MADE SMARTER INNOVATION

Delivered by Innovate UK, EPSRC and ESRC

Celebrating our impact

Made Smarter Innovation (MSI) Challenge

Version 2 - Published August 2025

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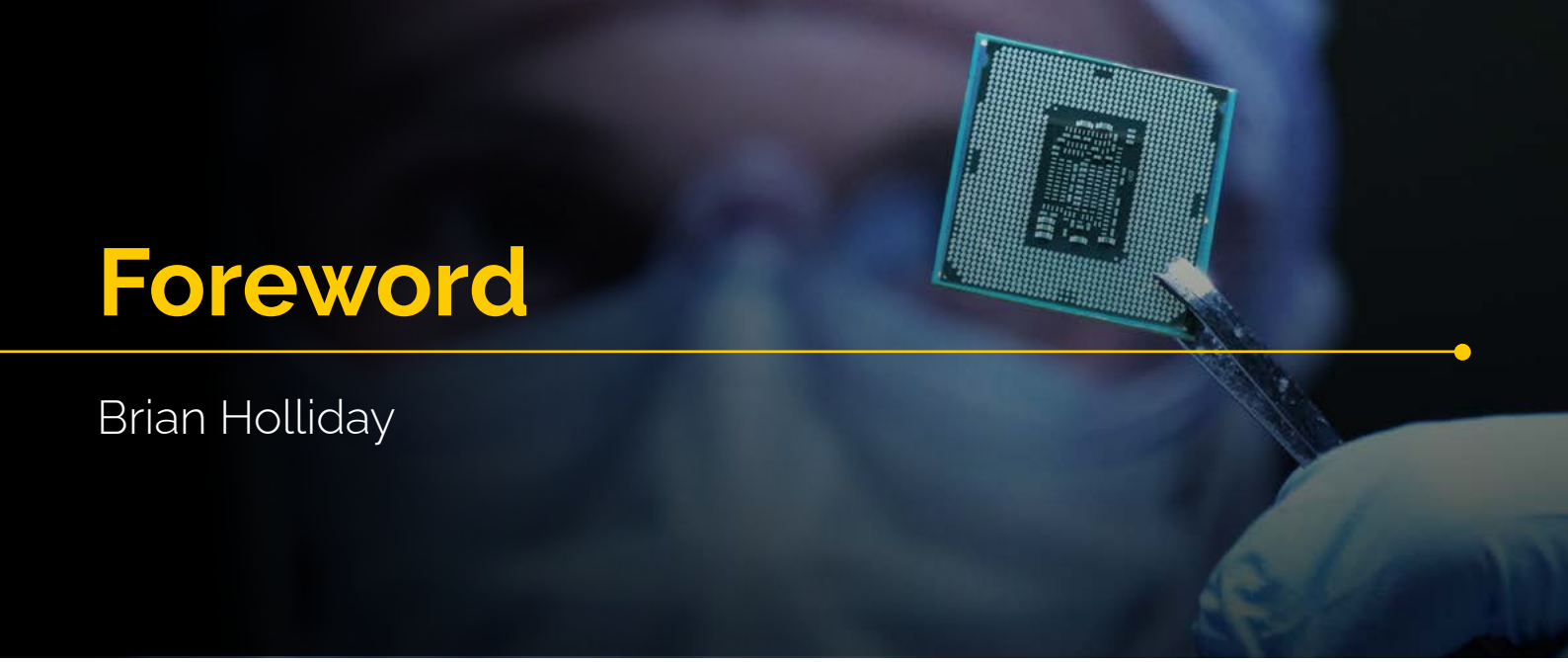

Foreword

Brian Holliday

UK manufacturing continues to grapple with several challenges. Ongoing pressures such as the need to improve productivity, ensure resilience of production lines, maintain cyber security, and strive for even better energy efficiency and net zero operations are at the heart of boardroom discussions for businesses of all sizes.

While it may sometimes feel that each of these pressures requires individual thinking and its own focus, they are all very much connected. And, by virtue of that, businesses can make significant progress in tackling them all in tandem, through digitalisation and the adoption of technology.

I've long argued that technology is essential for the UK to have a world-leading manufacturing sector. Made Smarter, which is the UK Government's initiative to help small and medium-sized manufacturing businesses adopt digital technologies to improve productivity, efficiency, and growth, is critical in achieving that ambition. We know that small and medium enterprises (SMEs) are the backbone of the UK economy. Ensuring that they can modernise to become more competitive, resilient and sustainable using technology is integral to the future of the country.

Launched in October 2017, the Made Smarter Review, which was an independent review of industrial digitalisation, set out a series of proposals designed to help UK industry equip itself with the means to embrace the next industrial revolution. Since the Review, the pace of innovation hasn't slowed down. Many would argue it's getting faster. The onset of revolutionary technologies like generative AI will only accelerate it.

We know from our experience in running the Made Smarter Innovation and Adoption programmes that when SMEs can overcome the barriers to technology adoption, they see almost immediate benefits. In fact, the Department for Business and Trade's review in March 2024 found that 97% of firms that had adopted digital technologies reported benefits – including production planning efficiency, better use of data, and, crucially, cost reduction.

It has also supported many in the sector to co-learn with peers and benefit beyond technological deployment. Importantly, for instance, 71% of firms reported positive impacts on skills development because of engaging with Made Smarter.

Foreword

Through the Made Smarter Innovation programme, which is building a digital ecosystem that supports manufacturing, we're also making it easier for manufacturers of all sizes to navigate the UK's innovation landscape and learn how to collaborate with digital experts on new technologies.

The benefits are twofold for the UK. Manufacturers themselves can test and learn, with the aim of creating better processes. Meanwhile, digital companies can also develop and deploy new concepts in a market where there are a huge variety of use cases for technology.

It's why the Government's choice to extend the programme in the 2024 Autumn budget, with additional investment into technology innovation and adoption for SMEs, is a vital move for the industry's growth.

UK manufacturing sits alongside some of the world's major markets in terms of manufacturing output. The sector is vital to the ongoing growth of the economy. As other countries deploy technology across their markets, it's important that the UK keeps pace.

The good news is that many of the technologies that can have the biggest impact are now on the market and in many instances are scalable for SMEs and large corporates alike. Made Smarter will continue to push for the ongoing evolution of the sector's digitalisation. Together with industry, we can make the UK one of the best countries on the planet to sustainably design, make, use, and export goods.

Brian Holliday,
Managing Director of Siemens Digital Industries in the UK and Ireland, and Co-Chair of the Made Smarter Commission

Outlook

Dr Ben Farmer

The future of UK manufacturing is intrinsically linked to its digital transformation. As the nation navigates an uncertain economic landscape, digital technologies offer a beacon of hope, promising increased productivity, resilience, and sustainability. The Made Smarter Innovation (MSI) challenge, a pioneering initiative funded by UK Government and delivered by Innovate UK, the Engineering and Physical Sciences Research Council, and the Economic and Social Research Council, has been at the forefront of this transformation, providing invaluable insights into the challenges and opportunities that lie ahead.

This guide celebrates the impacts of the projects supported by the Made Smarter Innovation challenge. We are very proud of the many impressive achievements that the ecosystem we set out to create has achieved, and we invite you to learn more about them.

One of the key lessons learned across the last five years of the MSI challenge is the stark divide between so-called frontier companies (the majority of which are large organisations) and most SMEs – small to medium sized manufacturing companies. These small companies are important as 90% of manufacturers are small and medium and account for 60% of employment and 48% of business turnover (UK Government figures) (99.3% to be precise). While some larger manufacturers have embraced digital technologies with gusto, many SMEs are struggling to keep pace. This disparity presents a significant opportunity for policymakers and technology providers to level the playing field and ensure that the benefits of digitalisation, including carbon abatement, are accessible to all.

To address this challenge, a multifaceted approach is required. First, we must bridge the information gap by segmenting the SME population and identifying their specific technology needs. This can be achieved by characterising firms based on their energy usage and waste production, providing a more granular understanding of their unique challenges, building on the work of the Smart Manufacturing Data Hub. Second, we need to foster a vibrant ecosystem of low-cost, affordable technologies such as AI and Machine Learning (ML), that are tailored to the needs of SMEs, regardless of their size or industry.

Through the MSI challenge, we have identified that by focusing on resource and energy efficiency, this can lead to significant benefits for UK manufacturing firms. By reducing their consumption of energy and

Outlook

materials, these firms can not only reduce their carbon emissions but also improve their resilience and increase their productivity. Digital technologies play a crucial role in achieving these goals by enabling more efficient resource management and data-driven decision-making, making the UK more resilient in its production of essential goods and exports, driving economic growth.

By focusing on these areas, we can create a more equitable and sustainable manufacturing landscape. Digital technologies have the potential to transform the UK manufacturing sector, making it more competitive, resilient, and environmentally friendly. As we look to the future and the next phase of the MSI challenge, it is imperative that we seize this opportunity and embrace the digital revolution.

Although the challenge was originally conceived to complete in March 2025, following from the Autumn 2024 budget, key areas of the Made Smarter Innovation challenge have been extended for a further year. These include:

- The Digital Supply Chain Hub
- The Smart Manufacturing Data Hub
- Digital Medicines Manufacturing and People-Led Digitalisation Research Centres
- The InterAct Network
- A number of high impact potential follow-on projects in our Collaborative Research and Development portfolio

In addition, in 2025 we will be:

- Launching programmes to support global activities to take key innovations from the Made Smarter Innovation challenge to international markets.
- Launching a competition for feasibility projects in pursuit of ensuring provision of low-cost, easy to use and low-risk industrial digital technology for SMEs, and
- Developing specific industrial digitalisation technologies for the hard-to-abate and hard-to-ignore foundation industries.

The MSI challenge has played a vital role in paving the way for a digitally enabled manufacturing future. By building upon its successes and addressing the challenges that remain, we can ensure that the UK manufacturing sector not only survives but thrives in the years to come.

Watch the video

Dr Ben Farmer,
Deputy Challenge Director,
Made Smarter Innovation Challenge,
Innovate UK

Executive Summary

Working together for the people-led digital manufacturing future we want

With our partners we're investing £300 million to develop digital ideas more quickly.

MADE SMARTER INNOVATION

MADE SMARTER INNOVATION NETWORKS

RESEARCH

Made Smarter Innovation has invested in 5 research centres to identify early stage, transformative innovation ideas, covering both technological and societal aspects.

Our InterAct project is a call to arms for academics from the social sciences to support the innovation and diffusion of digital technologies that will result in a stronger more resilient UK manufacturing industry.

COLLABORATIVE R&D

So far over 320 participants and over 80 projects have been supported over multiple themes:

- Fast Start
- Digital Supply Chain
- Sustainable Smart Factory
- Robotics & Automaton Industrialisation

INNOVATION HUBS

The Digital Supply Chain Hub is a digital innovation ecosystem that empowers organisations to work together to make supply chains smarter.

The Smart Manufacturing Data Hub supports small and medium-sized manufacturers to become more competitive by harnessing the power of data.

DIGITAL ACCELERATORS

Connecting leading UK manufacturers and pioneering technology start-ups to develop innovative technology solutions to many of the UK's manufacturing challenges.

GLOBAL

Supporting UK companies, working with leading industrial nations, to develop global innovation bridges and global collaborative research & development to increase exports and inward investment opportunities.

Origin

When the £300 million Made Smarter Innovation challenge was announced in September 2020, the target was to improve productivity, sustainability and jobs across the UK manufacturing sector. The challenge was delivered by Innovate UK, the Engineering and Physical Sciences Research Council (EPSRC), and the Economic and Social Research Council (ESRC), which are all part of UK Research and Innovation (UKRI).

It followed the 2017 Made Smarter Review led by Juergen Maier to accelerate digital innovation, creating smart factories and connected supply chains.

The Made Smarter Review defined that

"By 2030, the UK will be a global industrial leader in creating, adopting and exporting advanced digital technologies, shaping how the world does business."

The review outlined the significant impact digital technologies could have on improving productivity and competitiveness of the entire UK manufacturing sector whilst growing the technology sector that enables the improvement.

Key Achievements

Reach and Impact

800+

organisations engaged

More than 800 organisations received funding, directly or indirectly through Hub funding, demonstrating the programme's reach and impact.

AI

A Game Changer

Artificial Intelligence (AI) alongside data, communication and visualisation, emerged as a crucial player in driving improved processes and products to answer the manufacturing industry's call for AI to meet manufacturing challenges.

Investment

£200 Million+

investment from industry

Significant co-investment of over £200 million from industry, demonstrating strong buy-in from business.

Jobs and Skills

521

new jobs created

8543

people increased skills

8051 people increased skills in the use, development and application of Industrial Digital Technologies (IDTs) across the programme.

Version 2 - data presented in this brochure is correct as of June 2025.

Demonstating success

Value of projects funded by work strand £187 million

521
new jobs created

980
use/business cases developed

542
demonstrators developed

300
organisations engaged directly

104
projects funded directly

£200 m +
co-investment

570
publications produced

404
new IDT solutions developed for manufacturers

8543
increased skills in the use, development and applications of IDTs

28
Start ups and spin outs

139
digital tech businesses developing IDT solutions

45
patents applied for or registered

730
increased adoption of new IDTs

Version 2 - data presented in this brochure is correct as of June 2025.

IDTs in Practice

404

new IDT solutions developed for manufacturers

730

companies using new industrial digital technologies

601 companies using new industrial digital technologies to meet productivity and sustainability goals.

Demonstrators

139

digital technology providers have delivered

542

demonstrators with

980

use/business cases developed.

Resource and Energy-Efficient Manufacturing

Digitalising the manufacturing process facilitates the production of data which helps identify manufacturing inefficiencies, particularly in relation to resource and energy use. By improving the efficient use of resources and energy, we can significantly reduce carbon emissions.

In fact, in our work with the Institute for Manufacturing in Cambridge, we have shown that by digitalising the manufacturing process, we could exceed the Government's interim carbon abatement target by **almost 100%** (i.e. an additional 12Mt reduction in CO_2e emissions)

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Background and Purpose

Mission

The mission of Made Smarter Innovation is to improve the productivity, resilience, and carbon emissions of the UK manufacturing sector. Our aim is to remain internationally competitive in manufacturing and therefore provide more UK economic growth via four key initiatives:

1. Digitalise UK manufacturing to enable the generation of data, allowing the analysis and optimisation of the manufacturing process. This includes things like AI-powered production optimisation, robotics and automation, and advanced materials manufacturing.

2. Innovate easy-to-use and affordable manufacturing Industrial Digital Technologies (IDTs) that will improve resource and energy efficiency within the manufacturing environment, leading to improved resilience, productivity, and carbon abatement.

3. Innovate secure, data-sharing technologies to facilitate connected factories and expand supply chains. This involves improving information flow and traceability, leading to more efficient logistics, and superior resilience.

4. Innovation, utilising the very latest technologies such as AI, will ensure the UK remains a world leader in the advancement of manufactured goods.

By partnering with experts along the way, makers and digital solution companies alike have been transforming the face of manufacturing. Manufacturers have been able to create better, more competitive and sustainable products and processes, while digital companies have had the opportunity to develop and deploy their game-changing concepts in an exciting market.

Objectives

The challenge purpose was to harness the transformative power of the ecosystem to deliver a modern, connected, resilient, flexible and environmentally sustainable UK manufacturing sector that is significantly more productive, and a vibrant technology sector that enables that transformation. By increasing the sustainability of the UK manufacturing industry, this will create an increase of reusable resources and reduction in waste and carbon emissions.

By 2035, the aim of the investment in the projects supported was to:

- Increase GVA by up to £2.3 billion
- Create thousands of highly skilled jobs
- Raise productivity by up to 30%
- Decrease UK carbon emissions by up to 4.5%
- Decrease manufacturing waste by up to 25%.

The Made Smarter Review highlighted the critical digital technologies that could help deliver this improvement as:

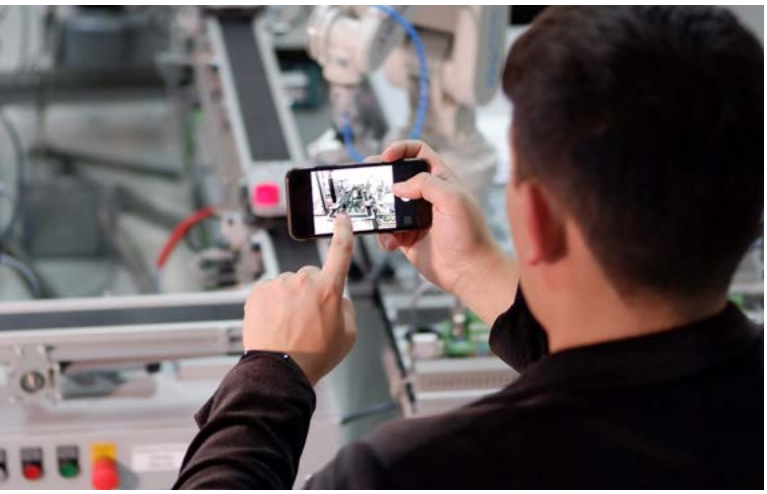
- Artificial Intelligence (AI), Machine Learning (ML) and data analytics
- Additive Manufacturing
- Robotics and automation
- VR and AR
- Industrial Internet of Things (IIoT) and connectivity (5G, LPWAN (Low Power Wide Area Network), etc.).

To provide additional focus, and to complement a challenge-led approach, the Made Smarter Innovation challenge developed a technology strategy based upon an analysis of global and domestic manufacturer demand for technology, and the UK capability to address under-developed areas for the supply of technology.

Background and Purpose

Key focus areas were identified:

- **AI** — orientate the globally competitive capability in the UK towards apparent demand from manufacturing. This is currently heavily clustered in the London area
- **Robotics** — build on significant public investment to increase mature industrial applications
- **Additive Manufacturing** — key to aerospace and defence but lacks full cross-sectoral advocacy
- **Net Zero** — a critical role for digitalisation and a primary catalyst for change with profound impacts on how to make and move things
- **Design** — a critical enabler for future products in all sectors, including design for future manufacturing capabilities
- **Integration** — identified as a strategic technology element in all IDTs, but it is not clear how to bring this to product-level
- **Platforms —** ability to challenge the notion that it is too late for the UK to become a platform player.



It is essential to recognise that some significant technology areas were not specifically addressed by the Made Smarter Review. In particular:

- **Synthetic environments/digital twin** — a key strategic area for further review
- **Blockchain** — there's a strong pull seen within the competitions and a very active UK space.

These insights have led MSI to invest in targeted areas such as:

- The use of data in driving improved processes and factory operations
- The orientation of early-stage AI companies in addressing manufacturing net zero challenges via an accelerator programme.

Context and strengthening rational

The imperative at the start of the challenge was to rapidly assist manufacturers in dealing with the emerging consequences of the Covid-19 pandemic and associated supply chain shocks, which were further compounded by other global geopolitical events: such as the Ukraine conflict, resulting in further disruption.

The response to this was to immediately launch a £20 million 'Fast Start' collaborative research and development competition to unlock quick-to-market solutions.

Key Principles

A key step early in the challenge was the establishment of some key principles by which the challenge would be designed and executed:

1. Connected collaborative ecosystem

- Creating a pathway from the best ideas through to industrial scale solutions
- All interventions have manufactures, technology solution providers (both large and small) and universities.

2. People at the heart of digitalisation

- Harness the power of diversity – current ideas and voices and getting the best from everyone
- Connecting and supporting innovators and disruptors – creating communities
- Ensuring compellingly adoptable solutions were created.

3. Delivering the digital manufacturing future we want to:

- Become a productivity powerhouse
- Deliver flexibility as standard
- Become a sustainability champion
- Produce a happy and sustainable workforce.

People and Culture

The challenge placed people at the heart of manufacturing digitalisation. Specifically, programmes delivered through the Economic and Social Research Council (ESRC) and the Engineering and Physical Sciences Research Council (EPSRC) invested in:

- **InterAct** — a £4 million network that aims to bring together economic and social scientists, UK manufacturers, policymakers, and digital technology providers to address the human issues resulting from the diffusion of new technologies in industry. The programme was granted an additional £1 million for InterAct Global international activity.

- **People-Led Digitalisation** (P-LD) — a £5 million Research Centre supporting the entire UK manufacturing network in adopting digital technology using a people-led approach. Through rigorous research and testing, P-LD has unearthed valuable insights and developed practical tools that foster digital engagement — driving sustainable, ethical and effective digital transformation journeys.

Further to this, each MSI Research Centre has a proportion of social science content to complement their technical focus.

Smart Factories

Funding was allocated to accelerate progress on Smart Factories — £22 million supporting two collaborative research and development competitions focused on data-enabled sustainable smart factories and late-stage robotics:

- The £20 million Smart Manufacturing Data Hub which set out to unlock the power of shared data for small medium enterprises (SME) businesses.
- £2 million Sustainability in Manufacturing Accelerator, connecting technology providers with the resource and energy efficiency challenges of manufacturers.

In addition:

- £4.7 million Research Centre for Smart, Collaborative Industrial Robotics, based in Loughborough, Strathclyde, Cranfield, Bristol and Warwick Universities, is eliminating barriers to adopting robotics and accelerating their widespread use in manufacturing.
- £5 million Research Centre for Connected Factories, based in Nottingham, Cambridge and Sheffield Universities, to create a 'Morphing Factory' where production can be easily repurposed in response to changing market demand. An example of this was during the Covid-19 pandemic when drinks manufacturers transformed their production lines to make hand sanitiser.

Digital Supply Chains

Funding was allocated to enable more efficient and resilient supply chains:

- £18 million connected digital supply chains feasibility and industrial research Collaborative Research and Development (CR&D) competitions
- £10 million Digital Supply Chain Hub which has created a community of people, tools, and resources to build more efficient, resilient, and sustainable supply chains
- £1 million International Supply Chain Accelerator
- £4 million Digital Medicines Manufacturing Research Centre, based in Strathclyde, Cambridge and Loughborough Universities, creating digital supply chains that enable medicines to be supplied on demand and enable clinical trials to operate more flexibly
- £4 million Materials Made Smarter Research Centre, a joint endeavour between four EPSRC Future Manufacturing Hubs – MAPP, SUSTAIN, CIMComp and LiME. It worked with materials intensive industries to address the challenges in adopting digital tools and technologies, while supporting UK industry at the forefront of the nation's technological advancement and green recovery.

Demonstrating Success

Programme impact

Productivity, CO_2(e) and waste

Increase in productivity **12%**

Reduction in CO_2(e) **18%**

Reduction in waste **17.5%**

Industrial Digital Technology solutions developed and adopted

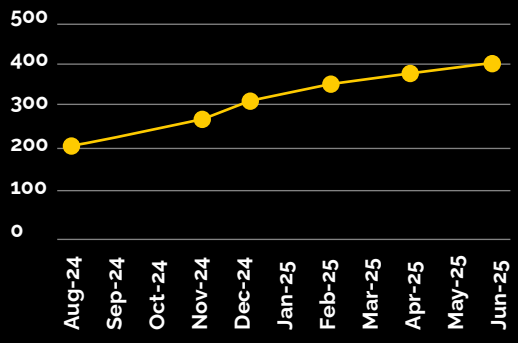
404
Number of new IDT solutions developed

730
Adoption of new MSI technologies

The progress of MSI challenge logic model has been tracked quarterly across 48 of the challenge projects via an impact tracker questionnaire. This impact data has been used to demonstrate the success against the challenge outputs and outcomes. Percentage figures for productivity, CO_2(e) and waste are a median average of the 48 projects reporting impact data.

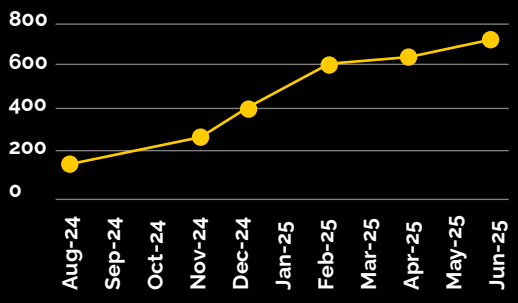
Output

Number of new IDT solutions developed



Outcomes

Increased adoption of new IDTs



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People and Culture

Putting people at the heart of digitalisation

People are at the heart of driving innovation in manufacturing. From design and research to developing new production methods, a skilled workforce is essential for staying competitive in a global market.

The MSI challenge consistently applied the following principles:

- Get the best from everyone by harnessing the power of diversity
- Create communities by connecting and supporting innovators and disruptors
- Create compellingly adoptable solutions.

Two projects have made significant contributions in this area:

- InterAct
- Centre for People-Led Digitalisation.

People and Culture

InterAct

Led by the University of Strathclyde and Loughborough University

InterAct, an Economic and Social Research Council-led network, is an ESRC network initiative that unites economic and social scientists, UK manufacturers, and digital technology providers to address the human issues posed by modern technological advancements in the industry. By fostering a collaborative and interdisciplinary community, InterAct provides funding to researchers, generating actionable insights that benefit UK businesses.

Purpose and vision

InterAct aims to "pioneer human insight for industry" by encouraging social scientists to support the adoption and diffusion of digital technologies, ultimately strengthening UK manufacturing. The network is particularly focused on navigating pressing global challenges, such as climate change, supply chain instability, and demographic workforce shifts. To achieve this, InterAct aligns with the objectives of the Made Smarter Innovation initiative and prioritises four key themes:

1. Productivity
2. Resilience
3. Sustainability
4. People.

Core research areas
InterAct anchors its research in three primary areas:

1. The future of digital manufacturing ecosystems

Project Lead: Professor Janet Godsell, Loughborough University

This research area investigates the globally integrated supply chains and systems that drive manufacturing. As businesses face rapid technological disruptions, the need for adaptability, sustainability, and efficiency is more critical than ever. The research team has produced a comprehensive report outlining potential future scenarios and opportunities that manufacturers can leverage to stay competitive.

2. The future of work

Project Lead: Professor Jillian MacBryde, University of Strathclyde

With technological advancements reshaping workplaces, human capital remains a key factor in successful business operations. This research explores:

- UK public perceptions of manufacturing
- New technology, skills and workforce agility.

By understanding public attitudes, businesses can refine their branding and employee offerings to attract top talent. Additionally, insights into the impact of emerging technologies on workforce training and adaptability provide manufacturers with a strategic advantage in securing skilled labour.

3. The future of the economy

Project Lead: Professor Vania Sena, University of Sheffield

This research branch explores economic themes relevant to manufacturing, including:

- Advanced manufacturing employment and the impact on inter-generational social mobility
- The benefits and impacts of local innovation systems
- Local manufacturing emissions tracking and the implications for net zero.

The InterAct team has hosted several webinars discussing topics like regional productivity, Industry 4.0, and EU industrial policies, offering valuable insights into the evolving economic landscape.

Commissioned research programme

InterAct functions as a hub for curating and disseminating knowledge, collaborating with over 100 researchers from various institutions on more than 30 projects.
To support this work, InterAct has provided funding through several mechanisms:

- Two systematic review calls of £40,000–£50,000
- Traditional open calls for research grants of up to £50,000
- A sandpit event offering grants of up to £90,000
- Early career researcher fellowship grants of up to £5,000
- An 'Actionable Insight' fund for developing and disseminating existing insights with grants of up to £18,000
- A Storytelling fellowship programme, offering researchers and industry participants the skills and knowledge to deliver compelling stories about the intersection of manufacturing, people and digitalisation.

These funded projects have generated a wealth of accessible research and insights, helping manufacturers and technology providers navigate digital transformation.

Through the InterAct website, stakeholders can explore a variety of topics, including:

- Strategies for attracting young talent into manufacturing
- Business model optimisation for digital transformation
- The role of open innovation in manufacturing digitalisation
- The potential for new technologies in SME export growth
- Managing digital transformation effectively
- The effects of global supply chains on sustainable manufacturing
- The interplay of growth, innovation, and regional productivity.

Industry engagement and knowledge sharing

InterAct has actively promoted industry engagement by participating in over 70 events, both in-person and online, drawing more than 2,000 stakeholders. The network's membership exceeds 700 active participants, reinforcing its role as a crucial link between academia, industry, and policy.

To further knowledge dissemination, InterAct offers:

- Blog content featuring diverse academic and industry perspectives
- Explainer videos on digitalisation and manufacturing trends
- Recorded events and discussions on emerging technological challenges.

InterAct Global

In 2022, InterAct received an additional £1 million in funding to expand its research on human-centric insights in manufacturing digitalisation to an international level. This led to research missions in Singapore, Malaysia, India, Australia, and Sri Lanka, where teams collaborated with local partners to examine regional manufacturing practices and technological innovations.

The research missions provided insights into:

- The application of cutting-edge manufacturing technologies
- Workforce development strategies in digitalised industries
- Sustainable manufacturing practices across different economies.

Findings from these global research efforts will be compiled in a final report, set for release in Spring 2025.

Stakeholders interested in accessing insights, reports or contributing to future research can visit the **InterAct website** or contact **info@interact-hub.org.**

Watch InterAct video

Find out more about InterAct

People and Culture

People-Led Digitisation

Led by the University of Bath

The future of manufacturing might be driven by technology, but it will be powered by people. The Centre for People-Led Digitalisation (P-LD) has worked with industry to generate and implement human-led solutions that enable UK manufacturers to embrace digitalisation with confidence. The research and resources created help industry adopt new technologies effectively, ethically and sustainably, giving it a competitive advantage in the global marketplace.

What is people-led digitalisation?

Digital technologies have the potential to deliver significant economic, environmental, and societal benefits. However, their implementation often faces challenges related to people and cultural factors. For instance, individuals may worry that the technology could change or replace their jobs, or they may lack the digital skills needed to operate it. To fully realise the benefits of digital technologies, it is essential to ensure that people are prepared — both capable and willing — to adopt and implement these innovations.

This is where people-led digitalisation is key. People-led digitalisation aims to improve the outcomes of the adoption of digital technologies, by putting people, not the technology, at the heart of the process, so the technology is designed and implemented in a way which best meets their needs.

To achieve this, P-LD collaborated with industry partners to co-create research focused on developing, implementing and sustaining people-led solutions. These efforts focus on empowering UK manufacturers to embrace digitalisation with confidence and in doing so improve the productivity of the sector and maximise the wellbeing of the workforce.

Co-created research

Driving momentum for change requires supporting a wide range of stakeholders. This includes manufacturers aiming to adopt new technologies effectively, ethically, and sustainably; consultants and change leaders seeking tools and processes for implementing scalable digital transformations; and policymakers and developers working to establish ethical guidelines and standards for digitalisation.

Through workshops and events, the P-LD brought their industry partners together to identify key areas of focus for their research to translate academic outputs into tools and insights which are practical and useful for industry. This collaborative approach has been groundbreaking, bridging disciplines such as engineering, philosophy, and management, and engaging with a diverse range of sectors — from defence to cell and gene therapy.

By uniting these varied perspectives, P-LD has driven innovation and ensured that its research addresses real-world challenges while delivering meaningful, cross-industry impact.

Industrial impact through co-creation

In 2023 the P-LD showcased some of its co-created research through a 'Mighty Mingle' poster exhibition, followed by an 'Industry Forum' in February 2024 where over 20 tools and insights for industry were presented. Over the following year P-LD worked with its partners to apply these tools and insights in an industry setting. To date this has resulted in nine published impact 'Case Studies' demonstrating from a standing start, how outputs from P-LD have created industry impact, three of which are outlined overleaf.

Watch P-LD video

Find out more about P-LD

Rolls-Royce Submarines Division case study

With so many digital solutions available, the key question is which of the available options best meets the needs of the organisation, its workforce, society, and sustainability. A set of cards was developed to explore legitimacy.

These cards were trialled by Rolls-Royce Submarines Division in three sessions at the company with a total of 15 participants both online and in person.

Find out more

Key Outputs, Outcomes and Impacts

"Given the breadth of potential digital investments and opportunities, P-LD tools such as the legitimacy cards have the potential to help better facilitate discussions around digital demands ensuring holistic understanding and assessment of the opportunity are considered, especially where there aren't obvious quantitative factors. This will enable those with the most value and benefit to be selected for delivery to the business."

Liam Ruff,
Digital Integration Engineer,
Rolls-Royce

Eyelit Technologies case study

Manufacturing Execution Systems (MES) provides valuable data-driven insights that enable companies to manage critical functions such as planning, scheduling, tracking, and quality control more effectively. However, the question remains: are organisations fully realising the potential value of their MES systems? And if not, what is stopping them?

An engineering master's student conducted research in collaboration with cloud-based MES software company Eyelit Technologies. Over the course of the three-month project, they reviewed more than 900 ticket logs — records of issues reported by manufacturing companies to the MES provider — and compiled and analysed detailed questionnaires completed by MES users from various manufacturing companies. Five key recommendations in relation to people were identified.

Key Outputs, Outcomes and Impacts

"The system is highly complex and must align with the nuances of each manufacturing process. Success requires careful planning, clear objectives, strong leadership, and ongoing commitment to refining the system over time. It's not just about installing software but about embedding a digital tool into the core operations of a business.

The work that was completed in this project gave us confident confirmation that the investment we had made in recruiting a technical writer to improve our documentation was wholly valid."

Nicole Ballantyne,
Head of Customer Success,
Eyelit Technologies

Find out more

BIM4Water case study

How can technology meet neurodiversity to create equitable workplaces?

It is forecast that there will be 27,000 vacancies in the water sector between 2020–2029, with 48% of the workforce retiring in the next 20 years. In correlation to this, research shows that 85–90% of neurodivergent individuals are unemployed or underemployed. Change is required, not only for the benefit of these individuals but to also address the resource challenges that the sector faces. A shift towards digital innovation and transformative solutions can enable change.

The collaboration and active partnership between BIM4Water and P-LD aimed to enhance the employment prospects of neurodivergent individuals, enabling them to access and thrive in the workplace, raise sector awareness and equip them with the knowledge to recruit without boundaries, and tackle the resource shortages head on. Instead of focusing on individual businesses, they co-created research to produce evidence and new knowledge that would have a significant impact across multiple sectors.

Key Outputs, Outcomes and Impacts

"The partnership between BIM4Water and P-LD aims to create systemic change and a legacy of impact. We are striving for broad, impactful reforms that affect the entire structure and operations of the sector, rather than just small, isolated changes. With an estimated 15-20% of the population thought to be neurodivergent, it is crucial to ensure these individuals are not disadvantaged and to recognise the valuable skills they bring to the labour market and more importantly the water sector.

"Acknowledging the importance of this work, P-LD has continued to support this research, including providing an autistic person with a fully funded PhD studentship. They have also recruited a second autistic person to examine whether digitalisation intensifies work and if so, how the impact might be mitigated."

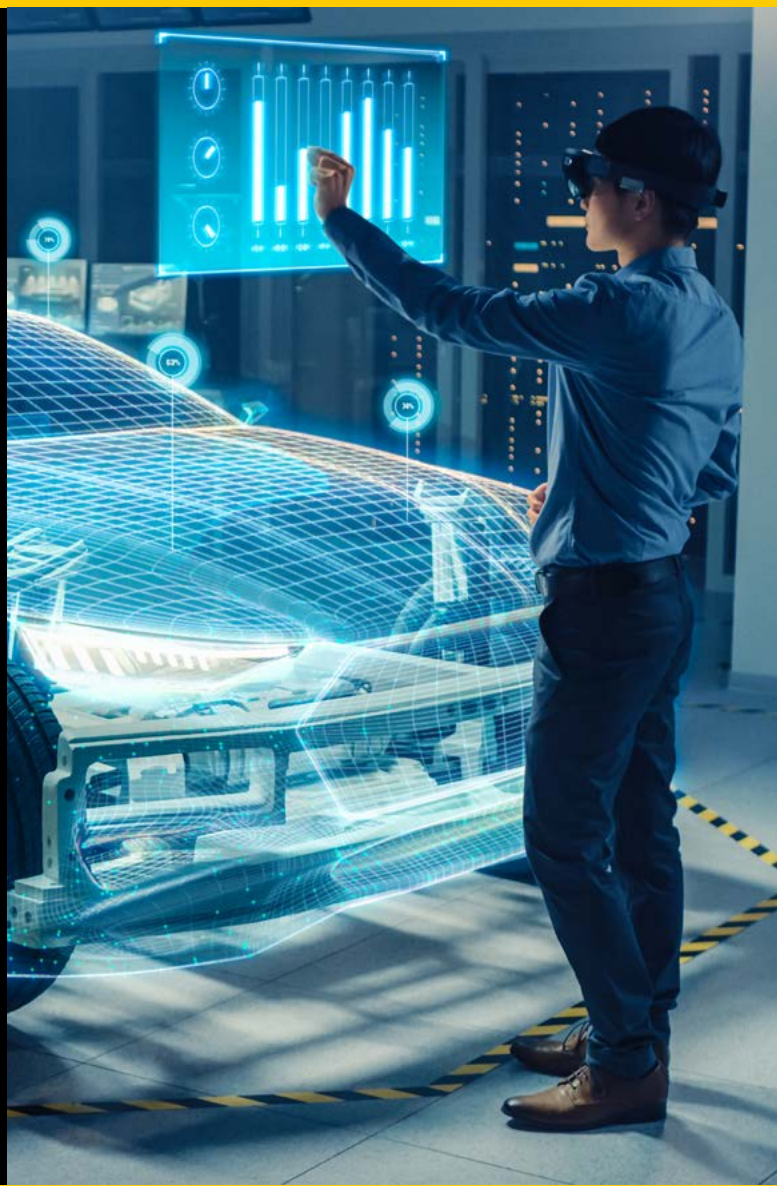
Claire Taylor,
Chair of BIM4Water and Head of Digital Delivery, MWH Treatment

Find out more

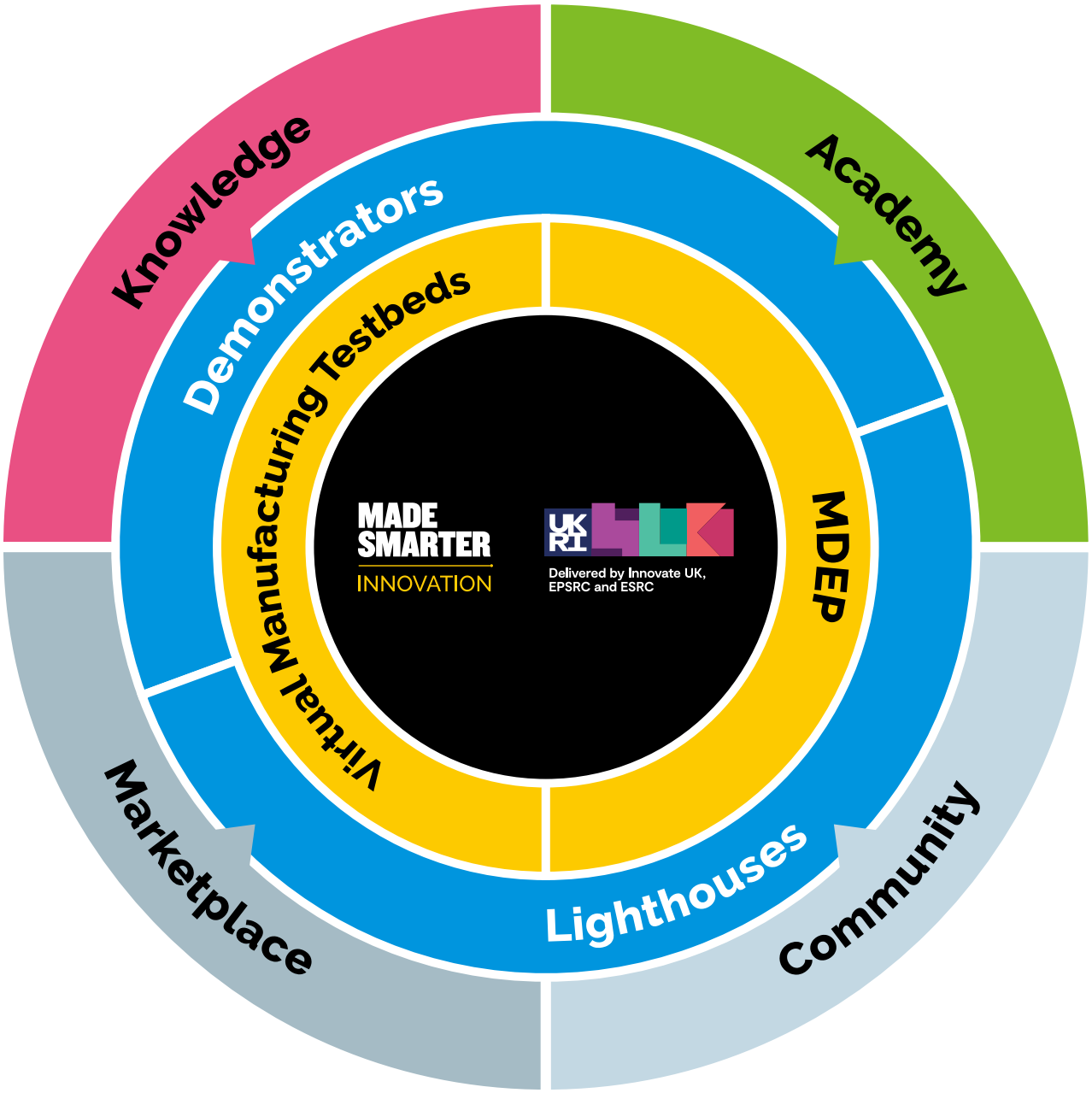
Smart Factories

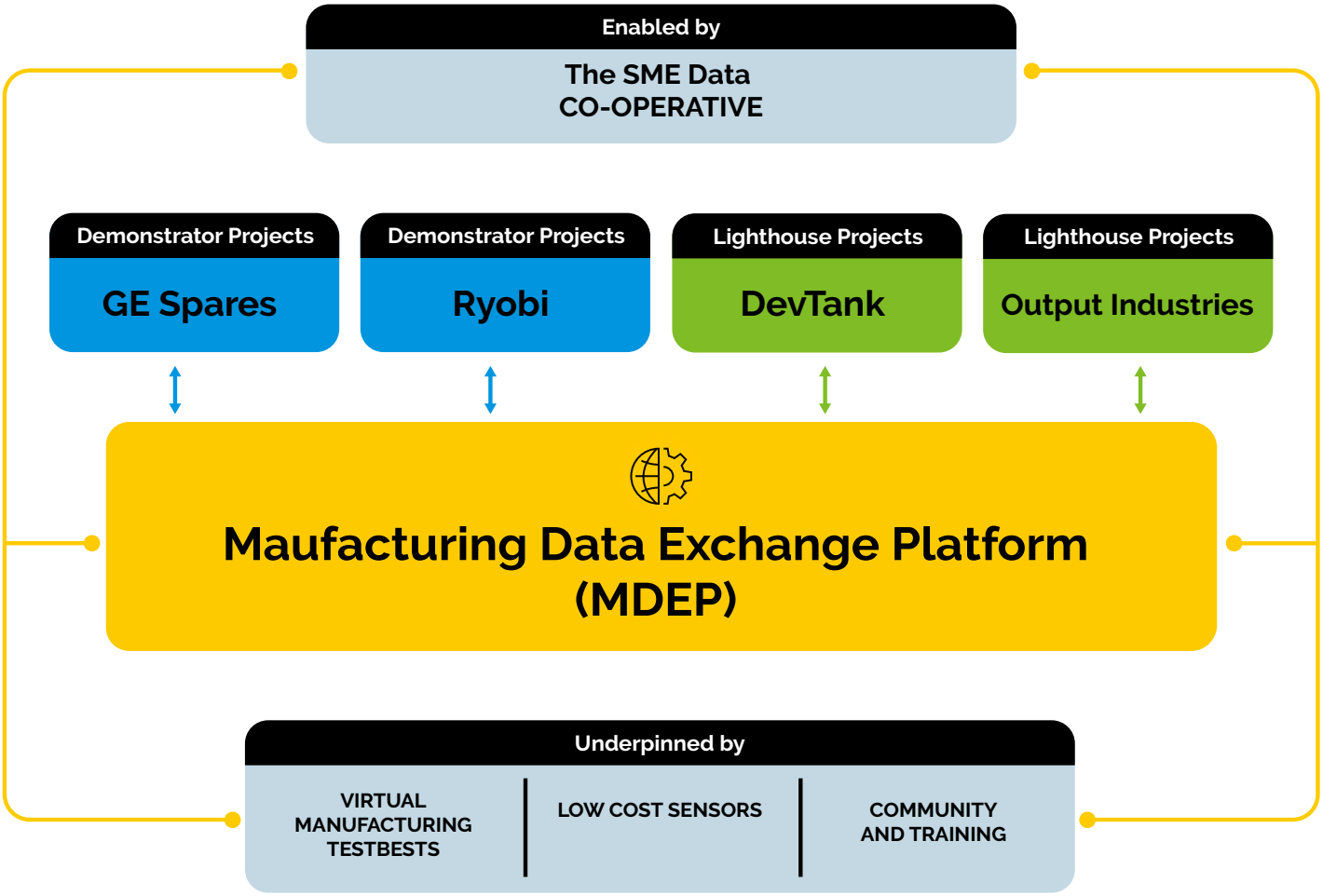
To accelerate progress on Smart Factories, funding has been awarded to;

- **£22 million supporting two collaborative research and development competitions** focused on data-enabled sustainable smart factories and late-stage robotics
- **The £20 million Smart Manufacturing Data Hub** which sets out to unlock the power of shared data for small medium enterprise (SME) businesses
- **£2 million Sustainability in Manufacturing Accelerator** that connects up and coming technology providers with the resource and energy efficiency challenges of manufacturers
- **£9.7 million supporting two Research Centres**



Smart Manufacturing Data Hub





The Smart Manufacturing Data Hub (SMDH) programme comprised £20 million of grant funding and a further £30 million of industry funding, delivered through a consortium of partners spanning all four UK nations. SMDH supports small and medium-sized manufacturers to become more competitive by harnessing the power of data. The Hub inspires innovation in factory data insights through accelerated sensor deployment, internet of things (IoT) connectivity and use of digital analysis approaches – through a mix of bespoke digital platforms and operated by a team of specialist technology and data science experts.

Key operational focus areas include process control, quality control, equipment condition monitoring, performance analysis, compliance, energy monitoring and environmental monitoring.

Key work packages offered under the SMDH programme:

1. The Manufacturing Data Exchange Platform (MDEP)

MDEP is a central platform where manufacturers can securely upload and share their factory data, allowing them to access data analysis, insights, and visualisation tools to improve operational efficiency and decision-making. The data sets are stored on the platform, and under the data owner's full control, in terms of who the data is shared with.

SMDH data scientists extract valuable opportunities – identifying trends and opportunity. By exchanging information, businesses can adapt to changing market trends and create opportunities to explore partnerships and expand into new areas through leveraging other people's skills, expertise, and resources.

MDEP offers:

- Visualisation of secure data exchange
- Visualise real-time data analytics
- Access to the latest data analytic tools
- More informed business decisions.

2. Virtual Manufacturing Testbeds (VMTs)

SMDH developed a suite of VMTs for SMEs to experiment with new technologies remotely, enabling exploration of technologies to innovate, streamline processes, and adapt to ever-changing market demands and evaluate whether these technologies are applicable for their organisation.

The VMTs created include

- Additive manufacturing
- An industrial robot
- 3D factory layout visualisation
- Systems automation
- Quality assurance

3. Low-cost and quick to deploy sensors

To accelerate the digitisation of factory activities, SMDH and its delivery partners have championed easy to deploy sensor solutions, in many cases developing new low-cost solutions.

Examples of sensor deployments include monitoring of power/energy, temperature, air quality, air particle, plus downtime capture and job tracking.

4. Community and Training

SMDH offered community support through training courses, knowledge sharing and discussion forums. Popular discussion topics include data analytics, sensors and AI.

The impacts of the SMDH can be seen through their various case studies, four of which are highlighted on the next few pages.

Devtank's smart monitoring solution transforms SME manufacturers through data-led insights

Lighthouse Project, Devtank has developed an environmental and energy monitoring device called Open Smart Monitor, with the support of SMDH.

Devtank is one of 12 Lighthouse Projects, funded by SMDH to develop a market ready solution for deployment and dissemination to SMEs. Devtank has deployed its open-source software and hardware to 50 manufacturers to capture environmental and energy data, which is analysed and displayed on its visualisation platform for transformational insights. Data is also shared with MDEP, where anonymised data is reviewed using data science methodologies.

"While larger companies have rapidly embraced the challenges of the new paradigm and are currently working intensively on the introduction of Industry 4.0 technologies, SMEs are struggling. Devtank wants to help overcome that by offering SMEs low-cost solutions for energy management and environmental performance to identify efficiency and productivity opportunities."

Tim Telford, CEO and co-founder, Devtank

Key Outputs, Outcomes and Impacts

Devtank has engaged with 50 SME manufacturers, deploying 300 sensors to address various challenges to help manufacturers achieve marginal gains in energy monitoring, predictive maintenance, and productivity insights, contributing to net zero goals.

Early results show a steel fabrication business with increased productivity of 10%, and a door manufacturer with improved machine efficiency and energy use. Ritchie Precision is using the solution to monitor machinery and reduce costs and emissions. The success of this project has led Devtank to hire two more employees and secure resellers in Germany and Singapore. Devtank is also exploring a software/ hardware integration partnership.

Output Industries accelerates SME manufacturers' productivity and net zero gains with analytics platform

Manufacturers are amid a data-driven revolution. With access to real-time production data, they can become more efficient, productive and sustainable. But many SMEs lack the resources and know-how to deploy data capture technology and combine the different data sources into one cohesive view. It is also common for a company to have a vast array of machine types with varying brands, ages and compatibilities.

SME manufacturers are experiencing productivity and net zero gains after deploying manufacturing analytics software through Made Smarter Innovation's Smart Manufacturing Data Hub (SMDH). 25 companies have partnered with Output Industries, a software start-up based in Cornwall, one of 12 Lighthouse Projects, funded by SMDH to develop a market ready solution for deployment and dissemination to SMEs.

By connecting their operations to Output Industries' Busroot platform, a manufacturing analytics platform that provides accurate, real-time information regarding the status of all machines, processes, and production via an easy-to-use web interface accessible on any device, manufacturers can make data-led decisions to enhance operational and energy efficiency and drive a culture of high performance. Early results suggest productivity gains of between 10–15%.

From day one, these manufacturing organisations have been given access to core manufacturing KPIs including Overall Equipment Effectiveness (OEE), cycle time analysis, production output, yield rates, downtime analysis, labour efficiency, waste and scrappage, and energy inputs. The data is then shared with the MDEP, via the Busroot platform, where data scientists have provided data analytics, data analytics tools, and benchmarking insight.

Key Outputs, Outcomes and Impacts

Output Industries has rolled out the solution to 23 of the 25 companies in sectors including machinery, food and drink, textiles, medical devices and plastics and are forecasting productivity increases of between 10–15% across all 25 companies. Manufacturers are also beginning to collect the energy consumption of those machines or stations, and use Busroot to understand and benchmark consumption, as well as correlate that to production.

One company, a manufacturer of heavy machinery, has reported an 11% increase in productivity after monitoring machine downtime and improving asset utilisation. Adey Steel, based in Loughborough, is trialling the Busroot platform across multiple Computer Numerical Control (CNC) machines, and has experienced an increase in productivity and efficiency in a key area of their manufacturing process.

"Using the insights we gain from Busroot, we have identified areas for improvement in efficiency and productivity. Our next step is to integrate energy monitoring, which will provide further insights into our production operations and assist us in achieving our net zero goals in 2025 and beyond."

Richard Greasley,
Group Production Director,
Adey Steel

The project has enabled the business to expand its team by 33%, targeting growth and new business through supporting manufacturers using the Busroot software.

"Output Industries has been a real success story. By collecting and anonymising a variety of different data sets our analytics team are now merging it with other Lighthouse projects to create valuable industry benchmarks. By the end of the programme, we are confident that we will have created a trusted environment where manufacturers share their data safely, gaining value for their own businesses, while supporting UK manufacturing."

Cara Roberts,
Business Development Manager,
SMDH

GE Spares unlocks innovation and net zero goals with low-cost sensor technology

Northern Ireland-based steel manufacturer GE Spares collaborated with the Smart Manufacturing Data Hub to improve operations, reduce costs and support net zero ambitions using low-cost sensors and data analytics.

A pilot project focused on monitoring a plasma cutting machine using a non-intrusive sensor system connected to a multifunction meter and microcontroller. Real-time data was displayed on an accessible dashboard, enabling analysis by shift, day, or week to uncover inefficiencies and potential productivity gains. Over a four-week period, the plasma cutter's availability was just 42%, prompting plans to increase capacity to 60% or more.

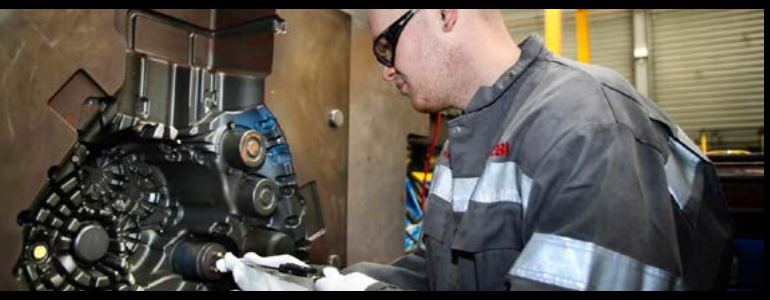
Key Outputs, Outcomes and Impacts

The pilot resulted in a 50% productivity boost for one machine. GE Spares is expanding sensor deployment across its operations to enhance machine performance and enabling predictive maintenance. Integrating energy data with its ERP system will allow precise cost analysis for each product, supporting accurate pricing and profitability.

Ryobi unlocks game-changing emissions and efficiencies through innovative energy data project

Ryobi Aluminium Casting, a Northern Ireland-based manufacturer of aluminium automotive components, partnered with SMDH to optimise operations through data analytics. Using SMDH's MDEP cloud-based platform, Ryobi integrated and analysed energy and production data, achieving groundbreaking insights to improve efficiency, reducing costs, and emissions.

The project utilised two die-casting machines, combining energy sub-meter data, production output, and Overall Equipment Effectiveness (OEE) metrics. Granular tariff data allowed Ryobi to assess how energy costs influenced production expenses over a daily, weekly, and monthly basis, enabling comparisons between machines and identifying inefficiencies.



Expected Outputs, Outcomes and Impacts

Initial findings revealed one machine was 13% more energy-efficient and 11% more productive, uncovering opportunities for significant cost savings and emission reductions.

This pilot project gave Ryobi a benchmark for energy and production data, prompting investment in a bespoke platform with automated data exchange and real-time visualisation. By scaling the solution to its 22 additional machines, Ryobi anticipates reducing overall energy consumption by 20% in the first year.

The initiative will support cost savings, environmental goals, and investments in renewable technologies, driving the company toward a more sustainable and profitable future.

Smart Cobotics Centre

The Smart Cobotics Centre, led by the Loughborough University, was a partnership between 7 Academic institutions and 87 businesses (26 SMEs). The mission of this Centre was to unlock productivity, growth, and healthier workplaces by addressing some of the key barriers holding industry back. The seven universities collaborated closely to advance the following:

- Intuitive interaction and collaboration between people and robots
- Enable robots to use more human like dexterous manipulation skills
- Reduce the effort of designing, deploying, verifying and validation of human-robot collaborative systems
- Explore the wider social, regulatory, and legal challenges holding back the deployment of smart collaborative robotic technology in a manufacturing context.

There are a number of research activities addressing industry specific challenges, such as Industrial Digital Technologies (IDTs) and feasibility studies between academic and industrial partners. A selection of the 35 IDTs (of which 27 have developed demonstrators) and 6 feasibility studies are detailed on the next few pages.

Click to watch the video

Find out more

Distributed multi-camera networks for markerless body tracking in complex human-robot workspaces

Traditional human-robot collaborations struggles with accurately and reliably tracking human movements resulting in inefficiencies, safety risks and limited interactions between humans and robots.

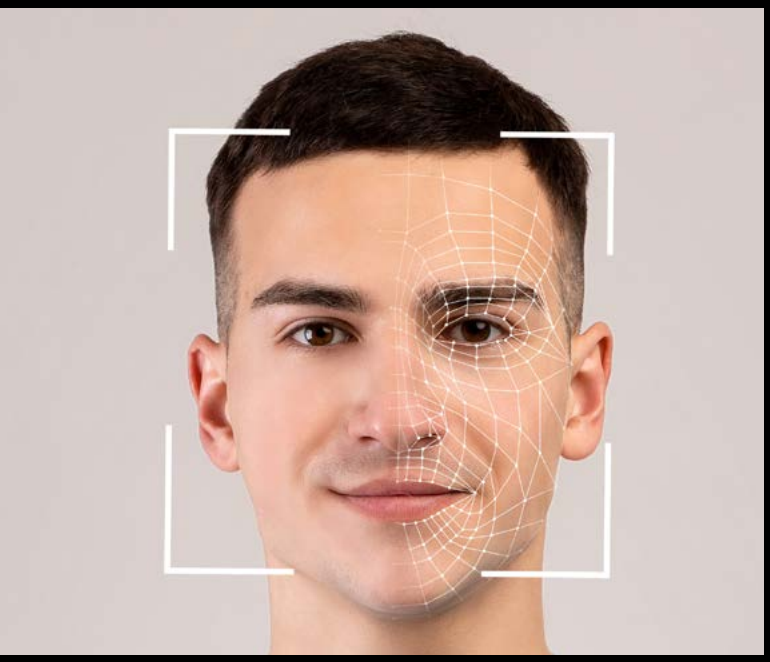
The system represents a significant advancement in accurately capturing human movement across larger and more complex spaces, including those with static and dynamic occlusions. It provides comprehensive coverage and detailed analysis suitable for various applications beyond human-robot collaboration, such as understanding and analysing human behaviour in workspaces.

Key Outputs, Outcomes and Impacts

- **Enhanced accuracy** — improved detection and tracking of human movements
- **Real-time performance** — improved the latencies by decentralisation
- **Robustness in dynamic environments** — maintains performance in various lighting conditions and occlusions
- **User-friendly Graphical User Interface (GUI)** — simplified configuration and control for easy accessibility.

Emotional recognition system for safe and responsive Human-Robot Collaboration (HRC)

The aim of this project was to develop an integrated framework for robotic systems that enable adaptive and safe interactions by identifying human emotional states via facial and physiological data.



Key Outputs, Outcomes and Impacts

- Providing data-driven insights to improve safety in HRC
- Minimising downtime by detecting operator fatigue for timely breaks
- Increased productivity by optimising robot responses to human emotions, reducing errors
- Providing open-access ML models and datasets
- Groundwork for future innovations in emotionally aware robotics.

Robot assisted lifting and assembling of unwieldy and heavy objects

This feasibility study project is for a human-robot co-manipulation system offering a transformative solution for industries that require the handling of heavy objects. By combining human dexterity and decision-making with robotic strength and precision, it improves safety, efficiency, and precision in various applications.

Key Outputs, Outcomes and Impacts

- Trust with multiple robots
- Improved precision
- Psychological wellbeing: Stress (psychological, physical) and fatigue.

Modular tooling and control for tactile manipulation of pastes

This feasibility study project addressed the challenges in evenly and delicately spreading paste substances of various viscosities and solid compositions onto various surfaces. The techniques and technology could be applied in spreading difficult material like pastes in various industries.

Key Outputs, Outcomes and Impacts

- New manipulation methods for tools, which interact with difficult surfaces.

An ethical framework for Human-Robot Collaboration (HRC) in manufacturing

This framework outlines ethical considerations and implications for responsibly shaping the future of a human-centric industry towards organisational (and societal) governance. It identifies a set of principles and design goals targeting the different layers of an organisation, with human robotic collaboration scenarios on the shop floor and the ethical governing role and practices of management.

Find out more

RESEARCH CENTRE FOR
CONNECTED
FACTORIES

Research Centre for Connected Factories

The Research Centre for Connected Factories, led by the University of Nottingham, focused on factories of the future and technologies to enable manufacturers to respond to changing market requirements by being resilient, adaptable, and reconfigurable.

The future prosperity of the UK will increasingly depend on building and maintaining a resilient and sustainable manufacturing sector that can respond to changing supply and demand by adapting, repurposing, relocating, and reusing available production capabilities.

The Covid-19 pandemic influenced our perspective of manufacturing operations and brought into focus the capacity challenges of delivering critical products and maintaining production in the face of major disruptions. It also accelerated the emerging trend for more localised, greener, and cost-competitive indigenous manufacturing infrastructure with the ability to produce a wider set of complex products faster, better, and cheaper. To meet these long-term structural challenges, new transformative methods of building and utilising future factories by embracing complexity, uncertainty, and data intensity in a dynamic and rapidly changing world are necessary.

The Centre introduced the concept of the "connected morphing factories" as a platform for next-generation resilient connected manufacturing services where manufacturing operations are delivered by ubiquitous production units that can be easily repurposed, relocated, and redeployed in response to changing market demand.

Find out more

"Today we are presented with a unique opportunity to rewrite the rules of manufacturing created by the advancement of digital technologies"

Prof. Svetan Ratchev,
Director of Research Centre for Connected Factories

This was done through three related strands:

1. To deliver the principles, methods, and models for the future autonomous morphing factory in terms of architecture, topology, configuration methods, IoT digital awareness, in-process monitoring and AI based autonomous control through:

- Architecture, behaviour and formation of morphing factories
- Sensing and Internet of Things (IoT) for factory digital awareness
- In-process monitoring, control and certification.

2. To address emerging industrial needs through a set of application studies to evaluate, validate and demonstrate core principles and methods for connected morphing factories (our technology solutions). Collaborating closely with industrial partners to deliver five application studies (AS) as exemplars of the morphing factory configuration and behaviour, addressing specific industrial needs:

- Rapidly configurable machining processes
- Variable Organisation and Operation Management (VOOM) demonstrator
- Autonomous assembly of aerostructures demonstrator
- Industrial cyber security and multi-site connectivity
- Low-cost digital solutions for supply chains.

3. A programme of networking activities with industry, other research centres and the public to maximise the impact of the research, encourage accelerated technology uptake and increase public awareness.

Project outcomes, impacts and outputs:

Emerging from the Centre are several technology solutions in various stages of development. These technology solutions are includeded on the next few pages.

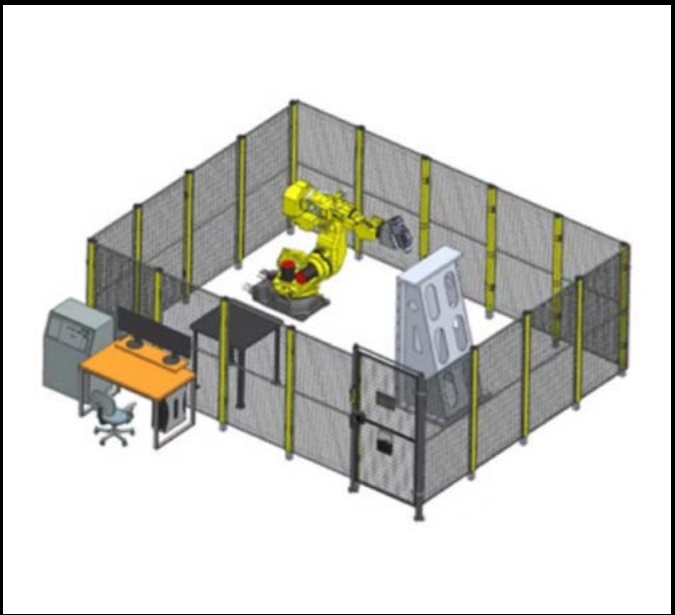
Virtual manufacturing for planning and simulation: Smart factory layout optimisation

University of Nottingham

Factory utilisation is key to economic competitiveness. Traditional fixed production layouts cannot easily scale dynamically to mitigate demand or product variation. Although a flexible factory can help with this, additional challenges emerge when trying to optimise for assembly zone areas, production assets and time. Quantifying the trade-offs inherent in build philosophy and choice of process technology is also a significant challenge to modern industry.

This project identified, developed and demonstrated a methodology to optimise the facility utilisation and layout for a given product family, based on expected demand curves, considering predicted learning curves and failure rates. Non-recurring infrastructure costs and recurring costs, in terms of energy consumption and people time, can be estimated.

Applying this technology will enable businesses to select the correct production process and system for a given product and more easily identify required change triggers during production. This in turn leads to higher utilisation and efficiencies, increasing the cost-effectiveness of the programme.



Machine Learning (ML): Reinforcement learning control in 3D printing

University of Cambridge

Quality control in extrusion-based additive manufacturing (AM) remains a critical concern, despite the significant adoption of the technology across various industries. Achieving consistent print quality is a complex challenge due to the dynamic and intricate nature of the 3D printing process.

Factors such as material flow rates, nozzle temperatures, and environmental conditions can all impact the final product, leading to potential defects or inconsistencies. Without robust quality assurance mechanisms in place, the reliability and precision of the printed components are often compromised. This can result in material wastage, extended production times, and diminished performance in the final product.

Therefore, the need for implementing real-time quality control systems during the 3D printing process is paramount. Such systems would ensure continuous monitoring, adjustment, and optimisation of critical parameters, paving the way for more efficient, reliable, and scalable manufacturing solutions. As additive manufacturing continues to evolve, the integration of intelligent quality control methods will be essential to overcoming these challenges and maximise the potential of this transformative technology.

A novel on-the-fly closed-loop setpoint adjustment system for 3D printing that integrates a vision transformer-based computer vision (CV) module with a deep Q-learning reinforcement learning (RL) controller is being developed.

This combination effectively addresses the dynamic challenges of the 3D printing process. Both components undergo separate training before being integrated for real-time deployment in actual 3D printing environments without further tuning.

The CV module extracts crucial features related to extrusion, providing reliable feedback on extrusion conditions while minimising the impact of uncertainties and variability in the printing environment. With ample domain randomisation, the vision transformer (ViT) model is trained to deliver high accuracy and strong generalisation capabilities. On the RL side, synthetic data is generated from a distribution of classification results and simulated temperature tracking, enabling flexible adjustments to the policy network's architecture and hyperparameters, while narrowing the gap between simulated and real-world conditions.

The four-phase reward shaping strategy, which uses progressively refined elliptical reward functions and accounts for classification inaccuracies, guides the policy network toward stable convergence despite environmental randomness.

Setpoint adjustments, such as flow rate and temperature, are executed asynchronously to accommodate their differing response times.

By utilising offline training and a zero-shot deployment approach, the agent can make real-time decisions during live 3D printing operations. One example to adjust setpoints starting from an over-extrusion error (300% flow rate and 230 nozzle temperature) is shown as Figure 1. The system is scalable, allowing additional process parameters to be integrated by expanding the reward function and modifying action execution schemes. Moreover, the flexibility of this method allows for application to other additive manufacturing processes.

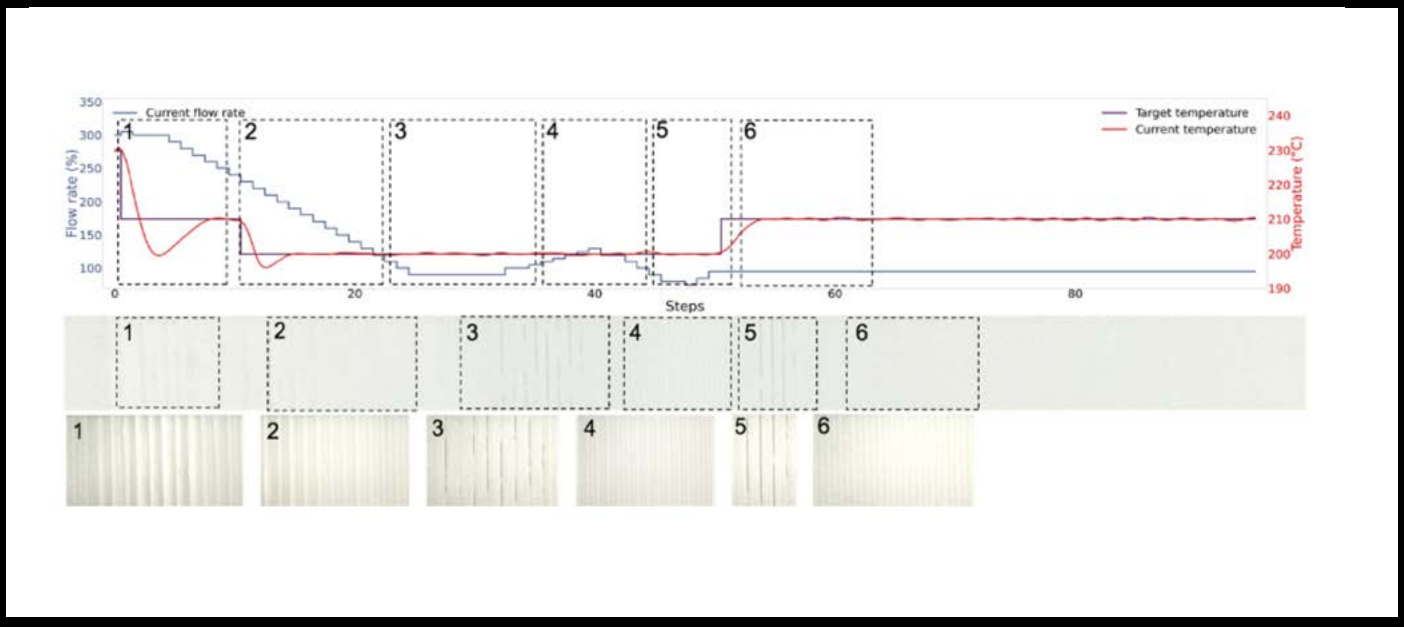


Figure 1: Setpoint adjustments with a start point simulating over-extrusion error.

Augmented Reality guided manual assembly

University of Cambridge

As part of the ongoing industrial digitalisation, augmented reality (AR) technology offers unique potential for enhancing industrial operations by providing a real-time blend of digital and physical worlds.

AR can be used to effectively guide workers through intricate tasks, furnish step-by-step instructions, and highlight potential hazards, particularly within the context of manual assembly. AR interfaces can be enhanced with computer vision algorithms to provide real-time verification of the assembly progress. However, the current state of AR technology remains relatively immature, necessitating in-depth studies to fully harness its potential and address the challenges associated with its implementation in industrial settings.

In a typical manual assembly guidance context, the AR system actively updates the displayed visual cues to align with the current stage of the process or any identified issues. A wide range of visualisation options are available for AR-based manual task guidance. Drawing upon existing research, these visualisations were categorised into four primary groups and a crowdsourcing experiment conducted to evaluate their effectiveness in a pilot study.

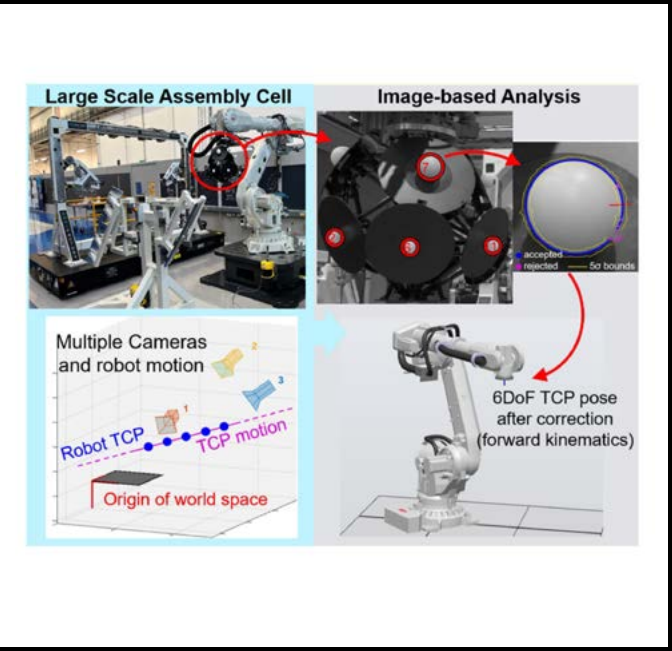
Assembly rework tasks that were initially examined, received AR guidance upon identification of an assembly error. Given the diversity of potential visual guide types that can be utilised in AR guidance, this particular use case scenario is well-suited for the crowdsourcing approach, as the traditional in-lab experimental approach could be a lengthy and resource-demanding process.

Furthermore, to ascertain the practical efficacy of AR-guided assembly training in authentic industrial environments, field studies were conducted with manufacturing apprentices tasked with performing manual assembly of engineering components in distinguished controlled and uncontrolled environments. Tailored AR-guided manual assembly systems were developed that were adaptable to different levels of asset complexity. The results suggest a substantial increase in task performance within the industrial workshop, characterised by faster turnaround times, reduced error rates, and a subjective improvement in the overall work experience. These counterintuitive findings highlight the need to evaluate AR-based assistance systems under real-world conditions to obtain accurate information about their effectiveness and usability.

Enhanced process control: Low-cost metrology-driven robot calibration

University of Nottingham

The automation of modern manufacturing tasks depends on the seamless integration of feedback sensors, and there is a growing demand for computer vision to enable informed decision-making. While image-based solutions offer a cost-effective approach, they face limitations in accuracy and precision-critical applications. Photogrammetry is an effective way to improve the accuracy of automated assembly in flexible production environments.



A multi-camera system has been developed to automate this photogrammetry in a robotic cell. The system uses three high-resolution cameras strategically placed around the assembly cell to capture images of a target artefact on the robot's end-effector. These images are used to calibrate the cameras and triangulate from 2D images to accurately reconstruct the robot's tool centre point position.

Sensorised production systems: Human-aware mobile robots for precision assembly

University of Sheffield

Current aerospace assembly requires multiple skilled workers for manual component alignment and joining, with inspection and access constraints creating significant time delays.

Research integrates precision sensors and real-time control systems into assembly jigs, enabling automated pose measurement accurate to 0.1 mm. Multi-modal sensing combines machine vision and direct measurement to capture component position and orientation. Advanced algorithms compute optimal alignment paths while respecting physical constraints and assembly sequences.

The system currently operates in an automated mode that controls mobile robots for component positioning and joining.

Industrial validation shows the potential for a significant reduction in setup time and improvements in first-time-right assembly rates. The modular design integrates with standard aerospace tooling, at one-third the cost of traditional automated solutions.

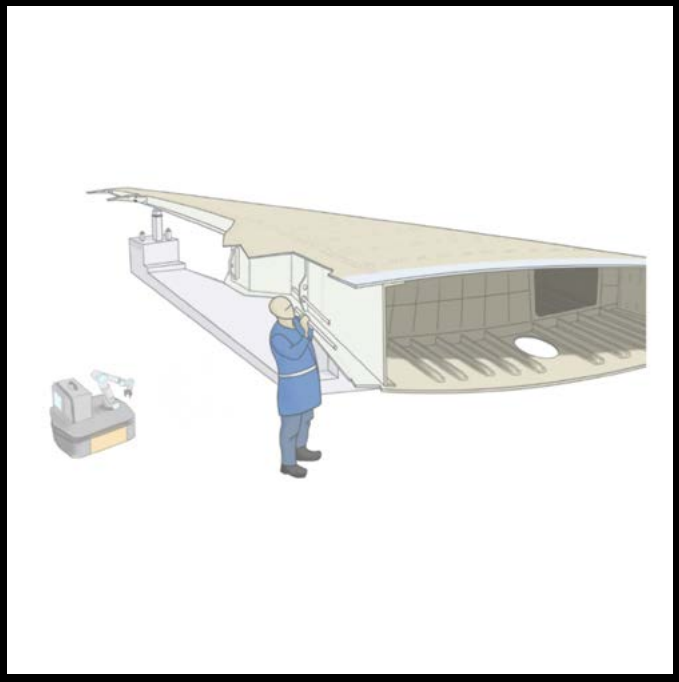


Figure 2: Graphical depiction of the precision mobile robot technology to assist manual assembly.

Tracking and monitoring: Tracking system design tool

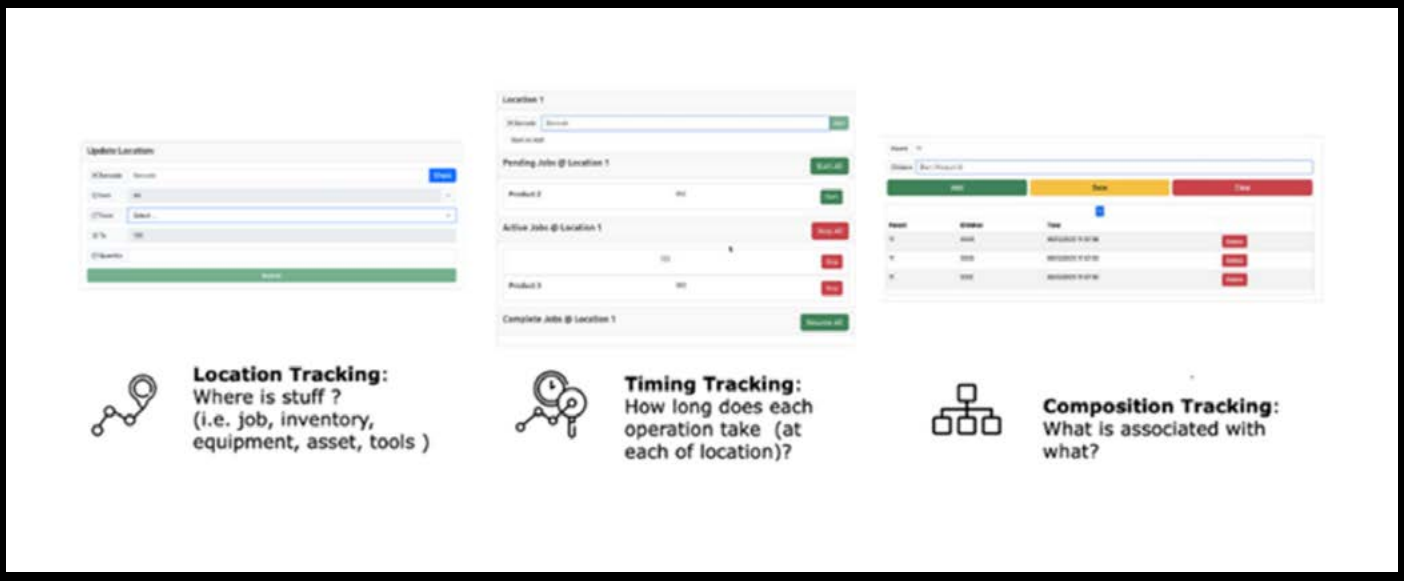
University of Sheffield

Tracking data can be vital for manufacturers and help provide context to other types of data recorded. Building and deploying an effective tracking system is a significant challenge because most tracking systems are highly customised to a factory's operation.

A design framework was developed to guide the development of multi-purpose manufacturing tracking systems.

Three low-cost modular tracking systems were developed, which can be used if no existing tracking software or technology is available.

The design framework has been trialled successfully in a demonstration environment and is available for companies to deploy or test.



MADE SMARTER | TECHNOLOGY ACCELERATOR

Made Smarter Technology Accelerator

Led by Digital Catapult

Delivered by Digital Catapult, the Made Smarter Technology Accelerator (MSTA) connected leading UK manufacturers with pioneering startups to develop innovative technology solutions for some of the UK's most relevant industry challenges.

Startups developed their ideas into prototypes and minimum viable products (MVP) in response to individual challenges set by industry challenge owners (ICOs).

To deliver impact for industry, the Made Smarter Technology Accelerator focused on five themes that addressed manufacturing challenges:

1. Intelligent factory/site management and control
2. Intelligent product verification and validation
3. Transparent and data-driven procurement
4. Digitally enabled factory workforce
5. Resource measurement and analytics.

These themes set out to deliver:

- Optimised manufacturing operations
- Trusted and resilient supply chains
- Higher quality with lower waste
- New revenue opportunities
- More sustainable businesses
- Improved factory productivity.

The Made Smarter Technology Accelerator has been able to deliver impact for both industry and participating startups including:

- 8 of the 14 startups are still in discussion with their industry challenge owners
- One startup received further funding for their solution (£20,000 trial and £10,000 proof of concept)
- Three startup companies have gone onto other programmes at Digital Catapult
- Seven startups increased their technology readiness level (TRL) by participating in the programme
- 11 new jobs created and increased skilled people in startups to 9.

The next few pages look at some of the projects that received funding.

Jetsoft & Babcock International Group

JetSoft's innovative systems unlock the extraordinary value in inspection data for manufacturers, enabling them to drive operations, reduce waste, maximise quality and increase productivity.

Working with Babcock International Group on the Warrior base overhaul challenge, JetSoft developed a solution using existing equipment and combined data output to create an automatic 3D dataset that eases the hull inspection process.

Benefits to Babcock International of digital adoption:

- Reduction in lead time to customers
- Better customer service leading to repeat orders
- Reduction in manual hours checking for errors.

Click to watch the video

Read more

Machine Intelligence & BAE Systems

Machine Intelligence Limited specialises in developing computer vision and machine learning techniques for both industry and academia, and offers expertise in systems integration, software development and Artificial Intelligence (AI).

The Machine Intelligence solution for BAE Systems uses a custom, novel machine learning technique to identify defects within X-ray images during routine inspection. Detecting issues quickly and reliably improves the quality of the end product, reduces waste and results in a more economical production process.

Benefits to BAE Systems of digital adoption:

- Reduction in time taken per inspection
- Increase in jobs completed per week
- Reduction in time needed for reporting.

Click to watch the video

Read more

"The MSTA gave us an exciting opportunity to engage with a world-leading company and further develop our AI technology. The programme exceeded our expectations, as previous interactions with funding bodies have been a bit more hands-off. The level of involvement was just right to help us as a smaller business working with a top-tier company. We are now well-placed to continue to grow and innovate in the field of AI-powered visual inspection."

Simon Harding,
Director and Technical Lead,
Machine Intelligence

Riscon Solutions Ltd & Northumbrian Water Group

Riscon is a UK-based global consulting company specialising in information and knowledge management, including net zero planning, implementation guidance and reporting.

Telkoa (formerly Inventia) is a mobile and IoT company thriving to improve networks and create innovative IoT services. It provides actionable insights, helps reduce costs, increase ARPU, and enables new services for telcos and IoT providers.

Riscon Solutions partnered with Telkoa to work with Northumbrian Water on the water network monitoring challenge. The solution developed used networked sensors with two-way control that were deployed in the water network. Data was fed to a cloud analytics dashboard for tracking, and a risk management framework was used to deliver a cloud-enabled remote water quality monitoring solution.

Benefits to Northumbrian Water Ltd of digital adoption:

- Increased water quality compliance and risk identification
- Increased customer satisfaction
- Ability to monitor health of assets.

"New digital technologies are giving us the ability to get real data at a granular level within our network. It's enabling us to make better decisions, target investments, and – overall – deliver a better service."

Andrew Blenkharn,
Technical Policy Manager,
Northumbrian Water Limited

Click to watch the video

Read more

Total Control Pro

Total Control Pro (TotalControlPro®) enables manufacturers to track people, product and performance in real time, through its intelligent cloud-based platform, DynamxMFG®. As experts in process and integration, they help businesses to improve productivity and efficiency.

The company's dynamic, data-driven resource optimisation solution for Safran Landing Systems tackled the challenge of complex planning and resource scheduling by identifying the best possible planning options to make recommendations for scheduling, and as learning occurs, these become more accurate and responsive to manufacturing conditions.

Benefits to Safran Landing Systems of digital adoption:

- Improved forecasting and capacity projections
- Better visibility of data improves agility and resilience
- Real time data insights to tackle issues as they arise.

Read more

"It's astounding how a small company was able to achieve so much in such a short period of time. It's something we can definitely learn from."

Par Eliason,
Industrial Project Leader,
Safran Landing Systems

Smart Factory Collaborative Research and Development Project Case Studies

Rapid Sand-Casting Production

Led by Raplas Technologies

Raplas Technologies, in collaboration with FMS, a foundry machinery expert based in Walsall, and Northumbria University, developed an innovative automated solution to revolutionise the sand-casting industry. The project focused on creating a more efficient, cost-effective, and sustainable method for producing complex sand-cast components.

Traditional sand-casting processes are energy-intensive, wasteful, and reliant on labour-intensive mould tooling and CNC post-processing. While 3D printing offers improvements, existing solutions are prohibitively expensive, deterring widespread adoption in the foundry industry.

The consortium developed a modular 3D printing system tailored to customer requirements and easily integrated into existing foundries. Key innovations included:

- **Affordable Technology** — off-the-shelf printheads, reducing costs and improving availability
- **Adaptability** — options for automation or manual operation to suit various foundry sizes
- **Sustainability** — a recoater system adapted from agricultural technology and plans to use an environmentally friendly phenolic binder.

Key Outputs, Outcomes and Impacts

- Lower running costs through reduced energy consumption and smaller equipment
- Affordability via accessible, replaceable printheads
- Flexibility to meet diverse production needs.

3D printing delivers innovative, cost-saving designs with unrestricted free-flowing geometry thereby reducing material costs by eliminating traditional tooling cost and all the heavy post-production machining. This project has provided a step change innovative solution to the foundry industry that will enable cost effective use of 3D sand printing that is 50% quicker compared to traditional processes.

This groundbreaking innovation offers the sand-casting industry a practical path to modernise production, enhance efficiency, and reduce environmental damage.

"There is clearly a need for innovation in the casting industry to remain competitive and become more efficient and sustainable. Few foundries are using additive manufacturing because current systems are large, expensive, and are difficult to integrate into production lines. We saw the opportunity to develop low-cost, automated, rapid manufacturing capability which speeds up cycle times, remains cost competitive for production volumes and enables the ability to tackle previously unachievable geometries."

Dr. Richard Wooldridge,
CEO,
Raplas

"The additive manufacturing of sand moulding means you can move away from the restrictions that traditional processes give you. Being able to 3D print the required shape replaces the need for traditional tooling, thereby also reducing material costs. This project has provided a step change innovative solution to the foundry industry that will enable cost effective use of 3D sand printing and is 50% quicker compared to traditional processes."

Nigel Dowsett,
Special Projects Manager,
Raplas

Read more

AI 3D printing factory network across the UK

Led by Batch Works

Led by Batch Works, in collaboration with Matta and Plus X Innovation, this R&D project under MSI's 'Sustainable Factories' programme developed an AI-driven, automated 3D printing facility. The solution enhanced local batch production, improved energy efficiency, and minimised waste, paving the way for more sustainable and scalable 3D manufacturing.

While 3D printing offers design flexibility, reduced waste, and faster production, its application in manufacturing is limited due to issues such as quality control, high failure rates, scalability challenges, and lack of expertise.

The consortium introduced five technology solutions, including:

- AI-powered computer vision to monitor and control fused deposition modelling (FDM) printing processes
- Continuous autonomous FDM machinery with real-time error detection and parts removal
- A factory management interface and a material tracking system.

Read more

Key Outputs, Outcomes and Impacts

A demonstrator factory at Plus X Innovation's Brighton hub enabled testing and refinement, producing over 2,000 parts. Results include AI-driven failure detection and autonomous operation, boosting productivity and reducing energy consumption by 25%. Batch Works projects 1,700 tonnes of CO_2e emissions reduction over three years. The success has spurred patents, new hires, spin-out projects, and plans for commercialisation, supporting sustainable 3D manufacturing growth.

Reducing energy consumption and material loss in steel production using predictive machine learning

Led by Deep.Meta

Led by Deep.Meta, in collaboration with the Materials Processing Institute, Spartan UK, and Grosvenor, this R&D project developed the 'Deep Optimiser', an AI platform aimed at reducing energy consumption, CO_2 emissions, and material loss in steel production. This innovative solution uses factory data to optimise production processes, achieving simulated reductions of 24 kWh per tonne of steel, a 5% CO_2 cut, and a 20% productivity improvement.

Steel production accounts for 8% of global CO_2 emissions due to its energy-intensive processes. Inefficiencies, such as excessive furnace heating, contribute to waste energy and higher costs. The 'Deep Optimiser' leverages historical and real-time furnace data to optimise steel reheating processes. By creating a digital twin of plant dynamics and training AI agents on 40 years of production cycles, the platform provides actionable insights, recommending the ideal temperature for steel processing. The solution integrates live sensor data and material properties to deliver real-time recommendations via a cloud-based app.

Key Outputs, Outcomes and Impacts

Simulations demonstrated significant energy savings, reducing energy use by 24 kWh per tonne - equivalent to the energy consumption of 3,000 UK homes for a year, for a 2-million-tonne steel producer. If used across 1,600 steel plants globally, this could see a reduction of around 500 megatons of CO_2 every year. That is the equivalent to a 20% reduction in the overall CO_2 associated with steel production. This project showcases the potential for AI-driven efficiency in energy-intensive industries.

"The potential productivity gains are very exciting. From a business perspective, reducing the energy and the CO_2 per tonne of steel means being able to produce more with a lower unit cost per product, improving the margins significantly. If used across 1,600 steel plants globally, we could see a reduction of around 500 megatons every year. That is the equivalent to a 20% reduction in the overall CO_2 associated with steel production."

Dr. Osas Omoigiade,
Founder,
Deep.Meta

Read more

Butterfly: Intellium's innovative AI tool transforms manufacturing workforce into citizen data scientists to achieve productivity and sustainability gains

Bristol-based Intellium AI, alongside GKN Aerospace and other collaborators, developed 'BoostBot', an AI platform that converts complex manufacturing data into conversational English. This cloud-based enterprise solution empowers engineers to optimise processes, enhance productivity, and drive net zero goals by providing actionable insights in a user-friendly format.

Carbon abatement in manufacturing requires modernising outdated manufacturing processes with digital solutions. AI adoption faces barriers such as skill gaps and perceived complexity. Intellium addressed these by creating an intuitive tool that simplifies data interpretation and supports workforce upskilling.

Key Outputs, Outcomes and Impacts

BoostBot employs advanced predictive modelling and process optimisation to analyse real-time and historical data to identify inefficiencies, suggest actionable solutions, and predict outcomes to drive productivity and sustainability in manufacturing. This innovation has been applied to aircraft cockpit window coatings to improve coating consistency and reduce rejection rates, leading to a 5% reduction in CO_2 emissions (20,000 kg/year). Similar emission improvements were seen in the manufacturing of aircraft wing ribs. Intellium AI has expanded its team by two to 15 as part of its growth strategy.

"BoostBot puts AI in the hands of engineers and operators as another tool in their toolkit, effectively turning them into citizen data scientists. Our solution accelerates the adoption of AI across a range of businesses, ensuring that AI is accessible and impactful regardless of business size."

Kiran Krishnamurthy,
CEO,
Intellium

Read more

Low Energy Autonomous Digital (LEAD) Factory

Photocentric, a pioneer in 3D printing, collaborated with partners Games Workshop, Essentra Components and the Manufacturing Technology Centre to develop the 'LEAD Factory', a groundbreaking autonomous 3D printing production line. Powered by Photocentric's patented LCD-based technology, the line produces parts every 20 seconds, achieving up to two tonnes of components daily. Dynamic carbon footprint analysis showed an 86% CO_2e reduction compared to injection moulding, highlighting its scalability, energy efficiency, and sustainability benefits.

Traditional 3D printing is limited to prototyping or low-volume production, with no industrial-scale solutions available. Photocentric's experience during the pandemic — producing 4 million face shields in a print farm — demonstrated the flexibility and sustainability of digital manufacturing, inspiring the LEAD project to scale this approach autonomously.

The project introduced '**JENI**', an autonomous robotic 3D printing line that integrates printing, washing, and curing without human intervention. CAD input allows for instant design variations, eliminating downtime. JENI integrates seamlessly with Manufacturing Execution System (MES) & Enterprise Resource Planning (ERP) and systems for full process tracking, offering unmatched scalability and customisation.

Key Outputs, Outcomes and Impacts

JENI enables mass production of 3D printed parts, **reducing costs, waste, and emissions**. Validated tests showed an **86% CO_2e reduction** for small parts. Essentra could save 727,200 kg CO_2e annually by adopting this technology. JENI supports onshoring and agile supply chains, with future plans to integrate AI and machine learning for further innovation.

Read more

Global Programme

Eureka Global Stars is a EUREKA global programme promoting international innovation collaboration between EUREKA member countries and innovative markets outside the network.

In 2018, the Netherlands launched the first EUREKA Global Stars call with Taiwan on the topic of photonics in collaboration with France and Denmark. To continue this innovation synergy, a new call was organised with Taiwan, the Netherlands, the United Kingdom, and Canada in 2021. A total of eight projects were selected for funding, covering fields such as semiconductors and photonics, smart manufacturing, and circular economy. MSI funds three industrial collaborations between Eureka Global Star Taiwan and UK digital.

Global Programme

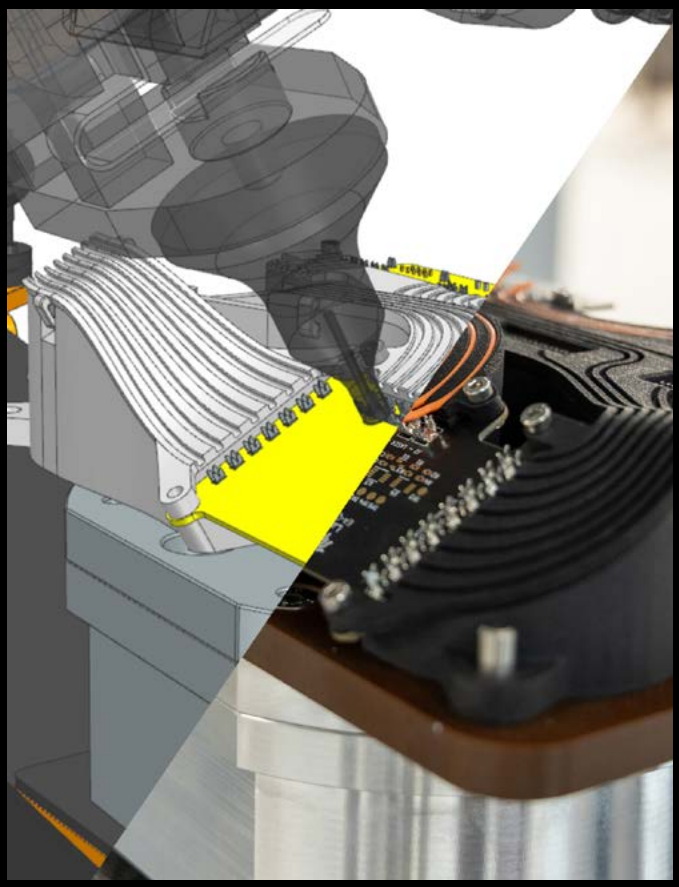
3D printing for substrate materials

Printed electronics can be an enabling technology for lightweight, functional components in many applications, including automotive, aerospace and consumer electronics.

Although processes for forming 3D-printed circuitry are available, the technology has limitations on usable substrate materials. Alternative, material-agnostic processes are possible but require development for commercialisation.

Q5D is helping business by developing the equipment and processes required to build 3D-printed components with integrated electronics.
These integrated electronics use a combination of a spray-coated precursor, which is subsequently selectively activated by laser into a seed layer for electroless plating.

This plating means that the thick conductors formed by plating are suitable for high-frequency antenna required in the latest generation mobile phones. Demonstrator phone antenna will be manufactured as part of the project.



Read more

Global Programme

Bioproduction in Chinese Hamster Ovary (CHO) cells by interdisciplinary engineering and AI

GeneNet Technology, in collaboration with the Centre for Process Innovation (CPI) and Taiwan-based Cytena BPS and Instant NanoBiosensor, engineers a stress-sensing genetic circuit and AI cell embedded into current bioproduction (incubator) using a real-time testing method. Combining innovative technology from Cytena BPS' next-generation bioreactor, this technology has many benefits:

- Culture fine-tuning and real-time data collection from culturing and physiological conditions
- Instant nano biosensors' fiber optic particle plasmon resonance technology, which detects biomarker expression. This will be used to gather comprehensive culturing, physiological and biomarker data during CHO cell bioproduction.
- The data is then fed into GeneNet's ground-breaking technology – artificial neural network (ANN) genetic circuits.
- ANN genetic circuits have been at the forefront of synthetic biology and genetic engineering in the past decade. Synthetic genetic circuits only applied simple logic (AND/OR/NOT) gates to biocomputing
- GeneNet's ground-breaking technology makes genetic circuits analogous to deep learning computers, turning CHO cells into smarter AI computers
- This enables the engineering of smart, stress-sensing CHO cells to maximise protein production efficiency and yield, benefiting down stream clients as well as wider industry and society.

Read more

Digital Supply Chains

To enable more efficient and resilient supply chains we have funded:

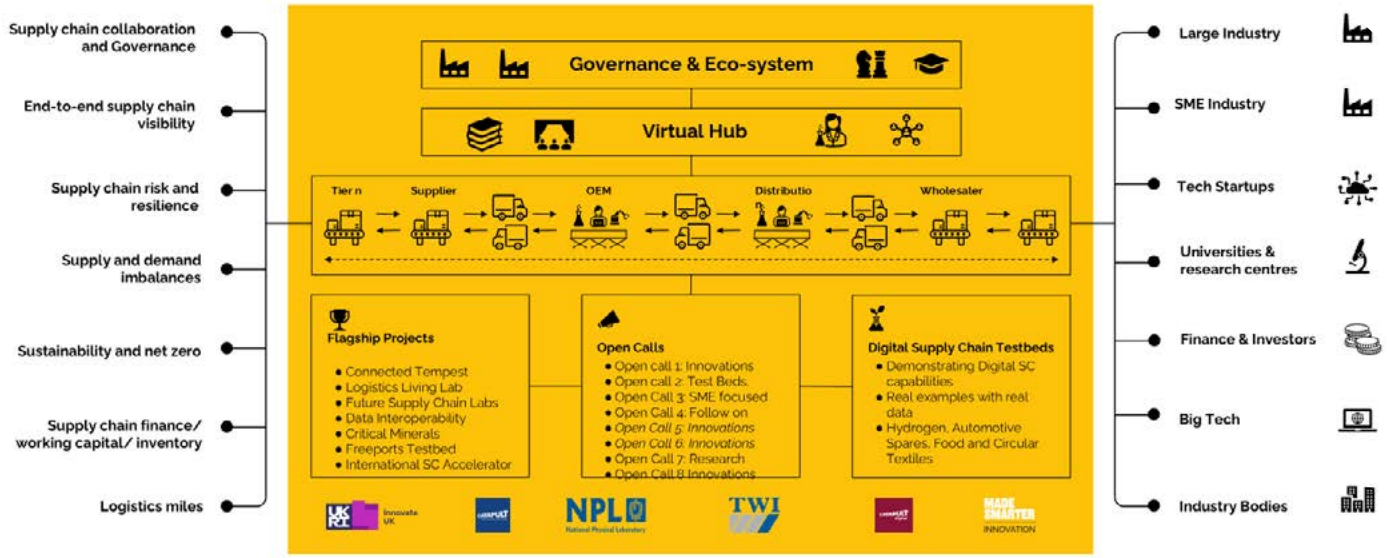
- £18 million connected digital supply chains feasibility and industrial research Collaborative Research and Development (CR&D) competitions
- £10 million Digital Supply Chain Hub
- £1 million International Supply Chain Accelerator
- £4 million Digital Medicines Manufacturing Research Centre
- £4 million Materials Made Smarter Research Centre.

Digital Supply Chain Innovation Hub

A digital innovation ecosystem that empowers individuals and organisations to work together to make supply chains smarter

Made Smarter Innovation: Digital Supply Chain Hub

£25 million was invested in creating a portfolio of digital capablities to deliver smarter supply chains.



Developed by Digital Catapult and funded by the Made Smarter Innovation challenge, the programme is transforming UK manufacturing through digitally empowered supply chains that are more efficient, resilient and sustainable.

The Digital Supply Chain Hub helps businesses realise the relevance and critical value of digital supply chain technology by improving the flow of data through supply chains and the surrounding ecosystems.

Backed by an influential consortium of technology, industry, academic and governmental players including BAE Systems, Bentley Systems, Deloitte, Edge Digital, Incept Consulting, International Chamber of Commerce (ICC-UK), Mott MacDonald, Northumbria University, Rolls-Royce and Sainsbury's.

Key Outputs, Outcomes and Impacts

- 37 programme projects delivered from £11.44 million grant funding
- £14.22 million worth of industry co-investment committed to date
- 267 businesses engaged across 18 sectors
- 56 manufacturing SME and 35 tech SME engagements
- 109 industry collaborations across innovation projects
- 38 new industrial digital technologies (IDT) being developed
- A total of 12% productivity improvements and 15% waste reduction across all projects to date.

"Through the practical application of deep tech solutions, the Made Smarter Innovation Digital Supply Chain Hub has delivered real industry impact with a 13% reduction in waste, an increase in productivity rate by 13% and a reduction in CO_2 emissions by an average of 9% across 37 projects delivered. By convening UK industry, tech innovators and academia, the programme has been driven by the power of collaboration to build digitally empowered supply chains that are more efficient, resilient and sustainable."

Tim Lawrence,
Director of Digital Supply Chain at Digital Catapult, leading on the Made Smarter Innovation Digital Supply Chain Hub

Addressing supply chain challenges

Supply chains play a critical role in our lives and their resilience is fundamental to how we thrive and survive. The Digital Supply Chain Hub programme addresses seven key challenges;

1. Supply chain risk and resilience
2. Supply and demand imbalances
3. Supply chain sustainability and the move to net zero
4. The circular economy
5. End-to-end supply chain visibility
6. Finance, working capital and inventory
7. Logistics optimisation.

The Digital Supply Chain Hub programme delivered 37 targeted interventions and projects designed to address challenges and overcome barriers to adoption in critical areas of the UK supply chain economy, supporting both the manufacturing industry and technology companies through:

- **Innovation** — developing 40 new digital innovations to address the challenges defined through new technologies
- **Deployment into testbeds** — creating environments where digital technologies can be tested and the value proved without risking the business in the automotive spares, hydrogen, food and textiles sectors
- **Adoption by industry** — adoption and scaling of digital across supply chains of both large and SME manufacturers in the UK.

Five flagship projects form the backbone of the Digital Supply Chain Hub programme:

1. **Connected Model-Based Enterprise (CMBEE)** — creating a new standard for interpreting engineering information to allow better coordination across more resilient supply chains
2. **Critical Minerals** — improving the sustainability and resilience of the supply chains through better informed sourcing decisions through the development of a digital toolkit to govern and incentivise data pooling in the critical minerals supply chain
3. **Interoperability** — overcoming barriers to information flow in supply chains to optimise decision making through the creation of open, extensible, and verifiable AI and ML based solutions to enable data sharing across the network
4. **Logistics Living Lab** — reducing the number of trucks running empty and the impact to the environment of logistics operations, bringing the UK closer to its net zero ambitions and using technology to better coordinate last mile logistics
5. **Physical assurance for digital trade systems (PROGRESS)** — developing core capabilities in digital consignment tracking across borders to enable simpler, cheaper and more efficient cross border trade processes and supporting the transition to digital trading.

The next few pages outline some of projects that received funding;

Read more

Logistics Living Lab

Showcasing a truly collaborative approach to innovation, the **Logistics Living Lab** project consortium led by Digital Catapult, drew on the expertise of partners AF Blakemore & Sons, Fuuse, Incept Consulting, Microsoft UK, Pairpoint, and Parity Technologies. The project team was able to achieve a **9%** improvement in vehicle fill rate, a **37%** reduction in overall transport costs and the potential to reduce transport CO_2e emissions by **15–30%.**

Read more

Using AI to overcome supply chain challenges

Working with **Sainsbury's** and **Cranswick** the retailer's pork supplier for its Taste the Difference Range, **Singular Intelligence** has revolutionised the UK pork supply chain through its AI solution. Sainsbury's achieved a **2–5%** improvement in product availability and a **50–70%** reduction of food waste. Cranswick saw a **15–25%** decrease in oversupply of pork sent to the retailer and improvement in the average fill rate per store of **7–9%.**

Read more

Versed AI

Partnering with **BAE Systems** and receiving a £100,000 grant to develop technology for bill of materials-based mapping, a client-demanded feature that was initially set aside due to its complexity and development requirements before reaching commercial viability. Versed AI created an AI-based solution that combines automatically generated bills of material with multi-tier supply chain visibility to give customers a hyper-relevant view of their supply chain upstream. The result is a detailed supply chain map showing which suppliers produce specific components at each level and tier in the supply chain. In some cases, up to **95%** of relationships can be excluded from the supply chain map, meaning that customers receive a smaller volume of highly relevant data, enabling them to reduce time on triage and move straight to action.

Read more

Enhancing supply chain visibility

Kavida AI collaborated with **Dyer Engineering** and **NBT Group** to address the procurement challenges faced by SMEs. By integrating task management and risk detection capabilities, Kavida AI significantly reduced inefficiencies, decreased costs and enhanced operational visibility. This included **43%** reduction in man-hours due to workflow automation; **32%** improvement in collaboration between suppliers and organisations; **60** procurement hours and **30** collaboration hours saved due to automation.

Read more

Enhancing transparency and efficiency in supply chains

Ubloquity, based in Northern Ireland, was matched with **McColgan's Food**, a family-owned pastry maker often faced with multiple audits to meet compliance requirements. Ubloquity's distributed ledger technology (DLT) solution significantly reduces the amount of time needed to transfer data, while also ensuring that the entire process is secure and as a result of using blockchain technology, it reduces the time spent on in-person audits. The partnership is projected to produce a **30%** cost efficiency due to the ability to use one piece of data securely across multiple supply chain stakeholders.

Read more

Enhancing purchasing decisions for SME manufacturers

Flowlens is tackling the significant issues of timeliness and cost-effectiveness in purchasing decision making by supply chain managers in SME manufacturing. **Flowlens** collaborated with **Denchi**, a London-based manufacturer of custom battery pack chargers, and Lumen Electronics, a contract device manufacturer from Northern Ireland to test its digital solution functionality, achieving industry validation and gathering valuable insights from SMEs actively involved in supply chain operations. The solution could save SME managers between two to eight hours per week and a potential improvement of **3–5%** on supply chain costs.

Read more

The Digital Supply Chain Hub has been able to deliver exceptional impact following its inception in 2021.

Examples of outputs, outcomes and impacts include;

The Digital Supply Chain Hub platform

The platform is designed to accelerate adoption of digital solutions by manufacturers through knowledge sharing and facilitating connections with digital solution providers.

The Hub offers tailored matching capabilities to connect businesses with the right partners to help address specific supply chain challenges. Members can:

- Connect with businesses and supply chain professionals
- Assess data readiness and supply chain resilience
- Learn about digital supply chains with bespoke educational courses
- Discover new partners with the UK supply chain directory.

International Supply Chain Accelerator

The International Supply Chain Accelerator engages with international bodies, multinational ICOs and global technology sponsors, with the aim of introducing them to the UK's leading technology and innovation companies.

Six chosen innovators work with three ICOs and relevant international bodies across two key supply chain challenge areas:

- **Seamless trade across borders** — to streamline import and export processes by encouraging the adoption of digital trade documents
- **Product Carbon Footprint (PCF)** — to support the reduction in Scope 3 emissions by creating a common product ID mapping system to significantly increase the number of digital PCF exchanges.

The Digital Supply Chain Hub platform is open to all, visit **hub.digitalsupplychainhub.uk** to sign up.

Digital Medicines Manufacturing Research Centre (DM²)

Led by CMAC, at the University of Strathclyde

Medicines manufacturing is a crucial sector for the UK, investing over £4 billion in R&D and generating exports worth over £25 billion. While drug discovery is accelerating, developing processes to convert molecules into formulated medicines still takes 10–12 years and is expensive. The bottleneck often lies in the development of chemistry, manufacturing, and controls (CMC) processes. Data, which fuels Industrial Digital Technologies (IDTs) like AI and automation, is often siloed and unstructured across organisations.

Led by CMAC, a medicines manufacturing research centre, the aim of DM² is to develop and accelerate the adoption of IDTs in the pharmaceutical sector to improve data generation and communication across pharmaceutical supply chains.

Based at the University of Strathclyde, CMAC collaborates with over 30 partners including Cambridge and Loughborough Universities, pharmaceutical companies including AstraZeneca, Pfizer and UCB, along with SMEs, technology companies, Made Smarter Innovation, and public sector organisations.

DM², along with its partners, has produced a suite of innovations involving collaborative robotics, AI and digital twins that can enable on-demand, autonomous, low quantity pharmaceutical manufacturing that can adapt quickly to the needs of emerging clinical trial supply demands or the personalisation of specialist locally produced medicines.

Their table-sized tableting CMC DataFactory® rapidly generates large, structured data, turning it into actionable insights for pharmaceutical manufacturing that allows rapid tablet development, reducing manufacturing times from months to less than a day — up to a 90% improvement — using minimal materials, reducing waste by 60% and costs by 50%.

To accelerate industry's adoption and use of this new manufacturing approach, DM² has developed an online learning resource known as the SkillsFactory, to offer training in existing and emerging IDTs.

"The pharmaceutical industry faces the global challenge to enhance the development and manufacture of medicines to be faster, more cost effective and productive, to embed sustainability and to deliver improved security of supply whilst still assuring the quality and safety of medicines to patients.

"DM² has shown how technology can transform medicines manufacturing, by making it faster, more efficient, and sustainable. It has been a remarkable example of the level of innovation that can be achieved through collaboration."

Prof. Alastair Florence,
CMAC Director and
Principle Investigator, DM²

The innovation

Over the last three years, DM² has developed five integrated platforms to enhance the medicines manufacturing supply chain with innovative IDTs.

1. They developed an extract, transform and load (ETL) tool for automatic data acquisition from multiple instruments, future-proofed for easy integration of new data. An intuitive interface and dashboard help users upload and analyse data
2. A tableting CMC DataFactory®, an AI-driven robotic platform for autonomous micro-scale development, manufacturing and testing of tablets. It uses predictive models and real-time feedback to optimise tablet formulations and processes, generating large data sets for hybrid computational models
3. Digital design tools for quality control, including the ESTAN toolbox, which assesses data information content and enhances digital twins' prediction capabilities. Methods were developed to identify key process parameters and material properties, establishing a "robust design space" for real-time quality testing
4. Application of IDTs in real-world healthcare manufacturing supply chains, focusing on patient demand data and supply-side production capabilities. They developed digital interventions in three use cases: a digital platform connecting patient demand to manufacturing operations, a model for unlicensed specialty medicines, and a tool to improve clinical trial resilience
5. Bringing together a network of academic and industrial groups to share developments across the industry. The team has also developed a SkillsFactory, an online platform to reskill and upskill in the medicines manufacturing community.

CMAC in collaboration with The Glasgow School of Art, have also developed an AR application which visualises multi-modal data to support data-driven decision making for operators, and a Mixed Reality (MR) application to enable real-time, remote monitoring in a structured, user-friendly way.

Read more

Key ouputs

DM² has been a groundbreaking example of collaboration with project partners collectively supporting the creation of 13 first generation and 23 second generation demonstrators.

DM² has laid the foundations for a systems approach which registers supply chain demand signals, triggering a rapid manufacturing response drawing on a unique CMC data platform, and using the digital quality control tools to release the medicines safely and efficiently to meet that demand.

Central to its success has been the development of the tableting CMC DataFactory® which enables the rapid generation of large, structured data, turning it into actionable insights for data-driven decisions. As a result, tablet development has been accelerated to under 24 hours using only a fraction of previously required materials.

The SkillsFactory, launched in Spring 2025, will offer personalised, flexible learning in IDTs to boost employability by filling the gap in existing educational platforms. The use of immersive technologies is forecasted to enhance training, safety, virtual collaboration, process understanding, and boost productivity.

Education and engagement around the capabilities of DM² has been widespread with over 20 published articles, 300+ research presentations, and six public/ patient engagement activities. These activities, as well as workshops and webinars have upskilled around 600 people in the capabilities of IDTs in the pharmaceutical sector. The programme has further developed a critical mass of medicines manufacturing expertise and capability in the West of Scotland, alongside the National Manufacturing Institute Scotland (NMIS).

"DM² exemplifies a forward-thinking model for UK medicines manufacturing, by paving the way for rapid, data-driven responses to healthcare needs. Beyond the current achievements, future efforts could focus on advancing these technologies and applying the acquired insights to additional dosage forms, such as inhaled and liquid medicines, for targeted therapeutic modalities."

Prof. Alastair Florence,
CMAC Director and
Principle Investigator, DM²

Digital Supply Chains

Materials Made Smarter Research Centre

The Materials Made Smarter Research Centre (MMSC), led by the University of Sheffield, drove the future of manufacturing by harnessing the power of digital technology. As a hub for collaboration between academia and industry, the Centre transformed cutting-edge research into real-world applications that enhanced efficiency, reduced costs, and improved product quality across various sectors, including aerospace, automotive, and material production.

Pioneering digital innovation

MMSC made remarkable strides in advancing materials and manufacturing technologies. Notably, it supported the launch of two groundbreaking spin-out companies, demonstrating its ability to translate research excellence into commercial success.

M2i2: Smarter material predictions

M2i2 specialises in advanced predictive modelling software, offering engineers the ability to accurately simulate material behaviour, component performance, and manufacturing processes. Its web-based platform uses high-fidelity computational models to optimise manufacturing processes, reduce material experimentation costs, and accelerate product development. The platform supports additive manufacturing, welding, and heat treatments of metallic alloys, providing critical insights into 3D microstructure and mechanical properties. Additionally, M2i2 integrates real-world sensor data, enabling highly customised modelling solutions for users.

One practical application of this technology is its ability to predict microstructure changes in stainless steel welding. M2i2 is also contributing to AI development by generating training and validation data for additive manufacturing microstructures.

INSTRUCT3D: Elevating Additive Manufacturing

INSTRUCT3D enhances Additive Manufacturing (AM) by providing smart machine instructions that optimise key parameters, ensuring that printed materials are defect-free, reliable, and meet industry standards. While AM is known for its ability to create complex shapes, ensuring material integrity is equally vital, especially in safety-critical sectors like aerospace and automotive.

INSTRUCT3D's patent-pending technology enables manufacturers to push the limits of AM while improving quality and reducing build time. This innovation ensures that 3D-printed components are not just structurally sound, but they also meet stringent performance requirements.

Key Outputs, Outcomes and Impacts

Indstruct3D was spun out of the University of Sheffield to 'revolutionise the 3D printing industry' through developing machine instructions for metal 3D printers.

Preventing defects in Additive Manufacturing

By replicating real-world manufacturing conditions in a laboratory setting, researchers observed how spatter in AM can cause surface defects, reducing the durability of printed components. Using high-speed synchrotron X-ray imaging, a team from University College London uncovered a spatter-induced cavity mechanism that contributes to these defects. Their findings now allow manufacturers to model this phenomenon and develop strategies to improve the surface quality of laser powder bed fusion (LPBF) parts.

Optimising hot strip mill operations

Traditional manufacturing is also benefiting from MMSC's innovations. In steel production, the final coiling temperature is a critical quality indicator. By working with industry partners, the Centre developed a "particle swarm optimisation" framework that analyses historical production data to help operators determine the best cooling strategies for different steel grades. A proof-of-concept has already demonstrated significant improvements in operational performance.

Additionally, machine learning models have been developed to predict expected cooling temperatures. By comparing these predictions with real-time production data, operators can fine-tune cooling processes to minimise defects and improve efficiency.

Organisational Change Toolkit: Recognising that technology adoption is as much about people as it is about innovation, MMSC has developed an organisational change toolkit to help companies navigate digital transformation successfully.

Digital Attitudes assessment: This tool gauges employee perceptions of technology adoption and organisational support, helping companies identify potential barriers and areas for improvement.

Scenario Planning tool: This tool helps businesses roadmap their digital adoption process, evaluating multiple pathways and selecting the best strategy for implementation using a socio-technical approach.

MMSC's success is a testament to the power of collaboration and innovation. By bridging the gap between research and industry, the Centre is empowering UK manufacturers to adopt smarter, more efficient technologies, ensuring their sustainability and competitiveness in the global market. With a strong focus on practical applications and real-world impact, MMSC is paving the way for a more digital and resilient future in manufacturing.

Digital Supply Chain Case Studies

A digitally connected food supply chain to deliver transparency, sustainability and efficiency

Led by Foods Connected

Increasing consumer demand for information on food sourcing and production has highlighted the challenges in tracing food data, often relying on manual and disconnected systems.

Foods Connected, in collaboration with Hilton Foods UK and OSI Food Solutions UK, worked together to **improve transparency and efficiency within the food supply chain** by creating a centralised cryptographic ledger, using Internet of Things (IoT) technology to provide real-time, traceable data from farm to fork.

The system enhances food manufacturers' ability to track products quickly, **improving efficiency, reducing waste, and verifying sustainability claims**.

Read more

Key Outputs, Outcomes and Impacts

- Enables faster decision-making
- Supports sustainability initiatives across supply chain partners
- Strengthens transparency within the food industry
- Demonstrates ethical practices
- Provides consumers with clearer, verifiable information about the food they consume, driving both operational improvements and consumer trust.

Providing visibility of carbon throughout the supply chain

Led by SupplyVue Limited

Traditionally, supply chain decisions are based on the three pillars of cost, quality, and service, but if manufacturers are to meet the challenges of delivering net zero, they need to also consider their carbon footprint.

SupplyVue developed CarbonVue, a digital platform that provides visibility of carbon throughout a supply chain using a digital twin, enabling integrated real time carbon and productivity management.

The project used supply chain data from partners Tata Steel and aerospace supplier Moveero (formerly GKN Wheels), while defence company Babcock International provided specific insights for product development from their sector and position at the head of a supply chain. Working with the University of Warwick they were able to develop algorithms for supply chain analysis and modelling.

Key Outputs, Outcomes and Impacts

- Manufacturers could predict the carbon impact of changes in their processes
- Incorporating data from the entire supply chain improved collaboration by using carbon as a measure of efficiency, fostering trust without sharing sensitive cost information
- Enhanced transparency and prioritised carbon management in supply chain decisions.

"Collaborating with these partners enabled us to capture data all the way from steel coils arriving in a factory, through processing, and into finished goods.

Poor supply-chain collaboration is a barrier to end-to-end efficiency, but this technology has the capability to unify supply chain partners in a common low carbon goal.

The need for the UK's manufacturing sector to be more productive and to reduce carbon emissions is a clear imperative but improvement is slow. CarbonVue could provide the catalyst for change."

Andy Birtwistle,
CEO, SupplyVue

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Enhancing the NHS advanced therapies ordering prototype IT system with insights from an electronic batch manufacturing system

Led by Autolomous Limited

Enhancing the efficiency and scalability of advanced therapy medicinal products (ATMPs), is crucial in personalised medicine for treating conditions like cancer and regenerative diseases. Current scheduling relies on manual methods such as diaries, whiteboards, and emails, which lead to inefficiencies and unpredictability.

Autolomous, in collaboration with the University of Birmingham and the University Hospitals Birmingham NHS Foundation Trust, integrated its 'AutoloMATE' platform into the NHS prototype ordering system for ATMPs. Manufacturing ATMPs presents unique challenges, as each batch is individualised, requiring testing, approval, and meticulous data capture.

The AutoloMATE platform streamlines scheduling and ordering processes for these therapies, which typically involve collecting patient cells, manufacturing treatments, and ensuring timely delivery to hospitals.

Key Outputs, Outcomes and Impacts

The integration of AutoloMATE has resulted in:

- 85% reduction in scheduling activities
- 50% reduction in manufacturing time
- Enhanced safety by reducing manual errors, critical when dealing with live cell products.

The project demonstrates how the software can scale up production without increasing risks, ultimately driving down costs and increasing the supply of advanced therapies for patients.

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Adaptive self-learning robotic finishing and polishing

Led by Advanced Automation and Assembly Ltd

Advanced Automation and Assembly Ltd (A3L) and HAL Robotics developed a self-programming robotic system designed for finishing and polishing processes. Processes, such as sanding and polishing, are typically manual and can be expensive, inconsistent, and slow. The new system overcame these challenges by adapting to the size, shape, and requirements of the part being processed, offering increased productivity and efficiency.

Three key breakthroughs were generated:

1. HAL Robotics created an adaptive programming solution, allowing operators with no robotics expertise to influence robotic tasks through simple workflows
2. For complex geometries, a 3D CAD model is generated, and digital image analysis directs the robot's actions
3. A3L developed an adaptable end effector capable of handling shape variations and ensuring consistent surface finishes using sensors to adjust the toolpaths.

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Key Outputs, Outcomes and Impacts

- Boosting productivity — reprogramming existing polishing technology took up to a week but the new technology reduced this to seconds
- A plastics manufacturing test process was reduced from 10 days to just 12 hours
- The technology has been successfully applied in automotive polishing, with further applications being explored
- HAL's software is now marketed as "decode" for use in various industries, democratising robotic deployment in finishing processes.

Certified AM Parts Finished with Intelligence Robotics Engine (CAMPFIRE)

Led by Rivelin Robotics

Rivelin, in collaboration with five partners, has created a complete digital postprocessing solution for the automated finishing of flight parts, orthopaedic implants and gas turbine components produced using metal AM processes.

The project demonstrates the capabilities of netshape robots at the next level, with the potential to revolutionise tightly regulated industries (such as aerospace, healthcare and energy, as well as civil aerospace, defence and automotive) to address operational considerations such as repeatability, quality control, long lead times and high costs. The five partners include Attenborough Medical, GKN Aerospace and Materials Solutions (a Siemens Energy Business) alongside hardware providers YASKAWA EU and Saint-Gobain Abrasives.

Key Outputs, Outcomes and Impacts

- Enhanced the efficiency and quality of additive manufacturing processes by integrating advanced robotics and automation, streamlining production and reducing human error
- Promoted the development of certified additive manufacturing parts, ensuring that products meet stringent quality standards, crucial for industries such as aerospace and healthcare
- Creation of new business models and opportunities between technology providers and manufacturers
- Increased competitiveness in the manufacturing sector, driving economic growth and technological advancement.

"Users of metal AM for production are unanimous in their demand for an automated solution for support removal and finishing. Regardless of the parts and how or where they will be used, the shared pain in getting those parts from the AM machine to the point of use is prevalent and engenders collaboration to solve the issues. This is exactly what Project CAMPFIRE aims to do."

Robert Bush,
CEO, Rivelin Robotics

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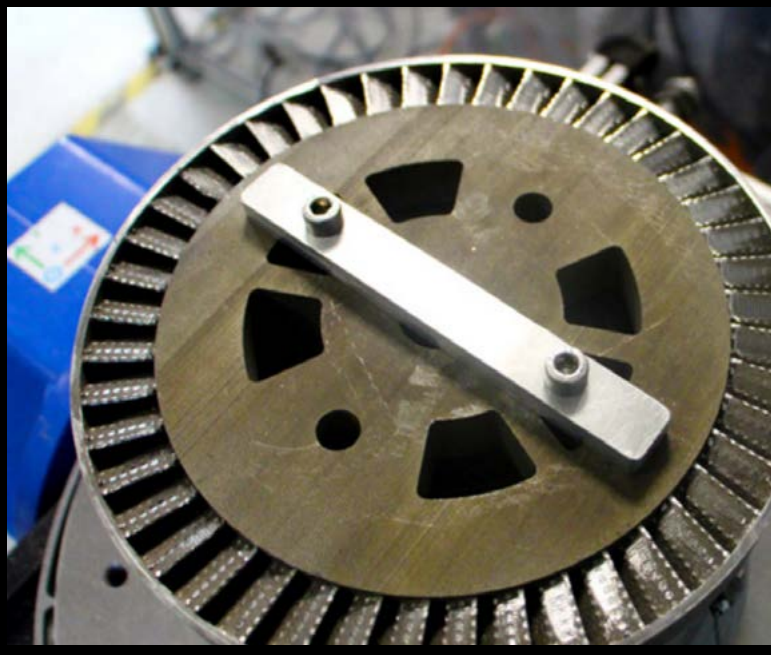

Independent Evaluation

SQW has been appointed to conduct an independent evaluation of the Made Smarter Innovation challenge against its objectives.

They are a leading independent provider of research, analysis and advice on economic and social development.

Their final report is expected to be published at the end of June 2025. This section will be updated with the final evaluation findings.

This brochure was delivered by the Made Smarter Innovation Network, a £1.5m project delivered by Innovate UK Business Connect to create an enduring and dynamic ecosystem of manufacturers and digital solution providers to help realise the benefits of industrial digital technologies.