CATAPULT
High Value Manufacturing

Technology capability roadmaps and innovation priorities for UK industry

A technology strategy consultation

UKRI Innovate UK · University of Sheffield AMRC · cpi · mtc where progress happens · ncc innovating for industry · NMIS National Manufacturing Institute Scotland · WMG THE UNIVERSITY OF WARWICK

To have impact on UK manufacturing and support the delivery of the government's modern industrial strategy, HVM Catapult's technology strategy must be shaped by our partners.

Scan the QR code or click here to take part in the consultation on our technology capability roadmaps and help shape the innovation priorities for UK industry.

Introduction

Prof Chris Dungey
Chief Technology Officer

The High Value Manufacturing (HVM) Catapult is transforming how we work to deliver greater impact for UK industry, aligning with national priorities and industrial needs by identifying the key technology capability development requirements.

In close collaboration with Innovate UK, research councils, academia, industry and government, we are forging a system-level partnership that can accelerate the UK's world-class science and engineering base into real-world, scaled applications where breakthrough research rapidly translates into industrial and societal benefit.

Our technology capability roadmaps are rapidly evolving into a strategic asset, clarifying our priorities, aligning with partners and shaping our future direction. Our technology strategy, accompanied by our work supporting supply chains and foresighting future skills needs, will directly support the government's modern industrial strategy and sector plans, by enabling delivery of HVM Catapult's strategic priorities.

Developed in lockstep with the Innovate UK Materials and Manufacturing Vision 2050, our forthcoming technology strategy will be informed and underpinned by our capability roadmaps.

But to truly succeed, we need your insight. This will help shape, improve and future-proof these roadmaps – ensuring they meet the demands of tomorrow's manufacturing landscape. We invite your engagement in shaping and strengthening this approach – to ensure it remains responsive to emerging challenges as a cornerstone of the UK's ambition to lead in modern advanced manufacturing on the global stage.

Delivering maximum impact for UK industry

A technology strategy is more than traditional technology planning.

It is an evidence-based framework that connects national strategy, research excellence and industrial needs with practical technological solutions.

HVM Catapult's forthcoming technology strategy will be informed by roadmaps aligned to fundamental technology capabilities. They will lay the foundation for HVM Catapult's strategic priorities in support of the government's modern industrial strategy, providing alignment with industry, government and academia to enhance productivity and drive economic growth.

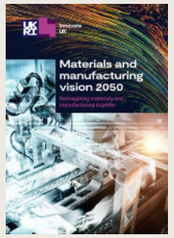
A technology strategy:

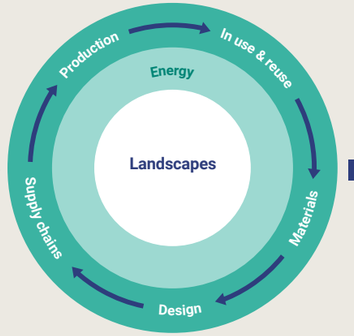
- Deepens collaboration between our centres, partners and the wider innovation ecosystem
- Presents a comprehensive view of HVM Catapult's collective capabilities
- Links HVM Catapult's technical capabilities with Innovate UK's Materials and Manufacturing Vision 2050
- Guarantees UK industry remains globally competitive with HVM Catapult helping it stay at the forefront of innovation.

With this in place, HVM Catapult can harness its unrivalled technology capabilities to solve industry's complex innovation challenges, with:

- Clear direction for technology capability development, delivery and cross-sector collaboration
- Clarity on industry priorities, gaps and investment needs
- Unprecedented insight on current capabilities and future industry requirements.

The technology strategy will be a key enabler of HVM Catapult's strategic priorities for UK manufacturing.





Our technology strategy is informed by the Innovate UK Materials and Manufacturing Vision 2050.

Six landscapes, aligned to the vision, provide the external outlook on key market trends and industry needs.

Technology capability roadmaps are informed by the landscapes and have been developed for each of HVM Catapult's fundamental technology areas.

Our technology strategy will be a technical enabler for our four strategic priorities and five landscape transformation priorities.

Our technology strategy approach

HVM Catapult is developing a comprehensive technology strategy which includes landscapes, technology capability roadmaps, innovation priorities and pathways to deliver these priorities.

Landscapes

Aligned to Innovate UK Materials and Manufacturing Vision 2050

- World class production
- Longer in use and reuse
- Materials for future economy
- Smart design
- Clean energy
- Resilient supply chains

Market pull ↓ ↑ Technology push

Technology capability roadmaps

Advanced manufacturing technologies

- Additive manufacturing
- Biomanufacturing
- Composites manufacturing
- Joining engineering
- Near net shape
- Subtractive manufacturing

Cross-cutting technologies

- Advanced materials*
- Assurance
- Digital manufacturing
- Engineering design*
- Robotics and automation

Innovation priorities

Priority pathways

*Advanced materials and engineering design roadmaps will be published at a later date.

HVM Catapult has developed six landscapes to give a comprehensive external perspective on the technology innovations required to make the greatest impact. They represent the market pull in our technology strategy, identifying key drivers to propel industry forward.

Five themes emerged from the landscape analysis:

- Sustainability and the mission to achieve net zero
- AI, data connectivity and digital readiness
- Increased productivity and process efficiency
- Through-life approaches to products and services
- Resilient and competitive supply chains.

Nine technology capability roadmaps, aligned with HVM Catapult's core strengths and competencies, were then developed in response to the market pull identified within the landscapes.

The innovation priorities have been identified from these technology capability roadmaps and the pathways to deliver on these innovation priorities will be shared during the consultation process.

These four elements constitute our technology strategy, which will establish key industrial trends, challenges driving innovation, and alignment between our core technical capabilities and the national agenda.

> **It is encouraging to see the alignment with the Innovate UK Materials and Manufacturing Vision 2050 and how by working together we can strengthen our joint messaging and positioning. This work delivers an understandable logical flow from the HVM Catapult mission and strategic priorities through to technical priorities and investments. This approach will build on the linkages between grant investment and UK strategic priorities and help build a programme fit for the future.**
>
> **Mike Biddle**
> Executive Director for Net Zero, Innovate UK

Technology capability roadmaps and innovation priorities

Advanced manufacturing technologies

- Additive manufacturing
- Biomanufacturing
- Composites manufacturing
- Joining engineering
- Near net shape
- Subtractive manufacturing

Cross-cutting technologies

- Assurance
- Digital manufacturing
- Robotics and automation

The following pages contain a summary of each capability roadmap, highlighting: the key demand drivers, industry priorities and the innovation priorities.

On each page there are links to the detailed roadmap and supporting documents.

Scan the QR code or click here to take part in the consultation.

Additive manufacturing

Scope: Manufacturing processes that join materials to make parts from 3D model data, layer upon layer.

Why: key demand drivers

- Improved designs of next-generation components with better performance and value
- Reduced cost of manufacturing through a more efficient and flexible manufacturing process
- Sustainable manufacturing through reduced material waste and energy use
- Extend component life and value across the lifecycle, e.g. through repair
- Improved supply chain resilience.

What: industry priorities for additive manufacturing capabilities

- Improved cost, rate, scale and quality of AM processing to enable economic and sustainable applications
- Digital tools that enable an effective design workflow and digital thread
- Standards and best practice guidance for manufacturing and certification of AM components
- A mature, robust and flexible UK supply chain with a capable workforce, manufacturing equipment and material.

How: HVM Catapult's innovation priorities

- Develop and apply priority AM technologies to process materials and create components to enable new applications and life extension
- Develop end-to-end process chain that integrates with the AM processes
- Demonstrate an effective design workflow and digital thread, supported by material data, process simulation and process data capture
- Support pull-through of emerging technology developments to integrate into the AM process and to exist in the supply chain
- Implement technical and commercial training programmes, including apprenticeships and upskilling of existing roles.

Follow the QR code to read the **additive manufacturing capability roadmap** and supporting documents. You can also click here.

Biomanufacturing

Scope: A process of production which uses both natural and engineered biological systems, such as microorganisms and cell cultures to produce materials across numerous sectors.

Why: key demand drivers

- Next generation therapeutics require innovative biological production methods
- Biomanufacturing processes seek optimisation for efficiency and sustainability
- Global food systems need sustainable and secure production solutions
- Industries are transitioning to sustainable biobased materials and chemicals
- Healthcare diagnostics require biomanufactured components for reliable and innovative detection and monitoring.

What: industry priorities for biomanufacturing capabilities

- Alternative and novel antimicrobials to combat resistant pathogens
- Cost-effective and environmentally sustainable biomanufacturing processes adopting digital and automation techniques
- Sustainable food and feed production systems
- Circular material systems using biological feedstocks
- Build a skilled workforce through comprehensive training platforms.

How: HVM Catapult's innovation priorities

- Develop novel biomanufacturing capabilities including new modalities, bioreactors, analytics, formulation, characterisation and access to scale-up for innovative production processes
- Leverage digital capabilities including digital twins, integrated analytics and automated process control to enhance biomanufacturing efficiency
- Support cutting-edge biomanufacturing facilities and capabilities underpinning public health and strategic priority response.

Follow the QR code to read the **biomanufacturing capability roadmap** and supporting documents. You can also **click here**.

Composites manufacturing

Scope: Advanced materials that blend different material types to achieve superior strength, reduced weight and enhanced performance.

Why: key demand drivers

- Fragile global supply chains for critical fibres used in composites
- Rapid shift to clean energy systems that demand new high-performance composite parts
- Making larger, high-quality structures more quickly – like wings and wind turbine blades – remains difficult
- Growing customer demand and legislation for recycled and circular composites.

What: industry priorities for composite capabilities

- Scalable advanced fibre production is essential to the UK's modern industry
- Automated, high-rate manufacturing for aerospace and wind sectors
- Standard ways to measure and record carbon emissions
- Qualified materials for extreme environments: cryogenic hydrogen storage and ultra-high temperatures
- Efficient, fully digitalised engineering and manufacturing workflows.

How: HVM Catapult's innovation priorities

- Scaling carbon-fibre pilot production line in the next five years
- Automated, large-scale deposition and moulding for aerostructures, propulsion and wind energy
- End-to-end composites capabilities – across design, build and test – in cryogenics and ultra-high temperatures.
- Offering mature digital design, simulation and data platforms to transform composites manufacturing.

Follow the QR code to read the **composites manufacturing capability roadmap** and supporting documents. You can also **click here**.

Joining engineering

Scope: The process of consolidating two or more materials into a more complex configuration using either a chemical, electrical, thermal or mechanical process.

Why: key demand drivers

- Advanced design practices that improve sustainability and circularity
- Through life assurance that leverages data-driven technologies
- Accessibility to skills – from technicians to engineers
- Process automation to boost productivity and reduce manufacturing costs
- Digitalisation technologies for predicting and optimising manufacturing processes.

What: industry priorities for joining capabilities

- Capabilities for dissimilar materials and recycled materials
- Advanced design practices to support end-of-life disassembly and recycling
- Advanced, automated and scalable joining technologies which improve integrity, reduce variance and enable high-throughput manufacturing of next generation products
- Robust certification, qualification and standardisation processes, to support adoption of recycled materials and end-of-life product responsibility
- 'Design for X' high-fidelity models across the product lifecycle.

How: HVM Catapult's innovation priorities

- Characterisation of joining performance in advanced, recycled and dissimilar materials
- Integrated in-process monitoring and inspection systems for enhanced manufacturing reliability and efficiency
- Integrated cost estimation, sustainability assessments and data governance for environmentally and economically sustainable joining practices
- Developing and validating advanced design and simulation techniques – including digital, predictive and lifecycle assessment models
- High-fidelity data capture, simulation and AI-assisted validation leveraging large-scale digital twin models for optimisation of joining processes.

Follow the QR code to read the **joining engineering capability roadmap** and supporting documents. You can also **click here**.

Near net shape

Scope: Advanced manufacturing processes – such as casting, forging, forming – that produce large, complex components close to final shape.

Why: key demand drivers

- Standardised, sustainable manufacturing and materials circularity practices by minimising waste, upcycling and re-use
- Increased the capacity for large-scale advanced manufacturing for aerospace, nuclear, offshore and hydrogen sectors
- Resilient UK supply chains to manufacture large, complex components for varied operating conditions
- Cost-effective, resource-efficient and carbon optimised manufacturing, through advanced tooling, design and simulation.

What: industry priorities for near net shape capabilities

- Viable methods to reconstitute critical metals into high-quality, complex components, using higher-recycled content, high-strength and longer in use materials
- Improved process control and assurance through intelligent monitoring, metrology and self-calibrating tooling
- Accelerated at-scale process development, optimisation and qualification through advanced process modelling and digitalisation
- Standards to support (re) manufacturing, enabling an increasing use of refractory and recycled materials
- Low-carbon feedstocks, electrified heating systems, energy-efficient tooling and precise digital process controls to reduce emissions and material waste.

How: HVM Catapult's innovation priorities

- The shift to hydrogen and electric furnaces enables cleaner thermal processing by replacing fossil fuel-based heating in high-temperature operations
- Advanced, localised heating technologies to improve energy efficiency and precision in forming, forging, and casting processes
- Integrated modelling, digital twins and system architecture to support real-time process optimisation and predictive control across manufacturing stages
- Scaled-up testing and prototyping capabilities to accelerate the validation of sustainable manufacturing technologies and complex component designs
- Increased automation and digitalisation to enhance production efficiency, consistency and data-driven decision-making.

Follow the QR code to read the **near net shape capability roadmap** and supporting documents. You can also **click here**.

Subtractive manufacturing

Scope: Manufacturing processes that shape parts by precisely removing material through a range of techniques such as milling and grinding.

Why: key demand drivers

- Advanced materials processing and characterisation methods for next-generation performance
- Digital transformation of manufacturing operations and process optimisation
- Modern manufacturing requires enhanced skills, standards and collaborative innovation ecosystems
- Strategic focus on emerging industrial opportunities
- Production systems shifting towards sustainable and circular manufacturing principles.

What: industry priorities for subtractive manufacturing capabilities

- Wider adoption of advanced subtractive engineering and integrated manufacturing systems
- Data-driven manufacturing and comprehensive digitalisation as standard practice
- Disruptive machining processes that continuously redefine manufacturing possibilities
- Flexible and reconfigurable manufacturing capabilities
- Next-generation materials processing capabilities for future product innovation
- Sustainable subtractive manufacturing as a core operational principle.

How: HVM Catapult's innovation priorities

- Pioneer new tools and techniques for challenging materials and integrate machinability solutions
- Connect manufacturing through digital twins, AI, and seamless data integration
- Adapt flexible systems with smart monitoring, versatile robots and human-in-loop automation
- Strengthen UK machining research base and develop skilled workforce through collaborative training
- Foster industry ecosystem via common standards and shared development partnerships
- Deploy green coolants, enhanced waste recovery and resource-efficient manufacturing.

Follow the QR code to read the **subtractive manufacturing capability roadmap** and supporting documents. You can also click here.

Assurance

Scope: Processes and practices used to provide confidence that new and existing manufactured products or systems will meet design requirements, standards, regulations and codes.

Why: key demand drivers

- Meeting compliance requirements with existing and emerging assurance routes
- Optimising the cost, time and waste of assurance activities
- Improving the traceability of assurance activities
- Embedding assurance within design activities
- Optimising assurance routes for new and existing processes.

What: industry priorities for assurance capabilities

- Data management robustness – traceable and validated
- Assurance data connectivity across the supply chain
- Democratisation and development of product and process standards
- Process maturity assessment and measurement audit
- Automated assurance decision making and closed loop decision making.

How: HVM Catapult's innovation priorities

- In-process assurance for product certification
- Build confidence in assurance data through digital thread and traceability
- Demonstrate trust in disruptive assurance methods
- Embed design for assurance principles.

Follow the QR code to read the **assurance capability roadmap** and supporting documents. You can also click here.

Digital manufacturing

Scope: The use of digital technologies to enable high-value production.

Why: key demand drivers

- Advanced, data-driven and digitalised manufacturing to improve productivity and competitiveness
- Address knowledge capture and retention challenges through digital technologies
- Maximise the value from the compliant use of data, digital threads and digital product passports
- Increase digital literacy, trust and industry-wide data sharing to drive effective digitalisation and meet rising user expectations.

What: industry priorities for digital manufacturing capabilities

- Agile, connected manufacturing through interoperable data models, digital threads and reconfigurable assets across distributed supply chains
- Integrated process optimisation linking automation, digital twins and connected enterprise systems
- AI insights: validated, ethical and transparent
- Intelligent and flexible production utilising connected supply chains
- UK-wide manufacturing digital skills framework encompassing education and professional development.

How: HVM Catapult's innovation priorities

- Development of ontologies, interoperable frameworks, digital passports and collaborative platforms to establish robust data and knowledge management
- AI-integrated modelling, simulation and process control using statistical, machine learning and advanced analytics methods for manufacturing effectiveness and validation
- Implement and demonstrate validated end-to end data-sharing platforms, visualisation and digital passports within a governance framework to ensure consistent data models and interoperability
- Demonstrators for interoperable, secure and governed data sharing platforms using adopted industry standards.

Follow the QR code to read the **digital manufacturing capability roadmap** and supporting documents. You can also click here.

Robotics and automation

Scope: The use of robotics, machines and control systems to perform previously manual tasks, improving productivity, quality and safety.

Why: key demand drivers

- Delivering mass customisation manufacturing through scalable, flexible and reconfigurable automation solutions
- Strengthened workforce skills for business continuity and long-term capability
- Maximise the value from the compliant use of data, digital threads and digital product passports.
- Resource and energy efficient manufacturing through advanced design, virtualisation and innovative materials.

What: industry priorities for automation capabilities

- Agile, intelligent, AI-powered automation systems for diverse and custom production with integrated quality control
- Data-driven manufacturing using digital twins, real-time verification and cloud platforms for smart decision-making
- User-friendly, plug-and-play systems with AI-enabled robotics to lower adoption barriers
- Training and upskilling for widespread automation adoption
- Automated design for assembly, disassembly and remanufacture to enhance reuse and productivity.

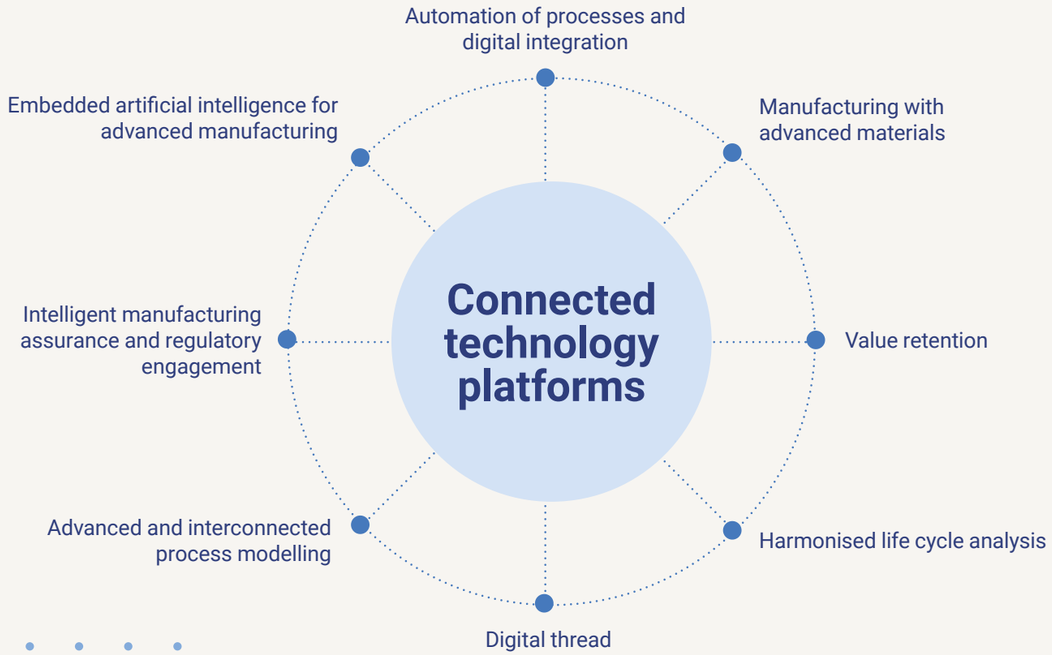
How: HVM Catapult's innovation priorities

- Modular digital platforms for data, AI, digital twins and design components
- Trustworthy, transparent autonomous systems for productivity
- Sensor-integrated automation for process control, defect detection and quality
- Easy-to-deploy, flexible automation with self-teaching robots and minimal intervention
- Flexible automation, mobile robots and dexterous grippers
- Accessible training and low-code tools for automation adoption and development.

Follow the QR code to read the **robotics and automation capability roadmap** and supporting documents. You can also click here.

Connected technology platforms

Eight connecting technology platforms have been identified, each relevant to many of our technology capability roadmaps. They highlight the need for collaborative effort across our technology domains to deliver maximum impact.



How can you help?

The HVM Catapult technology strategy will be informed by this consultation.

Throughout this document there are links to the technology capability roadmaps and we invite inputs from a broad range of UK manufacturing to shape them and the relevant innovation priorities.

Scan or click on the QR code to take part in the consultation and help shape the technology innovation priorities for UK industry.

The HVM Catapult technology strategy will be published following the consultation period.

Scan me or click here to share your feedback

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