Aerospace | Automotive | Construction | Food | Medical | Nuclear | Space | Strategic Technologies

University of Nottingham
Omnifactory Research Centre

OMNIFACTORY RESEARCH CENTRE

RESEARCH PARTNER OF CHOICE FOR AUTOMATED MANUFACTURING, ASSEMBLY AND THE DIGITAL FACTORY

OMNIFACTORY RESEARCH CENTRE IS AN INTERNATIONALLY RECOGNISED RESEARCH HUB WITH A MISSION TO CONDUCT TRANSLATIONAL INDUSTRY-FOCUSED RESEARCH IN SUSTAINABLE FUTURE MANUFACTURING ASSEMBLY SYSTEMS AND THE DIGITAL FACTORY.

CONTENT

WELCOME TO THE OMNIFACTORY RESEARCH CENTRE

The Omnifactory Research Centre is dedicated to developing the science and industrial technologies for the next generation of smart manufacturing systems. Focusing on advances in factory automation, data analytics and digital integration, we aim to redefine the manufacturing infrastructure of the future based on connected autonomous production units that can be easily repurposed, relocated and redeployed.

Originally set up in 2010 as an Airbus sponsored centre for aerospace manufacturing, the Omnifactory Research Centre has developed into an internationally leading research hub for manufacturing knowledge creation and a premier provider of new manufacturing technologies and digital factory solutions to industry.

Building on the excellent knowledge creation foundations of the University of Nottingham's Institute for Advanced Manufacturing, the Omnifactory Research Centre has grown its project portfolio and strategic partnerships with internationally leading businesses, including Airbus Operations, Airbus Helicopters, BAE Systems, GKN Aerospace, Hamble Aerostructures, Leonardo, Rolls Royce, Spirit Aerosystems and Siemens. For over 15 years, the Omnifactory Research Centre has successfully delivered numerous fundamental and applied research projects, supported by EPSRC, Innovate UK, Aerospace Technology Institute, EU H2020, CleanSky2, ERDF and direct industry funding.

The Omnifactory is unique internationally in its ability to deliver world leading manufacturing research and translate it into industrial technologies at Technology Readiness Levels 4-6. We are widely engaged within the UK and international research and innovation communities and work closely with the High Value Manufacturing Catapult and other research centres.

Officially launched in 2023 by Brian Holliday, CEO of Siemens Digital Industries UK, the Omnifactory® industrial testbed is a state-of-the-art national smart manufacturing demonstrator and a full scale experimental digital factory. Supported by leading OEMs and technology providers, it offers a proving ground for next generation smart industrial technologies, whilst utilising the latest commercially available equipment and software products. Originally funded by the UK Industrial Strategy Challenge Fund (ISCF), the Omnifactory testbed represents a step-change for the UK manufacturing sector, helping businesses to cost effectively deliver better, high-quality products in a more sustainable and secure way. This enables UK manufacturers to become more responsive, adaptable and resilient.

Building upon our heritage and experience in aerospace and defence manufacturing we also apply our expertise and capabilities across a range of other industrial sectors including automotive, construction, food and beverage, medical, nuclear and space.

The Omnifactory is a unique concept for future manufacturing, built upon the latest developments in manufacturing systems science, data analytics and digital technologies for factory integration.

Working closely with our industrial partners, we are transforming current practices and improving productivity across different sectors by developing the next generation of smart, highly agile and efficient factories, which will also support green localised manufacturing supply chains. By leveraging technologies such as the Industrial Internet of Things (IIoT), artificial intelligence (AI) and data analytics, we are dramatically accelerating the development of new products and their sustainable manufacturing in the UK, delivering significant societal, economic and environmental benefits.

Digital technologies are rapidly changing the face of manufacturing today. Omnifactory provides exciting opportunities for developing new research ideas, testing and demonstrating novel concepts, and supporting their accelerated translation into future sustainable production technologies in collaboration with our academic and industrial partners.

Manufacturing processes have a significant impact on the environment, with a large proportion of the carbon footprint of some products being created during their production and logistics. By creating a new generation of smart, highly efficient factories embedded in local supply chains, we aim to make a significant contribution to the net-zero agenda and a significant step towards the circular economy.

To deliver the highest quality applied research, we are proud to have adopted industrial best practices by introducing a PRINCE2 project management environment and a quality assurance system accredited by ISO 9001:2015.

Professor Svetan Ratchev
Director, Omnifactory Research Centre

TOWARDS FUTURE TRANSFORMABLE ASSEMBLY

INDUSTRIAL CHALLENGES

Assembly of final products is a crucial process in high labour cost regions like the UK. To address current challenges, including reducing energy consumption and waste, and a shortage of skilled workers, manufacturers need to transform capital-intensive assembly lines into smart, adaptable systems capable of responding to internal and external changes, as well as healing and reconfiguring themselves when required.

This transformation is driven by:

1. The demand for rapid scalability of production systems.
2. The lack of autonomous responsiveness in current assembly systems to disruptions and demand fluctuations.
3. Economic and societal shifts towards 'manufacturing as a service'.
4. Efficient product lifecycle management and long-term sustainability.

Future assembly systems must adapt to evolving product demands with minimal setup, low maintenance and seamless integration of new technologies. These systems will rely on data collection, self-assessment and autonomous decision-making. Rather than programming passive machines, humans and software agents will collaborate proactively, forming an adaptive manufacturing infrastructure exhibiting self-organisation and dynamic responsiveness.

As automation evolves, human operators will play new roles in hybrid decision-making, monitoring and system adaptation, fostering a seamless integration of human expertise and machine intelligence.

Changes in the international geopolitical environment have highlighted the need for competitive, sustainable manufacturing with sovereign capability to develop, produce and deploy critical technologies and products. Manufacturers face increasing pressure to achieve sustainable growth while managing product complexity, extended product lifecycles, environmental impact, supply security and competitiveness.

TECHNOLOGY OUTLOOK

Technological developments such as big data analytics, intelligent and autonomous machines and systems, smart devices and the Industrial Internet of Things (IIoT) are reshaping manufacturing enterprises and supply chains.

These innovations form the foundation of the Industry 4.0 agenda, which focuses on the vertical integration of smart production systems, horizontal integration across global value networks, through-life engineering and rapid progress by exponential technologies.

The European IoT market, valued at approximately $200 billion in 2023, is projected to reach $300–400 billion by 2028. This rapid evolution highlights the critical need for companies and nations to lead in digital transformation to avoid severe societal and economic consequences.

To secure a strong UK industrial base, it is crucial to embrace digital and intelligent manufacturing technologies, which additionally creates environmental, societal and economic benefits.

Advances in informatics and digital technologies provide a unique opportunity to build upon and redefine the 'Intelligent Manufacturing' concept traditionally characterised by adaptive, minimally supervised production processes capable of meeting diverse requirements.

Three key research challenges need to be addressed:

1. Developing scalable and adaptable smart manufacturing systems that can be seamlessly scaled and transformed to deliver radical new manufacturing methods and applications.
2. Exploiting intelligent data analytics and IIoT to achieve operational excellence within a connected manufacturing infrastructure.
3. Enabling a step change in the long-term sustainability of the UK manufacturing sector in terms of productivity, responsiveness, resource efficiency, low carbon product lifecycle management and dramatic waste reduction accelerating its transition into a low carbon sustainable industry.

AT THE OMNIFACTORY RESEARCH CENTRE WE ARE ADDRESSING AND PROVIDING REAL-WORLD SOLUTIONS TO THESE CHALLENGES.

OUR RESEARCH VISION

We are addressing key challenges in digital and intelligent manufacturing through EPSRC funded programmes focused on transformative approaches:

Evolvable Assembly
This programme developed and applied techniques for autonomous distributed decision-making, context-aware systems, multi-agent control, swarm intelligence and self-adaptation in a manufacturing context. It integrated advancements in complex networks, machine learning, distributed control and ubiquitous computing to create manufacturing systems capable of managing high levels of product and process complexity. By combining sensing, control and IT capabilities, the programme delivered adaptable, intelligent assembly systems.

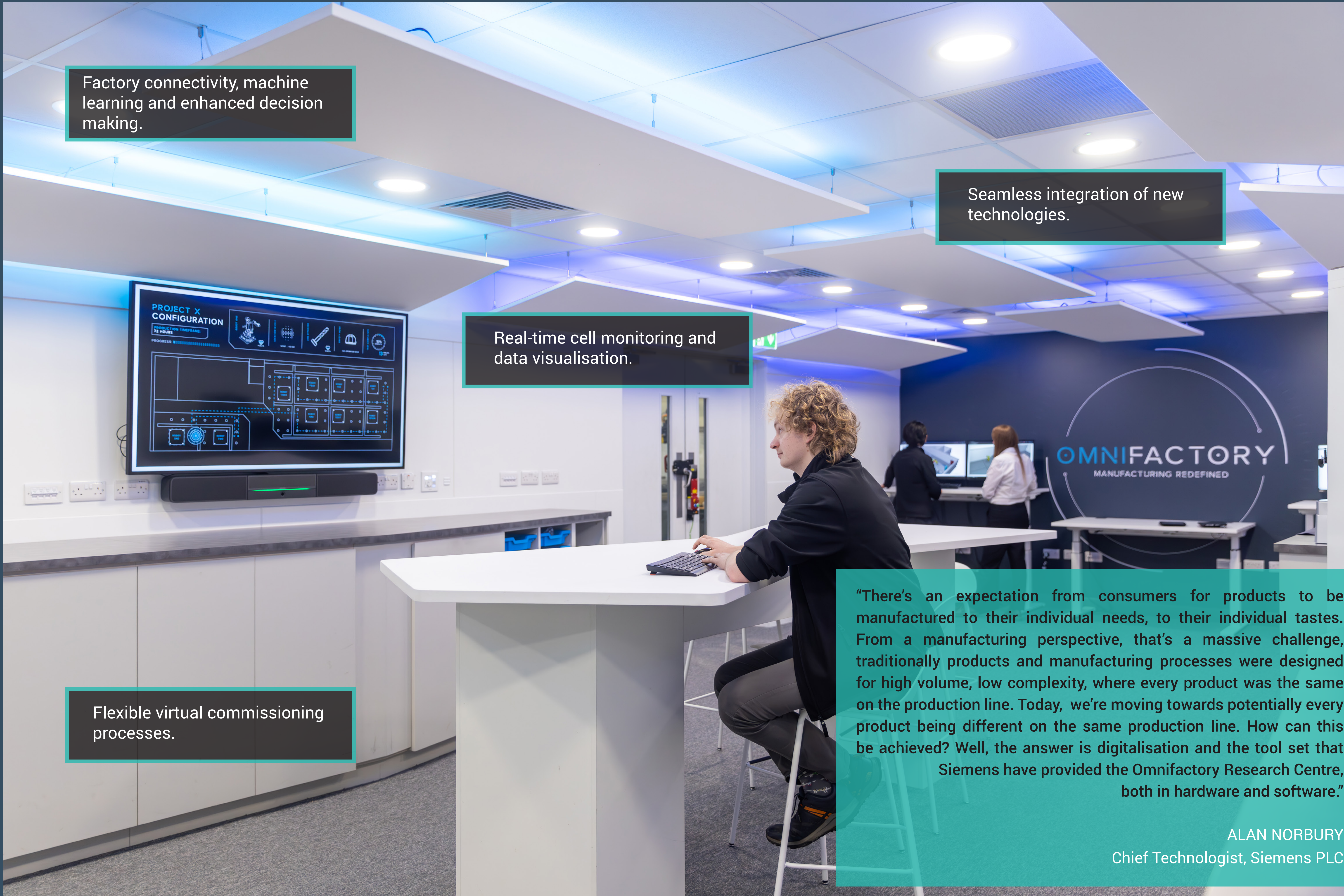
Cloud Manufacturing
This research focused on developing resilient, scalable and cost-effective manufacturing platforms by exploring the integration of production capabilities and services into a cloud-based framework. The research defines theoretical models, algorithms and architectures to enable distributed manufacturing across the entire lifecycle design, production, maintenance and recycling, facilitating knowledge-intensive and flexible manufacturing operations.

Elastic Manufacturing Systems
The work explores manufacturing as a service, driven by dynamic resource requirements and provision. Drawing from elastic computing principles, it introduces methods to scale manufacturing systems reversibly and develop highly elastic operations. Using collective decision-making, cognitive systems and context-aware networks, the approach enables cost-effective production of high-quality products across variable volumes and demand profiles.

Connected Factories
This research is helping to build a resilient and sustainable manufacturing sector, capable of adapting to dynamic supply and demand. Inspired by lessons from the Covid-19 pandemic it focuses on enabling factories to repurpose, relocate and reuse production capabilities. The project emphasises localised, greener and cost-competitive manufacturing infrastructures, capable of producing diverse and complex products quickly and efficiently. It will deliver a platform for resilient, connected manufacturing services, allowing production units to adapt dynamically to changing market demands.

These programmes collectively aim to redefine manufacturing with intelligent, adaptive and scalable systems that address modern complexities and opportunities.

DIGITALLY CONNECTED INFRASTRUCTURE



Factory connectivity, machine learning and enhanced decision making.

Seamless integration of new technologies.

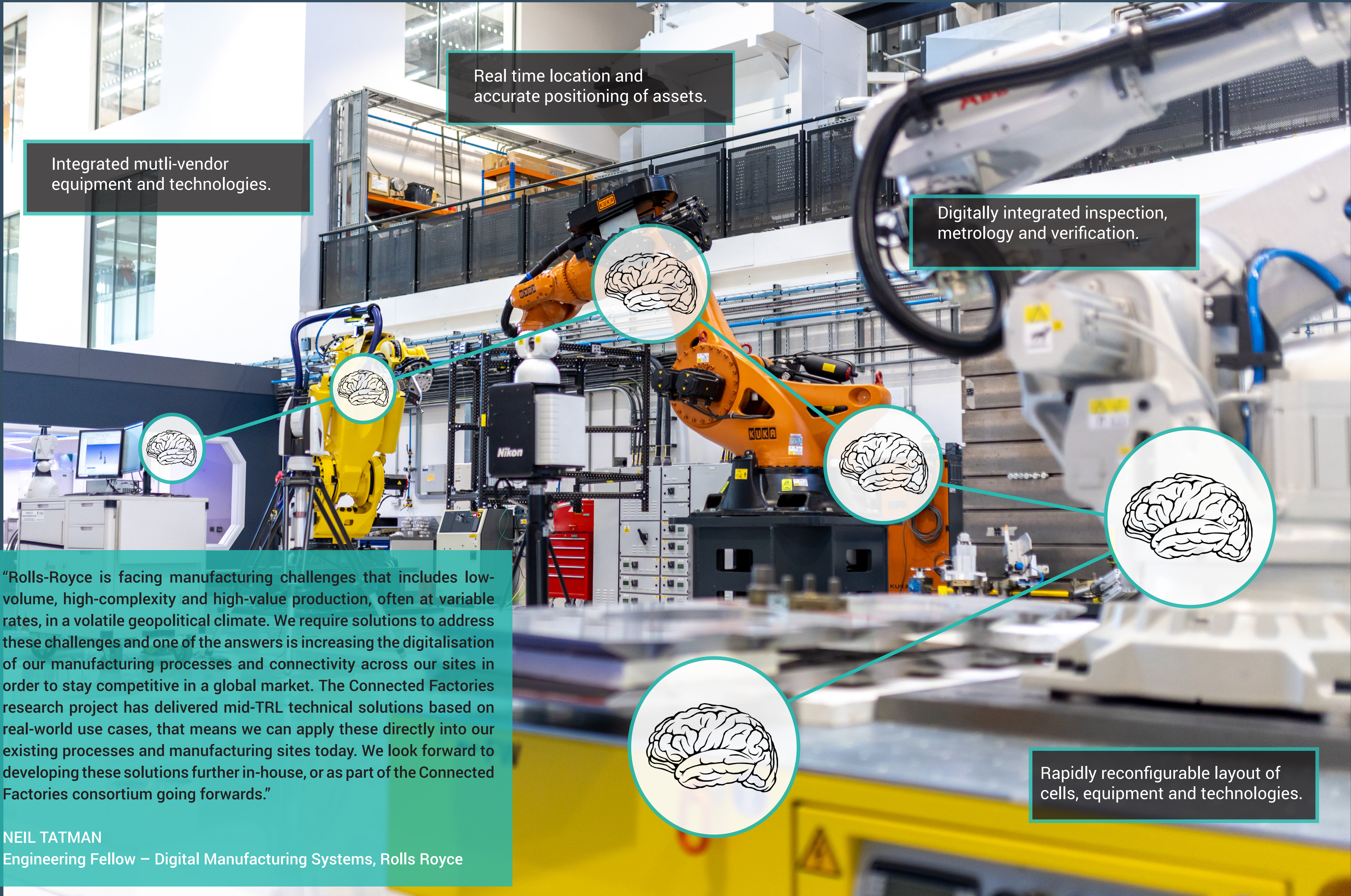
Real-time cell monitoring and data visualisation.

Flexible virtual commissioning processes.

"There's an expectation from consumers for products to be manufactured to their individual needs, to their individual tastes. From a manufacturing perspective, that's a massive challenge, traditionally products and manufacturing processes were designed for high volume, low complexity, where every product was the same on the production line. Today, we're moving towards potentially every product being different on the same production line. How can this be achieved? Well, the answer is digitalisation and the tool set that Siemens have provided the Omnifactory Research Centre, both in hardware and software."

ALAN NORBURY
Chief Technologist, Siemens PLC

FUTURE AUTOMATED AEROSPACE ASSEMBLY DEMONSTRATOR (FA3D2)



"Rolls-Royce is facing manufacturing challenges that includes low-volume, high-complexity and high-value production, often at variable rates, in a volatile geopolitical climate. We require solutions to address these challenges and one of the answers is increasing the digitalisation of our manufacturing processes and connectivity across our sites in order to stay competitive in a global market. The Connected Factories research project has delivered mid-TRL technical solutions based on real-world use cases, that means we can apply these directly into our existing processes and manufacturing sites today. We look forward to developing these solutions further in-house, or as part of the Connected Factories consortium going forwards."

NEIL TATMAN
Engineering Fellow – Digital Manufacturing Systems, Rolls Royce

NATIONAL SMART MANUFACTURING DEMONSTRATOR AND TESTBED

"Airbus has been working with the University of Nottingham Centre for Aerospace Manufacturing (CAM) for several years primarily focusing on automation and tooling developments. As one of the strategic universities for Airbus, the expansion of the CAM, now known as the Omnifactory Research Centre, to develop complete manufacturing systems is seen as a positive move forward and one that Airbus is excited to see develop further over the coming years."

DAVID RAMSAY HARRA
Head of Industrial Systems and Aircraft Co-Design, Airbus

DELIVERING SOLUTIONS TO INDUSTRY

The £24M state-of-the-art Advanced Manufacturing Building (AMB) was opened in December 2018 and serves as the flagship of a £100 million investment in manufacturing research and training at the University of Nottingham. This investment is supported by the University, research councils, industry, UK government and the European Union.

In March 2023, the multimillion Omnifactory® facility was officially launched within the AMB.

Discover	Understand	Adapt	Validate

- Manufacturing Science
- Dispruptive Technology Development
- Laboratory Trials and Tests
- Systems Integration
- Systems Integration Industrial Testbeds
- Business Case Developement
- New Production System
- Production Demonstrators

TRL 1	TRL 2	TRL 3	TRL 4	TRL 5	TRL 6

OMNIFACTORY

The Omnifactory Research Centre has the capability to deliver solutions from fundamental research through to industrial applications:

- Translating Basic Research into Industrial Applications: Building on EPSRC funded research programmes.
- Applied Research: Innovate UK, Horizon Europe, Clean Aviation.
- Clear Pathways to Industrial Applications: Working with HVM Catapult centres and key technology partners.
- Contract Research & Development: Providing bespoke solutions and products through direct industry funding.

Advanced Tooling and Fixturing		Automated Assembly Systems		Digital Factory	
End Effector Tooling and Processes	**Jigs, Fixtures and Work Cells**	**Sensing and Metrology**	**Industrial Robotics Development and Implementation**	**System Integration**	**Smart Factories**
Gripper Technology	Modular Reconfigurable and Adaptive Jigs	Rapid Design and Verification of Jigs and Fixtures	Smart Assembly Systems	Component Design for Manufacture	Factory of the Future, Digital Factory and Industry 4.0
Joining Technologies (Drilling, Sealing, Fastening)	Rapid Tooling Manufacture	Metrology Assisted Assembly (MAA)	Advanced Metrology Assisted Robotic Guidance	Digital Twin Process, CAD Simulation and Optimisation	Plug, Play, Adapt, Learn and Autonomously Control
Parts Handling	Handling Large and Flexible Components	Wireless Sensing and Part Location Via Vision Systems	Cooperating Robots, Multi-Robot Planning and Robotic Swarms	Build Stress and Tolerance Analysis, Tooling Design Stress Analysis	Resource Planning and Whole Lifecycle Analysis
Smart Fixtures and Tooling	Flexible Work Cell Design	Sensor to Cloud and Smart Sensors	Multi-Sensor Fusion Techniques	Intelligent High-Level System Architecture Development	Process Design and Process Reliability

OUR TECHNOLOGY PARTNERS

The Omnifactory Research Centre utilises the latest commercially available hardware and software, working in close collaboration with technology providers to deliver innovative digital and smart solutions for the UK manufacturing sector.

SIEMENS

Siemens provides hardware and software that enables Omnifactory to have one of the most advanced digitally connected infrastructures in a production environment.

This connected infrastructure serves as a transformative enabler, seamlessly integrating product requirements into the entire developmental life cycle while establishing a direct link to the manufacturing system.

By synchronising product design with the build of materials and processes, Omnifactory's framework enables the formulation of comprehensive models and simulations of the manufacturing workflow.

This capability not only ensures precision in planning but also supports dynamic adaptability, accommodating late-stage design modifications with remarkable efficiency.

Such modifications automatically generate updates across a spectrum of critical facets, including bills of processes and materials, models and simulations, robotic coding, workplace instructions and programmable logic controllers (PLCs) which orchestrates the operations.

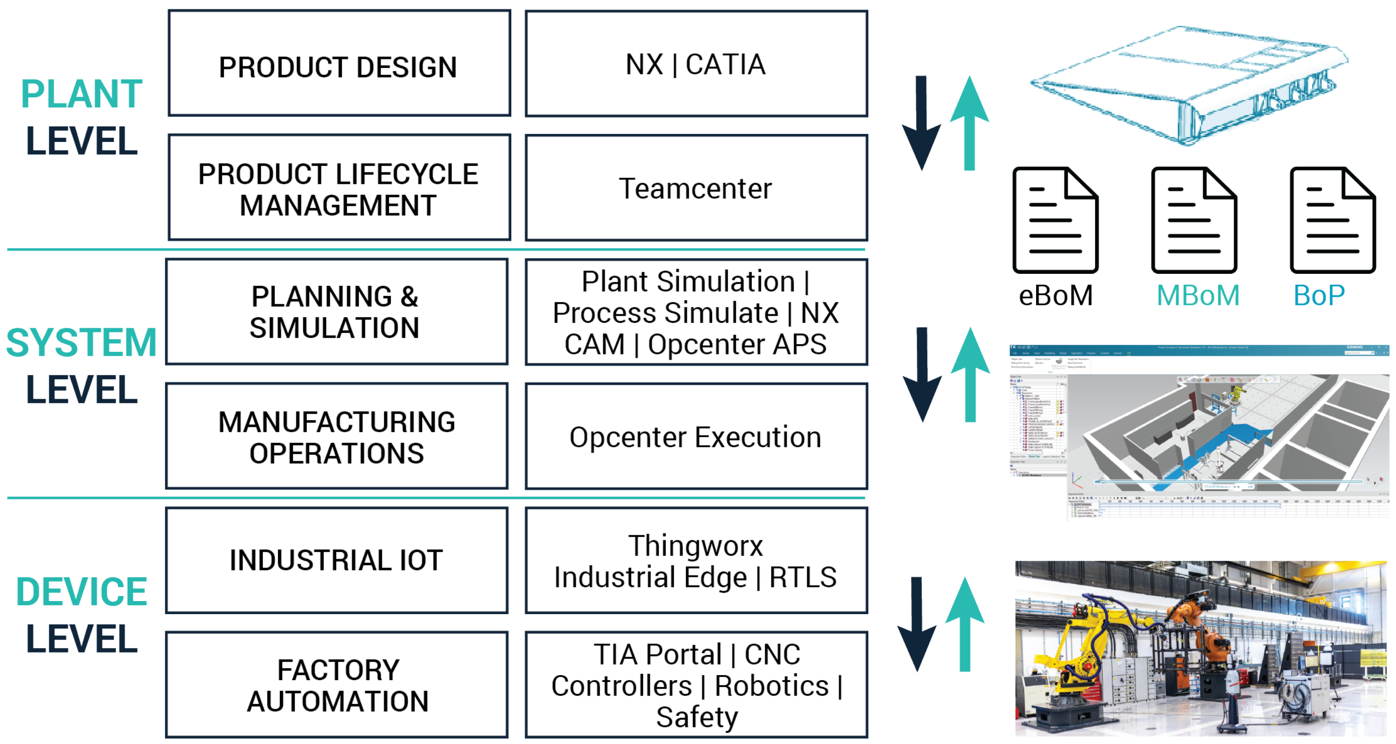
This coherent integration prevents the need of repeating tasks from the initial stages, thereby significantly improving operational efficiency and adaptability within the developmental framework.

The digital infrastructure creates a virtual manufacturing environment, known as an advanced digital twin, of the entire production process, which eliminates waste, costs of building physical systems and optimises the processes.

Virtual manufacturing and commissioning eliminate the need for physical prototypes by enabling complete system validation within a digital environment. This approach significantly reduces uncertainty around technology investments, as performance and integration are verified prior to physical deployment.

When the system is built, it functions exactly as intended because its operation has already been proven in the virtual model.

CONNECTED INFRASTRUCTURE



OUR TECHNOLOGY SOLUTIONS

Presented below are four of our technology solutions, developed through our research and application study initiatives.

Comprehensive information on all our technology solutions is available on our website.

LOW-COST METROLOGY DRIVEN ROBOT CALIBRATION

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/precision critical applications. Photogrammetry is an effective way to improve the accuracy of automated assembly in flexible production environments.

We have developed a multi-camera system 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.

The technology solution is cost-effective, scalable and adaptable in improving robot positioning accuracy in complex assembly tasks. Additionally, it enables the future development of multifunctional machine vision systems when integrating capabilities like object detection and defect identification.
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RIGID CONTOURING END EFFECTOR

We are developing a robotic machining cell to enhance our capabilities in the manufacture of representative aerospace components and allow deeper investigation into how the versatile machining equipment can be utilised in a flexible, digitally connected manufacturing environment.

The existing FANUC R-2000iC/190S heavy payload, short arm robot will be installed in a new machining cell in the Aerospace Technology Centre (ATC), University of Nottingham, geographically separate from the existing Omnifactory® facility. This will allow research into real-time monitoring, control and optimisation of equipment in disparate facilities, enabled by connecting the two factories into the same Omnifactory digital infrastructure. Options for off-line programming and integration with the digital technology stack will be investigated and tested.

The robot cell will allow trimming of aircraft panels up to 4m x 2m, and allow creation of complex mould tools. A low-cost off-the-shelf spindle will be rigidly mounted to the robot flange, with options for swarf and dust extraction to be investigated. Data will be obtained from onboard sensors, to be stored in the product DNA and enable future machine learning research opportunities.

SMART FACTORY LAYOUT OPTIMISATION

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 tradeoffs inherent in build philosophy and choice of process technology is also a significant challenge to modern industry.

We have identified, developed and demonstrated a methodology to optimise the facility utilisation and layout for a given product family, based on expected demand curves, and taking into account 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.

DIGITAL-TO-PHYSICAL TWIN ALIGNMENT METHODOLOGY

Rigid manufacturing systems are limiting investment in digital technologies due to high costs and variable volume manufacture, resulting in inefficiencies. 3D digital twin layout planning and optimisation can help manufacturers to improve production efficiency and flexibility.

Our multi-functional design space integrates robot path planning, control synthesis, design validation and metrology simulation, aligning process-level and system-level objectives. Unlike the traditional methods, 3D digital twin simulates production scenarios and estimates KPIs, allowing early error detection and shorter development cycles. These KPIs can guide machine learning models and optimisation algorithms to find the most suitable layout plan.

Combining shopfloor data and advanced analytics, our approach supports data-driven decision making for resource allocation and process planning. This technology supports the selection of optimal production systems for specific products and facilitates early identification of required changes, improving utilisation and overall cost-effectiveness. Manufacturers can better simulate production environments, accelerating time to market and volume.

OUR CASE STUDIES

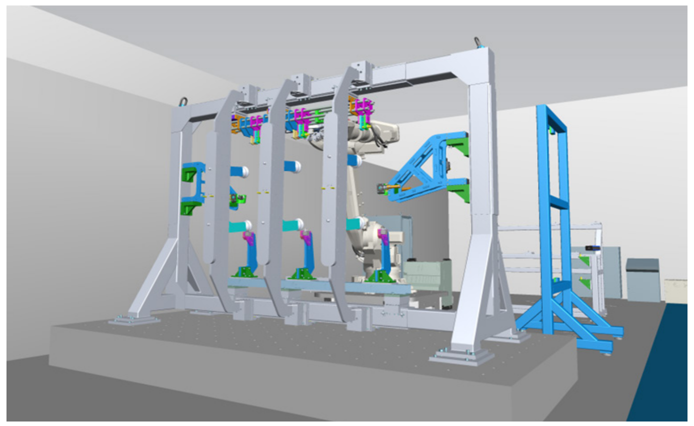
ELCAT | Enhanced Low-Cost Automation Technologies

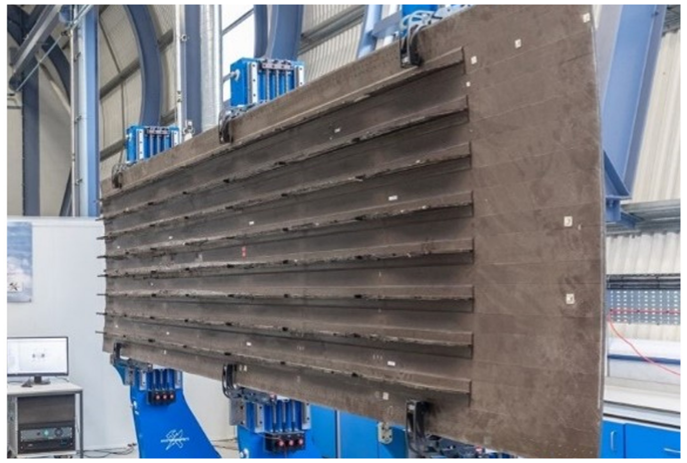
Funded by the ATI, this project set out to enable flexible manufacturing systems without the need for expensive "black box" integration. The project comprised of two parts, one virtual and one physical.

In the physical space, a rapidly and automatically reconfigurable tooling system was conceived in-house to meet aerospace assembly requirements. This solution was lower cost than existing assembly fixtures and enables the use of automated processes.

In the virtual space, a common framework architecture was developed to enable virtual commissioning and control of automated processes. The project utilises the Omnifactory physical and digital infrastructure and was demonstrated at TRL5 in the facility at Nottingham.

*"GKN and the University of Nottingham jointly developed the vision for the ELCAT project by fusing real-world industrial experience with game-changing theoretical proposals backed by academic analysis. Now the Omnifactory will allow this thinking to be taken to a point of physical reality, maturing and de-risking the associated technology threads to a level ready for development and adoption in GKN". **Andrew Portsmore, Technology Director, Assembly Systems, GKN Aerospace***





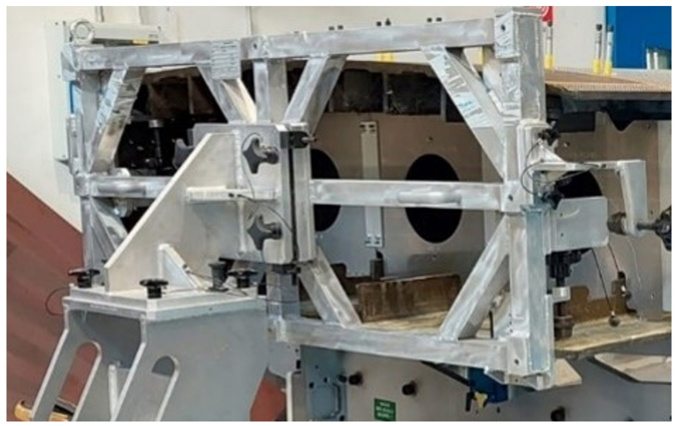
VADIS | Variance Aware Determinate Assembly Integrated System

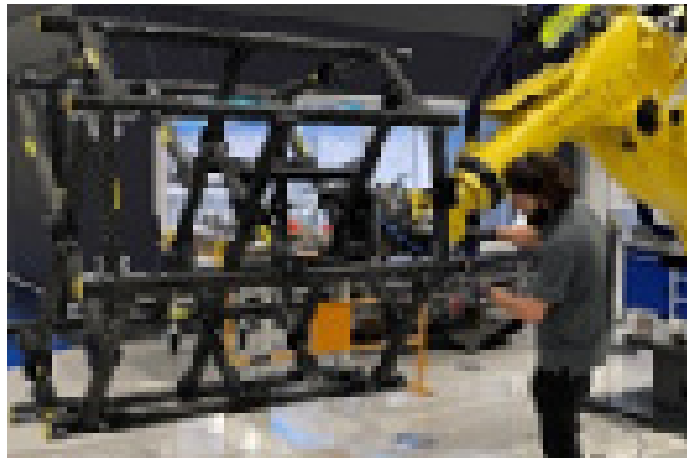
Funded by Clean Sky 2 and in partnership with Leonardo S.p.A., Electroimpact and Thyssenkrupp, the project developed advanced assembly methods for cost-effective wing manufacturing for next-generation regional aircraft, using reverse engineering, intelligent process adaptation and variability-aware tooling.

This project aimed to achieve high measurement accuracy across the full working volume, optimise part-to-part wing box assembly for next-generation wing performance, conduct geometrical tolerance analysis, and develop and validate a test cell.

Outcomes included development of an advanced metrology approach, computer-aided tolerance optimisation, inspection-assisted predictive maintenance for shimming and fettling, self-adaptive fixturing to restore skin key characteristics and adaptive model updating of the digital twin.

*"Working with the team at the University of Nottingham was critical to our demonstration and validation of novel wingbox assembly processes. Collaborating on this project combined industrial requirements from Leonardo S.p.A., ElectroImpact's automated tooling and fixturing expertise, and pioneering measurement and optimisation methods from University of Nottingham, to create a bespoke solution that otherwise would not have been possible."**Gianni Iagulli, Head of Manufacturing R&D, Leonardo S.p.A.***





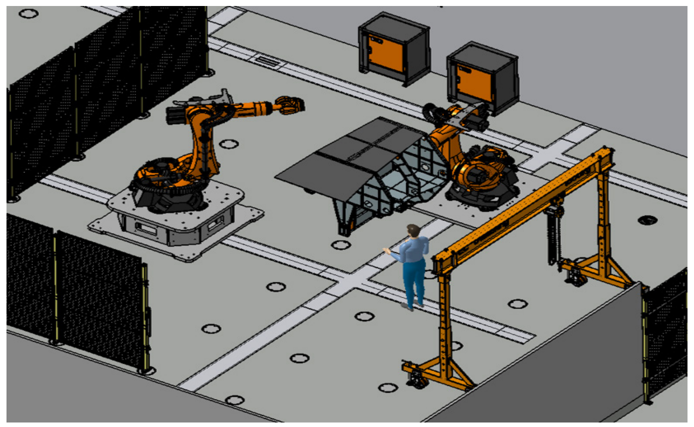
FLEXCELLE | Flexible Nacelle Manufacturing

Funded by the ATI and partnered with BAE Systems, Spirit AeroSystems, Toolroom Technology and University of Sheffield, this project demonstrated that fuselage structures can be successfully produced using measurement assisted determinate assembly (MADA) processes, and that jig-less assembly of fuselage structures is possible.

A key innovation achieved is the ability to automatically inspect large-volume, reorientable products to validate the 'as-built' condition. This has previously proven challenging and led to products being inspected in a single position, or orientation, which either increases process duration or reduces inspection capability.

The approach developed in Nottingham delivers more information, more quickly, to manufacturers of aerostructures, allowing them to make better decisions, faster, regarding the assembly of their products. Ultimately, this reduces time, cost and waste in aerospace manufacturing.

The output of the project is game-changing for employing the processes developed will dramatically reduce the non-recurring costs (NRC) and time required to bring a new aircraft product to market. Depending upon the aircraft product, the techniques developed have the potential to reduce NRC by over 50% relative to existing assembly techniques.



ASTRAL | Advanced Wing Structure for Rotorcraft Additional Lift Demonstrator

Funded by Clean Sky 2, this project oversaw the development of innovative design, manufacturing and testing solutions for the wings of the future fast compound rotorcraft. It centred on digital design and simulation methods, alongside efficient, quality-focused and cost-effective manufacturing processes, which were validated to support a world-leading rotorcraft wing.

The project delivered a bespoke wing design optimised for weight, aerodynamic drag, stiffness, stability, robustness and manufacturability. It also defined a manufacturing strategy to meet performance requirements while reducing both recurring and non-recurring costs, developed all necessary tooling, produced wing components using high-performance sustainable materials and processes, and completed the assembly and testing of the flying demonstrator wings.

*"The collaboration with the University of Nottingham has been pivotal to the digital industrial assembly and integration success of the ASTRAL Wings, Nacelles and Flaps structures. Co-development of Model-Based Engineering & Simulation techniques in the Omnifactory synthetic environment has been a fundamental advancement in our technology roadmap and improvement in our industrial footprint". **Philip Scott, Head of Design, Research & Development, Hamble Aerostructures***

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WORKING WITH US

We provide comprehensive support for your digital transformation journey.

Our advanced manufacturing expertise focuses on next generation manufacturing methods, technologies, systems and services, enabling us to deliver solutions from fundamental research to industrial applications.

Contact us for more information or to arrange a meeting with our experts.

omnifactory@nottingham.ac.uk
www.nottingham.ac.uk/omnifactory

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