ISSUE 1 2021

DIGITALNOW

DRIVING A DIGITAL REVOLUTION IN THE SOUTH-WEST

Re-imagining sustainable products of the future

Can AR and VR make a big difference within the manufacturing process?

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DETI DIGITAL ENGINEERING TECHNOLOGY & INNOVATION

WEST OF ENGLAND Combined Authority

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Foreword

There is a climate and biodiversity emergency. So shifting towards a low-carbon economy is vital.

At the West of England Combined Authority which I lead, we are passionate about accelerating innovation to tackle this urgent challenge. The Digital Engineering Technology & Innovation programme is a key part of our commitment.

We have set out to inspire a generation of young people to pursue careers in science, technology, engineering and maths. Let's demystify the wonderful world of digital engineering, so that more people from every background, see what a fulfilling career it could be.

This key programme will build the digital skills and technologies we need, and demonstrate that the West of England is the go-to place for high value design and engineering in the UK and the world.

In turn, this will create more high quality jobs for our residents, and make sure our region has the knowledge and ability to find new, sustainable ways of doing things.

It's fantastic to be able to share some of the progress we have already made, but let's build the momentum, to create an ever brighter future.

Dan Norris, *West of England Metro Mayor*

WEST OF ENGLAND
Combined Authority

Introduction

For engineers, the design of complex products is about improving performance and customer satisfaction, while ensuring manufacture can be performed at low cost, as fast as possible and always right, first time.

Competing in a digitally fuelled race, we are being tasked to find innovative new solutions using cutting edge digital technologies to optimise and improve not only the development process but also the products themselves. Underpinned by net zero targets and ensuring a sustainable future for generations to come the challenge has become much bigger, but so are the opportunities.

DETI brings together the expertise, skills and knowledge of its partners to explore and showcase new technologies of what a digital future might offer. Addressing gaps in capability that we have identified, the Skills programme is contributing to building a diverse, inclusive digital ready workforce, engaging with 3,400 children across 54 schools in the region. Even more critical post Covid-19 where the importance of digital technology has been emphasised, the research that we have undertaken will fast track innovation, develop sustainable products and processes while helping UK engineering businesses to pursue a more competitive position. Read about our new ultra-secure Quantum communications network, to digital prototyping systems for sustainable products of the future and the Engineering Curiosity STEM programme. I'm delighted to be able to share with you a selection of highlights from the Digital Engineering Technology & Innovation (DETI) programme.

DETI brings together the expertise, skills and knowledge of its partners to explore and showcase new technologies of what a digital future might offer.

Richard Oldfield, *Chief Executive Officer*, National Composites Centre

NATIONAL COMPOSITES CENTRE

Vision

To transform engineering for the digital era and inspire the next generation of engineers.

Purpose

To create a new, diverse engineering community and systems to investigate, develop & demonstrate the advanced digital technologies and skills needed for the sustainable products of the future.

About Digital Engineering Technology & Innovation (DETI)

By the end of this decade, to deliver a low carbon global economy, everything we make will need to be completely re-imagined and re-engineered. Digital technology is revolutionising traditional engineering practice. Shorter product development times, faster routes to market and the need to develop sustainable products is providing us with an exciting opportunity to maintain engineering leadership. UK businesses need to develop new ways of working that enable agility, flexibility and competitive advantage in a global marketplace, that will support future generations socially, economically and sustainably.

UK businesses need to develop new ways of working that enable agility, flexibility and competitive advantage in a global marketplace, that will support future generations socially, economically and sustainably

The digital revolution is fundamentally changing the way engineers work, requiring new skills. There are few digital test-grounds to explore and test technologies used in design and manufacturing processes. This is where Digital Engineering Technology & Innovation (DETI) comes in.

DETI will connect, accelerate and inspire, the people and technologies that will lead into the next phase of clean and sustainable growth. We will support industry to reduce carbon emissions by helping companies to optimise design and manufacturing processes and produce better products that are more fuel efficient and have less waste – through undertaking research and innovation in our increasingly virtual world.

Encouraging diversity and inclusivity, DETI will initiate a comprehensive skills and workforce development programme to ensure the current and future workforce is digital-ready, inspiring future generations. Equipping the current and future workforce with the necessary digital skills to fulfil roles in digital engineering, it will provide the foundation to change the future and meet net zero targets.

DETI DIGITAL ENGINEERING TECHNOLOGY & INNOVATION

WEST OF ENGLAND Combined Authority

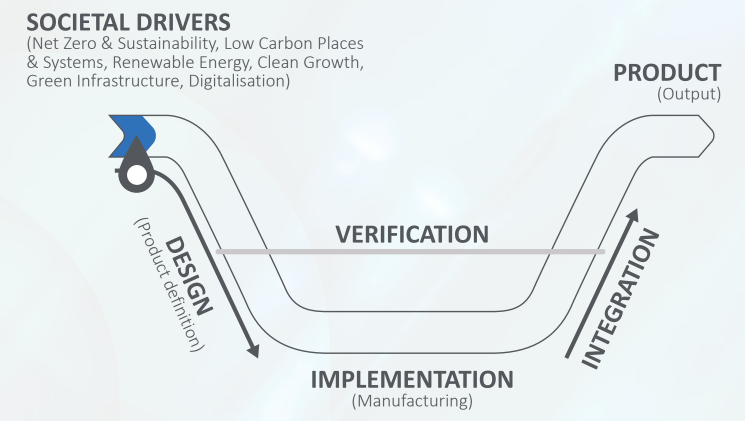
RESEARCH HIGHLIGHTS

As an initial 2-year programme, DETI is focused on helping companies to overcome the challenges to digitalising design and manufacturing processes.

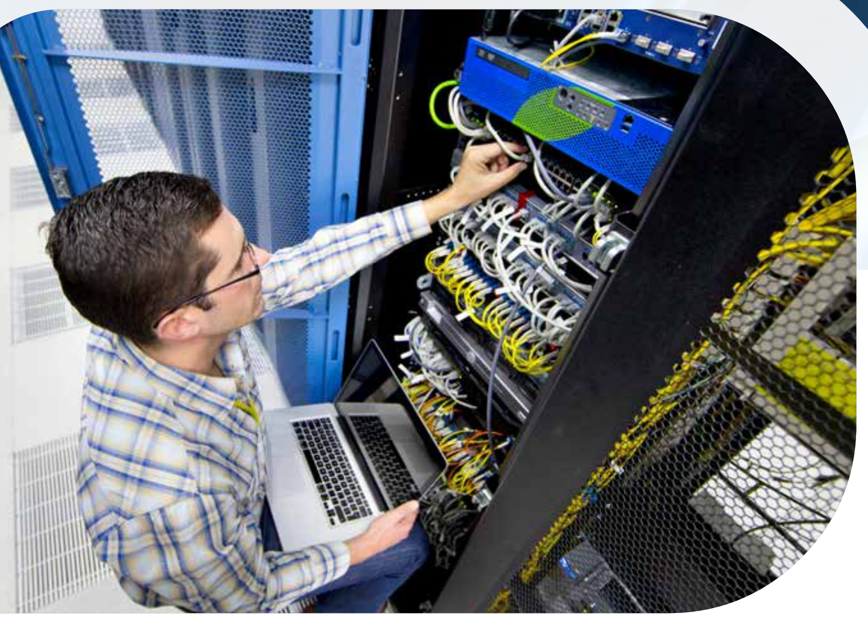
It seeks to identify the technologies that will drive innovation in developing sustainable products, systems, businesses, infrastructure and transport that underpin a net zero environment. Enabling the region with the necessary digital skills to achieve sustainability goals, it will develop a comprehensive skills and workforce development programme to ensure the current and future workforce is digital-ready, inspiring future generations.

Presented below are a selection of research highlights from the first 12-months of the DETI programme.

For further information about a specific highlight or to access the technical information, email **ncc@deti.uk.com**



A **digital thread** definition



CHALLENGE

The past decade has seen an explosion in digital engineering technology and capability with industry quickly exploiting and adopting it into their practice. This is referred to as the "Digital Transformation" of industry, often known as "Industry 4.0". However, the rapid update has led to an heterogenous digital engineering landscape with no one organisation featuring the same IT infrastructure and architecture as another. The result is digital engineering silos and constrained workflows that do not exploit the full capabilities digital engineering has to offer in terms of design and manufacturing optimisation, traceability of information, decision making, engineering process improvement and business intelligence.

'Digital Thread' is the term given to the activities, tools and practices that will address the challenges brought about by the rapid democratisation and uptake of digital engineering technology. The Digital Threads will connect data and information flows across digital engineering workflows and tools such that the full potential of digital transformation can be exploited in support of the next generation of products and meet the pressing challenges of net zero and sustainability.

RESULTS AND THE DIGITAL OPPORTUNITY

- Definition
- Current Practice
- Capability and Knowledge
- Digital Thread Demonstrator

CFMS have reviewed academic literature to determine a consistent definition of the term "Digital Thread" which was determined to be:

"Data and/or information flow between systems and/or people that is systematic, consistent and auditable delivering the right information at the right time to the right people through the right mechanism."

Through this review, seven types of Digital Thread were identified for engineering organisations:

1. **Internet-of-Things.** The sensing and translation of physical information into the digital. Examples include sensing a manufacturing facility (e.g., humidity and temperature), manufacturing processes (e.g., tolerances, production rates), the product (e.g., inertial measurement units, temperature, GPS), and decommissioning processes.
2. **Twinning.** The data and information flows that enable synchronicity between digital and physical assets and inform the Digital Twin, a virtual representation of a physical process or object.
3. **Operational.** The data and information flows that serve to enhance productivity and efficacy of an organisations' operations.
4. **Exposing Digital Assets.** The data and information flows that provide the ability to interrogate and query across an organisation's digital assets.
5. **Business Intelligence / Data Science.** The data and information flows that enable exploration and interrogation of data to provide insights that can add value to a business through re-shaping and optimising their processes.
6. **Lessons Learned.** The data and information flows that feedback information to improve future engineering processes.
7. **Inter-Organisational.** Exposing data and information for other organisations to query and use within their processes.

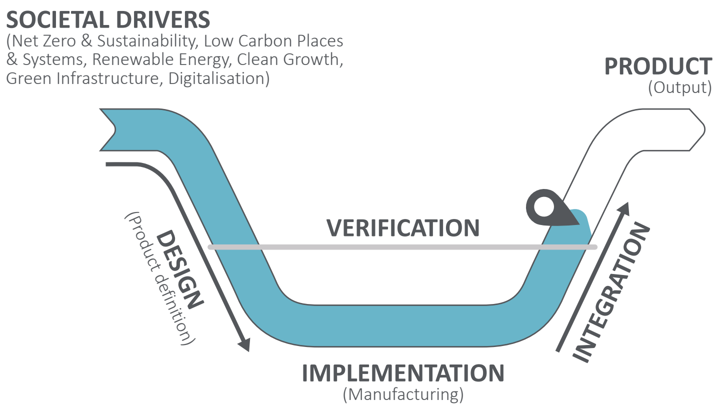
With the definition of Digital Thread determined, the research continues with a review of current Digital Thread implementations in industry, with the goal of identifying the typical tools, skills, and management practices required for the successful application of the Digital Thread.

Results indicate that while the necessary technologies and tools exist, it is the management practices, roles within an organisation, how one architects the Digital Thread for an organisation, and the up-skilling of the engineers that require further support and development. Future focus and development of this research will result in a Digital Thread demonstrator, which will showcase the connection of the threads of data across an organisation, driving efficiency and reduced time to market in developing sustainable products and processes.

Partner

cfms

Automating and digitalising the inspection process of composite materials



CHALLENGE

Despite their numerous advantages compared to traditional materials, carbon fibre composites still have challenges associated with their efficient and defect-free manufacture.

In particular, the black and shiny nature of the composite surfaces make both manual and automated inspection of both raw materials and completed cured parts difficult. Commonly used in aircraft wings, fuselage, tail surfaces and doors, polarisation imaging is used in this scenario to detect surface roughness, scratches, dents, surface coatings and stress to composite materials.

RESULTS AND THE DIGITAL OPPORTUNITY

Facilitated by DETI, a novel software system has been developed which is based on state-of-the-art Machine Learning (ML) techniques. ML is the application of Artificial Intelligence (AI) that enables systems to access data and automatically learn and improve for themselves without being programmed. The system that has been developed is able to automatically detect the (manually induced) defects, as shown by the rectangles.

The image below (left) shows a polarisation image of a defected component – that is, an image emphasising the effects on surface structure on the nature of light reflected towards the camera. The defected regions are clearly more visible compared to the standard image (right).

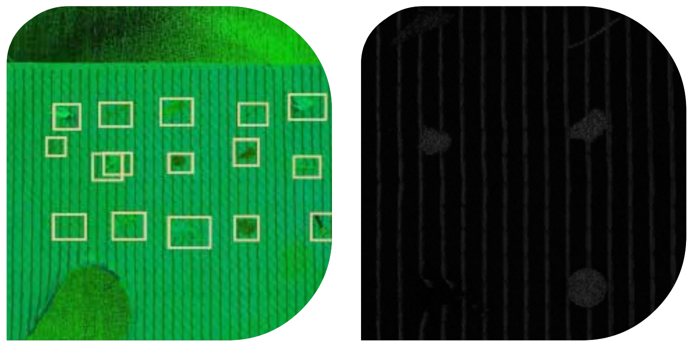


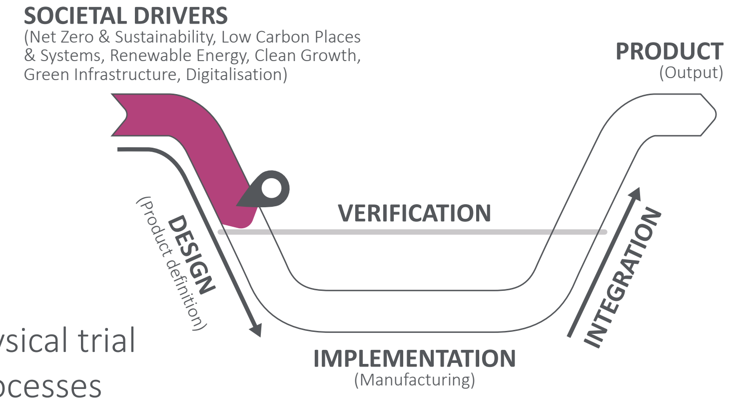
Figure: Polarisation of a fabricated defect component compared to a standard image

The next stages of the project will involve the optimisation of this approach to detect real defects and the incorporation of the moving-light scanner to detect more subtle and hard to detect issues with the material.

Partner

UWE Bristol University of the West of England

Driving sustainable prototyping **with digital technology**



CHALLENGE

A physical prototype is a working model of a product, which can be used to perform a physical trial to validate the design and manufacturing processes prior to investing in full scale manufacture.

Physical trials help to understand the number of variables in the manufacturing process, which need to be controlled to make the right product. As we introduce new, sustainable materials or lower energy processes, continuing with a more traditional physical trial approach to understand the variables and develop the manufacturing process will become more wasteful. The use of advanced simulation, data driven decisions and digital technologies in manufacturing processes will reduce physical trials, developing a 'right first time every time' approach, generating less waste and environmental impact.

This is particularly true in sectors where composite parts are commonly used; aerospace, automotive, marine and construction sectors, to name but a few. As the number of products being made from composites is significantly increasing, a change to traditional physical prototyping processes is required. Composites are viewed as a solution to achieving net zero targets due to their light weight which will reduce emissions, and offer flexibility in design, and high-performance strength and durability. Known for their longevity, they hold up well against fatigue, corrosion, and are resistant to many environmental factors such as UV, temperature, chemical and moisture exposure.

RESULTS AND THE DIGITAL OPPORTUNITY

DETI has successfully trialled a digital system that monitors the application of a composite resin when injected into the manufacturing mould of a product, designed to produce 'right time first time' products and prototypes.

The system focuses on providing the engineer with a digital tool that will aid monitoring and controlling resin distribution. The use of digital technology in this process will enable informed decisions to be made, increasing the effectiveness and outcome of the process. This is crucial to producing a high quality, fault free product. Referred to as Liquid Resin Infusion (LRI), this manufacturing technique produces high performance composites, for use in sectors where lightweighting, strength and durability are key.

Consisting of a series of sensors which are placed inside the mould, the system allows the engineer to view the movement of the resin through the mould using a visual dashboard, gathering the data relating to the process. As this type of composite is cured in high temperature ovens, the system also gives the engineer crucial visibility into the process which allows them to make interventions when required, supporting and enhancing operations delivered.

This is the first time in industry that this type of sensor has been used in a 4G network, allowing the data to be displayed on an app accessible from any device, enabling more flexibility in analysing, processing and integrating the data.

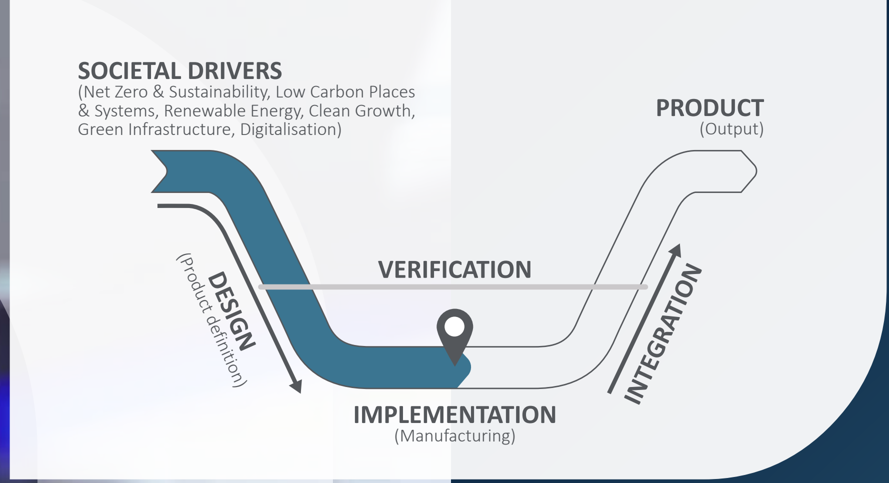
Incorporating digital technologies into manufacturing process development will help to refine and validate composite designs requiring less prototypes to be made, reducing the amount of waste produced, and a better outcome for the environment.

This project builds off the earlier partnership between NCC and CFMS from the Computer Learning in Automated Manufacturing (CLAMPS) project.

Partners

NATIONAL COMPOSITES CENTRE
cfms

Inclusive digital careers **for diverse engineers**



CHALLENGE

The West of England is a hub for innovative Science, Technology, Engineering and Mathematics (STEM) industries, but as with the rest of the UK, there is a huge skills and employment gap for future engineers.

Women make up just 12% of Engineers, and 26% of the UK Science, Technology, Engineering and Mathematics (STEM) workforce, despite making up 51% of our population. Similarly, people from Black, Asian and Minority Ethnic backgrounds make up 7% of engineers, despite being 13% of the UK population. People from low socio economic backgrounds or those with specific learning difficulties also find it harder to access engineering education. Many people will have no knowledge of adults who work or have worked in STEM careers, which gives them very little science capital.

Both recruitment and retention are important – more people need to connect with STEM professions as socially conscious, creative, and collaborative disciplines, and more employees need to be supported to make a difference in the workplace. That's why DETI is investing in future skills for digital engineering and technology for sustainability in the West of England region. It will initiate a comprehensive skills and workforce development programme to ensure the current and future workforce is digital-ready, inspiring future generations. The Skills work from DETI aims to connect and bring together organisations in this sector to amplify our work across the lifespan. DETI Skills aims to break stereotypes and challenge perceptions about STEM careers for the future.

RESULTS AND THE DIGITAL OPPORTUNITY

DETI brings together three strands of work and programmes on inclusive skills:

Inspire - Inspiring and engaging future generations in digital engineering and sustainability, through coordinating and connecting the STEM ecosystem, support packages for schools, and better messaging/language around engineering careers.

Transform - Transforming the education and skills landscape through, for example, new digital engineering courses and work experience to inspire future apprentices.

Innovate - Innovation in workforce development through a Diversity Demonstrator Programme to role model amazing talent across the West of England, leadership in inclusive workplace development through listening to minority groups, and CPD/short courses to address the Skills Gap and Build Back Better.

"Women make up just 12% of Engineers, and 26% of the UK Science, Technology, Engineering and Mathematics (STEM) workforce, despite making up 51% of our population."

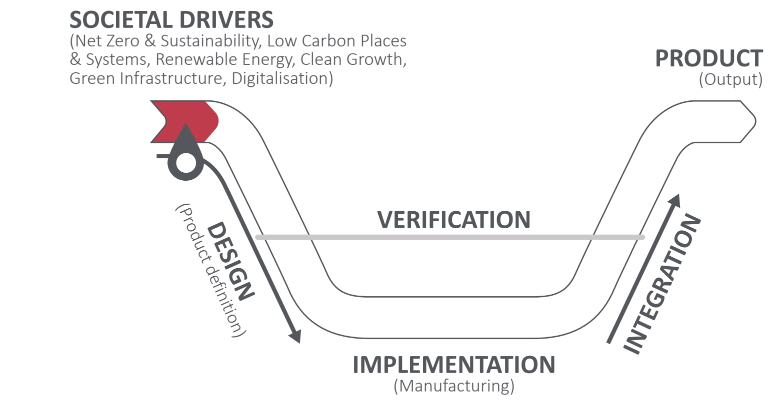
DETI Skills has developed the Diversity Demonstrator network – a database of STEM Ambassadors who are diverse engineering role models in the West of England. To accompany this, a digital BoxEd called Engineering Curiosity, which role models diverse engineers from across the region has been created, consisting of a Top Trumps card set and curriculum packs. Launched at the 'Big Beam in' event, in conjunction with STEM Ambassadors and publicised through the Curiosity Connections network, it amplifies inspirational primary STEM education throughout the region, reaching over 3,400 children across 54 schools.

Continuing the focus on diversity and inclusivity, the Innovate programme is delivering a series of Listening Workshops to hear from diverse engineers about building inclusive workplace cultures. This will culminate in two CPD Workshops, and continue into an Executive Masters in Digital Engineering.

Partners

CURIOSITY CONNECTIONS | UWE Bristol University of the West of England | STEM Ambassador Hub

Re-imagining sustainable products of the future



CHALLENGE

Developing and designing a product is a complex process which involves thousands of computer aided design iterations, followed by building and testing multiple physical prototypes of what the product will look like in real life. Very often, the product that is manufactured is different from the original design because of the changes that the design goes through to ensure that it is safe, sustainable and meets the requirements of the customer. To deliver a shift to low-carbon, the design process also needs to have sustainability built into it from an early stage.

RESULTS AND THE DIGITAL OPPORTUNITY

The DETI Partnership has researched and analysed a range of new digital technologies and tools that companies can use when designing and manufacturing sustainable products, to help to create better products, and in a shorter timescale - potentially reducing costs.

These technologies enable industry to digitally view and understand how users will interact with their product from many different angles, which can't usually be seen until the product is made. Presenting a very accurate 3D image of what it will look like when physically produced, these technologies allow designers to test and review the product on screen.

The technologies will also empower manufacturing to visualise processes that are normally hidden from view. Additionally, training of individuals can be deployed in a safer, and more cost effective way prior to exposure to the real product and environment.

In sectors like marine and aerospace where product development lifecycles are often lengthy, costly, and high performance is critical, this technology could dramatically reduce environmental impact by generating less waste throughout the prototyping stage.

DETI's research has examined best practice for the presentation and visualisation of design and manufacturing data, using immersive technologies, specifically Augmented Reality (AR) and Virtual Reality (VR).

Augmented Reality (AR) describes the environment in which real objects or products are inserted into computer-generated virtual environments.

Virtual reality (VR) is an artificial environment that is created with computer software that is like the real environment.

Product Design

AR allows designers to see a product during development in context, at low cost. Engineers can access this technology through a mobile device, using the camera function to project a dynamic image of their product or prototype in situ providing insights into its benefits and limitations.

Remote Inspection

Remote AR assistance can enable real-time collaboration between field maintenance engineers and on-site teams by displaying crucial images and work instructions in the real world when repairs and servicing are required. For example, this means work can be carried out remotely on a commercial aircraft with exacting guidance and an intuitive experience for the engineers. From a sustainability perspective, AR equips businesses to overcome challenges more quickly, without the need for potentially wasteful rework or the physical movement of products and teams.

Learning and Training

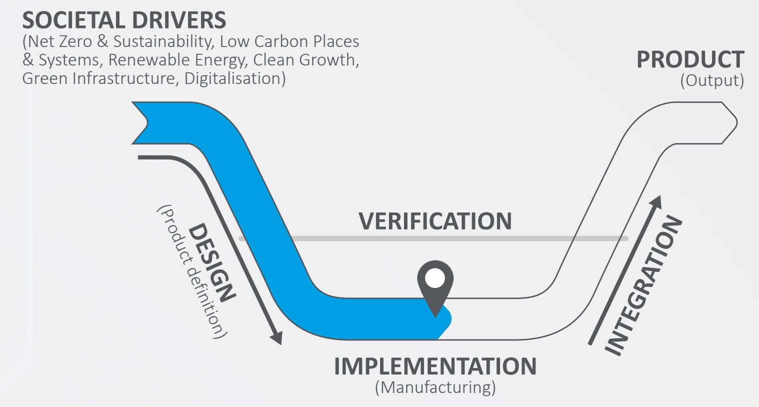
AR training can support engineer education via on-the-job and classroom training, by offering an intuitive experience for visualisation of procedures and conceptual information. In industries where product quality is highly dependent on the personal skill of the engineer, AR provides a focused and practical training method, imparting hands-on guidance.

The UK is currently Europe's largest market for VR and AR, tapping into what is predicted to become a $160 billion immersive technologies market. It is a vibrant, growing market which will revolutionise many sectors including education, training, healthcare, manufacturing, construction, retail, and ecommerce.

With our report in place, DETI's next challenge is to produce a toolset to help organisations and sectors find solutions to their challenges through the use of immersive technology.

Partner

NATIONAL COMPOSITES CENTRE



Securing our cyber future

CHALLENGE

New powerful, fast computers referred to as 'Quantum' computers, are predicted to come online in the next few years. They will enable us to solve problems, create new inventions and improve the way that we do things. They will help us to look at and understand large amounts of data, and solve sustainability challenges to help us find better way of living that will be better for our people, planet and the environment.

However, they will also be capable of obtaining and reading sensitive information such as emails, phone messages and financial data. Companies that use digital technologies will need to find a secure way of protecting their commercial information.

RESULTS AND THE DIGITAL OPPORTUNITY

To defuse the security threat, organisations are already implementing services to mitigate the potential risk. DETI is helping to develop and demonstrate commercially viable solutions and investigating secure technologies and practices to protect digital communications - which will stop potential hackers of the future.

DETI, BT and Toshiba have created a highly secure communications network that will protect voice, email and data traffic.

DETI, BT and Toshiba have created a highly secure communications network that will protect voice, email and data traffic. This is the first network of its kind in the UK, known as a 'Quantum Key Distribution' network. This capability has been largely untested until now.

The network is designed to be used in conjunction with existing cyber security services and software. The initial phase of the network exists between the National Composites Centre (NCC) and the Centre for Modelling & Simulation (CFMS), to be extended into the University of Bristol, and beyond.

In April 2021, the network was successfully tested where it was used to share live information, change product designs and remotely manufacture part of a product. The network is integrated with the DETI industrial test bed, where companies in the West of England can investigate digital technologies, knowing that their design and manufacturing data is secure.

The network has been used to demonstrate the potential for operating a 'smart factory' which is a digitalised manufacturing shop floor that collects data and shares this through machines, devices and production systems, optimising manufacturing output.

The market for Quantum technology is predicted to drive the creation of a £1billion industry, with further commercial opportunities being realised within many sectors (source: UK National Quantum Technologies Programme). The UK is ideally placed to lead the global market, with Bristol fast establishing the region as a UK research and commercial playground for Quantum organisations. One of the fastest growing technology areas, it is one of the top growth areas for digital skills.

Partners

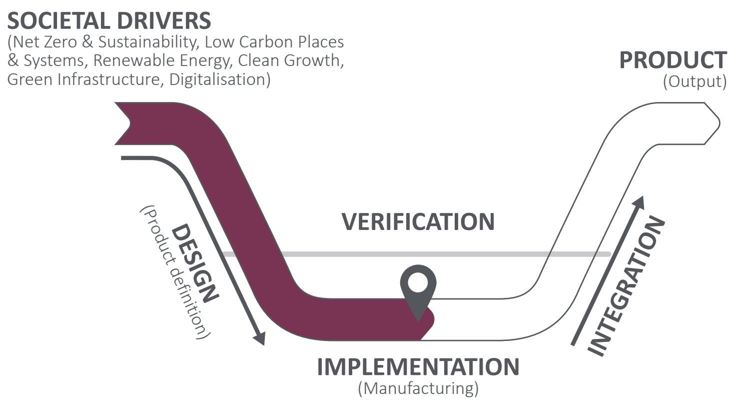
cfms · NATIONAL COMPOSITES CENTRE · BT · TOSHIBA

Bringing **digital visualisation** to the manufacturing process

CHALLENGE

To meet net zero targets, manufacturers need to reduce scrap and waste while making ever more complex products that employ advanced methods, using novel sustainable materials.

Traditional manufacturing processes rely heavily on experienced operators, where knowledge has developed over time using costly physical testing, driven by paper-based processes. As more novel materials and processes are introduced and the complexity of manufacturing tasks increase, new techniques are required which allow operators to gain this experience in an accelerated fashion with reduced physical testing.



The use of immersive technologies such as Augmented Reality (AR) and Virtual Reality (VR) to bring digital visualisation to manufacturing delivers a number of benefits including increased levels of safety, quality inspection and reduced error rates, while also providing visual instructions for manual assembly, maintenance and training. As a complimentary technology for production operators for example, it can assist with unfamiliar tasks, reducing the rework of complex product assembly, and can increase productivity in complex tasks.

RESULTS AND THE DIGITAL OPPORTUNITY

This research project will deliver a proof of concept system that guides the user through a specific manufacturing process using AR. Two use cases have been selected to demonstrate the chosen process and how the AR tools developed will be applied.

In the first use case, vacuum bagging a composite part is a specific process which entails the composite being sealed in a vacuum bag, ensuring that all air is evacuated, and the bag tightly sealed compacting the composite material. A digital workbench used by the production operator has been designed which incorporates a suite of 3D depth sensors, user tracking and machine vision cameras, complimenting a downward facing projector system to create a mixed reality work environment. This allows the operator to visualise virtual and real-world data, such that specific feedback can be provided through the projection system.

The second use case demonstrates how the principles and technologies in the first use case can be transferred to a new domain, agritech fruit picking. With a reconfiguration of the appropriate sensors, AR goggles provide feedback to the user (fruit picker) which details which fruit are ready to be picked.

In both use cases, the system developed incorporates real time object detection to identify objects in the scene, and where necessary, compare this with the expected position and feedback the error, or simply guide the user to a target position or part of the process.

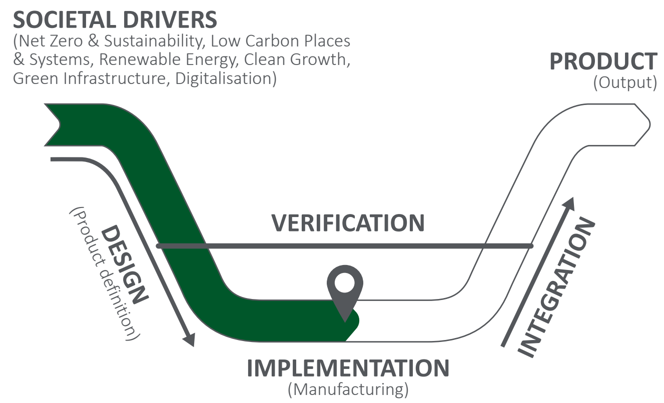
This project, when fully complete will deliver a digital proof of concept demonstrator that will demonstrate the processes in operation.

Partners

UWE Bristol University of the West of England

NATIONAL COMPOSITES CENTRE

Calculating the carbon footprint of manufacturing products and processes



CHALLENGE

The greatest challenge facing society is the preservation of the environment. Net zero legal commitments have already been made to reduce emissions by 80% by 2050, with ambitions to make this happen by 2030. By the end of this decade, to deliver a low carbon global economy, everything we make will need to be completely re-imagined and re-engineered. A vital step towards reducing carbon emissions will be the ability to accurately measure the carbon footprint of our products and processes.

Engineers and manufacturers must focus on acquiring, analysing and accurately interpreting data such as energy and waste, which are vital to calculating the carbon footprint of products and processes - but this is especially difficult on legacy equipment. By collecting and aggregating the data from sensors, the equivalent carbon footprint can be calculated in a standard way - and precisely allocated to individual projects and products to keep traceability.

Digital Catapult has partnered with the National Composites Centre (NCC) and other companies to drive innovation in the design and manufacturing of composites using Internet of Things (IoT) solutions, developing software that uses cutting-edge technology and specialist engineers to calculate carbon footprint more accurately.

RESULTS AND THE DIGITAL OPPORTUNITY

DETI has successfully developed a proof of concept for an application called the 'eco-meter' – which measures the carbon footprint of products manufactured by the Automated Fibre Placement (AFP) team in the Electroimpact Cell at the National Composites Centre (NCC). AFP is where continuous fibre tapes are precisely laid to manufacture multi-layered composite products such as parts of aircraft wings, cars, etc.

Using sensors, and by streaming information on equipment's materials, transport and storage, compute costs and waste, the eco-meter will allow us to visualise carbon footprint data in real time, as well as providing retrospective data to enable decision-making and planning based on the carbon footprint.

This will allow the AFP team to price jobs, choose to use the equipment differently and perhaps invest in different, more environmentally friendly equipment in future. It will also allow the AFP team to start working on an offering that makes carbon footprint analysis and estimation part of their value proposition.

While only a proof of concept at this stage, there is a view to explore the provision of the eco-meter as a service to wider industry - aiding engineers and technicians in manufacturing businesses to make intelligent decisions and cut emissions across their programmes.

Partners

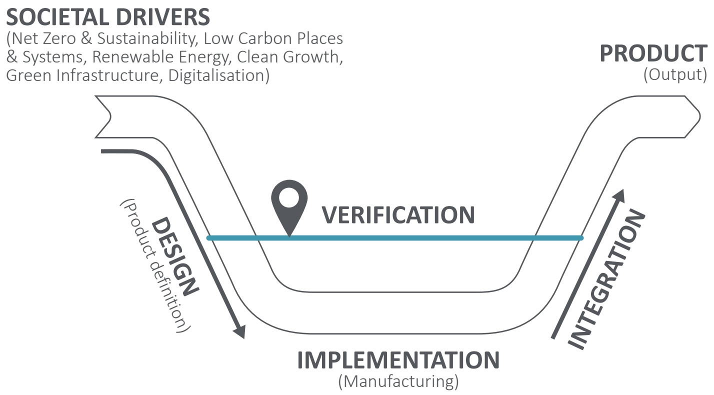
CATAPULT Digital

NATIONAL COMPOSITES CENTRE

Using **disruptive technology** to streamline product verification

CHALLENGE

Disruptive technologies offer the opportunity to accelerate innovation, providing us with new digital tools and processes to develop through-life product sustainability, and shorten product development time. Everything that we design and manufacture needs to be verified to prove that it conforms to the requirements and specifications that it was built for. Ensuring that there are no defects or inferior quality levels, it safeguards manufacturing investment and high-quality output. Undertaken at all stages of the product lifecycle, verification is traditionally a manual process which involves the inspection of a product, process or system.



RESULTS AND THE DIGITAL OPPORTUNITY

Focused on demonstrating the use of Augmented Reality (AR) in an industrial verification process, an AR application has been developed and applied to show the benefits of immersive technologies. The project demonstrates the digital verification of a Liquid Resin Infusion (LRI) process where live data is captured through sensors, transferred wirelessly through a 4G network and visualised through a smart device.

The application developed uses a gaming engine that allows for 3D environments to be created, and real-life 3D visuals of an object to be placed inside it. This allows the user to view the simulated object on a smart device and rotate it to enable different views.

A number of different software solutions were used to develop the AR application which is hosted on a tablet device. A HoloLens 2, a wearable head mounted device also enables the user to see the AR environment through the glasses.

The use of digital tools in this process will enable faster decision-making and greater traceability, creating a connection between physical and virtual systems that will enhance the certification process. We will continue to embed the techniques and technology into further applications and to train engineers to use the system developed. The deeper understanding available to manufacturing by visualising the normally hidden behaviour supports existing skills and knowledge, and enables the full exploitation of new manufacturing techniques.

Live process on the left, showing the simulated/visualised environment on the right

Partners

CATAPULT Digital

NATIONAL COMPOSITES CENTRE

Collaborate and Connect with DETI

DETI will help the UK to re-imagine and re-engineer engineering.

Whether you're an individual, a digital pioneer, a SME, or large industry organisation, you need to be part of DETI.

Digital pioneers help some of the world's leading engineering firms transition to digital, that's why we want you to be part of the solutions to some of the most complex challenges our world faces.

Developing and demonstrating an effective digital transformation strategy for your business is crucial to retaining your competitive position. As a large organisation, we can provide access to digital prototypes that will de-risk implementation, demonstrate ROI and increase your agility.

As a small and medium sized organisation, your entrepreneurial success, flexibility and responsiveness plays a key role in the supply chain. Promoting procurement processes based around simplicity, transparency and inclusivity, we want to make it as easy and competitive as possible for you to engage.

We want to inspire you, our future engineers to pursue a career in digital engineering. To deliver a low carbon economy, everything we make, from aircraft to cars, bridges to wind turbines, will need to be re-imagined and re-engineered. We want to support you, and your future generations socially, economically and environmentally, developing new skills, training courses and careers opportunities.

DETI is part of the West of England's action plan for digital transformation. Join us.

For more information, to invest or collaborate on DETI, email **deti@nccuk.com** or visit **deti.uk**

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DETI DIGITAL ENGINEERING TECHNOLOGY & INNOVATION

WEST OF ENGLAND Combined Authority

THOUGHT LEADERSHIP

The West of England is home to the UK's largest advanced engineering and aerospace cluster and a vibrant digital community. As such, the region delivers the expertise, living labs and a technology test bed that companies need to progress.

Our thought-leaders working within the DETI programme share their expertise and skills on the challenges and the opportunities ahead, as we investigate, develop and demonstrate the advanced digital technologies and skills needed for the sustainable products of the future.

Digital Engineering Technology & Innovation (DETI) is a strategic programme of the West of England Combined Authority (WECA), delivered by the National Composites Centre, in partnership with the Centre for Modelling & Simulation, Digital Catapult, the University of the West of England, the University of Bristol, and the University of Bath. Industry partners include Airbus, GKN Aerospace, Rolls-Royce, and CFMS, with in kind contributions from UWE, Digital Catapult and Siemens. DETI is funded by £5m from West of England Combined Authority, with co-investment from the High Value Manufacturing Catapult.

Stress testing design for digital engineering

Amit Visrolia, Chief Engineer for Digital & DETI, at the National Composites Centre (NCC), discusses the evolution of design, and if it will survive the stress test when applied to manufacturing at scale.

The rise of digital, where complex systems are seamlessly linked, data shared and laborious processes automated, challenges us to consider the question: 'what can engineers be now?'

As engineering has evolved, so has it fragmented, reflecting different – sometimes conflicting priorities: we've had 'design for cost', 'design for manufacture' and increasingly 'design for sustainability'. However, with digital the divides come down. We're no longer designing 'for', we're designing 'from' – with data shaping and refining every stage of the process.

Big data certainly has the potential to be game-changing for manufacturing. The digital toolkit, from Machine Learning and Artificial Intelligence to High-Performance Computing and Virtual Reality, presents huge potential. But, right now, it feels like the hype is running ahead of hard evidence.

The right questions must be asked of the data. Domain knowledge will remain critical. Machines, however smart, do not push boundaries. Only we can do that.

The terms "AI" and "machine learning" are sprinkled liberally, so it's easy to overlook that the question of what, exactly, they can do for a physical industry such as manufacturing is still pretty unknown. This is what we're investigating at the Digital Engineering Technology and Innovation (DETI) Programme.

We are all familiar with the Systems Engineering V model: the drawing up of requirements and specifications, moving to integration and production to validation and verification in a linear, sequential pattern of work. It's tried and tested - it's just that we know, we can work better.

Digital engineering flattens the 'V', as all the parameters need to be considered in parallel. It requires a multi disciplined approach, where teams work concurrently, with the majority of effort focused on the design and development stage. This is about integrated design driven by data – from the machines making the product to customers and back again, virtual testing to design-out problems early and deliver faster manufacturing cycles.

Few companies have the bandwidth, especially in the current climate, to take a forensic look at the digital toolkit and work-out, from first principles, how their operations and structures might need to change in order to extract the most value from it.

At DETI, we are applying the tool kit to a series of test cases, the first being the production of a design system for a hydrogen pressure vessel. The majority of these are constructed using metals, but with increasing focus on hydrogen powered transportation, comes growing demand for composites to create strong but lightweight alternatives.

The cross-disciplinary project team is working together to bring forward the complexity of detailed design and manufacturing data at an earlier stage in the design process. We will model the numerous combinations of design decisions that go into a product to create the initial design concept. As an interconnected, multidisciplinary design system, we will rapidly be able to identify the impact of each choice on the overall performance of the product and optimise to get the 'best' output. The equipment used for the filament winding of the carbon fibre will be fitted with multiple sensors to then gather and feedback the data into the platform to verify the choices, and to inform the next iteration of the design.

We will encounter some dead-ends and bumpy roads on the road to digital, but that's the point: we do the work so UK businesses don't have to. In the years ahead, there are problems which engineers will be called on to solve – and that means getting to grips with digital now. The right questions must be asked of the data. Domain knowledge will remain critical. Machines, however smart, do not push boundaries. Only we can do that.

Why engineering design is critical to long-term growth

Ian Risk, Chief Technology Officer (CTO), at the Centre for Modelling & Simulation (CFMS), makes the case for why engineering design is critical to long-term economic growth.

In order to address the challenges of an environment that is rapidly evolving in terms of technology and business practice, the UK Government established an Industrial Strategy in 2017 with the prime objective to improve national productivity. So far, government-sponsored initiatives that this policy initiated, such as Made Smarter, have focused on the importance of industrial digitalisation for manufacturing and the impact this will have on our economy.

Whilst the importance of this is clear, it loses sight of the fact that, first and foremost, to successfully develop new products, businesses need engineering design. Without this, nothing of any consequence can be manufactured, it is an essential element to secure a stable and resilient industrial base. It must be the primary requirement of any industrial strategy.

High value design is critical

As should be apparent from recent industrial events, the proximity of design to manufacturing operations is a key determinant of operational activity for global companies, especially in times of major technological change. The design process develops the characteristics, quality and performance of the product which, in turn, creates customer interest and establishes a brand.

High quality design provides the intellectual capital on which a product is based and differentiates it in the marketplace helping to define purchasing behaviour. In the modern era, this is not just about performance, the impact on our environment is more important, and the ethics of a product can determine its commercial success. This all starts with design.

In terms of industrial operations it also has a major influence on the type of manufacturing process required and the capabilities needed to realise a viable product that meets customer requirements, such as a shift from metallics to composites.

The automotive sector provides clear examples of how critical the engineering design process can be. Those companies that adopted a commercial 'build to print' approach left their operations highly exposed to market fluctuations, thus damaging resilience to change. Reductions in global demand have led to some major brands retrenching their activities to internal design hubs that are responsible for developing new product lines. The intellectual property embedded in highly skilled and experienced design teams takes years to build and becomes part of the intellectual fabric of a region, whereas pure manufacturing operations are more portable and can easily move from one location to another, especially when cost is the primary driver. As a result, building and retaining design capability in advanced engineering is critical to securing business operations, as it holds the key to long-term economic growth and stability.

The business case for investment

Research has identified huge commercial benefits from the adoption of design as an integral part of company strategy. Organisations that use design engineering out perform their counterparts by more than 200 per cent over a ten-year period. Evidence shows that every £1 invested in design generates a return of £20 in revenue and £5 of exports. Given advanced engineering contributes more than 25 per cent of UK GDP [and is a key industry for the West of England], investment in this field is not only vital to retain market presence but it also offers the opportunity to reap major rewards. The most recent Science and Innovation Audit recognised advanced engineering as the cornerstone of our regional economy and highlighted the need for investment in 'High Value Design' to keep pace with global developments - both technically and commercially.

Recent developments in digital technology are creating new business models that illustrate this changing environment. An increasing number of manufacturers are now focusing on selling services or 'capability' derived from usage data rather than just simply a product (so-called servitisation). Design is, therefore, no longer just about initial form and function, instead it must consider and demonstrate the through-life capability, cost and reliability of the product. This means more needs to be known about the product before it is built. With continually reduced lifecycles and increasing costs of physical prototyping, this can now only be done virtually and so simulation and design tools are critical. In most cases, these are developed and refined over many years to ensure their validity and reliability. Increasingly, operational data is critical to this process as it can provide insight into how products are used in practice and how a design needs to evolve or improve. This changes the nature of the relationship between vendor and customer, where the latter will play an increasingly more important role in product development.

Design & agility

Irrespective of the market, the evolution of products has been shown to follow a similar pattern, whereby disruptions in the market occur sporadically as new technologies are adopted to enhance performance and offer customers improved capability. The speed at which these technological changes are now happening is unprecedented, creating huge opportunities for agile companies that can adapt but extremely destructive for those unable to match customer expectations.

Industrial agility is dependent on a business's ability to create, develop and test new products at the speed demanded by the market. For today's world, this means that the design culture, tools and methodologies must evolve at the same pace as the digital sector to maximise the potential of new technology. Within advanced sectors such as aerospace, design methods for each new market 'disruption' have historically been refined over approximately a thirty-year period to progressively improve product performance. In the modern era, this time frame simply does not exist. Additive Manufacturing (AM) is a prime example of this phenomenon, in which years of traditional design and manufacturing experience are no longer valid. Companies preparing for this market development will be well-placed to exploit AM to the full while those not will, most likely, fail.

Global opportunity

Engineering services are strategically important to the UK with a domestic market worth between £30-40 billion annually and a global market approaching at least £1,000 billion by 2025. The UK only has a five per cent share of this and design is the key to unlocking this opportunity. Design is the phase of the product lifecycle that has most influence over cost. By controlling this, manufacturers can exert stronger influence over the value chain and procurement policy for the product. Major national investments, such as the new Tempest aircraft for the MoD could be worth in the region of £20 billion for the West of England economy. However, with current design methods alone, the question is whether developers will be able to realise a viable, cost-effective solution.

This evolution in design methods is necessary to keep pace with technological advances such as the availability of improved power/weight electrical power sources, or regulatory changes such as emissions targets. The breadth of development and the costs associated with this is beyond the potential scope of any one organisation. Effective partnerships between industry, academia and government are necessary to maintain a leading edge in design capability and economic security.

To unlock the potential in high value design, we continue to reach out regionally and nationally to those organisations who can work with us to push the boundaries and provide the foundations for the UK's future industrial design needs.

Engineering stakeholders continue to work with government to realise this ambition, but with major technological disruptions facing industry, more needs to be done, sooner, to avoid serious economic impact to the UK.

For those that can influence the debate, design creates, design evolves, design pays and design matters.

Everything you need to know about **immersive technology**

Immersive technology has transformed the digital experience by bringing together the virtual with users' sight, sound, and even touch. Recent developments in immersive technologies have created new opportunities for businesses to use virtual reality (VR), augmented reality (AR), mixed reality (MR), haptics and more, to solve problems, seize new opportunities, and push innovation forward.

What does immersive mean?

The word 'immersive' is used to describe experiences that completely surround a person to make them feel part of an alternative environment - for example, immersive theatre requires the audience to interact with the set, props and actors.

In the context of technology, 'immersive' refers to any technologies that digitally extend or replace reality for the user; this might sound like a vague definition, but that's because immersive technologies come in many different varieties, and as such can be used in very different contexts.

What are immersive technologies?

Immersive technologies come in three main categories, based on the extent and application of immersive experiences.

What is VR?

Virtual reality (VR) completely replaces a user's surroundings with a digital environment using a head-mounted display (HMD) with two displays, one for each eye. The HMD also has a motion sensor to track head movements, creating a seamless visual experience. VR is often also supplemented with audio to add sound to the experience and immerse the user even more.

With VR headsets and VR-compatible consoles becoming more accessible, the video game industry has really taken advantage of immersive technology in a creative context to bring innovative experiences to users. VR has also been used for a whole range of workforce training purposes. One use case is military training, where it is used to realistically simulate dangerous environments without actually putting trainees in harm's way, and has been used by NASA for training purposes since the 1990s.

What is AR?

Augmented reality (AR) creates an immersive experience for users by fusing reality with the virtual. Using a digital device, such as a smartphone with a camera, users are able to see, hear, and/or interact with virtual assets in real time. This technology is made possible by computer vision algorithms, which let devices 'see' the physical world through depth tracking, localisation and mapping; the device can then place the virtual assets in a realistic, immersive way.

AR has many applications, from highly specialised fields to everyday 'fun' uses. A great example is the Snapchat filter functions that place dog ears or change the shape of a user's face - the camera maps the user's face to determine where the digital assets need to be placed.

What is MR?

Mixed reality (MR) comes in many variations, and is usually visualised as a 'spectrum' between AR and VR. Like AR, mixed reality relies on computer vision technology to accurately place the digital elements according to the user's environment, while also creating a sense of 'presence' for the user as with VR systems. MR devices such as HoloLens, a holographic computer worn like a headset, allow users to place virtual items in physical spaces, manipulating and interacting with them without the need for smartphone screens.

The variability and versatility of MR makes it a useful tool in many contexts. The combination of real and digital, along with the ability to seamlessly interact with virtual elements, makes this an important development for entertainment industries like film and video-games who seek to bring more interactivity to their audiences.

What is haptics?

Haptic technology is also known as '3D touch' or 'kinesthetic communication', and unlike other examples of immersive technology, involves tactile feedback by using pressures, vibrations, and movements. These elements are all used to give the user feedback based on their actions or environment, creating an immersive experience simply through touch.

Haptics is already widespread in smartphones, using haptic vibration to silently notify users without the need for ringtones. However, haptics also have useful applications in industry contexts; the development of haptic gloves can allow users to interact with remote objects or equipment, which is especially useful in manufacturing and product development. Haptics can also be used alongside VR to immerse users through sound, sight, and touch.

Why immersive experiences or solutions?

Immersive experiences have a lot to offer in any context they're applied to. The continued development of the aforementioned immersive technologies has already had an impact on the economy and in many industries, as it offers new ways of interacting, analysing, and creating. Here are a few examples of why immersive experiences and technologies have been applied to existing processes:

Training

From the military, to healthcare, to sports, immersive technologies have transformed the way training is done across sectors. The use of VR and AR has increased the speed and quality of training, and allows a more hands-on training experience which is very valuable and usually difficult to achieve in conventional classroom settings.

Online shopping

Immersive technologies can solve a frequent problem in online shopping - customers simply don't know how a product will actually look when it's in their hands. This is especially an issue in big-ticket items such as furniture; however, developments in AR technology allow prospective customers to 'place' the desired item in their homes, making them more confident in their purchases. Companies like Amazon and Ikea are already using AR on their online platforms for exactly this reason.

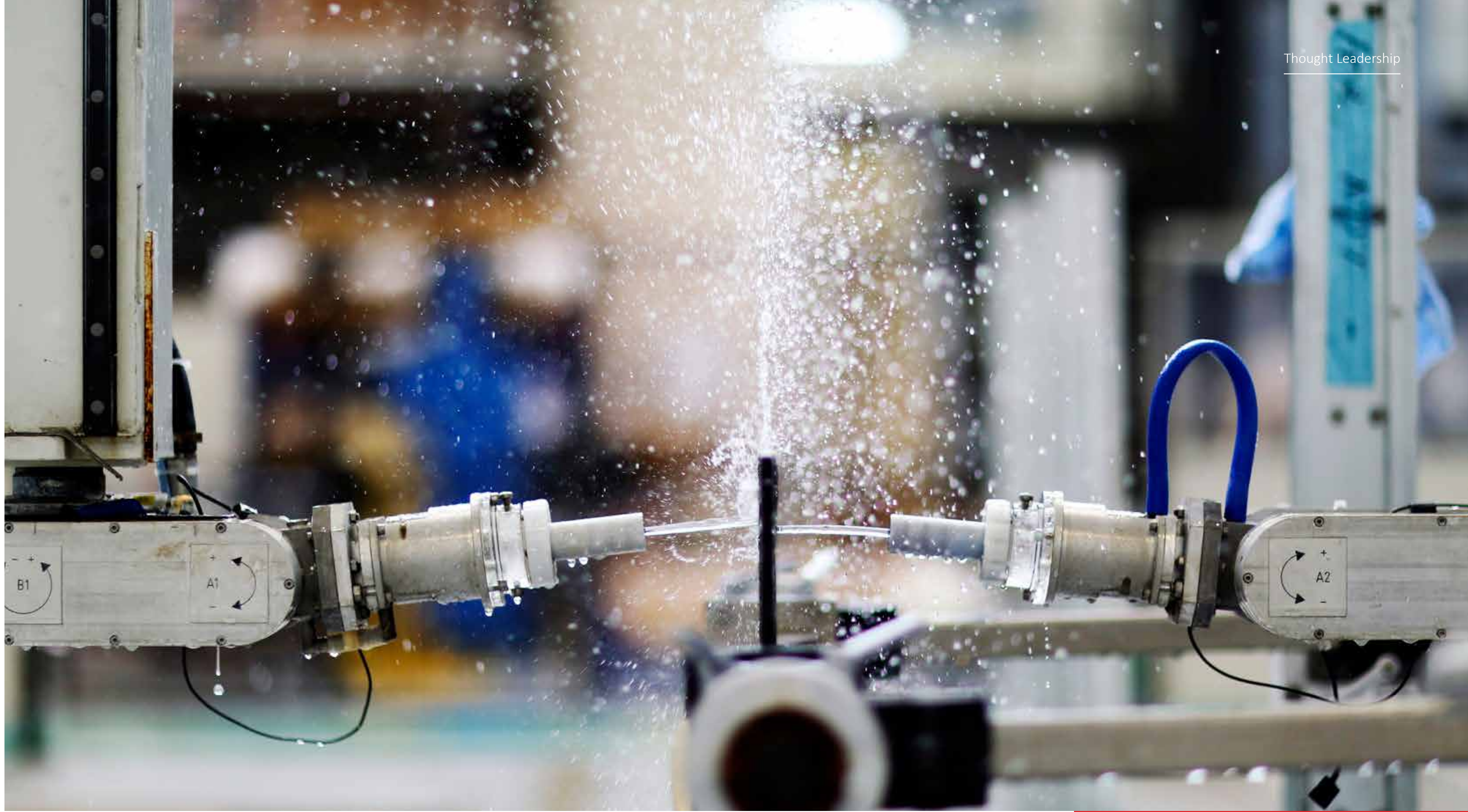
Product design and prototyping

Immersive technologies will allow product development teams to quickly and cheaply create virtual prototypes, while creating opportunities for remote collaboration. Leaps in immersive tech will continue to revolutionise product development, removing obstacles such as time, cost, and location.

How immersive is VR?

VR has come a long way since the first virtual reality HMD system in 1968. The VR systems available today use various motion sensors and localisation technologies, along with dual display and surround sound to make the VR experience as immersive as possible for users through sight and hearing.

In future, further innovation around VR and other immersive technologies will likely heighten the 'realness' of VR even more - perhaps, as predicted by science fiction writer Stanley G. Weinbaum in 1935, virtual reality will also include smell, touch and taste to give a completely immersive sensory experience and making "real a dream".



What is an engineer anyway?

– Communicating engineering careers to pupils with DETI's Engineering Curiosity project

When children are asked what an engineer is, and what they look like, it can often be a tricky question. They may jump to the image of an engine mechanic, or a man in overalls with a spanner and a hard-hat. They may also have trouble recognising familiar jobs as coming under the umbrella of engineering.

Engineering is defined as 'working artfully to bring something about'. More literally, it is the application of science and maths to solve problems. And it's a career that is more relevant than ever – to achieve net zero and a low carbon global economy, everything we make and use, from aircraft to cars, batteries to wind turbines, will need to be completely re-imagined and re-engineered.

When a child does not personally know an engineer, or does not recognise the role of engineering in solving the problems faced by a society, then this notion of an engineer becomes more removed from their view, and critically, from their career aspirations. In science communication, we encounter children with low science capital throughout our work. So how can the children dream of becoming an engineer, if they don't know what one is?

You can't be what you can't see

It is difficult for children to imagine themselves in that job, when the engineer does not look like them. Encouraging girls and children from minority ethnic groups into engineering careers, and STEM careers more broadly, is a key focus of the DETI Skills Inspire team working out of UWE.

In collaboration with My Future My Choice, as well as many local engineers; the DETI Skills Inspire team at UWE have developed the Engineering Curiosity cards and lesson resources for schools. The aim is to bring the diversity of the West of England's amazing engineers into the classroom and enthuse and inspire both primary and secondary pupils. Through not only learning about what an engineer is and recognising their role, but also introducing them to real-life local engineers that may come from similar beginnings, so that they can start to think of engineering as something that could be for them!

Engineering Curiosity

Engineering Curiosity is a collection of 52 cards, based upon 52 local engineers in a wide variety of different roles and industries, in a kind of 'Top Trumps' meets 'Happy Families' style game. The engineers featured have also each produced an engaging TikTok style video, giving a fun snapshot of their role and their route into it. The project has developed lesson plans, curriculum linked worksheets and activities, and school-wide assemblies to accompany the cards and videos, all to aid schools in running sessions that involve the real engineers joining them live in the classroom through video link.

During the recent British Science Week, local schools around the West have been taking part in DETI's 'Big Beam In!', bringing the sessions to life and reaching over 3500 pupils. Some of which may just be the West's future engineers!

Looking to inspire in your science communication, or want to check out all the engineering roles for yourself? You can find the resources, lesson plans and cards on the Curiosity Connections website.

DETI Skills Inspire builds on the success of previous projects founded and launched in the Science Communication Unit (SCU) at UWE Bristol, including Curiosity Connections – the network for inspirational primary STEM education in the West of England, and Women Like Me – a tiered mentoring project for women engineers. The project is led by Dr Laura Fogg-Rogers and includes Ana Bristow, Sophie Laggan and Josh Warren from the SCU.

Novel research technique for Ford results in huge CO_2 savings

Globally unique experimental and simulation techniques result in CO_2 savings equivalent to removing 109,000 cars from the road every year

When challenged with the requirement to reduce CO_2 emissions without compromising vehicle performance, researchers at Bath worked with Ford to develop globally unique experimental and simulation techniques, to achieve the challenging targets set whilst also significantly shortening the vehicle development process.

"The challenging brief set by Ford called for an innovative, yet sustainable approach to future product development processes, something our system-level approach and facilities enabled us to embrace. Combining our expertise in bridging the gap between real driving conditions and the accuracy and repeatedly of the lab environment contributed to Ford achieving an outstanding CO_2 saving across their EcoBoost fleet whilst also substantially strengthening their product development processes."

Professor Chris Brace, *IAAPS Academic Director*

Increasing regulation called for improved product development processes

The automotive industry has been under pressure to shorten its product development processes whilst also adhering to increased regulatory requirements on CO_2 emission reductions. Within this complex environment, Ford needed to deploy new product development techniques across its Ford Focus fleet that would deliver significant CO_2 reductions without compromising vehicle performance. In 2013, while planning the development of its revised EcoBoost engine to meet new CO_2 and performance targets, Ford asked the University of Bath to apply their expertise in highly downsized engine systems to better understand and model the complex engine boosting system.

Novel Experimental and Simulation System Development

The research at Bath began in 2014. Specifically, the Bath team studied how non-steady energy transfers from a highly pulsating exhaust flow affect the performance of a novel mixed-flow turbocharger. A subsequent aim was to incorporate the new techniques into an improved development process.

Extending the use of digital development tools

As laid out by the Automotive Council, over the next decade the automotive industry needs to adopt new development practices to shorten product development from 5 years to 18 months, under increasing regulatory pressure. This requires a change from today's practice, where around 95% of product verification is achieved experimentally, to an end state where 95% of the process is digital. The challenge is enormous and will require much better digital models of complex powertrain systems.

A key obstacle is the lack of accuracy in simulation of the dynamic performance of turbochargers, commonly leading to overly optimistic design choices that later result in unacceptable performance deficiencies in real world use. Existing design techniques for engine development use simple models of turbocharger performance based on datasets captured experimentally under steady flow conditions. True dynamic performance cannot be assessed until much later in the development process when the engine and turbocharger are fitted into a vehicle. Evaluations of dynamic performance in the vehicle at this stage occur late in the vehicle development programme, when any changes are enormously expensive.

To provide greater insight into dynamic performance at an early stage in the process, the Bath team designed a technique to move from steady state to dynamic real time data. They developed a novel experimental system that could be used to study the behaviour of the turbocharger under pulsed air mass flow and high-speed pressure fluctuations, realistically recreating the phenomena seen in an engine. The University of Bath team, led by Professor Sam Akehurst and Dr Colin Copeland, designed, built and demonstrated the first facility of this type in the world.

The exhaust pressure pulses caused by individual engine cylinder firing events were recreated by a novel hot gas pulse generator. Changing the frequency of the valve events simulated changing engine speed. To achieve robust, high fidelity measurement of the critical temperature and pressure fluctuations at the turbine inlet required the development of a high-speed mass flow sensing system using a novel, 3D printed, metal pitot tube architecture, complementing data from more traditional sensors. Similar challenges were overcome when quantifying unsteady turbine efficiency, which required the ability to measure the time-resolved mass flow rate at high speed. Full-scale engine studies further refined the technique to ensure correlation of the process with real-world behaviour across all operating conditions.

Improved experimental methods allowed CO_2 and fuel economy benefits to be realised with lower risk of delays and changes late in the vehicle development programme.

The data and insight gained were used to develop new dynamic simulation methods that predict the behaviour of the complete engine/turbocharger system under realistic dynamic conditions. The simulation was used to model system behaviour, demonstrating that the required dynamic performance was achievable. Additionally, the simulation provided an early warning of a control instability leading to flow disturbances that would render vehicle performance unacceptable. This was achieved at a point in the programme at least a year in advance of when such issues would normally be evident in vehicle testing. This led to a strong pull through for the research from Ford, who wished to use the improved experimental methods and computer model to allow fast, accurate understanding of how airflow influences the behaviour of turbomachinery. This in turn allowed CO_2 and fuel economy benefits to be realised with lower risk of delays and changes late in the vehicle development programme.

Recognised as 'Globally Unique'

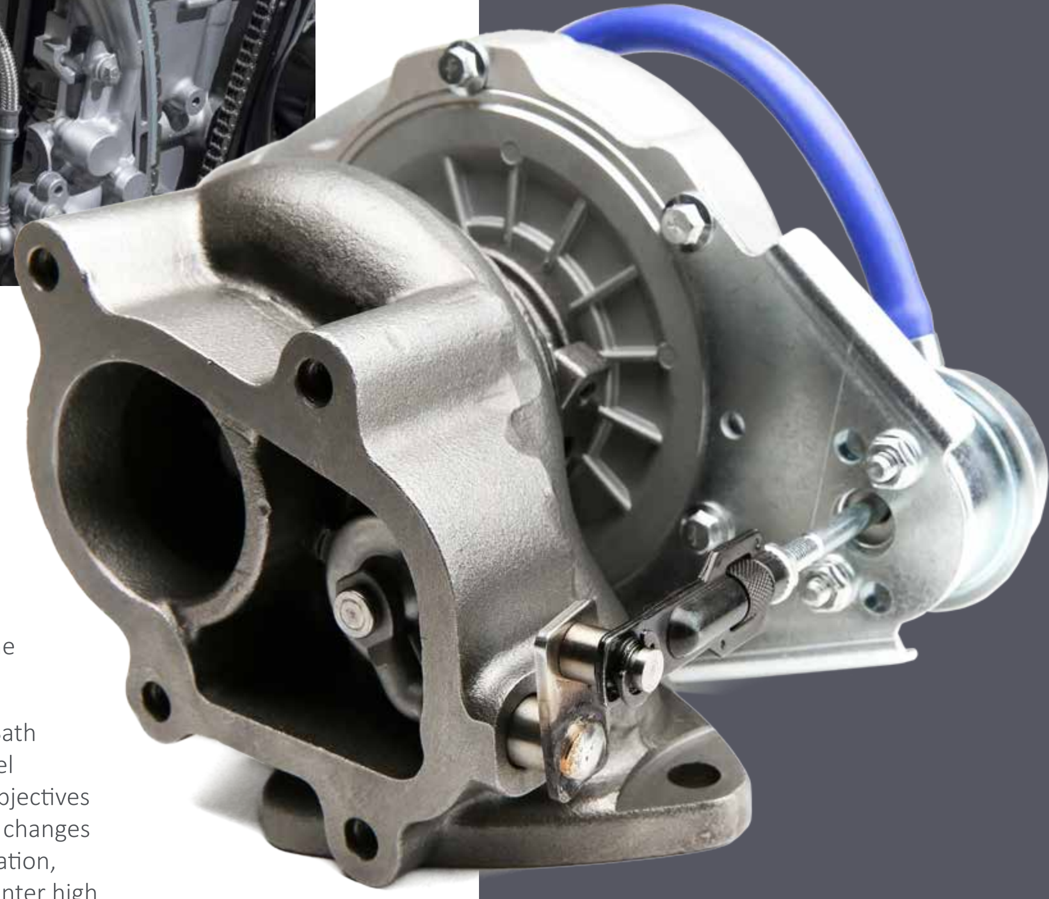
This new capability, developed by the team at Bath, has been recognised by the Government's Technology Strategy Board as globally unique, and the technique has been patented (GB2536760A·2016-09-28). To make the improved understanding delivered by this research more widely available and to reduce the cost and time required to apply it, the University of Bath then used data and insights from the laboratory simulations to support the development of a high fidelity, computer-based dynamic model of airflow within a turbocharger.

The techniques developed by the Bath team have been incorporated into the product development process used by Ford to develop the revised 1 litre EcoBoost and subsequent engines. This has improved the quality and speed of the development process and enabled evaluation of performance issues at least a year earlier than previously possible using the incumbent product development approach.

The adoption of this novel approach to Ford's development processes has allowed outstanding reach for the impact, initially to include additional Ford engine programmes. Its subsequent adoption by engine and system designers at other companies has further contributed to the automotive industry's strategic goal of greater deployment of virtual product development processes, by improving the fidelity of the analysis to a level not normally achieved until the physical hardware is available in a vehicle.

As stated by Ford:

"The Bath team developed a novel pulsating flow experimental test facility to characterise and optimise the turbocharger. This facility was so effective and unique that Ford Motor Company filed a patent to secure its IP, with Akehurst and Copeland as named inventors. (DE102016121974 and GB2536760)."



Exceptional UK and Global CO_2 Reductions

Passenger cars represent the 60.2% of EU road transport CO_2 emissions, themselves equivalent to 21.6% of all EU's CO_2 emissions. The Ford Fiesta is the 4th best-selling passenger car in Europe, first in the UK. Therefore any improvements that can be made have outstanding international reach due to the huge number of vehicles affected.

The primary impact of the University of Bath research was to develop and apply a novel research technique that allowed Ford's objectives to be met through precise but significant changes to turbocharger design and engine calibration, allowing their CO_2 reduction strategy to enter high volume production. The programme passed Ford's 'Judgement Gateway' in August 2016, meeting or exceeding all targets for fuel economy, CO_2, pollutant emissions and refinement. Engine production began in November 2017 with fitment planned for the Fiesta, the Focus (the UK's second best-selling vehicle) and seven other Ford models.

As noted by Ford:

"as a consequence of Bath's research… the ACTIVE programme demonstrated a 13% improvement in vehicle fuel economy with 9% due to the engine technologies. The engine went into mass production in 2017 and is now available across a wide range of the Ford vehicle portfolio, to date more than 300,000 engines have been produced utilising the technology developed, peak demand for the engine family is expected to be around 1.4M vehicles per annum. This would equate to approximately 200,000 tonnes of reduced CO_2 for a single year of production." Furthermore, "around 1.4 million new Ford vehicles each year emit less CO_2 and pollutants because of this work, delivering an annual, cumulative CO_2 saving equivalent to taking 109,000 average cars off the road every year."

Delivering sustainable, global impact

This impact delivered by the research with Ford has outstanding international significance in CO_2 terms alone. More efficient engines also offer the driver improved fuel economy, roughly equivalent to the percentage CO_2 reduction, saving money for the business or individual operating the vehicle and reducing the need for fossil fuels.

The University of Bath work contributed to Ford winning the 2019 global Engine of the Year award following assessment by 70 specialist judges from 31 countries.

Ford of Britain Chairman, Graham Hoare stated that:

"Bath directly contributed to fundamental research to improve the performance and integration of our 1 Litre EcoBoost engine, which was voted best Sub 150PS engine in 2019."

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