An Action Plan for Materials 4.0

May 2026

Materials sit at the heart of the UK's industrial, scientific and security systems, from aerospace and energy to defence, life sciences, transport and clean technologies.

Global competitors are now investing heavily in data-driven materials innovation. To maintain competitiveness, the UK must accelerate adoption of Materials 4.0: the integration of high-quality materials data, AI, physics-based modelling, digital infrastructure, ontologies, and lifecycle traceability across the full materials value chain.

The UK has significant strengths - research excellence, sovereign compute investments, and national laboratories and facilities - but progress is slowed by fragmented data, low uptake, inconsistent data standards, and security and IP concerns. To deliver at a pace that meets or exceeds international progress, government must take coordinated action across the entire R&D and industrial landscape.

BACKGROUND

Last year, the Henry Royce Institute launched the National Materials Innovation Strategy. This highlighted materials science as a cutting-edge research and industrial discipline that the UK has a long history of leading. Businesses exploiting materials innovation contribute an estimated £45 billion each year to the UK economy, equivalent to 2% of the UK's total GVA.

OVERVIEW

- Materials 4.0 is the application of digital tools to the discovery, manufacturing, use and recycling of materials.
- The Henry Royce Institute is publishing a national framework for Materials 4.0 that defines its scope, value, example use cases and action plans.
- In consultation with industry and research stakeholders, Royce has identified four priority cross-sector challenges that are holding back Materials 4.0:
  - Availability of high-quality data
  - Incentivising uptake
  - Data interoperability
  - Security and governance
- It is critical to act now to retain the UK's lead in the global materials innovation sector. Actions for UK Government against key challenges are provided.

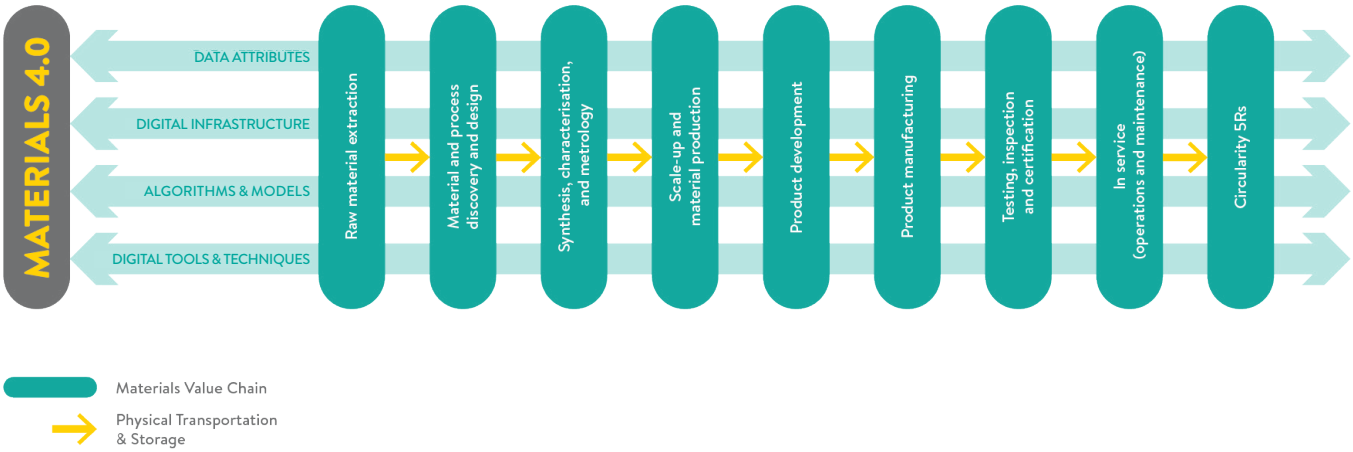
▶ READ THE FRAMEWORK

▶ READ THE INTERIM REPORT

The strategy defined Materials 4.0 as the highest priority cross-cutting theme for all opportunities in materials. Royce is now publishing a national framework for Materials 4.0, which provides a common definition of the data and digital tools that underpin materials innovation. Working with IfM Engage, Perspective Economics, Urban Foresight, and Frazer-Nash Consulting, this framework is the result of extensive review, economic modelling, and stakeholder engagement to define both the framework structure and priority actions for realising its potential in the UK.

THE MATERIALS 4.0 NATIONAL FRAMEWORK

Materials 4.0 spans the full breadth of processes that take place across a material's lifecycle to derive value. It constitutes four digital elements: data attributes, digital infrastructure, algorithms and models, and digital tools and techniques.



The framework has scoped and defined these digital elements to further the application of Materials 4.0 in a standardised manner.

THE VALUE OF MATERIALS 4.0

Innovative and strategically significant UK businesses derive substantive and growing commercial value from investment in materials data, models and digital tools. The commercial significance of Materials 4.0 is clearly conveyed in high demand for materials-related research and innovation projects, of which there were nearly 6,000 since 2005. Across the materials value chain, industry representatives reported benefits of Materials 4.0 that include:

- Faster development and time to market, through reduced testing, better use of modelling and more efficient product development.
- Lower cost and improved process efficiency, by reducing waste, avoiding failure events and improving manufacturing and testing productivity.
- Stronger safety, compliance and traceability, through better quality assurance, regulatory evidence and confidence in material provenance.
- Improved in-service performance and decision-making, by linking materials data to inspection, operational and lifecycle information.
- Higher-value circularity and recovery, through better end-of-life visibility and more informed reuse, repurposing and recycling decisions.
- Greater supply-chain resilience and market access, by supporting transparency, accountability and readiness for customer and international regulatory requirements.

These benefits contribute to a UK economy with accelerated innovation cycles, higher industrial productivity, sovereign and resilient supply chains, internationally competitive digital capabilities, and access to growing global markets in critical sectors.

MATERIALS 4.0 EXAMPLES

- Digital passports that trace the critical minerals used in batteries to effectively recover them at the end of their operating life, reducing demands on mining and extraction.
- Programmes that digitally design and test new composite material systems, without long physical trial-and-error cycles, accelerating the discovery of new structural capabilities and the components needed for our green energy sector.
- Computational modelling of the lifetime performance of steels used in nuclear components, drastically extending the durability of critical assets with reliable insight into their safe operation.

PRIORITY ACTIONS

There are pervasive barriers to the wholesale development and adoption of Materials 4.0. This framework activity has identified four priority cross-sector challenges that must be addressed through focussed, coordinated effort, stimulated by UK Government.

PRIORITY 1: Availability of High-Quality Data

Valuable materials data is often hard to find, inaccessible, poorly described, difficult to exchange between organisations, or locked in legacy systems.

UK Government must support and persuade organisations to generate, manage and share materials data in ways that are consistent, proportionate and reusable, while recognising that different materials, processes and use cases require different levels of structure and detail

PRIORITY 2: Incentivising Uptake

Investment in Materials 4.0 activity is already taking place across the UK, but capability remains uneven and siloed - adoption is still at too early a stage in many parts of the materials community.

UK Government must apply incentives and stimulate practical delivery mechanisms to help organisations adopt Materials 4.0 approaches in operational settings, building skills and overcoming cultural barriers, while coordinating effort at sector level where this can reduce future barriers to entry.

PRIORITY 3: Data Interoperability

Even where materials data exists, it is often difficult to combine, exchange or reuse because definitions, ontologies, formats and software tools are inconsistent.

UK Government must stimulate activities nationally and internationally to enable materials data, software tools and digital workflows to work in unison across global organisational and lifecycle boundaries through shared semantics, interoperable standards and federated approaches to connectivity.

PRIORITY 4: Security and Governance

Supply chain actors are protective of certain materials data that they hold. Formulations and processing histories are protectable IPR, and they do not want to share this data in systems that could expose it to competitors.

UK Government must help create enabling processes and secure collaboration environments needed for supply chain actors to confidently share their valuable materials data with partners.

NEXT STEPS

Materials 4.0 is a strategic capability for the UK, central to productivity, industrial resilience, and scientific leadership. It is critical to realising the national materials innovation strategy and maintaining the UK's leadership in the global materials sector.

The UK has the foundations to lead but requires decisive action across four priority areas.

Acting now will ensure that the Materials 4.0 national framework delivers across the entire innovation supply chain, from fundamental research to industrial deployment and circular recovery, strengthening national competitiveness for the decades ahead.