating a dye recipe, which mixes the required powdered dyes to achieve the colour. Typically, the dyes are then added to a boiling bath in which the fabric is running as part of the dyeing process - while there is some level of control with this process, there is always an element of uncertainty, which can prove costly or even wasteful should the colour fail or require additional dye pigments.

While DP Dyers have learned to deal with a wide variety of different substrates, it is through their collaboration with Future Fashion Factory, that they have been able to increase accuracy and efficiency even more. Through the adoption of new technologies, they have delivered better shade prediction and repetition.

"The funding from FFF gave us a unique opportunity to work very closely with DP Dyers, a highly respected piece dyer in Yorkshire. The piece-dyeing business is particularly complicated but together we were able to better understand the variables in their processes and identify small but important changes to their processes that will save money and improve colour consistency," Professor Steve Westland, academic lead on the project.

With increased performance in piece dyeing producing solid shade fabrics that have high levels of colour continuity and accuracy, these developments are ideally placed to meet customers' requirements. While customer satisfaction has always been the primary objective within the production environment, outcomes of the project undoubtedly have a range of positive impacts.


Materra©

A radical approach to more sustainable cotton production

Demand for cotton continues to grow across the global fashion industry; new solutions are needed to tackle the negative impacts of cotton production in the face of environmental challenges such as climate change and water scarcity.

In a collaborative project funded by Future Fashion Factory, Materra built the evidence base to refine the company's low-impact cotton farming technologies and continue to develop them on a commercial scale.

Cotton production accounts for a disproportionate volume of the world's insecticide, land, and freshwater usage. As companies have sought more sustainable options, organic cotton has become increasingly popular – while this requires substantially more land and exponentially higher volumes of water, it still creates serious challenges in managing the planet's natural resources.

Materra's vision represents a new approach to cotton farming; offering higher yields to reduce the amount of land required to meet demand, the start-up's techniques also use up to 80% less water and emit up to 30% less carbon, with a fully transparent supply chain built on close relationships with farmers.

Edward Hill, Materra's Chief Science Officer, says that upscaling the company's techniques to maximise their positive impact will require support from across the industry. To be attractive to future brand partners, customers, or investors, Materra's fibres would have to perform as least as well as traditional alternatives to become attractive to brands and manufacturers.

"We need to give brands a sense of the benefits of our cotton on a commercial scale," he explains. "The question is, do we have a proposition for marketing? And how can we shift the needle when it comes to customers' expectations of cotton?"

The startup needed to benchmark the properties and performance of their cotton fibres against those grown using traditional methods. To build this evidence base, Materra has collaborated with Professor Muhammad Tausif at the University of Leeds, analysing, and assessing cotton fibres grown at Materra's pilot farm in India and comparing them with samples used in denim by an Indian mill partner.

Traditional fibre characterisation testing was conducted by a commercial lab partner, providing insights into the current performance of Materra cotton against its competitor. In parallel, Professor Tausif's team conducted broader testing that gives the team deeper insight into the fibre's performance in areas like dye adhesion.

Making use of the University of Leeds' dedicated small batch processing equipment, Professor Tausif was even able to make yarns from Materra cotton to start to understand how it would perform in a commercial product. The data, insights and expertise gained at each stage are helping to pave the way for future research and development.

"The project has expanded the testing that was possible for us," says Edward. "It's given us a massive value add to the business and strengthened our commercial proposition, and the findings will show us the next areas to explore."

Materra is looking to test its fibres at different lengths as a next step; as the applications for the fibre vary with their size, this is a crucial step to understand how their current offering fits into the market. But the team hope to continue working together along Materra's journey to ensure quality, sustainability, and a fair price for farmers in meeting the world's demand for cotton.

Technical Solutions to Unlock Digital Fashion

Numerion Software©

Digital fashion is an expanding frontier, both in design and production and in the new retail experiences that it offers for consumers. Numerion Software is bringing its expertise in cutting-edge garment simulation from blockbuster movies into the fashion industry, enabling customers to experiment with new outfits virtually before making a purchase. In collaboration with Future Fashion Factory, the company developed a technical solution that empowers fashion companies to move into digital production and make the most of these new opportunities.

Numerion has applied its world-leading technology to a cloud-hosted virtual try-on service for brands, offering consumers an accurate sense of how garments would fit, drape, and move. Not only does this this provide a more immersive and engaging e-commerce experience, but it gives customers better information to make informed buying decisions – reducing waste and carbon emissions created when products are shipped and returned.

Working with fashion and textile companies has given Numerion an insight into the challenges facing brands seeking to adopt this technology. One of the biggest issues lies in managing digital designs and other assets as they are created and approved in such a fast-paced industry.

“It’s an interesting challenge. How do you create quality digital garments in four hours that would take a month in the film industry?” noted Dr. Michael King, Managing Director at Numerion.

“The only solution is to have the infrastructure in place so the correct, approved, final design is there and ready to work with straight away. To use what we have at scale, the missing piece is an effective asset management system.”

Numerion led a collaborative research project to develop an effective system for managing digital assets, which would be quick and easy to adopt and would accelerate the uptake of digital experiences in the fashion industry.

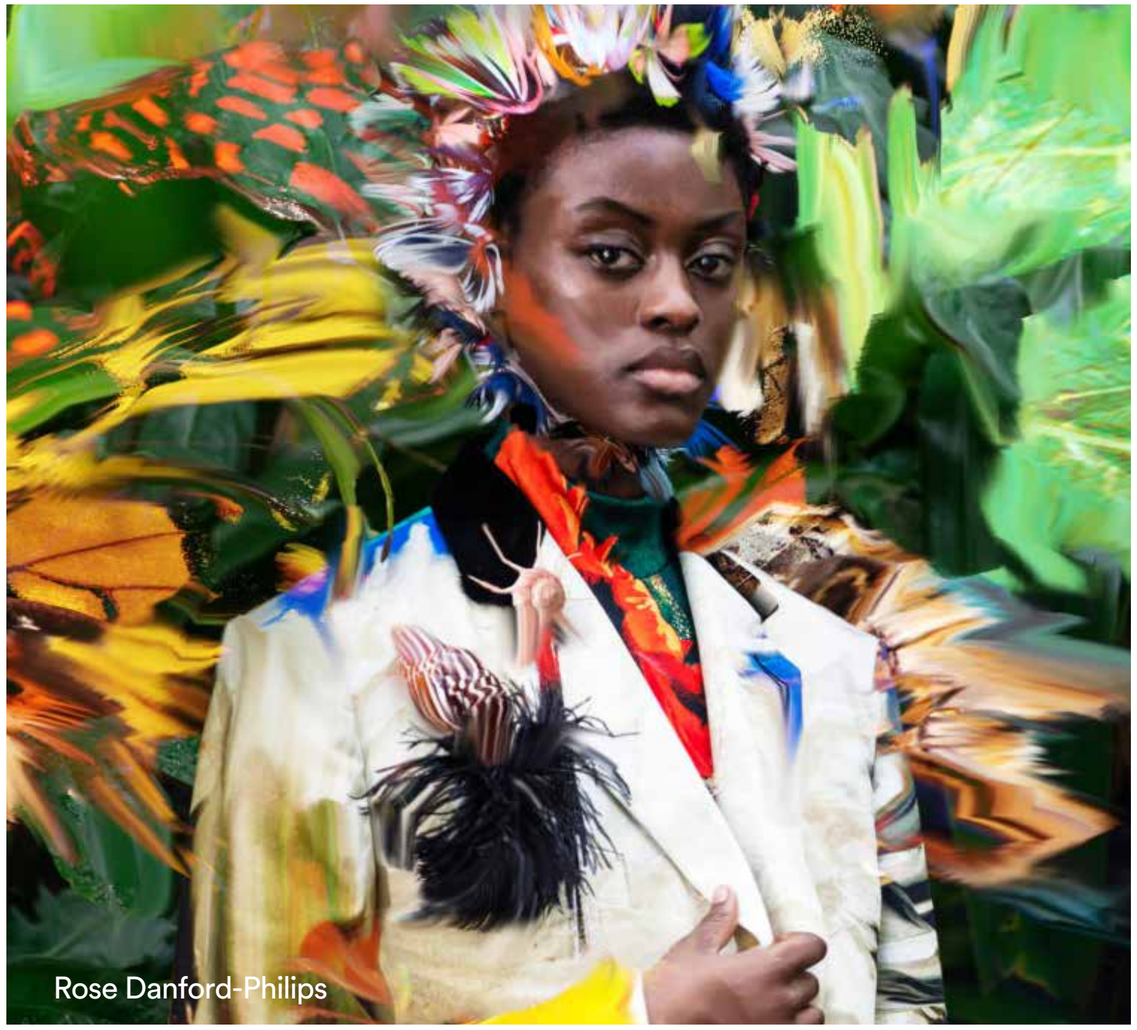
The project began by exploring how existing database platforms could handle different levels of approvals and types of assets, while Dr. Kevin Almond at the University of Leeds surveyed fashion industry professionals to generate more detailed insights into how the system might be used. A Leeds-based digital agency was also brought on board to handle the development, building out the workflows that would enable creatives and product teams to work with digital designs efficiently.

Numerion now plans to build a plugin enabling users to view 3D files, which will support their own digital fashion projects with major brands, and to use the system as part of its cloud-based virtual try-on solution. However, when the code base is built, Mike added that Numerion will share the blueprint for the new system with the wider industry: the project focused on open-source development so that as many fashion businesses as possible could benefit from the research.

By paving the way for more effective working with creative businesses across the fashion and textile industry, the new system could save fashion brands time and resources. Without the cost of licensing, companies will also only pay for what they need, making better asset management affordable and accessible to smaller brands so they can exploit the huge opportunities in digital fashion.

“We wanted to build a technical solution that was simple and fast to accommodate the speed of the fashion industry,” Mike explained. “There is a lot of potential here to enable new digital products and services for everyone.”

Rose Danford -Philips©



Rose Danford-Philips

A Holistic System for Natural Coloration

Having grown up with a close connection to nature, Rose Danford-Phillips has a fascination with natural tones and patterns informs her practice as a fashion designer today.

“This project had to demonstrate if there was potential for this to work,” Rose adds, “Now we’ll see how it can be scaled up as part of my business.”

Working with Future Fashion Factory researchers, Rose explored the possibilities of using natural pigments in printed fashion products as an alternative to traditional synthetic colorants.

Since graduating from the Royal College of Art, Rose has developed her fashion brand with an emphasis on nature-inspired patterns and prints – even moving away from knitwear and towards print design to ascertain greater control over her colour palette. However, in doing so the components of traditional pigments used in printing, often derived from synthetic materials, have led her to question the system in which her collections are made.

“If I’m inspired by nature, I don’t want to damage it!” Rose explains. “It makes sense to me to be as sustainable as possible. There’s an assumption that ‘sustainable fashion’ must be beige and unappealing, and I wanted to explore whether we could be more environmentally friendly and still produce beautiful colours.”

Collaborating with a team of researchers across RCA and the University of Leeds, Rose led an innovation project to replace the synthetic colorants with natural alternatives and test the results in fashion products.

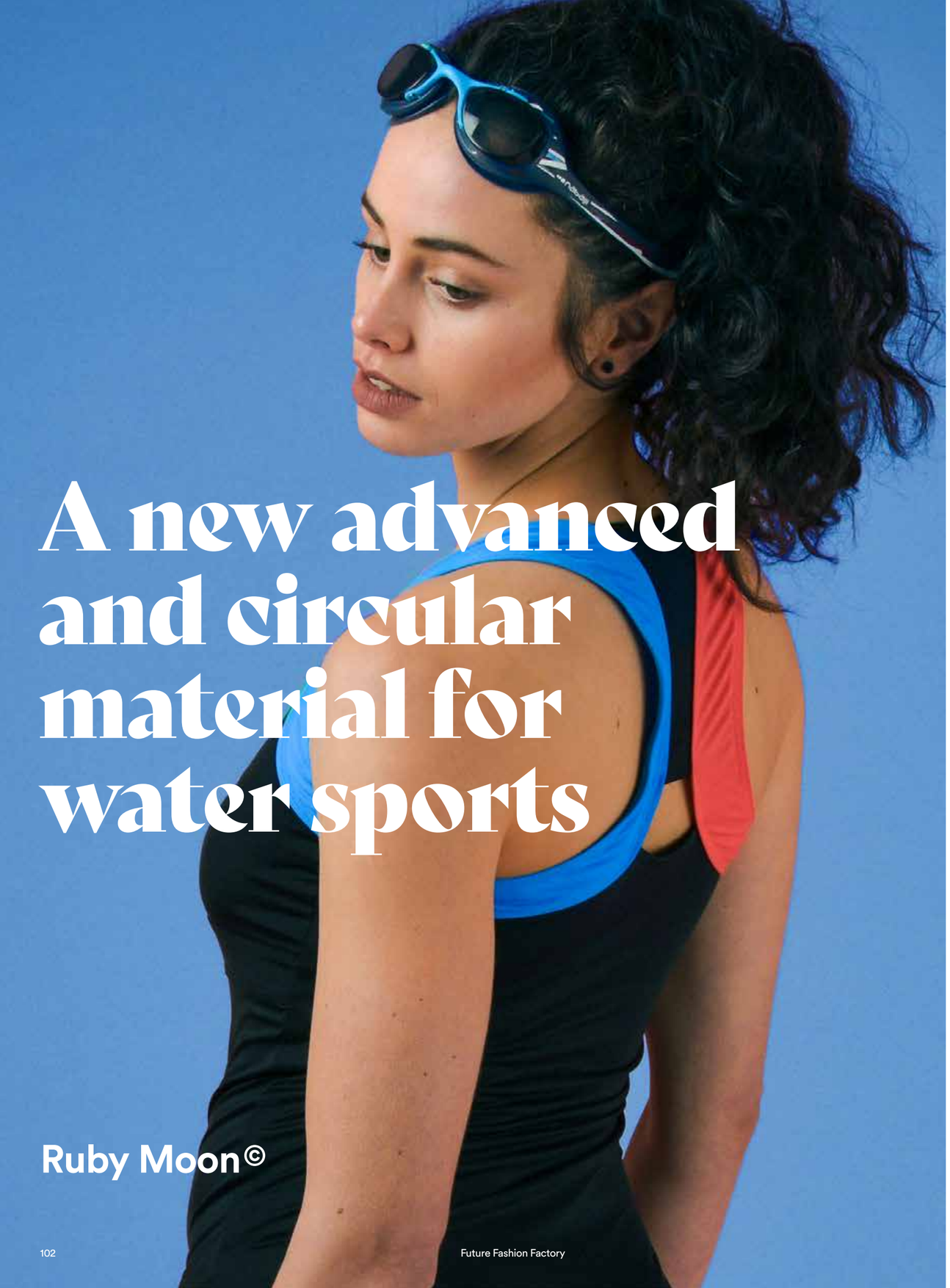
Dr. Nikitia Mexia and Professor Richard Blackburn at Leeds derived dyes from feedstock such as red cabbage, blackcurrants, turmeric, and carrots, comparing the shades and hues they produced at different Ph values with how the colours would change over time. The result was a set of pigments that Rose trialled in a workshop led by Dr. Dawn Ellams from RCA, alongside print designer Arantza Vilas at Pinaki Studios.

By experimenting with the process of layering the pigments and applying them to different fabrics, the team discovered additional shades that could be made from the same set of colours and learned more about how the pigments could be applied in a real collection of printed products.

“Some of the colours were quite unexpected, especially in their vividity,” Dawn explains. “The designers explored different ways of combining and applying them and thought about how they would actually receive and use the pigments in their work. That creative enquiry helped to expand the possibilities that came from scientific development.”

Additional technical testing is taking place to understand the performance of the pigments, such as how well the colours withstand washing. By understanding the wider life cycle of the products, Rose will be equipped to design appropriately – and with a few prints already inspired by the project, she has ideas for a whole collection using this new coloration system.

As part of the project, a toolkit of resources and assets is also being developed by the team at RCA, both to support designers working with the new pigments and to communicate the process and its benefits to customers: a USP for Rose’s brand on which she can build.



A new advanced and circular material for water sports

Ruby Moon©

Millions of tonnes of post-consumer textile waste is sent to landfill every year; while the majority is made from synthetic, plastic-based materials that increase global oil demand, swimwear garments pose a particular challenge. This is because of the combination of nylon and elastane fibres which give them stretch, but also make them very difficult to recycle.

With support from Future Fashion Factory, RubyMoon Gym to Swim is seeking to address the double challenge of waste and demand for new materials by developing a fully circular advanced fabric.

“Vast quantities of nylon end up in landfill every year, and we needed the technical help to see how we could turn waste into a resource,” says Jo Godden, Founder of Ruby Moon. “We’d been thinking about how to close the loop in our manufacturing for a while, but we had no idea how to go about it.”

Jo began collaborating with Professor Muhammad Tausif and PhD researcher Rebecca Cooper at the University of Leeds to lay the groundwork for a longer journey into circular synthetic materials for the swimwear market. As Associate Professor in Sustainable Textile Manufacturing, Professor Tausif’s technical expertise enabled the project partners to probe the specific challenges of analysing and processing textile waste.

“Sorting and separation is always the challenge with multi-component materials,” Professor Tausif explains. “That makes working with waste very complex, but there is so much of it in the world that we need to find more and better solutions for it.”

The project set out to analyse the existing materials and manufacturing landscape, identify the challenges that will need to be addressed to bring a viable product to market, and set the direction for the next phase of development.

The materials challenge across the sector was evident from the beginning. Unclear and inaccurate labelling meant the component mix in used swimwear was often more complex than expected, while the process of manually sorting through garments highlighted the need for automation. Similarly, the project raised the importance of having specialist equipment in the UK that can separate synthetic fibres.

By combining physical sorting and separation of materials and a variety of lab-scale experiments, Jo, Professor Tausif and the wider team developed a clear plan of action to bring a circular material to market. A subsequent R&D project was launched to build on this research, that added to its findings, and further tackled the core challenges around prototyping the recycled fabric.

RubyMoon is focused on enhancing the sustainability of its swimwear offering, but the impact of their current journey may be felt across the sector. Multi-component materials are ubiquitous in every apparel category, but the difficulty of separating fibres can make recycling synthetics economically unviable. New approaches to recycling synthetics could therefore increase the proportion of textiles being returned to the value chain – creating a circular economy that reduces the demand for resource-intensive, virgin synthetics.


Ponda©

Innovation for Planet-Positive Design

The textiles industry is damaging the planet by creating vast amounts of pollution and consuming too many natural resources - according to certain studies, up to 70% of an apparel brand's total environmental footprint comes from the materials it uses.

Additionally, wetlands now generate 5% of all anthropogenic carbon emissions due to drainage for agriculture, using the rich soils for farming cereals and vegetables. These carbon sinks have become carbon emitters, barren of biodiversity and empty of precious resources.

Ponda, formerly SaltyCo, is a biomaterials company that develops novel textiles from truly regenerative fibres. Ponda's mission is to accelerate both the movement to responsible materials for the textile industry and the regeneration of our most precious ecosystems.

To this end, Ponda collaborated with Professor Stephen Russell, Dr. Mark Taylor and Dr. Ioana Taylor at the University of Leeds on a Future Fashion Factory project that characterised and benchmarked the first prototype of their insulation material: a climate-positive plant-based alternative to synthetic materials or goose down.

Mark and Ioana's experience made them a perfect fit for the research: Ioana's PhD focused on performance clothing, while Mark has worked extensively with brands to optimise their existing insulation products. Ponda's product, however, offered an opportunity to work with something completely new.

"The material is amazing and the concept of using alternative water supplies has so many positives," said Mark. "Ponda has the right ambitions, and we can help them understand what is possible with the product."

The researchers were able to work in the campus lab facilities to complete each phase of testing, but pandemic-related travel and social distancing restrictions prevented the Ponda team from visiting in person. That meant regular progress meetings taking place online, while the researchers carefully photographed and documented different testing processes for the team.

Each meeting was an opportunity for the founders to understand more about their product and the technical processes behind it, and for the academic team to understand the commercial requirements from clients.

"This material can't actually be characterised in the same way as a conventional fibre, so we started by breaking down how to analyse it," says Ioana.

"Then when it came to reporting we made sure it was clear what the results actually meant for non-specialists."

Since the completion of the project, Ponda has gone on to achieve great success, launching their first product, BioPuff®, an insulation designed to keep customers warm whilst regenerating damaged wetlands. This next-generation insulation, which reduces reliance on feather and synthetic fillers, is created by extracting fibres from plants that are grown on regenerated wetlands. Today, Ponda partners with farmers and conservation groups to regenerate wetlands by cultivating Typha Latifolia, a native, shallow-water, rhizomatous perennial plant. Thriving in freshwater or slightly brackish marshes, Typha proves to be an ideal, low-maintenance crop for wetland restoration.

Working with researchers has given the Ponda founders access to specialised expertise and facilities, but the support and enthusiasm of the academic team has also helped renew their confidence in their goals.

"Others had been hesitant, but the Future Fashion Factory team was excited about the product from day one," says Antonia Jara Contreras, Chief Product Officer, and Co-Founder. "They've been in the industry so long and really know what they're talking about. Their seal of approval gave us so much confidence to keep going."

Antonia Jara, added, 'As recipients of the Future Fashion Factory Proof of Market grant, our focus remained steadfast on exploring the potential of Typha Latifolia within the textile industry. Our projects encompassed diverse facets, including product innovation, novel harvesting methods, and the development of farming and economic models. While the grant has concluded, we continue to leverage the connections established during that time, particularly with the University of Leeds, which provided expertise, financial support, and executional prowess. Together, we achieved significant milestones, such as the creation of the first characterisation and performance profile of the fibre. These collaborations have not only professionalised our vision but also catalysed meaningful discussions, shaping the trajectory of our practice.'

Colour-based machine learning to create new pathways for designers seeking inspiration in visual databases

Visualist©

Visualist is an app that enables creative designers to curate and manage sources of inspiration. In a visual database, text-based searching is not sufficient to produce accurate results. Collaborating with Future Fashion Factory researchers, Visualist is using AI and machine learning to enable users to search by colour. By building a more intuitive pathway for navigating by visual rather than textual cues, the project will open up new creative possibilities for designers as part of the startup's enhanced product offering.

Most databases rely on text searches to find relevant results. But for creatives, this model is restrictive - everyone interprets images differently, and often it is hard to describe an aesthetic in words. Visualist seeks to give creatives a visual pathway through a visual database. Searching by colour supports the creative process for designers while improving the user experience of the app, provided that it reflects how humans understand colour.

"Some of our team have a background in computer vision and AI, but we needed a robust technical base for our colour detection algorithm," says Cherie Yang, Founder of Visualist. "We could then combine this with our product knowledge and talking to customers directly to build a product that worked for them."

Cherie and her team collaborated with Professor Stephen Westland, Dr. Qianqian Pan and Jing Lin at the University of Leeds. As Professor of Colour Science, and Future Fashion Factory's Data-Driven Design Core Research Theme lead, Stephen was well-placed to support the project with his understanding of AI and machine learning.

"What Visualist needed was almost exactly what we were developing," he explains. "What we're doing is potentially quite disruptive, and a startup is a great collaborator for something so ambitious."

While Steve and his colleagues worked on training the algorithm using unsupervised machine learning, Visualist used an innovative approach to acquire data directly from their own users. Every week on the startup's Instagram Stories, followers took part in colour-matching exercises that showed how humans perceive colour. The results were shared so the researchers could compare the algorithm's performance against real users.

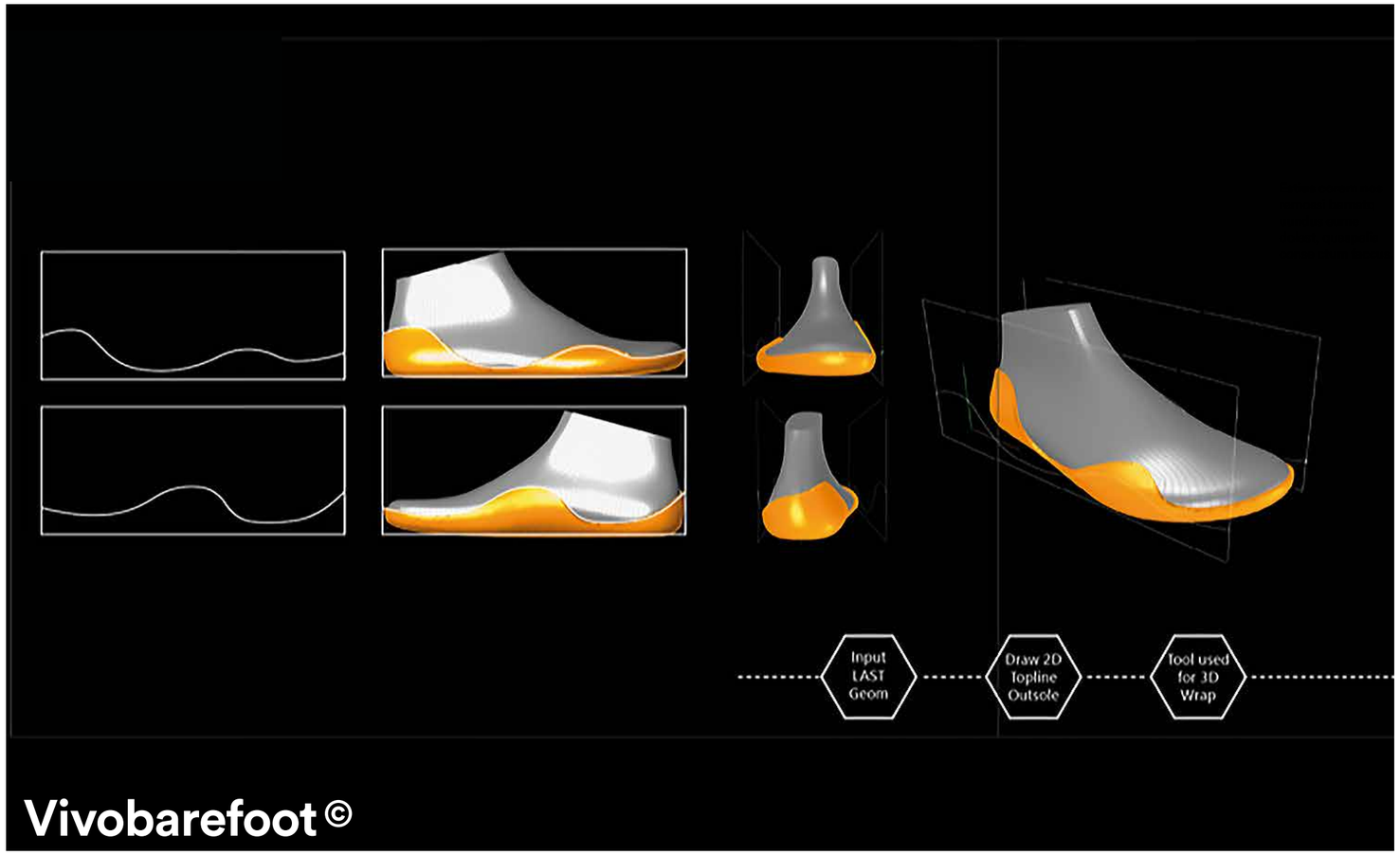
The project also gave the researchers an opportunity to push the boundaries of the research scope. Identifying the important colours in the image is crucial: for example, in a catwalk fashion show, the colour of the stage matters less to the viewer than the garments. Using supervised machine learning, Steve's team trained the algorithm to identify important colours based on their closeness to each other in the image, such as garments in an outfit.

"We could already detect dominant colours based on which appeared most often, but looking for colours that are spatially localised was totally new," Steve explains.

Colour detection and colour search are now launched in Visualist, while additional features are currently being implemented around colour relationships to offer users even more freedom. Feedback has been extremely positive from customer demonstrations.

"Users love it because it's just fun to search by colour," Cherie adds. "Colour is fun, colour is joyful, and we want them to enjoy playing in an environment that fuels creativity."

Having achieved so much in their first collaboration, the project partners are keen to keep working together to push the boundaries of AI in colour. Combining technical, creative and commercial expertise with real user data, the potential to keep building Visualist's product offering through cutting edge research and collaboration continues to grow.



Closed-loop manufacturing of customisable, sustainable, made-to-measure Vivobarefoot footwear.

Closed-loop manufacturing of customisable, sustainable, made-to-measure Vivobarefoot footwear.

Vivobarefoot ©

Vivobarefoot worked with researchers and students at the Royal College of Art (RCA) to develop customisable 3D-printed footwear within a circular business model, retaining the value of every resource to be recycled into new products. As a result of the project's success, the brand has expanded its commitment to collaborative innovation with new hires and ongoing relationships with universities, while RCA has had opportunities to reflect on how graduates are prepared to work in a rapidly changing industry.

Vivobarefoot set out to develop new data-driven tools to support the design of made-to-measure products. The brand also needed to offer an effective and attractive service to make sure customers would return products at the end of life.

Collaboration helped tackle these challenges. Research Assistant Dali Alnaeb was hired through RCA to work directly with the company, analysing huge volumes of footwear data to develop a 'smart last' - a digital version of the mechanical form used to guide footwear design. This completely new tool lays the foundations for the whole customisable design model. In parallel, Vivobarefoot saught the help of RCA students to develop a service model that would ensure footwear was returned by customers to be recycled at the end of its life.

Groups from the RCA course, MA Service Design responded to a brief set by the company to research and present proposals to keep customers engaged and maximise the volume of footwear returned.

Each strand challenged the team at RCA to consider the skills with which graduates need to be equipped.

Dali has given expert talks to RCA students since the project completed, and the university is keen to continue working with him to share his expertise with students from a variety of disciplines.

"It was interesting to see the skillset that Dali had and how that was used in an industry setting," explains Anne Toomey, Head of Textiles at RCA. "It led us to rethink elements of our own curriculum and how we can give our graduates those technical and digital skills, opening career opportunities for them and meeting an obvious need in the sector."

The project's success demonstrated to Vivobarefoot the value of dedicating resources to innovation. Dali has been hired as a permanent member of the team, retaining his knowledge, skills and understanding of the research. He will work to embed the customised design methodology in the next phase of the company's growth.

At the same time, the students' contribution highlighted a need for further research to refine the service design. Vivobarefoot therefore worked with RCA to launch a Knowledge Transfer Partnership (KTP) co-investment project, which would see a graduate work mostly at the company with support from RCA researchers to focus specifically on the design of a new service model.

"This comes directly from our experience with the students," explains Lee Spiteri, Performance Designer at Vivobarefoot. "They gave us real confidence that this initiative made sense, so now we're building on the insights from their work to refine our offering."

From one collaborative project, Vivobarefoot is now well on its way to a digitally-enabled, customised product within a commercially viable circular economy – a big step forward for sustainable footwear. The business potential of investing in innovation, and the potential to achieve even more with access to the support and expertise within universities, has become clear.

"We're a medium-sized business with big aspirations to drive change. Working on the main line means we don't always have the headspace to focus on ambitious new projects and innovation," added Lee Spiteri, Performance Designer at Vivobarefoot. "This project showed us the benefits of having dedicated person to do that. It gives us these small bubbles of pure clarity where new ideas can grow."

Assessing HD Shade Images with Heightened Accuracy

Abraham Moon & Sons©

This project centred on methods to critically assess HD shade images, which were submitted from Moon's external suppliers of dyed yarns, to facilitate more accurate colour matching. Heightened accuracy could invariably reduce wastage, processing time and reduce sample production and shipping costs. Ultimately, this reduction in waste can be directly measured as a reduction in carbon, which has the potential to reduce the environmental impact of operations of this nature.

Abraham Moon & Sons has traditionally colour yarn suppliers (both in UK and internationally) where shade approval is done by eye and by using spectrophotometry at source, it is then submitted and by using the same practical methods, approved by Moons' own team. The potential issues that could result have the potential to be substantial, particularly when shades were rejected, which could produce added costs, increased production resource and a raised likelihood of production delays.

In order to develop a simple yet efficient system to generate calibrated colour-measurement, the collaborative team first took to analysing the submission process and where colour measurements are first made. This involved data-gathering to map an array of standard operating procedures pertinent to Moons' top suppliers, and how differences between supplier assessment and Moon's own assessment methods differed. This data was further substantiated with market research into further systems that were currently available.

Building on these results, the collaborative team built a prototype solution, based on-site at the University of Leeds, that used bespoke software, as well as a camera system for assessing the shade and delta of wool & yarn on a calibrated screen that accurately displayed the shade and any differences together.

To achieve this prototype, months of solid testing, which included the checking for repeatability and reproducibility took place. The degradation of the system and calibration requirements was also tested against, to ensure they painted an accurate picture of how it worked, as well as the frequency in which maintenance would be required to ensure fully accurate monitoring and display. Moon also purchased a complete lab sample carding, drafting, spinning and sample knit line from mesdan to help with the continuity of shade checking which creates our 3 component stages of fibre draft(slither), yarn and fabric (knit) in a very short amount of time).

As a result of the new colour assessment technology, Moon has been able to improve the lead- time when supplying fabric to their customers. Not only has this facilitated more streamlined operations, but reduced waste, both in the sense that highly accurate colour matching reduces the likelihood of error and delays, but in that fewer samples are required to shipped worldwide clients as part of the process. It is through digital solutions such as these, that the fashion and textiles industry have a workable model to follow when ensuring standard operation procedures rely less on convention, but collaborative innovation.

Following the successful completion of the project, Moons have also been able to highlight the capital and resource requirements required to deploy the colour assessment solutions at supplier locations. This has meant that they have been able to include this system in purchasing negotiations and ensure that suppliers are involved in the process as they commit to work with together going forward. The outcome has been a training and education package which covers all technical aspects of the project, allowing the vertical mill to train more internal people in the process and ensure it has continuity as personnel changes.

Benchmarking the Feasibility of the Micro-Factory Model for the UK Fashion Industry

Assyst Bullmer©

Assyst Bullmer is one of the UK's foremost providers of Computer Aided Design (CAD) software. Where businesses have faced changes in technology and challenges in the move to global markets and production, Assyst Bullmer have developed solutions and grown to respond to industry needs. To achieve this, state of the art cutting technology and CAD software solutions have been at the forefront of their strategy, using technology made possible by the application of precise algorithms, expertise planning and an ever-attentive relationship with the wider textile industry.

Assyst Bullmer collaborated with Susan Postlethwaite, Professor of Fashion Technologies at Manchester Fashion Institute, as well as micro fashion designer fabricator business, ROBERTS | WOOD, in a project that explored how the latest technological innovations from the automotive and aerospace sectors could be applied in UK fashion manufacturing.

"The project highlighted the growing shift in SME business models towards on-demand manufacturing and revealed the potential for innovation when small-scale, accessible cutting solutions are embedded within design studios," noted Professor Susan Postlethwaite.

More broadly, the project examined the application of transferable technological advances into small scale tools, robotics and digital technologies that are agile, enabling UK fashion manufacturers to produce to an international standard. The project worked with designers and manufacturers to explore the feasibility of the 'microfactory' model for the UK fashion industry.

"We are excited to have been part of the project to enable the transfer of some of the latest technologies, which we have been developing, for use in microfactories. In the last few years, we have been heavily involved in integration of Robotics and Automation with our Bullmer CNC cutting machines," noted Martin Sofranko, Company Director at Assyst Bullmer.

"This is a new field, which promises wide range of opportunities for UK based fashion companies to automate their productions."

The outputs of the collaborative project will continue to allow designers and manufacturers to engage with and understand the potential opportunities for development within a micro-factory setting. As stated by Professor Susan Postlethwaite, "this limited study strongly suggests that the development of affordable and accessible tooling is the first step in enabling distributed on shored micro factory networks."

The collaboration will also allow any research insights to be used by ROBERTS | WOOD and Assyst Bullmer to inform further tools development for use within different scales of fashion manufacturing.

Democratising professional bra-fitting using Artificial Intelligence

Brarista©

Brarista is dedicated to democratising the bra-fitting industry, improving breast health, and reducing retail returns by way of streamlining the shopping experience, and improving inclusivity; using AI to do so.

Ill-fitted bras have been associated with a variety of issues, including scarring, muscle pains, skin irritation, poor breast health, and self-confidence concerns. According to a 2018 University of Portsmouth study, 80% of bra-wearers wear ill-fitting bras; 70% of these experience daily physical discomfort and poor self-confidence. Moreover, in-store bra-fitting is notoriously inaccurate, and when paired with inconsistency in fit and finishings across differing brands and styles, finding bras that are true-to-fit has become considerably more difficult.

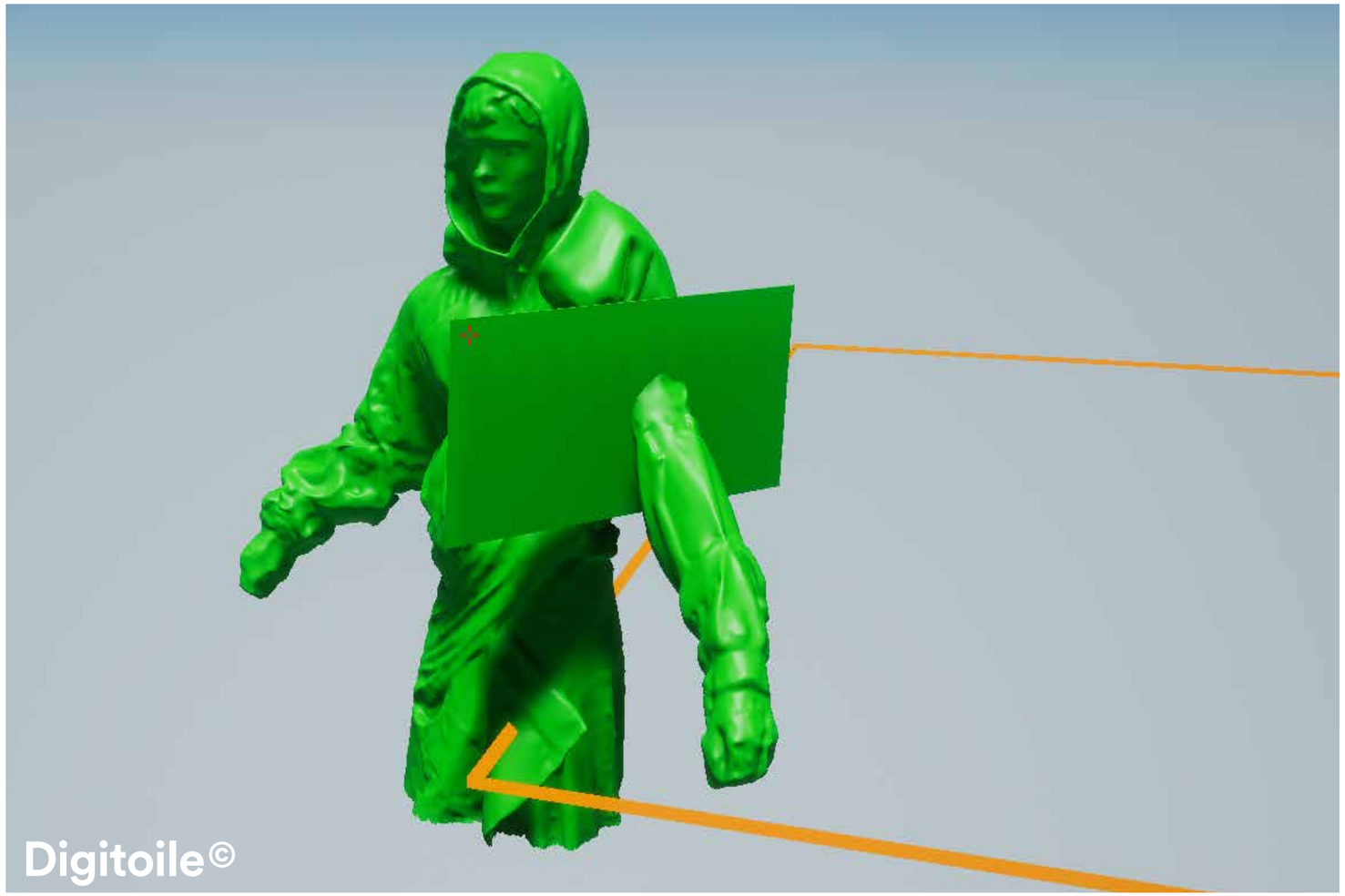
Sizing confusion, in-store shopping inconveniences, and general preferences for e-commerce lead to bulk-buying for home try-on, which in turn leads to mass waste in terms of product and shipping fuel. In 2018, up to 70% of bra-purchases were returned/exchanged, 90% were fit-and-size-related. In response to these concerns, Brarista set out to build B2B2C AI-enabled software, providing an online professional bra-fitting service to customers from a range of demographics.

Brarista worked with leading behavioural scientists from the University of Huddersfield (Mr Michele Buontempo, and Professor David Peebles, Professor of Cognitive Science) and London South Bank University (Dr. Joseph Teal, Lecturer in Decision Science, and Professor Petko Kusev, Professor of Decision Science).

Brarista also collaborated with Something Wicked, a luxury lingerie and existing Future Fashion Factory project partner, to validate and implement the usability of their bra-fitting technology using latest research.

The research findings were insightful, revealing that participants aged 49 and under were significantly more willing to use the application than participants aged over 49. Moreover, the conducted studies also revealed that participants judged privacy concerns higher when they received reassurance that they would not be recorded and that no files (video or photograph) would be stored, than when they did not receive reassurance about their privacy (i.e., did not receive any information about being recorded).

The outcomes of the FFF-funded research have enabled Brarista to gain an in-depth understanding of end-users' consumer experience and acceptance of this new technology. Using these findings, Brarista have launched their Beta testing with an unparalleled degree of consumer insight. Informed by their behavioural consumer research, Brarista will be able to launch into the market with a product that has an elevated likelihood of adoption. Moreover, to combat technology novelty and any other cybersecurity concerns, the application is expected to gain trust and maintain engagement with the end-users.



Digitising Fashion Workflows

Digitoile is a research and design studio founded by Kathy McGee. Working with digital tools and 3D technology to explore possible futures within fashion design, Digitoile. 3D is a project that aims to explore and develop alternative processes in the design and fabrication of apparel.

"It was a privilege to work with many experts across tech/ software development, fashion and education who gave their time and dedication to this complex concept."

The project team was comprised of Kathy McGee, Dr. Dawn Ellams, Senior Research Fellow at the Royal College of Art, a group of Metaverse developers from Dubit as well as 3D software engineers from Autodesk. Together they developed a proof of concept tool that is intuitive and accessible for fashion creatives to use as part of their digital-physical design processes.

There has been a gap in the market for accessible tools for Fashion product that support early stage experimental, creative, and innovative design across physical and digital workflows. Digitoile.3D aimed to fill this gap through the development of the prototype to enable customizable, accessible, and creative solutions, equipping designers with the necessary resources to hybridize their toolkit.

It has been important that Digitoile.3D was developed around the principles of accessibility, usability, sustainability, and with direct relevance for creativity in fashion design - a standard made possible by the design-led approach to the R&D development established by RCA within the project as well as Kathy McGee's wealth of design experience.

It is a given that this hybridization of the design process will reduce waste by eliminating the requirement to wholly rely on physical materials to bring a concept to life. However, while the emphasis has indeed been placed on the software's ease-of-use, the digital upskilling benefits to the user have also been tangible: Digitoile.3D was designed to help the user to feel rewarded at easy-to-use technological solutions that have been designed to celebrate their traditional skills and enable them to reduce their physical output. The advantages that designers feel confident that they are up to date with Fashion's changing landscape by using cutting edge digital tools as part of their creative practice.

To assist with the development of the project, the team worked collaboratively with Dubit Group (who build and launch digital products and services), who brought their expertise in technology, and ability to contribute to knowledge exchanges relating to virtual fashion workflows, new growth areas and expertise. The team also sought the collaboration of Autodesk, a 3D design, engineering, and entertainment software company, who delivered expert guidance through their Outside Network Tech Centre.

Working with these partners, Digitoile. 3D had greater flexibility to experiment with new workflows and methodologies relevant to fashion design with current digital tools. It is at this stage that they worked with games developers to support a dynamic digital design workflow, which has been able to promote a digital process that does not necessitate a high level of prior technical knowledge. the project was able to prototype the 'cut & unroll' digital tool, allowing the team to test the feasibility and effectiveness of the tool with partners, designer, and fashion students during this proof-of-concept project.

The goal is that designers will be able complement their practice with new tools that enable them to capture the immediacy of physical work, digitally. Critically, the accessibility of the tools will highlight exciting areas for further Knowledge Exchange Projects (KTPs) within the fashion and textile industry as well as in various education environments.

For Autodesk, the knowledge will enable them to observe workflows that move across different categories of software from 3D scanning, across various media and entertainment platforms and throughout product design. This could give insights into future developments for Dubit, as they capitalise on their interest in exploring virtual fashion elements within some of their games. Insights from this project could prove beneficial to developing interactive tools for open-ended fashion creation virtually.

For RCA, the project has been able to inform the research in development for creative tools that can cross over from digital creation into physical manufacture.

"An unexpected and joyful part of the process was seeing how committed and interested the tech, software developers/ engineers became in solving these equations for fashion outcomes, which sat quite outside of their usual outputs – so it became an interesting challenge," added Kathy McGee.


Hylo©

High Performance Running Shoes that Keep Pace with Sustainability

Michael Doughty, Co-Founder of Hylo Athletics, has always described the sportswear industry as being fundamentally broken. A former Premier League professional footballer and current runner, Michael had a keener insight than most when it came to the taboo subject of sustainability in sports. Encouraged to keep controversy to a minimum, the impact of sports and sportswear on the environment was a hushed discussion across the sporting industry.

However, this problem is worsened by the sporting and sportswear industries' increasing reliance on polyester. Despite being the world's most consumed textile fibre, some sources state that recycled polyester only contributes to 15% of total production. To not fall short of the UN's Sustainable Development Goal of recycling 90% of PET plastic by 2030, recycling of textile fibres such as polyester must be expedited dramatically. As part of this, processes which facilitate fibre-to-fibre recycling of polylactide will play an essential part. Luckily, Hylo's collaboration with FFF contributes in no small part to filling this crucial capability gap.

Hylo Athletics was formed as a direct response to Michael's dual passions for the sports and the environment. The brand was established in 2020 to protect the future of running and sport and uses materials science to create products that deliver high performance for athletes and low impact for the planet.

Through their collaboration with Professor Richard Blackburn at the University of Leeds, they trialled new end-of-life recycling processes for performance, supporting their development of a circular manufacturing model where used footwear can be recycled back into new products. This innovation improved the circularity of Hylo's production process by enabling more efficient recycling of polylactide fibres, an important component in athletic footwear.

Professor Blackburn commented, 'it is great working with a Hylo because they are a company who understand sustainability and the importance of understanding the environmental impact of consumer products through their full life cycle. The collaborative research we're working on is moving Hylo products towards increasing circularity and is adopting a detailed scientific approach to recycling the materials using innovation. It is great to be working on a project that is uncovering both new science and has the potential for impact at the product level."

The development of this innovative new process is promising not only for Hylo but hopefully for the entire athletic footwear industry.

Michael Doughty, Co-Founder and Managing Director, "we are very grateful to have the support of the FFF in our pursuit to ensure that Hylo takes accountability for its products from beginning to end."

Future Fashion Factory, along with Hylo, looks forward to seeing the impact that an improved polylactide fibres recycling process has across the sporting industry, thus tracking tangible changes towards the direction of sustainability.

Continuous Innovation through Collaboration

Optima 3D Ltd.©

Optima 3D's weaving technology is powered by a sophisticated software programme that creates a digital platform for the control of cutting-edge servo drive systems. In turn, this digital platform enables communication with external production analysis systems, ensuring the repeatability of weave pattern & machine setting data, including remote online access for service and software upgrading. Put simply, Optima 3D's technology guarantees a level of accuracy, consistency and waste minimisation otherwise made impossible by traditional weaving methods.

In collaboration with Future Fashion Factory, Optima 3D's breakthrough technology has been built upon further, in a collaborative project that has delivered a working robotic demonstrator which will further expand the flexibility of Optima's 3D-weaving machine.

Working with and a team of experts at the University of Leeds led by Dr. Lindsey Waterton Taylor, Optima 3D was able to develop new technologies that adapt-modify existing weaving principles, motions, and mechanisms of conventional weaving methods to produce a working demonstrator for flexible weaving. This has resulted in the development of a robotic prototype of a combined digital-design-engineering system for 3D-weaving of textile products.

The Optima 3D and University of Leeds partnership is a long-standing one, developing over several years through a wealth of shared experiences and knowledge. This partnership has only served to buoy the innovative technologies that have resulted from this Flexible Weaving Project.

Stephen Cooper, Managing Director at Optima 3D and a mechanical. Optima 3D Ltd mechanical engineer with a diverse background in the weaving and composites industry and Robert Alexander Bemg engineering lead, worked alongside Dr. Lindsey Waterton Taylor, academic lead at the 3D-weaving Innovation Centre, supported by postgraduate researcher, Sylwia Orynek, to deliver a working robotic demonstrator for a fully flexible weaving machine.

Conventional weaving technology, standard in UK weaving mills, produces traditional single-to-simple compound structures. These structures carry inherent limitations; carrying a fixed warp density or resulting in take-up during weaving.

With a combined digital-design-engineering-system, the robotic prototype for flexible weaving has allowed multifarious woven textile products, creating a route to seam free products.

By adapting and modifying weaving principles, mechanisms, and motors informed by previous and current research, the collaborative team has been able to develop a robotic arm for a flexible weaving machine.

As part of the project, the engineering of a working demonstrator has been supported by an interactive 'how it works' digital communications toolkit, which includes a concept visualisation tool for pre- and post-weaving.

It has been through this engineered robotic arm, supported by digital design and conceptual systems, that the production of 3D-woven forms has been achieved in a way that enables the diversification of existing woven product lines with consideration to sustainable manufacturing and future proofing customisation for a 3D/4D revolution.

This could include the manufacturing of a broad range of seamless 3D-woven products, suited to the apparel industry. Namely, within the capabilities of 3D-weaving, it could see the ability to increase warp ends, the elimination of seams, and more complex on-loom 'folding.'

Ultimately, the project has enabled fully integrated on-loom production of 3D-woven pieces, opening creative and commercial possibilities outside the constraints of conventional weaving technologies.

Using Artificial Intelligence to Drive Innovation in Weaving Technology

Pennine Weavers©

Collaborating with Future Fashion Factory, Professor Stephen Westland, and their software partner, Juno Software, Pennine Weavers unpicked the challenges behind the implementation of Artificial Intelligence as part of a weavers' operations and processes.

"Pennine Weavers has always prided itself at being at the forefront of systems development and implementation in the textile industry and we believe this project will not only have benefits for Pennine Weavers but potentially the whole industry," explains Gary Eastwood, Managing Director of Pennine Weavers.

"Working alongside the University of Leeds, we believe we can develop an AI-based planning system which will maximise effectiveness and efficiency of the resources employed internally and deliver considerable benefits to both our customers and suppliers."

Production planning for bespoke luxury fabric has typically been a laborious and time-consuming task, requiring both in-depth technical expertise and precision. However, by using machine learning and AI techniques to implement an automated workload scheduler, the project was able to develop an intelligent digital system to maximise the efficacy and efficiency of premium fabric manufacturing.

Challenges around the ways to streamline production processes have been critical to the industry, as issues caused by human error – even from experienced staff – can have a devastating impact.

Professor Stephen Westland stated, "it was really rewarding to work on this topic with an industrial member of the FFF network, developing an automated workload scheduler will have a critically positive impact on the company".

Through the AI Autoplan project, Pennine Weavers have been able to explore options that utilise machine learning and artificial learning within the production environment, an application with huge potential to maximise effectiveness both internally and to suppliers and consumers alike.

The outcomes of the project could reduce lead times, costs, risk and therefore ensuring that the business stays at the forefront of weaving both nationally and globally.

The project only scratches the surface when it comes to application viable AI applications across the textile industry – no doubt the technology behind the automatic workload scheduler can be used to facilitate a host of other automated processes.

Ruby Moon©

Gym to Swim - New Sustainable Swimwear

Building on the findings of the first collaborative R&D project, RubyMoon continued their efforts to enable circularity for Polyamide 6 textiles via low impact, low carbon methods.

"It was helpful to realise that we will need to be able to guarantee the materials we are working with before we start processing them to make a new fabric, and then ensure we have the infrastructure to do it in the UK at scale," explains Jo Godden, Founder of RubyMoon.

Most sportswear is intrinsically composed of a range of polymeric substances (polyamide and elastane for example), which are processed via melt or wet spinning and knitted together with elastomers to provide textiles that are uniquely fit for purpose. This project therefore de-polymerised and removed the elastomer from these textiles. This shored up the valuable polyamide 6 for re-use.

The process involved use of biobased solvents that are environmentally friendly and fully recoverable during the process, consuming less energy. The lab-based trials have demonstrated the efficacy of separating elastane and nylon, along with the reuse of recovered bio-based solvents. This has meant that the polyamide can be re-spun into new textiles and compared for quality and mechanical properties.

As RubyMoon works to authenticate its products, it is also aiming to impart a unique product signature to its products via embedding tracer particles within the nylon filament, this will also enable 'take back' and recycling.

Using a patented technique, the tracer particles are embedded within the nylon filaments, and the corresponding fabrics can be scanned to ensure the presence of the tracers. The tracers are durable enough to withstand the manufacturing processes including fabric manufacturing, dying/printing, and recycling. Hence, the tracers will be retained within the recycled filaments that would exhibit the authenticity of the claim that the recycled filaments have been used.

SEFF©

Sustainable Environmentally Friendly Fibre

SEFF Hemp, a ‘cottonised’ hemp, is produced utilising a patented environmentally friendly process that enables the fibre to be used in high-value applications for apparel, home and technical textile markets. Their innovative process produces a hemp fibre that is soft but strong, durable yet breathable and easily processable on multiple types of existing spinning technologies globally.

SEFF’s hemp fibre can be blended with many other types of fibres, including both short and long staple cotton, wool and synthetics. Due to the quality of SEFF’s material, it is possible to produce high percentage blends of SEFF hemp, maximising the environmental footprint of the product, without compromising on hand feel or quality.

Working with the Future Fashion Factory and East Yorkshire Hemp, SEFF optimised the quality of the fibres for multiple applications, and also developed a range of yarns and fabrics with varied amounts of SEFF hemp compositions (over 60% SEFF hemp achieved), pushing the boundaries of what was previously thought achievable.

The next phase of the project involved producing SEFF hemp-based fabrics with these various compositions. This was achieved utilising SEFF’s extensive supply chain network, both based in UK and abroad. Multiple fabrics in denim, non-denim and jersey were produced containing high percentage SEFF blends.

Together with a team of researchers at the University of Leeds, these fabrics were tested for their properties in terms of strength, lifetime, washability and hand feel (drape).

In the final phase of the project, SEFF hemp rich fabrics were tested against conventional counterpart fabrics (non-hemp). This university led, International Organisation for Standardisation (ISO) certified benchmarking, identified areas in which the SEFF hemp fabrics outperformed conventional fabrics.

Following the delivery of the project, SEFF Hemp will be used to drive positive change in the textile industry, back by scientific, certified testing and validation.

SEFF has already engaged in further yarn and fabric benchmarking testing with multiple global brands who have been inspired by the project, and due to project learnings, SEFF continues to innovate in the field of high quality, hemp rich products with a focus on sustainability, durability, and affordability.

“The Future Fashion Factory, together with Leeds University, has been instrumental in assisting SEFF in this vital research project. Brands and mills alike were excited for SEFF to be undertaking this analytics-based work, which is pioneering in the industry for cottonised hemp”. – Josh Nusenbaum, CEO & Founder of SEFF

Perfecting Biodegradable Sequins

The Sustainable Sequin Company©

According to a 2019 Oxfam press release, 1.7 million sequined items of clothing end up in landfill after Christmas in the UK alone.

Adding to the challenge, sequins are typically made from petroleum-based plastics - where a 100% cotton item of clothing can be recycled or downcycled, a typically nylon or polyester outfit adorned with sequins can't. There is a clear industry need and consumer demand for a sustainable alternative to polluting synthetic plastic sequins. Working with Future Fashion Factory, The Sustainable Sequin Company embarked on a collaborative R+D project to meet this demand. Specifically, Rachel Clowes, sustainable textiles designer and Founder at The Sustainable Sequin Company, worked alongside Professor Ningtao Mao and his research team at the University of Leeds and Dr. Dawn Ellams at the Royal College of Art, to perfect UK-made, commercially viable biodegradable sequins.

The project sought to make sequins from renewable feedstock, including waste and by-products. Collaboration between researchers, manufacturers and designers allowed the development and prototyping of these sequins, demonstrating how production could be quickly scaled up in the future. By the end of the project, there was also a full evaluation mapping of the value chain (from feedstock to end of life).

Speaking on the project, Rachel said, "The overall aim was to achieve maximum sparkle with minimum adverse environmental impacts; plastic-free sequins which look great, perform perfectly and biodegrade at end of life."

To achieve this goal, the project employed a circular design system that used renewable materials to create the sequin film in a sustainable and resource efficient process. Within this, the feedstock for the new polymers was further evaluated to investigate the feasibility of using industry waste streams for even greater long-term sustainability.

The polymers were refined, and their films prototyped at University of Bradford. Sequins were then punched from the film and wound onto recycled, reusable and recyclable cardboard spools produced by Cutting Edge, a professional die cutting service. These prototype sequins were stitched both by hand and using digital application to produce demonstration samples.

The fully market ready new sustainable sequin products were tested and mapped against conventional synthetic plastic sequins to show clear sustainability advantages. These sequins were designed to meet the needs of global fashion brands, allowing them to respond to the growing demands from their consumers for environmentally friendly fashion products with proven credentials.

The results were showcased in a garment created by fashion designer, Lee Hurst and exhibited across Future Fashion Factory's own exhibition events.

Weaving Sustainable Trousers in 3D

Weffan©

"The research of the proof of concept 3D woven trouser has been the foundation for developing an entire 3D-woven garment production method that exemplifies zero-waste, localised garment production."

Graysha Audren, Founder and CEO of Weffan

Weffan shortens production cycles by minimising fabric and resource waste. This is achieved by way of automated 3D-weaving method technologies that integrate textile production and garment manufacturing into one fluid step using existing jacquard loom technology as a base.

Weffan tackles the dilemma of unsustainable, unresponsive garment production supply chains by revolutionising how clothes are made. By partnering with Future Fashion Factory and the University of Leeds' Dr. Lindsey Waterton-Taylor, Weffan was able to accelerate their mission and engineer fully-fashioned 3D-woven garments in a single step. By merging textile and garment manufacturing, Weffan has been able to simultaneously create the structure of the garment in the weaving of the fabric, thus shortening the supply chain by reducing production steps, saving time and costs, and enabling near zero waste impacts.

To achieve this, Weffan collaborated with the University of Leeds' 3D-Weaving Innovation Centre (3D WIC) and S Dawes Weaving Ltd, a high-end jacquard manufacturer, located in the Yorkshire region. Together, they prototyped different state of the art weaving machinery and associated ancillaries, exploring sustainable material capabilities and finishing methods. The project was able to develop a proof of concept trouser range, which formed the basis of further collaboration opportunities.

Speaking on the collaboration and its impacts, Graysha Audren, Founder and CEO of Weffan said: 'The FFF project has been instrumental in developing Weffan's business; we have been able to develop a range of 3D-woven proof of concept trousers that have led to Weffan's first collaboration with its customer fashion brands.

"The trouser collection, designed in collaboration with fashion brand Liquid Editions, highlights the low-waste nature of Weffan's 3D-woven production method. This collection received the Design Futures Award by the Fashion District and sponsored by Pangaia.'

'Without the FFF grant, our 3D-woven trousers would not have been proven, and therefore without this enabling activity successful milestones would not have been reached. The partnership with the University of Leeds has been instrumental in our research success and has led to a continued partnership to continue our research.'

The potential ramifications of the collaborative project are many. Not only did the partnership shape the trajectory of Weffan as a business but will bring exciting new 3D-weaving IP into the industry. The new sustainable production process will undoubtedly diversify the UK manufacturing landscape, while also creating employment opportunities by supporting the training of skilled UK textile labour while maintaining the same level of production costs to the long run. Fundamentally, the project represents innovative, scalable technology that doesn't require much space or capital investment with a low barrier to entry and adoption.

AI that Battles Overconsumption

According to Dr. Jennifer Baumgartner, clinical psychologist, and author of the book, You Are What You Wear, most of us wear a mere 20% of our wardrobes 80% of the time.

The reasons behind aforementioned statistic are many: we buy clothing that is not suited to our body shape, or complexion, we do not have access to a personal stylist, we impulse buy to keep pace with the flurry of micro-trends. The result is singular – we're stuck with a closet that we do not love.

Future Fashion Factory member, Aistetic is tackling this challenge. A B2B software platform, Aistetic uses state of art technology to help customers make informed purchase decisions. With world-class founders from leading academic institutions, Aistetic uses a combination of computer vision and deep learning technology to enable highly accurate measurements via 3D body scans, thereby revolutionizing users' shopping experience.

By working with Future Fashion Factory and Dr. Raheleh Jafari, Aistetic was able to develop further features to its service by way of an AI style prototype. This prototype has been developed to use AI to capture preferences from shoppers and recommend garments that meet the preferences of the user.

Preferences are complex and emotive, and as such, the collaborative project was able to leverage Natural Language Processing (NLP) and Computer Vision (CV) algorithms to elicit and respond to these nuanced preferences. Aistetic was able to prototype the AI system to implement both text and computer vision-based analysis to reproduce the interactivity and personalisation of real-world style recommendations.

Working in collaboration with AVIE, a luxury womenswear brand that also sits within the FFF network, Aistetic was able to prototype AI driven style conversations, where the user can buy clothing that is tailored to their own tastes and bodies.

"As the Founder of AVIE, I am proud to have collaborated with Aistetic to deliver ground-breaking technology that enhances the online shopping experience and promotes sustainable fashion development," noted Sonya Bachra-Byrne.

Aistetic's user tested prototype is usable as a web application and is being promoted as an additional 'grey label' module as part of its service. In addition, Aistetic is currently commercialising its first product module, a 3D reconstruction and measurement service from smartphones that enables higher online conversion, lower returns and inventory for online brands and retailers.

"The Future Fashion Factory grant enabled us to draw on world class expertise at the University of Leeds in computer vision, natural language processing and fashion and textiles – we were able to prototype AI driven style conversations, to help customers make more informed purchase decisions." Duncan McKay, CEO, Aistetic.

On a macro level, this project focused on actionable impacts – to reduce clothing waste, reduce returns, and extend garment lifetimes through personalised style recommendations. When the wider fashion industry can reduce the likelihood of an item being purchased then returned, it can begin to tackle the 300,000 tonnes of clothing that ends up in household bins every year in the UK. Moreover, extending the life of clothing by an extra nine months can reduce carbon, waste, and water footprints by around 20-30% each (Source: Fixing fashion- Environmental Audit Committee-(EAC)- Report-2019).

"By working with Aistetic we developed an AI style prototype through the smart use of chatbots for online retailers that captures preferences from shoppers and recommends a series of garments that both meet the preferences of the user and follow style principles to ensure that the garments flatter that individual." explains Dr. Raheleh Jafari.

Digital Tools for Colour Management

Burberry©

As a core partner of Future Fashion Factory, Burberry has been working with industry and academic partners to make the fashion and textile industry more agile and to reduce environmental impacts throughout the design process.

In a collaborative project, working alongside Dr. Phil Henry at the University of Leeds, Burberry compounded their dedication to technology-driven innovation by designing a digital tool for colour management workflow.

During its initial phases, the project's scope was to develop an innovative technology-driven digital communication workflow for colour management, able to deliver colour integrity throughout the product journey - from the point of design, through manufacturing, to the end-product.

To achieve this aim, a road-map to apply artificial intelligence was employed, as well as further advanced technology mapping to deliver precise colour outcomes (thus reducing the levels of both dye and material waste) in the colour design process. This further streamlining of efficiency would eliminate human errors of colour perception, interpretation, and communication, as well as facilitate shorter manufacturing times.

Specifically, the project identified the opportunity to use machine learning to accurately capture the DNA of colours digitally at the point of creation, to analyse these colours for feasibility of accurate reproduction, to create a database for designers to choose. It was through navigating the technical challenges around the use of spectrophotometers to enable accurate communication of colour measurements, and the employment of machine learning AI that the feasibility of effectively meeting these aims were determined.

The primary research plan combined an evaluation of both design and technical workflows. The main purpose was to develop a definitive interpretation of digital colour as an integrated colour-management platform encompassing the creative-vision of the designer to the physical end-product. To this end, the objective of the preliminary work-package was to create a set of colour measurement data consistent between a range of spectrophotometer devices for the foundation of an AI/Machine Learning platform aligned to the design, development, and production environments.

The initial planned work packages proceeded in an unexpected direction: the technical quality control processes were identified as not being sufficiently reliable to produce the colour consistent dataset required for a machine learning platform.

The entry level handheld spectrophotometers did not prove to be as reliable as required to be effectively integrated into the colour management workflow to ensure as reliable pass/fail decisions on fabric samples as would be preferred. In addition, the introduction of multi-spectral device as an enhanced colour measurement tool did not add any specific improvement for the assessment of fabric colour standards.

This necessitated a new approach that built upon the lessons learnt, namely with regards to the efficacy of the tools across the necessary use cases improve to colour management workflow mapping. While the rigorous analysis of industry standard colour devices and quality control protocols revealed there to be both hardware and software-based processes that could be exposed to both human and technical errors, there was also evidence to indicate the potential for machine learning technologies to further improve colour measurement consistency. Furthermore, it was evidenced that using a reliable colour measurement dataset, clearer systematic trends in the data could be more easily identified.

These findings can not only carry clear advantages for Burberry, but potentially have a wider impact for the fashion and textile industry: with continued R&D efforts, machine learning-backed workflow communications will contribute to reducing waste on an industry-wide scale.

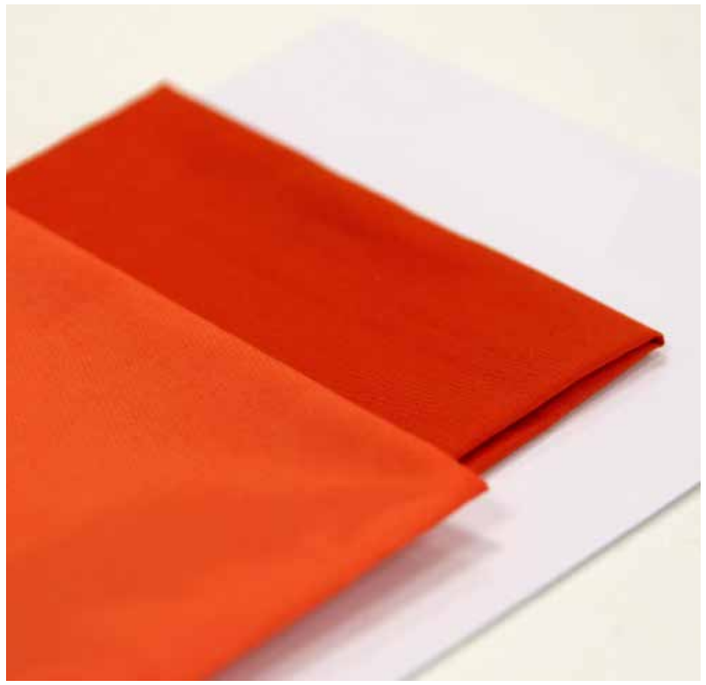
As a result of the project, Burberry were able to identify the most profitable areas for further development in their continued commitment to digitised colour management workflow.

Building on the strengths of the project investigation, Burberry identified value in developing an in-house Continuous Professional Development (CPD) course to further embed standardized colour assessment protocols for both technical and manual routines. Establishing this heightened standard level of colour-literacy throughout colour workflows would further entrench best practice from colour creation to colour delivery.

DyeRecycle©

Separating Dyes from their Fibres to Close the Loop

DyeRecycle has a mission to lead chemical circularity in the fashion industry. An Imperial College London spin-out, DyeRecycle can disrupt the textile recycling supply chain by way of a non-destructive separation technology of fibres and dyes. In fact, DyeRecycle claims that each of their garments use 85% fewer chemicals, 66% less water and generates 75% less carbon emissions.



Dyes make textile waste heterogeneous, meaning mechanical recyclers must intelligently blend colours, and chemical recyclers must decolour the material prior to or during the processing stage. At the other end of the supply chain, dyeing processes accounts for 20% of global wastewater pollution, and over 99% of dyes used are derived from fossil fuels.

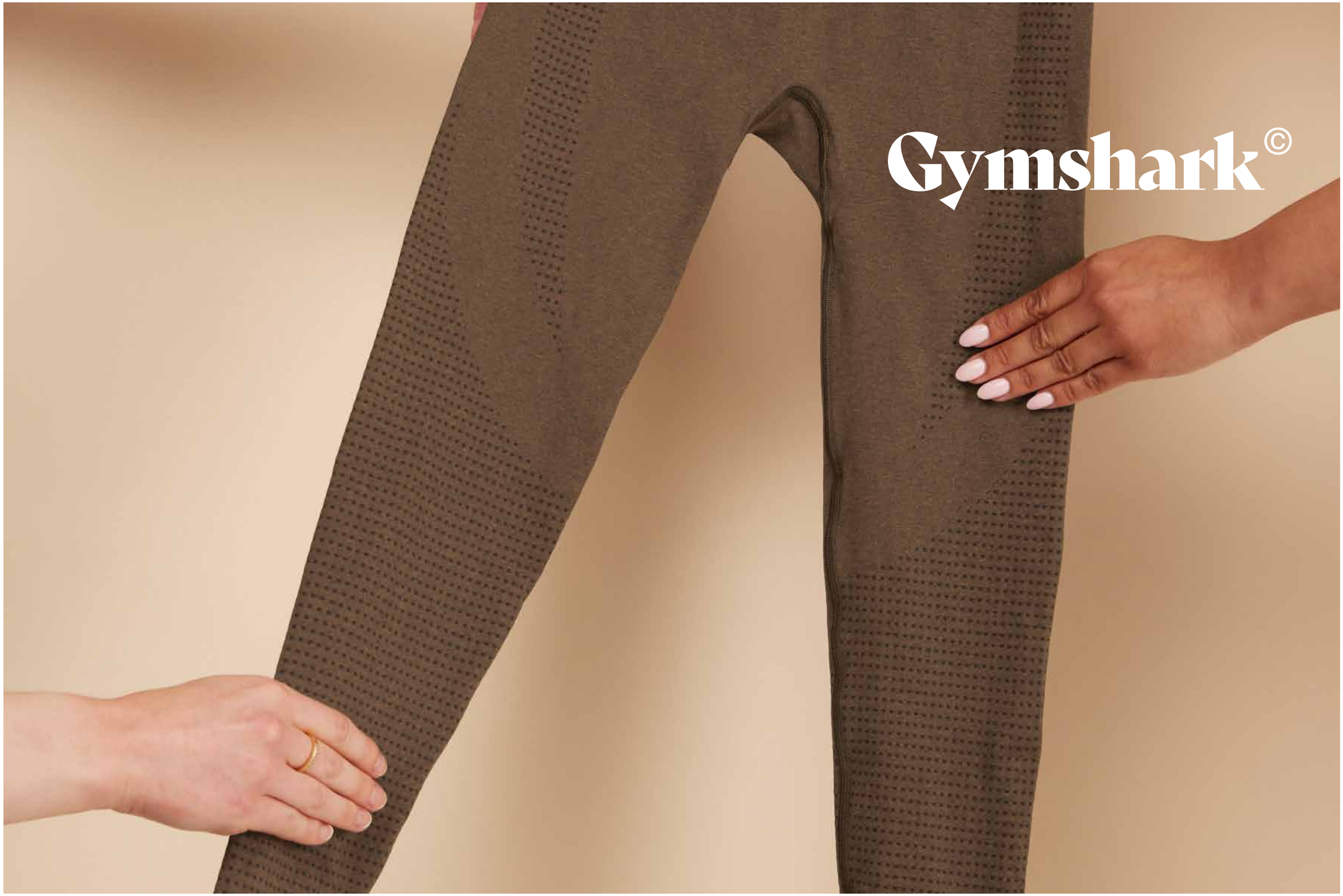
As pioneers of a chemical technology that creates sustainable dyeing solutions using textile waste, DyeRecycle have been ideally positioned to collaborate with Future Fashion Factory on a project that has been able to recycle dyes from pre-consumer textile waste at a 20l scale, and thus address challenges around wastewater pollution.

The collaborative project was conducted at the Biorenewables Development Centre in York, using pre-consumer textile waste provided by Camira Fabrics and by using DyeRecycle's own solvent. Using rigorous testing processes, trials were able to demonstrate textile waste decolourization and subsequent dyeing of new fabrics. Adding to the collaborative efforts, the University of Huddersfield, as led by Dr. Sohel Rana, conducted material characterization, establishing performance fit and quality, while the Royal College of Art, as led by Dr. Dawn Ellams, assisted in identifying end-applications and creating products.

Critically, the project has been able demonstrate a new dyeing and textile decolourization technology at scale, building on existing circular technologies. While there are in fact independent ways to decolour textiles, to dye without water and to produce dyes from non-fossil fuel sources known to the industry, these solutions each involve deploying at least three separate technologies, rather than the innovative, integrated process developed by DyeRecycle.

The project has also carried commercial advantages for DyeRecycle, helping to establish the technical viability of a further business model that explores the use of recycled dyes in powder form. DyeRecycle was also able to cement the ongoing viability of their technology by applying the input and feedback gathered from SMEs in the textile waste supply chain, allowing them to grow their business readiness level, and so being better positioned to attract future investors.

Speaking on the project, DyeRecycle founder, Aida Rafat stated: "dye recycling is a new area for this kind of R&D, but we are seeing that people in the industry actually want to work on solving this problem with us."


Gymshark©

Transparency about Sheerness to increase Gym-wear Opacity

The rationale behind developing leggings that are fully squat proof - insofar that they do no become sheer with stretch or sweat needs not be explained. Yet this sensitive issue represents a nuanced problem for the sportswear industry.

One of the biggest issues facing the sportswear business is creating leggings that are completely squat proof for all consumers. According to British fitness apparel and accessories giant, Gymshark, more than 7,000 of their consumers highlighted sheerness as a reason behind return products in 2021 alone.

Lightweight stretch fabrics often carry a risk of reduced bodily coverage; the squatting actions common to gym-based activity places additional stretch on the fabric and increases the risk of sheerness. It is no surprise therefore that the most important factor that consumers require from leggings is to be “squat proof,” with 40% identifying this as the number one consideration in their purchasing decision (according to Gymshark’s internal metrics).

By partnering with Future Fashion Factory and researchers at the University of Leeds in a cutting-edge collaborative R&D project, Gymshark has been able to address the problem of athletic wear that becomes sheer through use. Specifically, the project has brought together Professor Stephen Westland and Tom O’Haire, Innovative Materials Scientist at Gymshark, to examine the relationship between stretch, sheerness, colour, and user acceptability for leggings to ultimately develop a test that could be used to quantify sheerness as an embedded step within the design process.

By better understanding the causes of sheerness, the research team at the University of Leeds has been able to build a design methodology that will significantly reduce this issue and create truly “squat proof” leggings. To this end, the collaborative R&D project has been focused on the building and delivery of a metrology tool that evaluates the sheerness characteristic of raw materials and finished products. This metrology tool assists users in predicting the sheerness properties of materials and colours and to optimise product designs and construction accordingly. Colour experts at the University of Leeds have calibrated the tool with real consumer perception data to ensure it has the sensitivity and repeatability needed to afford maximum effectiveness.

Relevant to colour science research, this project will bring additional knowledge on the impact on colour on the measurement and perception of optical properties such as sheerness, which in turn, could have cross-industry impact, producing a variety of potential applications throughout the fashion and textile industries and beyond.

The business impact for Gymshark alone would be significant. Gymshark state that leggings contribute to around 30% of revenue and are a leading category for both new and existing customers. “Sheerness” is a significant contributor to product returns in leggings and has a tangible impact on their revenue. For Gymshark, an enriched understanding of what causes sheerness would lead to better product design, improved communication, enhanced reputation and ultimately, millions in revenue per year on leggings. For example, Gymshark noted that in 2021 alone, more than 7,000 customers cited sheerness as a reason for return.

Detecting misalignment for frequently-processed-fabrics

WT Johnson & Sons ©

Providing a high-quality fabric finishing service for many of the UK's premium cloth manufacturers, WT Johnson & Sons services add great value to the variety of textile products that are processed. The quality of the final finishing is paramount to their customers, yet the single biggest quality issue facing businesses such as WT Johnson is distortion and weft misalignment in the product during finishing.

WT Johnson built on the outputs of a prior Future Fashion Factory R&D project, seeking to further develop a system to detect misalignment for frequently-processed-fabrics. While weft straighteners were commonly employed and offer a solution to a point, the configuration and sheer bulk of the equipment meant that some distortion still occurred in some instances. The ability to deliver a digital solution which could rapidly detect misalignment for frequently-processed-fabrics was therefore of increasing importance. The capabilities of the misalignment tracking system were broadened so that it could intelligently-recognise specific fabric patterns and their pattern features before determining the parameters required to set-up the image analysis system. Specifically, a system able to alert operators and halt finishing machines prior to entry into the drying chamber would be able resolve quality issues encountered when weft misalignment exists in a final finished piece.

Forming the project team was Dr. Zhiqiang Zhang of the School of Electronic and Electrical Engineering, University of Leeds, Professor Ningtao Mao from the School of Design, University of Leeds, along with the team at WT Johnsons led by Mr Alan Dolley.

The team further improved the weft misalignment detection system, which consisted of a line scanning camera, a lighting source, as well as a software system to operate the image acquisition and subsequent processing. This project therefore developed the system so that it could intelligently recognise specific fabric patterns, and their pattern features and then determine the setting up parameters of the image analysis system. The end-result of the project was a working prototype of weft misalignment detection system.

To complete the working prototype, the team developed a camera calibration method to reduce the image distortion in real-time. They also employed machine learning algorithms to help detect these weft misalignments across a range of specific fabric types, which subsequently led into a feedback system to either alert operators or stop fabric inspection or finishing machines when a weft misalignment is detected.

Before working with Future Fashion Factory, fabrics having weft misalignment defects almost reflected around 1.2% of all the fabrics annually produced in WT Johnson. If 50% of fabrics can be rectified online before fabric setting using the technologies developed, 40,000 meters of fabric will be saved from being reprocessed; this would increase profits by £100k annually for WT Johnson.©

AW Hainsworth©

Computer Aided Design

Designing new fabrics for remote clients is a lengthy process involving multiple iterations of manufacturing (and sending) physical swatches, which consumes energy/raw materials and generates waste. Computer Aided Design (CAD) systems can help to visualise new fabric designs and map those fabrics onto digitalised products (e.g. clothing, upholstery), but cannot predict fabric performance (i.e. the corresponding fabric drape and 'feel') of the new fabric designs. This project developed a system that can help remotely evaluate and communicate fabric performance of virtual fabric designs before the fabrics are made by employing digital technologies.

Standard fabric CAD systems can create a visual representation of a new fabric design in pattern and colours, this allows fabric designers to communicate how fabric colours and patterns may look to remote clients without having to send physical samples.

While this system works well for communicating the surface visual appearance of a fabric's patterns, in many cases the fabric drape and tactile performance of a fabric are vital. For this reason, many clients still prefer to receive physical samples rather than rendered images of a new fabric design.

One way of conveying the physical properties of a fabric without sampling is to provide a means of visualising fabric aesthetic and tactile properties. For example, by showing a still image or animation of how a fabric drapes, it's bending, and shear stiffness can be inferred. In order to achieve this in existing garment design CAD software which could simulate, visualise and render fabric drapes, it is required that a) the physical properties of the fabrics as simulation input parameters are known; and b) the fabric properties of virtual fabrics designed are predictable using AI-based models and information from the properties of existing fabrics.

This project built a new system that can visually show, evaluate and communicate the aesthetic and tactile performance of a new fabric design solely created using CAD tools. The fabric mechanical properties of a new fabric design, which are generated in a fabric design CAD, were predicted from an AI-driven model based on existing fabrics.

The fabric properties predicted were then fed into a garment simulation platform to demonstrate fabric drape and tactile performance, which will help remotely evaluate and communicate fabric performance of any new fabric designs before they are made into physical fabrics. This eliminates the need to physically manufacture fabric samples during the fabric design process. The system could also be extended to allow users to 'interact' with a virtual fabric via VR technology. This would involve modelling the fabric system in real time to predict behaviour based upon imposed physical fabric properties, and then rendering out an image stream representing the result.

New fabric designs are often created through an iterative process that can include numerous sampling steps whilst the design is tweaked. Not only does the new system speed up the process of developing new fabrics (as the manufacturing of samples is very time and resource consuming) and significantly cut the lead time but reduces material and energy waste as many of these samples ultimately end up in the bin. For example, it's usually necessary to manufacture a considerable length of fabric to create a single sample-sized piece.

As a result of the project, a new system for fabric design that allows new fabric designs to be developed, evaluated and communicated in a faster and more responsive manner has been implemented into Hainsworth's workflows.

Heat-based transfers made for sustainability

CUSTHOM©

CUSTHOM, working alongside Conductive Transfers, and Professor Ningtao Mao have successfully completed research that enables the application of additive and electronic/smart transfer printing to material substrates more sustainably than previously possible.

Specifically, the project was centred around the development of alternatives to polyethylene terephthalate (PET) & Polyurethane (PU) carrier films used in their heat transfer printing of metallic finishes/electronic circuits onto fabrics and other fashion products. This was achieved without generating a harmful and polluting waste stream, by replacing PET film with cellulose acetate film, a feat that will undoubtedly have largescale possible ramifications on the businesses' sustainability practices.

CUSTHOM are a homewares brand who design and manufacture wallpaper and interior textiles, specialising in hand foil finished products. Using low temperature and pressure levels to release metals from carrier films, CUSTHOM have developed wallpapers that use textile transfer methods combining screen printed adhesives, heat, and pressure to achieve high shine and metallised finishes. Using this specialist knowledge, CUSTHOM have consulted and design fashion fabric ranges for brands and textile agencies including John Lewis, Farah and Whiston & Wright.

Conductive Transfers manufacture and supply printed circuits for smart garments. Their circuits are thin, light, stretchable, washable and cost-effective, using a novel process based on transfer printing for manufacture. Conductive Transfer's units are screen printed onto a transfer film and then cured in an oven one layer at a time, starting with an insulating layer, followed by a conducting layer, another insulating layer and finally an adhesive layer. The circuit is then finally heat pressed ontoa textile and the transfer film is removed.

Previously, both companies use thin sheets of PET as the transfer film, which can only be used once and are then discarded to landfill and are thus, markedly unsustainable. Undoubtedly, gained because of the project, the ability to use heat transfer processes that do not require single-use plastics, will have a significant effect on their ability to work both impactfully, but also sustainably.

Prior to the project, the base materials of the carrier films used in the PET application processes, with or without metallised finishes, were mainly made from paper, synthetic and vinyl polymers, which in turn were made from fossil fuels.

To contextualise this, the estimated market size of synthetic heat transfer printing films made from polyurethane, PVC and polyester was US$ 2.3 billion in 2022. Polyester films have superior thermal and thermal stability properties, thus making them the ideal candidate for heat transfer carrier films requiring high temperature (up to 1800C) and high-pressure conditions (2-8MPa).

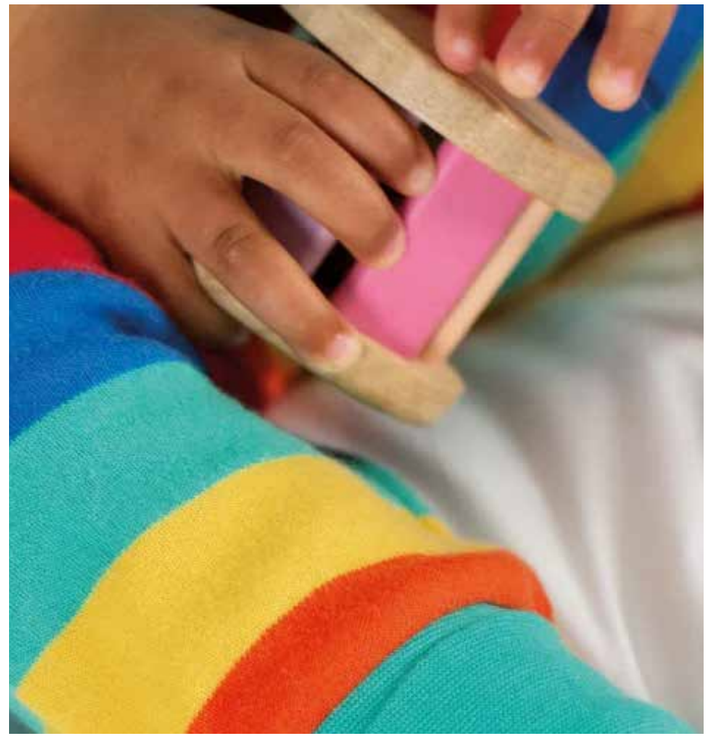
The process of finish/transfer printing is used across a breadth of apparel sectors, currently creating an abundant non-recyclable waste stream. Through our collaborative R&D project, we have been able to develop a suitable fully sustainable cellulose acetate as an alternative to the PET film, which will have the capacity to remove tonnes of virgin PET (as well as PU) currently produced as a by-product of hot foil stamping in the textiles industry.

Through the development of a novel, fully sustainable cellulose acetate alternative to PET/PU heat transfer films, as used across diverse sectors, we will be critical in the steps towards eradicating unnecessary PET/PU waste.

Frugi©

Sustainable Durability testing to Guarantee Children's Clothing

Frugi is a childrenswear brand that only uses sustainably sourced materials for their clothing including Global Organic Textile Standard (GOTS) Certified organic cotton grown by farmers they trust. The brand is on a circular mission is to guarantee that their garments can be handed down again and again, for child after child to enjoy. To do this, the requirement to create a new sustainable durability testing protocol was paramount, enabling the brand to accurately determine the usable life span of any piece of children's clothing.



Working with Future Fashion Factory, Mary Lawrence the Product Development Manager at Frugi formed a collaborative team with Dr. Mark Taylor, a Research Fellow from Leeds University and Eurofins Modern Testing Services, with the mission to develop a new sophisticated method to generate a more streamlined testing protocol. The project was able to examine the impacts of repeated washing and wear and tear testing on childrenswear. This shored up a streamlined and reliable method of predicting the sustainable durability of clothing.

By this token, the collaborative R&D project was, in effect, an exercise in increasing sustainability in the durability testing process to ensure that such clothing is capable of being passed from one user to another for a considerable period beyond the initial user. Ultimately, Frugi could use the project as a platform to reliably guarantee durability over their sustainable childrenswear.

The project was able to circumvent existing durability testing issues; prior methods for ensuring durability of clothing relied upon repeated laundering which involves the use of considerable volumes of water, chemical detergents, and energy to heat the water and dry the clothing. Replicating 1 wash per week over a 3-year life cycle would require 156 individual machine washes which is neither environmentally friendly nor commercially viable. Other properties such as abrasion, pilling, stretch and recovery and colour fastness have not been directly utilised, and the conventional tests carried out are not designed to assess long term durability of the product nor do they necessarily consider the different ways in which children interact with their environment (which, naturally, result in increased rates of wear when compared to adult clothing).

By identifying a robust means of predicting durability and sustainability of clothing but by using less rigirous testing methods and fewer resources, Frugi have been able to successfully design out materials and garment designs which may be prone to premature failure, all while optimising the choice of materials and construction techniques to maximise the lifecycle of the clothing.

Developing clothing which can better withstand the rigorous use of children over a longer period can assist in reducing reliance on less sustainable textile fibres while also promoting the longevity and recycling of garments – as they are shared between siblings or donated to second-hand outlets.

Through this innovative durability testing and prediction tool, unique to Eurofins Modern Testing Services there will be significant sustainability gains over current testing protocols, allowing for more sophisticated testing measures for wear and tear beyond those currently used.

There will be a significant in-house gain for Frugi, by way of their circular design principles, allowing them to improve circular manufacturing within their global supply base, and allow them to educate their customers on conscious consumption and the circular journey of a garment.

Digital Technologies to Support More Sustainable Bulk Production

DP Dyers©

It is a known issue that mass piece dyeing can struggle to replicate lab dyeing results, leading to excessive repeat dyeing, and wasted resource built into its processes. In the spirit of streamlining efficiency and reducing waste, DP Dyers collaborated with Future Fashion Factory in a project centred on computational modelling to analyse inconsistencies between lab and mass dyed fabrics.

Traditional piece dyeing is a process whereby woven lengths of white fabric are dyed to a specific colour using a dye recipe. Typically, DP Dyers have been commissioned to create new shades on new fabrics with complex fibre compositions. This means continually testing dye recipes and techniques in their lab to perfect the required shade before upscaling this process for mass dyeing. In theory, anything that is produced in the lab should be able to be scaled up to bulk without any degree of error. In practice, mass dyed fabrics can show significant and varying inconsistencies compared to their lab produced counterparts. If inconsistencies do arise, the whole process must be redone.

Conditions in the lab are very tightly controlled, with variables at an absolute minimum. The purpose of the lab process is to establish good matches prior to bulk dyeing, and as the lab is a fully controlled single unit it is inherently better at producing and repeating results.

Machine dyeing is often performed in the opposite environment, and thus often results in discrepancies due to inconsistencies in the capabilities of the machines, complications of upscaling the dye recipe and human errors in the process, leading to a series of iterations based on trial and error; this produces a lot of waste – especially in terms of water, gas, electricity, fabric, and human resources.

The precision possible in the lab is therefore the only way to ensure the perfect colour match for the end fabric in a sustainable and efficient manner. It has become essential that the transfer from lab to bulk is seamless and maintains the precision of the lab process: this has not been possible without substantial reliance on the skill of the dyer to adjust any variation that arises in the first bulk dyeing, which is both a lengthy, resource heavy and wasteful process.

DP Dyers, part of the WT Johnson Group, have worked with the University of Leeds' Professor Stephen Westland to adopt a process that has effectively digitally translated lab dye processes to be fit for mass manufacturing, without the trial and error involved previously – this has consequently helped to yield significant sustainability and efficiency benefits.

The computational modelling technology through its implementation of a matrix of complicated systems, built using a variety of mechanistic approaches and complex algorithms – has helped to reduce the need for repeat dyeing. A natural consequence is therefore the reduced amount of water, chemicals and energy needed in the dyeing process, thus saving time, money and increasing capacity for mass production.

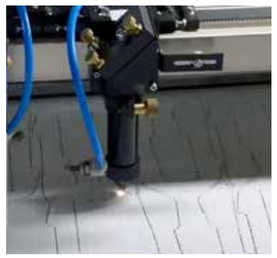
For DP Dyers, the project was critical when helping the team to better understand their skills and tackle a future where dye rejects can cause real problems. The potential risks could carry a need for repeat work, or even result in unacceptable delays when it comes to delivery times.

"This project has helped drive us on a path of improvement, to be able to compete and to meet the demands of our customers. We cannot stand still, and the history of WTJ shows we will use every new technology available to make those improvements," Alan Dolley, Technical Manager at DP Dyers and WT Johnson & Sons.

Paving PLA Solutions

Hylo Athletics©

With the aim of building upon their previous research exploring the end-of-life opportunities for the Hylo Corn Runner, Hylo partnered with Future Fashion Factory Professor Blackburn and the University of Leeds to drive their existing collaborations forward into a new stage of development.



Where the prior R&D project trialled new end-of-life recycling processes for Hylo Athletics' innovative running shoes, this project successfully identified and met the required next steps: to find a way to enable the mechanical and chemical recycling of dyed, coated, and contaminated shoes.

The collaborative research process was centred around finding solutions to these challenges. In doing so, Hylo have been able to trial multiple recycling cycles, elevating their testing processes from a lab setting to a more viable industry solution to polylactic acid (PLA) recycling.

Results of this testing have helped Hylo to identify ways to recycle a large proportion of virgin PLA with negligible effects on the thermal degradation of fibre quality. In addition, the research identified benign catalysts to chemically convert shoe PLA into useful monomers such as lactide and methyl lactide.

These developments will pivot Hylo towards an industry viable mechanical and thermal or chemical recycling solution for their Hylo Corn Runner product line. Moreover, Hylo have successfully partnered with EON to help introduce an NFC tag into their shoe product lines. This has the effect of acting as a product tracker that provides product specific information so that the shoe can be recycled.

Through collaborations such as these, as well as through building scalable solutions around PLA recycling with commercial partners, Hylo are naturally helping to increase PLA recycling awareness in the industry. The knock-on effect is simple but profound: through further collaborative partnerships, Hylo can encourage other brands to move away from fossil fuel-based materials such as polyester and instead create demand for more bio-based and renewable feedstocks.

This funded R&D project is therefore emblematic of the fact that designing for a product's end-of-life begins at its raw materials stages - a fact pertinent to the entirety of the fashion and textiles industry.

Regarding the benefits to Hylo Athletics, finding an end-of-life solution to one of the main materials used will enable full product accountability as well as circularity. This next phase in the project has therefore been pivotal in moving their research away from the concept level and towards real-life, practical solutions that can be shared amongst the industry at large, thereby creating a more circular economy.

A larger aim is to take other brands' waste and incorporate this into Hylo's recycling programme, therefore not only creating circularity within the company, but also from a wider industry perspective. For example, their findings can easily be shared with other UK businesses to benefit the UK fashion and sportswear industry overall.

A rise in sales and customer retention this would see Hylo's turnover significantly increase, allowing them to take on numerous staff to develop new circular products along with managing the recycling portal and customer journey. In support of this, the product tag, collaboratively implemented with EON, will not only add significantly to Hylo's turnover by continuing to facilitate this customer retention but also attract new customers looking for a circular product.

Michael Doughty, Co-Founder and Managing Director commented "We are very grateful to have the support of Future Fashion Factory in our pursuit to ensure that Hylo takes accountability for its products from beginning to end."

Professor Blackburn commented "It is great working with a Hylo because they are a company who understand sustainability and the importance of understanding the environmental impact of consumer products through their full life cycle. The collaborative research we're working on is moving Hylo products towards increasing circularity and is adopting a detailed scientific approach to recycling the materials using innovation. It is great to be working on a project that is uncovering both new science and has the potential for impact at the product level."

Future Fashion Factory: Digitally Enabled Design & Manufacture of Designer Products for Circular Economies

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https://doi.org/10.48785/100/310

The authors gratefully acknowledge the financial support of the Arts and Humanities Research Council (AHRC), Grant Ref: AH/S002812/1, which enabled the Future Fashion Factory programme to be delivered. Future Fashion Factory involved extensive collaboration between multiple industry partners and several HEIs including, the Universities of Leeds, Huddersfield, Manchester Metropolitan University (MMU) and the Royal College of Art (RCA). We wish to thank all industrial partners and academic colleagues who have contributed to the FFF programme since its inception. Special thanks go to those providing support and guidance on the FFF Steering Group and Programme Management Group, particularly to the UK Fashion and Textile Association that also Chaired the FFF Investment Committee.

We would like to thank the companies who are featured within this publication for allowing us to use their images, and for their consistent collaboration and support throughout.

ISBN 978-1-0369-1504-9.