



Strategic Technology Roadmap: Advanced Manufacturing Innovation Centre – Belfast City Region

Integrated Report: Mechanical, Electrical,
Healthcare & Process Industries; Food and
Drink Processing Industries; Composites

7th October 2022



Executive summary

Purpose of this report

This report is intended as a consultation document which summarises the results of extensive consultation and written submissions, interviews and two two-day workshops involving a wide range of contributors from industry, government, and academia.

Objective

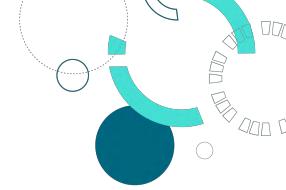
The objective of the consultation has been to develop a ten-year strategic technology roadmap, aligning the requirements of key stakeholders, for the Advanced Manufacturing Innovation Centre (AMIC) to:

- Establish key trends and drivers, manufacturing developments and associated technologies and enablers
- Identify areas for government and industry investment, particularly in AMIC as well as associated research priorities and business capability-building requirements
- Provide input to regional skills development objectives and identify other emerging corporate capability-building needs which can be owned by industry and regularly reviewed

Approach

Guided by the AMIC Steering Board a series of interviews were held with key stakeholders, following which a wide range of primarily industrial delegates were invited to submit their priorities in the field in advance of two two-day workshops designed and facilitated by the University of Cambridge Institute for Manufacturing (through IfM Engage Ltd). The two workshops used the same approaches, frameworks and input materials based on IfM Engage ecosystem mapping and roadmapping methodologies. Each workshop:

- Reviewed the collated delegate submissions
- Examined the advanced manufacturing landscape (trends and drivers; product, service and solution developments; and necessary supporting technology, capability, and enabler developments) for Northern Ireland and identified a series of priority development themes for AMIC
- Examined the relevant innovation ecosystem and potential opportunities for collaboration between industries



- Developed a series of roadmaps for identified business topics within each of the development themes, in which the priorities for AMIC were identified, together with the necessary skills and wider industry development capabilities
- Shared results amongst delegates, who provided feedback including an assessment of the scale of opportunity and feasibility for each of the topics

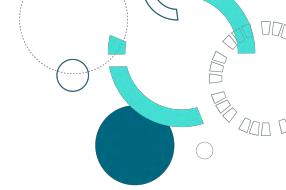
The first workshop, held at Queen's University Belfast on 12th and 13th April 2022 involved representatives of mechanical (including e.g., aerospace, automotive, materials handling), electrical, healthcare and process industries and excluding food and drink. The second workshop, held at the College of Agriculture, Food and Rural Enterprise on 30th and 31st May involved representatives from food and drink processing industries. Representatives with cross-industry interest such as information and computing, communications, automation, consultancy, and government agencies were present in both workshops.

Key findings

Across the range of industries Northern Ireland manufacturing, which is a significant part of the local economy, has a strong local competitive position, but a relatively weak global one. In general, across the sector, companies – aside from some well-known major and ‘niche’ players – hold a relatively poor knowledge of markets and competitors. The economy is dominated by a long ‘tail’ of small companies who presently have limited innovation capability and will, without considerable help and encouragement, struggle to take up new technologies and who risk falling prey to more agile international competitors.

AMIC has a potentially key role, in addition to the development of new technologies in concert with major players, in supporting the wider and extensive network of more local innovation initiatives for capability development in the tail of SMEs, and as an intelligence source and advocate for the region internationally and with policymakers. It should be clearly ‘industry led’ rather than ‘academic led’ in this activity.

Six key themes have been identified as priorities for AMIC, assessed as offering very substantial and persistent medium- to long-term improvement in Northern Ireland’s global advanced manufacturing competitiveness. The challenges associated with exploiting these themes vary as follows.



Four themes are assessed as able to be readily adopted by the supply chain or adopted with concerted efforts by government and industry, as the capability already exists:

Connected, integrated products and supply chain and business models including:

- Connected supply chain
- Sectoral leadership

Lightweight, high spec/high-performance materials including:

- Lightweight structures and components
- Manufacture and assembly of high-performance materials

Testing and simulation services including:

- Digital simulation of design, manufacturing, and installation
- Digitisation/capture of test data
- Materials evaluation and testing
- Data handling for testing and analytics services

Robotics, automation, and digital manufacturing including:

- Robotics, digital innovation, automation – strategic network
- Digital manufacturing test bed
- Supply chain digitalisation
- Intelligent automation including robotics and alternative energy vehicles

The following two themes are assessed as presenting a scale of challenge that needs significant investment at a UK ecosystem level. This offers the potential of a pioneering role for Northern Ireland.

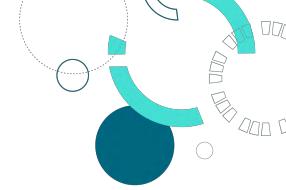
Manufacturing decarbonisation including:

- New manufacturing power sources (e.g., hydrogen/biofuel/electric)
- Circular economy
- Renewables including hydrogen

Food and drink processing including:

- Service for skills and knowledge transfer
- Lightweight sustainable packaging, processes, and components for agile, lean waste reduction
- Digital innovation support ecosystem
- Automation and digital integration with easy-to-use data analytics for decision making

The scale of the challenge in decarbonisation reflects the wider national picture in this area for what is a recognised major global issue, and the scale of challenge in food and drink processing reflects the even greater gap in innovation capability that



may exist in that sector (particularly SMEs) as described above, compared to other industries. In all cases, AMIC may offer a major opportunity, not only in exploiting technologies, but also – critically – in removing the associated gaps in industry skills and leadership capability that are the principal barriers to their exploitation.

A parallel exercise specific to composites, conducted by the National Composites Centre, has shown good alignment with the general themes and priorities identified in this study, together with further information on composites technology and capability development priorities.

Observations and recommendations

IfM Engage would make the following key observations:

- The Northern Ireland economy is dominated by SMEs who need to significantly increase their innovation capability and who may be reluctant to engage beyond a 'local' support centre
- Whilst there are notable exceptions, Northern Ireland's advanced manufacturing is seen by delegates as having a relatively weak global competitive position and low knowledge of international players and requirements
- Food and drink processing share many of the same development priorities as other industries, particularly regarding skills and knowledge transfer, digital manufacturing, and automation
- There are many regional initiatives so the innovation support landscape may be seen by some as complex and in need of effective integration
- The role of AMIC as an incubator as well as capability builder remains to be further developed
- A parallel exercise specific to composites, conducted by the National Composites Centre, has shown good alignment with the general themes and priorities identified in this study

Based on these observations, IfM Engage make the following recommendations.

As it represents the largest capability and investment, AMIC may consider acting as a **capability enhancement facilitator**, building consensus on priorities for the development of new technologies and building of innovation capability:

- Convener and direction setting
- Link to other UK and international facilities
- With a focus on mid technology readiness level, larger companies and innovation-ready SMEs
- Influencing policy development

Other local facilities may engage to provide additional capacity and capability in a range of areas including:

- Skills delivery
- 'Incubation'



- Engagement and signposting
- With a focus on high technology readiness level and smaller companies

AMIC should take an integrated approach across industries (including food and drink), particularly as regards skills and knowledge sharing, digital manufacturing, and automation, recognising particularly the need to ensure support to smaller companies.

In addition to leading on the development of capability, AMIC can have an important role both in promoting the industries' strengths in export markets and in improving local understanding of the global competitive position and priorities.

Immediate actions

Accelerate the delivery phase of AMIC, as per the approved plan.

Confirm capability development requirements:

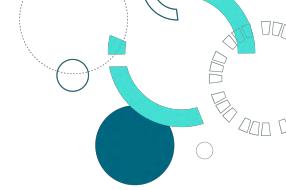
1. Map existing capabilities and associated supply chain
2. Confirm capability needs and make appropriate links to existing facilities (e.g., High Value Manufacturing Catapult)
3. Build the AMIC 'horizon scanning' capability for emerging technology trends

Implement early projects:

1. Respond to regional circular economy consultations
2. Develop a digital manufacturing testbed workshop and environment
3. Scope requirements for increased 'digital twin' capability

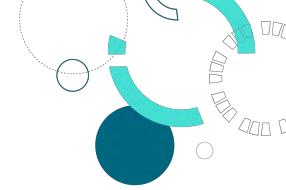
Next steps

This document is issued for consultation and review and as input to a formal publication by AMIC in support of the launch event in the autumn of 2022.



Glossary of acronyms

AEV	alternative energy vehicle
AI	artificial intelligence
AM	advanced manufacturing
AMRC	Advanced Manufacturing Research Centre
AR	augmented reality
CoE	centre of excellence
DFA	design for assembly
DFM	design for manufacturing
DFP	design for production
DTC	doctoral training centre
FoF	Factory of the Future
FST	flame, smoke and toxicity
FWCI	field-weighted citation impact
HVMC	High Value Manufacturing Catapult
IoT	Internet of Things
IP	intellectual property
KPI	key performance indicator
MaaS	Mobility as a Service
MTC	Manufacturing Technology Centre
NIACE	Northern Ireland Advanced Composites and Engineering Centre
NITC	Northern Ireland Technology Centre
OEM	original equipment manufacturer
PPRC	Polymers Processing Research Centre
QC	quality control
SHM	structural health monitoring
SIM	security information management
SME	small and medium-sized enterprises
TRL	technology readiness level
VR	virtual reality



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1. Introduction and objectives

1.1 Context

Funding has recently been approved for investment in a new Advanced Manufacturing Innovation Centre (AMIC) in Northern Ireland is aimed at securing Northern Ireland's manufacturing future and will be a springboard for manufacturing innovation in the province. The centre will operate at the interface between academia and industry, creating new opportunities for innovative manufacturing in the Belfast City Region. The involvement of both Queen's University Belfast and Ulster University will ensure that real-world industrial challenges based on market need are solved through cutting-edge research. AMIC builds on 50 years of sustained innovation and industry support through the Northern Ireland Technology Centre (NITC), the Polymers Processing Research Centre (PPRC) and the more recent university-industry partnership, NI Advanced Composites and Engineering (NIACE), and will consolidate and enhance these existing facilities.

A state-of-the-art 'Factory of the Future' is planned as the flagship facility of the project, with an ambition to be Northern Ireland's national centre for advanced manufacturing. This will provide companies with unprecedented access to the latest manufacturing technologies, as well as facilitating professional engineers with expertise in design and simulation. AMIC will be industry-driven and be accessible to manufacturers across Northern Ireland and beyond. It will develop technological capabilities to address industrial requirements, leveraging and enhancing existing infrastructure. Companies will be able to use the Factory of the Future (FoF) to experiment with new process flows and materials before implementing these in their factories. It will also allow start-ups to prototype ideas before financially committing to the installation of high-end equipment themselves.

There will also be tailored business support, which will include specialist guidance and advice on how to use these new and emerging technologies and enable industry experimentation with new advanced manufacturing processes together with support for skills development.

The development of AMIC to deliver this work will be done with full reference to the Northern Ireland 'Decade of Innovation' economic vision document¹, which sets out five steps to developing interventions to deliver the vision, shown in figure 1.

¹ See <https://www.economy-ni.gov.uk/sites/default/files/publications/economy/10x-economy-ni-decadeinnovation.pdf>

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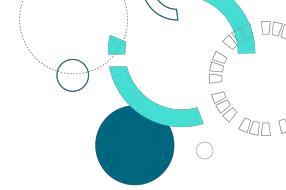
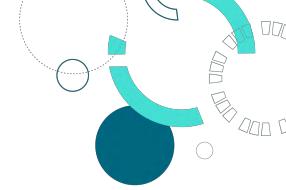


Figure 1: 'Five steps to developing interventions to deliver our vision': 10X Economy - an economic vision for a decade of innovation (2021).

AMIC has made an initial study of Northern Ireland industry sectors, covering industrial and academic strengths, relevant technologies, and areas of application. These are summarised in figure 2.

Northern Ireland Industry Sectors	Industrial Strengths	Academic Strengths	AMIC Technologies and Areas of Application					
			Digital & Automation I4.0 (with cybersecurity) FOF	Polymer Processing FOF/NIACE	Composites Manufacture NIACE	Selected Manuf Processes for Metals & Assembly FOF	Precision and Clean Room Processes FOF	HV Design DFM/DFA Model / Verification FOF/NIACE
Polymers and Composites	99 companies - 79 polymers and 30 composites comp. (with 10 overlap) With companies from ADS and Artemis Tech.	44+ academics CoE in Thermoplastic Polymers and their Composites CoE in Advanced Preforming Tech (FWCI 3.0 – 3.2)	Modelling & Simulation, Data Sensors & Automation	Process & Materials Development	Process & Materials Development	Moulds, Dies and Tools Assembly Integration and Test	-	Product and Process Modelling
Materials Handling	100+ companies £1.7bn+ turnover (Terex, Hyster-Yale CDE, Mallaghan)	General Engineering, Materials, Composites (FWCI 2.0 – 3.0)	Modelling & Simulation, Data Sensors & Automation	-	Lightweighting	Machining, Assembly Robotics	-	Rapid Product Design and Differentiation, Electrification
Aerospace Defence and Space	127 companies (composites, stress tooling, seating, precision, forming) £1.9bn 6 Primes, 2 Tier2, plus Space Apps Catapult	PKM Machining, Comput. Modelling, Tooling, Metrology, Digital Manuf with Cybersecurity Composites (FWCI 2.0 – 3.2)	Computational Modelling & Simulation, Data & Analytics, Sensors & Automation	Niche Applications (no-structural parts)	Composites For a range of ADS Applications	Machining PKM Machining, Jigs and Tools Assembly Integration and Test	DISC Project (Space Applications Catapult) Spacecraft assembly integration & test	Product, Process and Factory Modelling Computational Modelling Electrification Concepts
Photonics	Seagate (1,400 staff), Andor, Yelo, Raptor	Centre for Nanostructured Media + DTC	Modelling & Simulation, Data Sensors & Automation	-	-	Custom Factory Automation	Seagate Strength in Places bid Pilot Processes	Niche areas of Design in Photonics
Advanced Construction	Graham Construction, McAvoy, and SMEs	Civil Engineering Mechanical Eng.	Simulation, Data, Automation	Niche Applications	Lightweighting	Modular Building Elements, Assembly	-	DFM/DFA of modular elements
Transport and Automotive	Artemis, Sensata, Wrightbus, and Supply Chains	Mechanical Engineering	Modelling & Simulation, Data Sensors & Automation	Process & Materials Development	Lightweighting, Artemis Strength in Places Programme	Machining, Assembly	-	Electrification and Process Development Artemis Design
Pharma & Bio-Tech FMCG (COVID-19 REFOCUS)	Pharma & Biotech 31 companies in NI plus companies in UK and ROI	Pharmacy, Sustainability, Automation, Polymer Processing	Digital Manufacturing Accelerator	Packaging and Rapid New Process Industrialisation via Digital Accelerator	-	Processes for Packaging and Automation	-	Product packaging And DFM, DFA
Food & Drink (Phase 2 focus)	Phase 2 focus bco.		Simulation Data, Automation-	Packaging	-	Custom Factory Automation-	-	Niche areas -

Figure 2: AMIC study of Northern Ireland industry sectors.



AMIC subsequently engaged a team from the University of Cambridge's IfM Engage to assist in the process of refining this view and developing a strategic technology roadmap: a picture of the key steps required to achieve the goals of the centre and associated technology and equipment investments. The roadmap development process needed to be designed as a collaborative endeavour, with extensive engagement of industry and academic partners.

1.2 Project objectives

Project objectives were defined as follows:

To support the AMIC in the development of a ten-year strategic technology roadmap, aligning the requirements of key stakeholders in:

1. Establishing key trends and drivers, manufacturing developments and associated technologies and enablers
2. Identifying areas for government and industry investment, particularly in the AMIC as well as associated research priorities and business capability-building requirements.
3. Providing input to regional skills development objectives and identifying other corporate capability-building needs which may emerge

1.3 Report structure

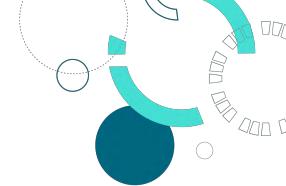
Following this introduction, [section 2](#) gives details of the approach used. [Section 3](#) presents a summary view of outputs. The subsequent sections discuss: the roadmap update for composites ([section 4](#)); conclusions ([section 5](#)); and recommendations and action summary ([section 6](#)).

The report has two appendices:

- [Appendix \(1\)](#): Participating organisations
- [Appendix \(2\)](#): Workshop delegate feedback

Four annexes, in PowerPoint form, are available on request:

- Annex (1): Workshop process
- Annex (2): Detailed roadmapping outputs – mechanical, electrical, healthcare and process industries
- Annex (3): Detailed roadmapping outputs – food and drink processing
- Annex (4): Outputs – NCC composites study



2. Approach

2.1 Overview

Two separate processes were run, using the same methodologies, terminologies, and frameworks but for separate industrial groups, integrated into a single report. Separate process and output reports are available on request:

- Mechanical, electrical, healthcare and process industries (excluding food and drink)
- Food and drink processing industries

Representatives of cross-cutting industries such as automation, consultancy services and government agencies were present in both processes. The processes used IfM's roadmapping and ecosystem mapping methodologies and was designed to provide a rationale for the technology and capability building priorities identified. It included the following key steps:

1. Planning, preparation, taxonomy design and innovation ecosystem mapping with the AMIC steering group
2. Recruitment by AMIC of 110 participant inputs (pre-statements, workshop attendance and stakeholder interviewees – note that some contributed to more than one input)
3. Delegate briefing, delegate pre-work and selected interviews with stakeholders (delivered remotely)
4. Collation of delegate pre-work and interview findings into a 'straw man' landscape
5. A face-to-face two-day workshop to refine landscape, identify key themes, develop roadmaps, and identify recommendations:
 - Day one: landscape finalisations, with four parallel workgroups in sector clusters each developing the landscape for their cluster
 - Overnight identification by the project team of key themes for development on day two, further divided into candidate roadmap topics
 - Day two: key theme development in which parallel workgroups further develop key theme ecosystems and develop topic roadmaps. Plenary output review, including opportunity and feasibility assessment and recommendations
6. Reporting to steering group and preparation and dissemination of the final report
 - This process, as summarised for workshop delegates is illustrated in figure 3.

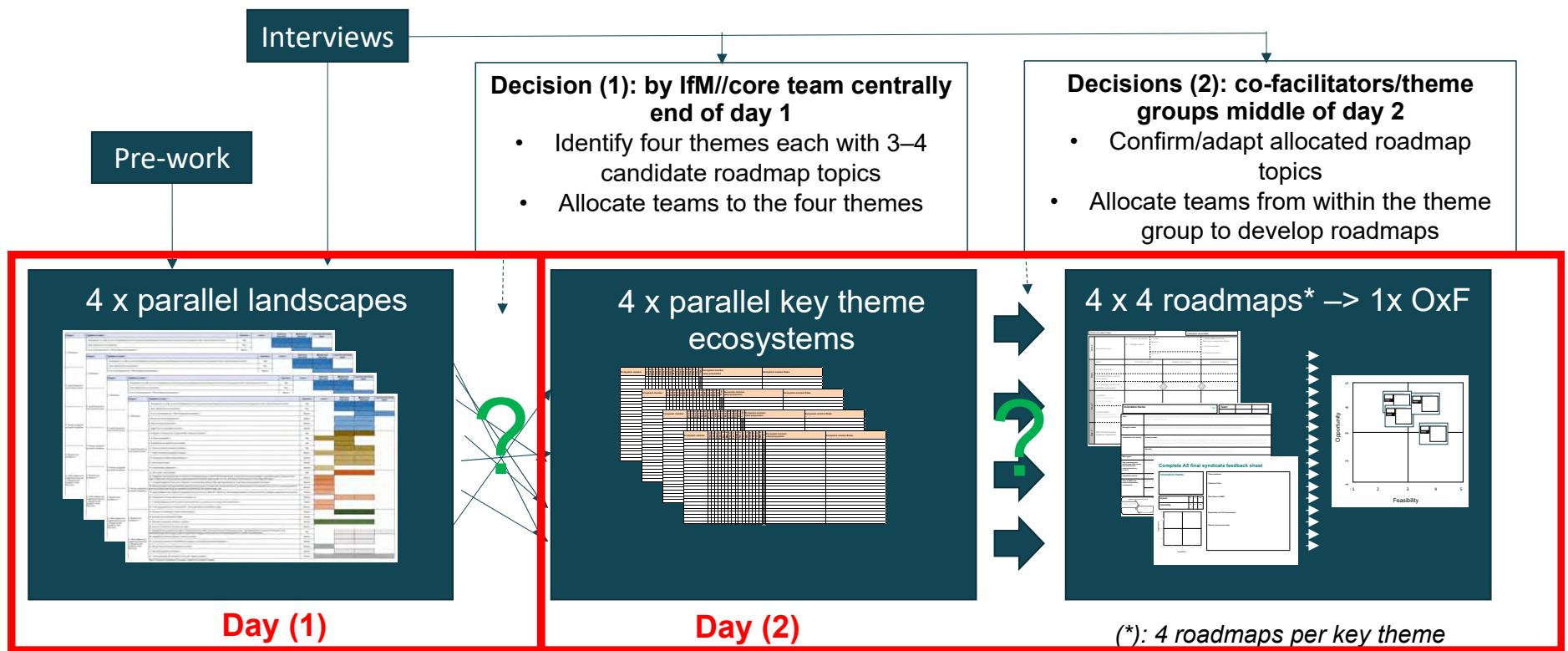
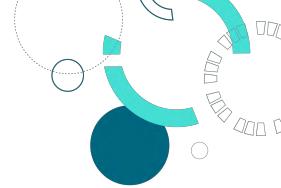
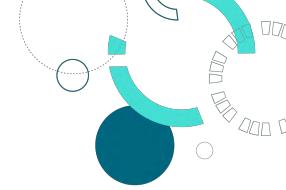


Figure 3: Illustration of process to achieve workshop outputs (Strategic technology roadmap development, AMIC – Belfast City Region).

An introduction to the methodology used is given below. More detail is available in annex 1, Workshop Process.



2.2 'Landscape' and key theme development

Delegate pre-work and stakeholder interviews were integrated by IfM Engage into a common 'straw man' landscape for input to each workshop. In IfM's approach the landscape creates three layers:

- **Trends and drivers:** global themes, strategic goals and market and needs which determine the key future developments required (tailored for the needs of the collaboration, particularly as regards the identification of appropriately segmented market/stakeholder requirements, opportunities and threats)
- **Products, services, and solutions (value creation opportunities):** key innovation opportunity areas which respond to the trends and drivers to create value
- **Technologies, capabilities, and enablers:** the key technologies, business and innovation ecosystem developments that will support the creation of new value

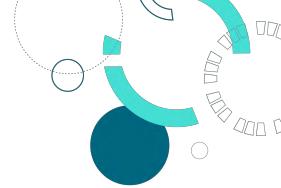
Figure 4 gives examples from each of these layers in the context of this project:

Today →	
Trends and drivers	Global and regional trends drivers market and business needs national and regional strategy international and national competition
AT products services and solutions	systems and services products materials, other value chain contribution including professional services
Technologies capabilities and enablers	Technology, systems integration incl. new business models supply chain people, systems and processes research and development incl. role of AMIC enablers e.g.: policy legal finance insurance standards and regulation

Figure 4: Landscape component illustration for workshop Strategic technology roadmap development, AMIC – Belfast City Region.

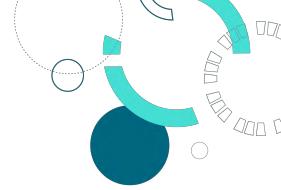
The layers in the landscape are considered sequentially and in relation to the previous layer. They are then aggregated to identify linkages and clusters and hence possible priorities for further development.

Figure 5 illustrates integrated landscaping outputs, showing the straw man landscape developed by this project. Note: depth of colour reflects the incidence of themes found in delegate pre-work and interviews: the deeper the colour the higher the incidence. Items in red font are based on the food and drink processing workshop outputs only.



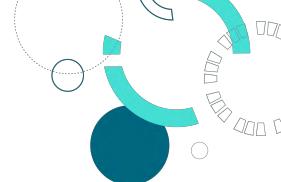
1. Trends and drivers

Layer	Element	Current	ST (2022 - 2024)	MT (2025 - 2027)	LT (2027 - 2032)
1. Social	Growing skills shortages driving up labour costs	Green	Green		
2. Technical	Digitalisation, automation and analytic technologies available and powerful		Green	Green	
	Supply chain shocks and need for resilience		Green	Green	
3. Economic	Onshoring and reshoring		Green	Green	
	High cost of energy		Green	Green	
4. Environmental	Net Zero targets, circular economy and rising materials costs	Green	Dark Green	Dark Green	Dark Green
5. Political	Development of regional capability		Green	Green	
	Unique political and economic position of Northern Ireland		Green	Green	
	Digitalisation, automation and analytics drive manufacturing supply chain improvement	Green	Green	Green	Green
	'Digital economy' drives creation of 'new' previously unseen products, services and processes	Green			
	Hydrogen as a fuel		Green	Green	
	Lightweighting, particularly of vehicles	Green	Green		
7. Market	Design excellence and manufacturing efficiency		Green	Green	Green
	Growth in aerospace		Green	Green	Green
	Electrification		Green	Green	
	Consumer interest in nutrition and plant-based foods		Green	Green	
	Wellbeing, diagnostics and health monitoring	Green	Green		



2. Products, services, and solutions

Element	Current	ST (2022 - 2024)	MT (2025 - 2027)	LT (2027 - 2032)
Theme 1. Connected, integrated products and new business models				
•Lightweight structures and components				
•High performance materials				
•High spec components				
•Connected, integrated products				
Theme 2. Manufacturing decarbonisation				
•New manufacturing power sources (e.g.: hydrogen/biofuel/electric)				
•Carbon capture and use				
•Renewables incl. Hydrogen				
Theme 3. Testing and simulation services				
•Digital integration, test, demonstration and operation services (including sensor and other automation elements integration)				
•Provision of neutral advice on Industry 4.0				
•Digital simulation of design/manufacturing				
•Data handling and analytics services				
Theme 4. Robotics, automation and digital manufacturing				
•Robots, cobots and autonomous systems				
•Consultancy and training in advanced manufacturing and digitisation				
•Data handling and analytics services				
Additional theme candidates: Manufacturing services				
•Sectoral leadership				
Theme 5. Food and drink manufacturing				
Skills and consultancy				
Packaging recycling processes				
Robotics, automation and digital manufacturing				
Digital data and information and simulation services				



3. Technologies, capabilities, and enablers

Layer	Element	Current	ST (2022 - 2024)	MT (2025 - 2027)	LT (2027 - 2032)
Product technology	Lightweight structures, composites and topology optimization				
	New sustainable inc. recyclable packaging technologies				
	Energy efficiency				
	Waste/recycling technology				
	Electrification: fuel cells				
Production technology	Energy storage				
	Automation, advanced robotics, cobotics, exo-skeletons				
	End-to-end manufacturing systems integration				
	Automated, high-rate polymer manufacture (including polymer composites)				
Enabling Digital technology	Digital systems integration, IoT and interoperability				
	I4.0 technology production and trials				
Other enabling technology	Carbon lifecycle analysis				
	Simulation and certification				
Materials technology	Circular materials				
	Advanced materials and additive manufacturing				
People, Processes and Organisation	Strategic skills and workforce plan to address skills deficit				
	New enterprise models (MaaS)				
Research and academia	R&D access to equipment, incentives and funding				
Funding, partnering	Partnering for accelerated innovation (AMIC + others)				
	Enabling policy, funding and legal support: Leveling Up				

Figure 5: Presentation of straw man landscape. Key: Red font items relate to food and drink processing sector workshop only. Depth of bar colour reflects the importance of themes across the exercise: the deeper the colour the higher the priority ascribed.



On day 1 of the workshop, delegates were grouped into work groups with common interests in advanced manufacturing innovation. The groups then separately explored and further developed the straw man landscape for advanced manufacturing, fine-tuning, and prioritising the output to tailor to their specific view.

2.3 Identification of the key themes

Outputs from the groups were gathered (annex 1 presents the process) to form a first-pass identification of key messages from the landscape. The project team then met at the end of day 1 to finalise the key themes to emerge from the parallel landscapes, for development on day 2. IfM Engage and AMIC team members examined the output from day 1 and confirmed a set of topics to be further worked in day 2. These were prioritised for their high potential interest and value for the region. In principle, themes could be cross-sector or sector-specific manufacturing development fields: the final mix would depend on the messages emerging from day 1.

Key theme development on day 2 saw the groups separately review their allocated key theme area². The groups were tasked with the following outline agenda:

- Refinement and prioritisation of the pre-prepared first-pass innovation ecosystem³, drawing out and/or adding those aspects relevant to the field and identification of potential innovation areas within the field
- Prioritisation and identified innovation fields for further development
- Development in small groups of 3–4 group members between one and four high-level roadmaps outlining the vision for the potential innovation field
- A collective review of small group outputs, including the initial establishment of the scale of opportunity and feasibility for each

Figure 6, which shows the workshop programme as introduced to delegates, summarises the above steps.

² The groups were remixed from day 1. Day 2 groups were organised by interest and expertise expressed at the end of day 1.

³ Having used the landscaping methodology on day one to establish a broad picture and identify a set of key themes, ecosystem mapping was employed to help explore the players potentially involved in the theme and how collaboration between them might generate new value.



Workshop agenda

Day (1)	Day (2)
<ul style="list-style-type: none">• Introductions, background, objective, and agenda• Summary of delegate pre-work• Exploration of the Northern Ireland Advanced Manufacturing landscape• First pass identification of key messages from the landscape• Outline of day (2)• Close <p>Delegate Dinner</p>	<ul style="list-style-type: none">• Recap from Day (1)• Review of innovation ecosystem and confirmation of topics for roadmap development• Development of topic roadmaps• Topic roadmaps review• Next steps• Close

12th – 13th April 2022: Mechanical, Electrical, Healthcare and Process Industries
30th – 31st May 2022: Food and Drink Processing industries

Figure 6: Workshop agenda: Strategic technology roadmap development, AMIC – Belfast City Region

The next section presents key outputs from each stage of the process.



3. Main outputs

This section summarises the main messages from stakeholder interviews (pre-workshop) and headline outputs from the workshop delegate groupwork. In both cases, the innovation landscape is explored first, to identify the potential implications for AMIC's role s and priorities.

3.1 Key messages from stakeholder interviews

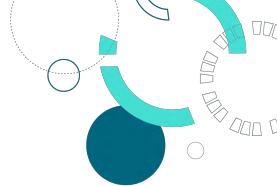
Ten interviews conducted with industrial sector and government representatives to inform the straw man landscape explored the competitive position of advanced manufacturing in different sectors of the Northern Ireland. Based on their assessments, interviewees discussed the roles and focus areas AMIC should adopt. The collated views of interviewees are reflected below.

Competitive position of Northern Ireland advanced manufacturing

Northern Ireland has world-leading mechanical, electrical, healthcare and process companies in multiple sectors; for example, materials handling, aerospace, and life sciences, and indeed offers unique selling points in nanotechnology/photonics, digital/cyber and composites. Food and drink processing has strong product quality and niche brands, together with growing willingness to innovate, but low productivity and competitiveness and historical reliance on immigrant labour, and low levels of administrative automation, with larger firms typically in low margin, commodity markets. At the same time, there is a significant competitive threat to supply chains. Manufacturing in Northern Ireland is dominated by small and medium-sized companies (SMEs), many of whom lack innovation capability. Northern Ireland's strengths include the following:

- The Strength in Places fund investment for the Smart Nano NI Consortium⁴ is boosting USPs in nanotechnology/photonics
- The digital/data/cyber and composites sectors are potentially world leading
- Aerospace is dominated by a small number of very large companies who are important exporters. These are supported by a strong network of SMEs. 30% of all aircraft interiors are produced in Northern Ireland.
- A significant materials handling sub-sector serving, for example, mining and earth moving for construction.
- Very high-tech satellite equipment is produced. Currently, however, it is inadequately promoted
- The energy and power sector consists mostly of SMEs. Despite the lack of large companies in this sector, the relatively small players are increasingly focused on international markets

⁴ See <http://www.discover.ukri.org/strength-in-places-fund/#group-section-Northern-Ireland-4amZ82sk0G>



- Large companies drive the important agricultural machinery and materials handling industries. 80% of their output is exported
- Life sciences in Northern Ireland is, in great part, composed of large manufacturing players and 90% export driven
- Pressure vessels have the potential to be world leading
- The green economy, an emerging sector, is growing and has a promising supply chain
- Other areas of note include medical devices and maritime

Knowledge of players and market in advanced manufacturing

There is a disparity between the approach of international companies to global markets and that of SMEs. International players have good knowledge of global markets, but many smaller companies are much less knowledgeable and rather uncertain; possibly, some lack ambition in this respect. NI food and drink processing industries are competing against much larger, for example US and New Zealand competitors – good market and customer knowledge are essential; however, there is no marketing body to help identify where the target markets of the future are.

Figure 7 summarises IfM Engage's initial mapping of the competitive position of Northern Ireland advanced manufacturing based on stakeholder interviews. Note the contrast between competitiveness in domestic markets and the weaker position in international markets, where SMEs are less engaged.

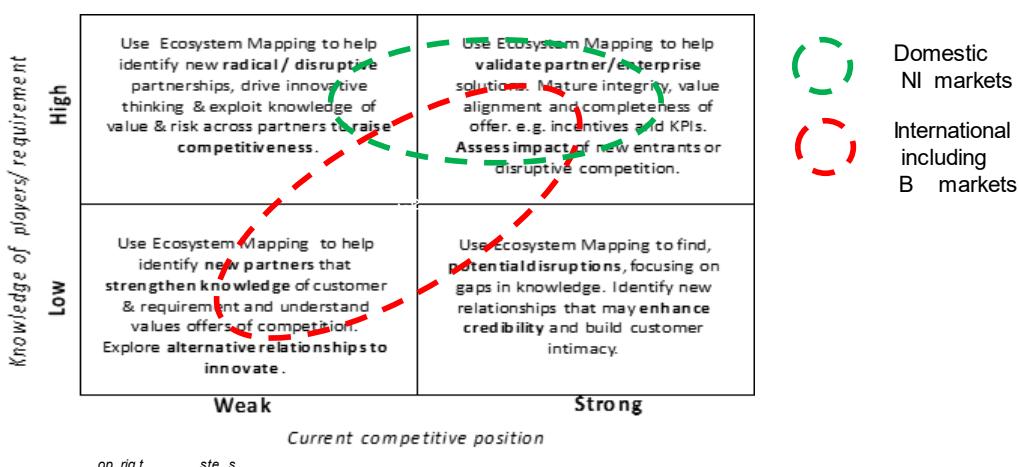
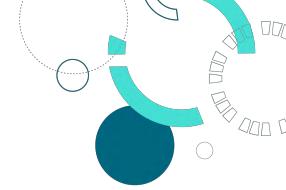


Figure 7: Mapping of competitive position of advanced manufacturing in Northern Ireland.

Role of AMIC

AMIC can have a vital role in promoting and enhancing advanced manufacturing, given the importance of manufacturing to the Northern Ireland economy. The innovation support landscape is complex and in need of better integration. A key role for AMIC, therefore, should be to act as a focus for, and broker of, the range of available support.

AMIC should ensure that as well as supporting large, world-class companies it also supports the core of smaller ones to enhance their innovation capability and



competitiveness. This role should include providing access to the wider UK innovation support network. The precise mechanisms for fulfilling this role remain to be defined.

AMIC should have a strong industry focus. It should focus on industrial priorities, rather than academic ones and ensure that its engagement style is responsive to the needs of industry (for example on timescales).

AMIC should support research collaboration in areas such as sustainability, digital and creation of more value-added products – in technologies such as digitalisation and automation, and particularly in food and drink processing where the sector is coming from a low base but there is a lot of ‘low hanging fruit’.

Learning transfer from between sectors, fostering links within the UK and beyond and helping companies to understand global markets, should be a strong focus.



3.2 Summary of landscape developed

The following points reflect the main conclusions from day 1 of the workshops.

Trends and drivers

Key trends and drivers identified include:

Social

- Growing skills shortages are driving up labour costs

Technical

- Digitalisation, automation, and analytic technologies are available and powerful

Economic

- Supply chain shocks and need for resilience
- Onshoring and reshoring are taking place
- High cost of energy

Environmental

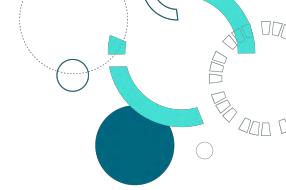
- Net Zero targets, circular economy, and rising materials costs

Political

- The unique political and economic position of Northern Ireland has major influence
- Development of regional capability is significant

Market

- Design excellence and manufacturing efficiency are imperatives
- Digitalisation, automation, and analytics drive manufacturing supply chain improvement
- The digital economy drives the creation of new previously unseen products, services and processes
- Rapid innovation and growth in:
 - aerospace
 - wellbeing, diagnostics, and health monitoring
- Consumer interest on nutrition and plant-based foods
- Transformation of transport (and other) sectors:
 - Light weighting, particularly of vehicles
 - Hydrogen as a fuel
 - Electrification



Products, services, and solutions

Products, services, and solutions identified are shown grouped below the theme headings derived and chosen for development on day 2. These are all strategic value-adding themes, which help provide focus to the capability investment of AMIC.

Theme 1. Connected, integrated products and new business models

- Lightweight structures and components
- High-performance materials
- High-specification components
- Connected, integrated products

Theme 2. Manufacturing decarbonisation

- New manufacturing power sources (e.g., hydrogen/biofuel/electric)
- Carbon capture and use
- Renewables including hydrogen

Theme 3. Testing and simulation services

- Digital integration, test, demonstration, and operation services (including sensor and other automation elements integration)
- Provision of neutral advice on Industry 4.0
- Materials evaluation and testing
- Data handling and analytics services

Theme 4. Robotics, automation, and digital manufacturing

- Robots, cobots and autonomous systems
- Consultancy and training in advanced manufacturing and digitisation
- Data handling and analytics services

Theme 5. Food and drink processing

- Skills and consultancy
- Packaging recycling processes
- Robotics, automation, and digital manufacturing
- Digital data and information and simulation services



Technologies, capabilities, and enablers

The following indicate areas of capability where AMIC might focus support:

Product technology

- Lightweight structures, composites, and topology optimisation
- New sustainable, including recyclable, packaging technologies
- Energy efficiency
- Waste/recycling technology
- Electrification: fuel cells
- Energy storage

Production technology and enabling digital technology

- Automation, advanced robotics, cobotics, exo-skeletons
- End-to-end manufacturing systems integration
- Automated, high-rate polymer manufacture (including polymer composites)
- Digital systems integration, IoT and interoperability
- Industry 4.0 technology production and trials

Other enabling technology

- Carbon lifecycle analysis
- Simulation and certification

Materials technology

- Circular materials
- Advanced materials and additive manufacturing

People, processes, and organisation

- Strategic skills and workforce plan to address skills deficit
- New enterprise models (MaaS – mobility as a service)

Research and academia

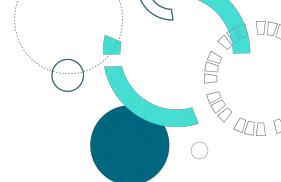
- R&D access to equipment, incentives, and funding

Funding, partnering

- Partnering for accelerated innovation (AMIC + others)
- Enabling policy, funding, and legal support: Levelling Up⁵

As illustrated in figure 8, the relative importance of different elements of the landscape was judged to change over time. Further detail is given in annex 2.

⁵ <https://www.gov.uk/government/publications/levelling-up-the-united-kingdom>



Landscape graphic

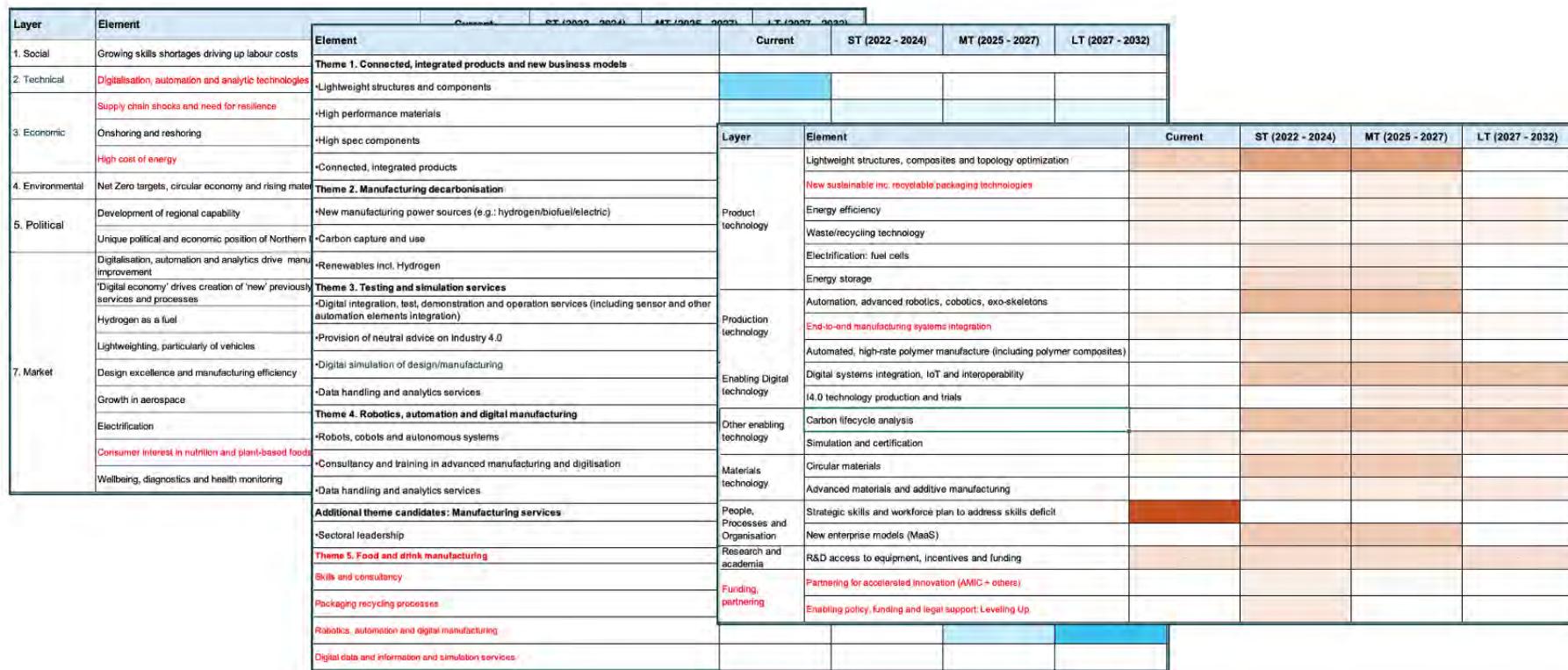


Figure 8: Landscape graphic showing workshop delegate importance rating of landscape elements 2022–2032. Key: Red font items relate to food and drink processing sector workshop only. Depth of bar colour reflects the importance of themes across the exercise: the deeper the colour the higher the priority ascribed.



3.3 Topics for which roadmaps were chosen for development post ecosystem review

The project team judged that the following themes emerged most strongly from the ecosystem review. Themes 2, 3, 4 and 5 were multifaceted and were each explored through three or four topics in subgroups. Theme 1 was split in to two separate themes each explored through two topics. Details of all the topics developed follow in section 3.4.

Theme (1a): Lightweight, high spec/high-performance materials

- Lightweight structures and components
- Manufacture and assembly of high-performance materials

Theme (1b): Connected, integrated products and supply chain and business models

- Connected supply chain
- Sectoral leadership

Theme (2): Manufacturing decarbonisation

- New manufacturing power sources (e.g., hydrogen/biofuel/electric)
- Circular economy
- Renewables including hydrogen

Theme (3): Testing and simulation services

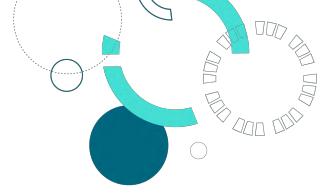
- Digital simulation of design, manufacturing, and installation
- Digitisation/capture of test data
- Materials evaluation and testing
- Data handling for testing and analytics services

Theme (4): Robotics, automation, and digital manufacturing

- Robotics, digital innovation, automation – strategic network
- Digital manufacturing test bed
- Supply chain digitalisation
- Intelligent automation including robotics and alternative energy vehicles (AEVs)

Theme (5): Food and drink processing

- Service for skills and knowledge transfer
- Lightweight sustainable packaging, processes, and components for agile, lean waste reduction
- Digital innovation support ecosystem
- Automation and digital integration with easy-to-use data analytics for decision making



3.4 Theme group outputs

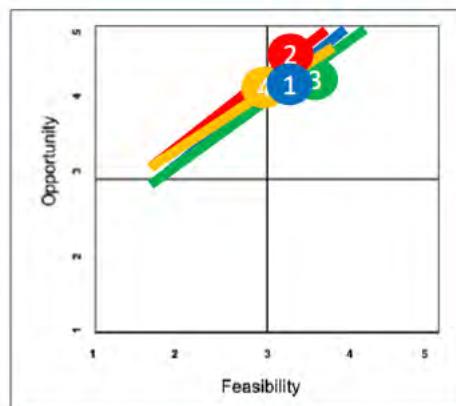
Shown below for each theme are:

- i) Opportunity and feasibility assessment by topic
- ii) Overview of current competitive position
- iii) Summary of the ecosystem discussion which informed i) and ii)
- iv) Roadmap headlines by topic, including priority actions for AMIC

Theme (1a) Lightweight, high spec/high performance materials

Opportunity and feasibility assessment

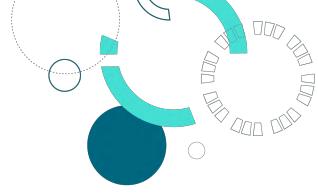
- A: Lightweight, high spec/high performance materials**
1. Lightweight structures and components
 2. Manufacture & assembly of high-performance materials
- B: Connected, integrated products and supply chain and business models**
3. Sectoral leadership
 4. Connected supply chain



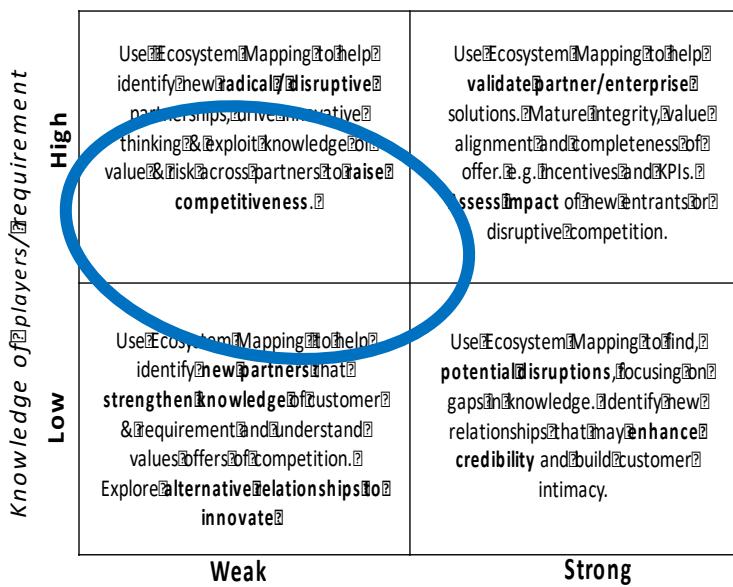
Opportunity assessment	
5	Very substantial and persistent improvement in Northern Ireland global advanced manufacturing competitiveness
4	Substantial medium term improvement in Northern Ireland global advanced manufacturing competitiveness
3	Short term improvement in Northern Ireland global advanced manufacturing competitiveness
2	Minor and temporary improvement in Northern Ireland global advanced manufacturing competitiveness
1	No improvement in Northern Ireland global advanced manufacturing competitiveness or negative impact
Feasibility assessment	
5	Capability already exists and in widespread use
4	Capability already exists and can be readily adopted by the supply chain
3	Capability required is available and can be adopted with concerted investment by government and industry
2	Capability required is identified but it is uncertain whether concerted investment by government and industry will realise
1	Capability required is unavailable in UK and no means is identified to obtain it

Key: Line represents high to low score **range** from delegates' views. Circle represents **weighted average** from delegates' views.

Figure 9: Lightweight, high spec/high performance materials opportunity and feasibility assessment



Current competitive position



Current competitive position

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Note: Mapping as determined by workshop delegates' combined view.

Figure 10: Lightweight, high spec/high performance materials current competitive position

Ecosystem discussion

Value creation

Aerospace, space and defence are high value markets. Lightweight components, particularly through advanced composites have a real opportunity to be highly competitive in the global market, but there is a need to strengthen critical mass in the materials supply chain (including biomaterials). Strategic partnerships can offer new competitive propositions to higher value clients, including services.

Supply chain

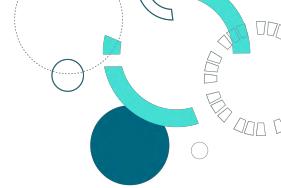
There are weaknesses in the automotive supply chain, but new strategic partners, particularly for electrification, could strengthen it.

Role of AMIC

- Provide improved facilities for materials innovation
- Build awareness of and across the manufacturing landscape
- Support, promote and access national investment funds (including from the UK government 'commodity investment' strategy)

Key industries (based on top-voted ecosystem members)

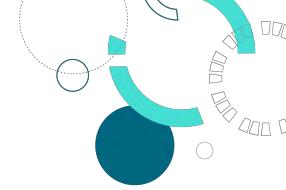
Aerospace; automotive; electronics; health and life sciences; materials handling; pharma and biotech labs and developers; photonics developers and producers; polymers.



Roadmap headlines

Table 1: Lightweight, high spec/high performance materials roadmap headlines

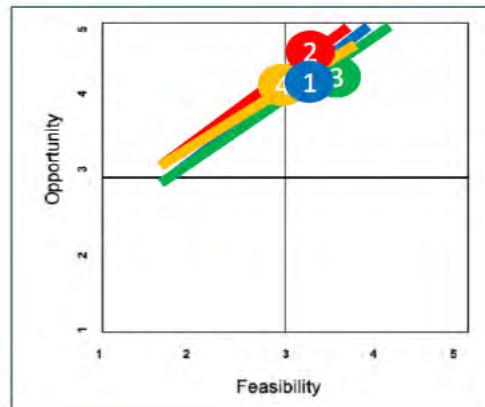
Topic roadmap	Pitch	Skills that need to be developed	Role of AMIC	Equipment needed (AMIC investment)	Immediate actions for AMIC
Lightweight structures and components	Creation of NI-based capability to design, manufacture and assemble lightweight structures and components for automotive/aerospace emerging markets – electrical/hydrogen	<ul style="list-style-type: none"> • Design authority capability to effectively link tier 2 suppliers to their tier 1 customers • Business development – technical sales • Full aircraft capability – structures/systems/integration 	<ul style="list-style-type: none"> • Provide access to funding sources • Agnostic R+D space – all sectors • Provide local access for engineers/operators to equipment 	<ul style="list-style-type: none"> • Catscan/3D core printer/pilot line – digital twin – simulation • DFP equipment • Design/structure optimisation 	Funding access – Aerospace Technology Institute programmes and Automotive Transformation Fund
Manufacture and assembly of high-performance materials	AMIC should be a test bed & skill centre for new technology to support the ecosystem in NI/UK for manufacture and assembly with high performance material i.e., automation/AI/smart/digital. For which future products remain to be confirmed	<ul style="list-style-type: none"> • 1–3 years: new training programme – need to understand what skills are required • 3+ years: new skills developed with technology development 	Centre of excellence to lead and drive change to achieve world-class manufacture and assembly with high-performance materials	Automation/smart/digital/AI/low carbon	<ul style="list-style-type: none"> • Horizon scan for technology map • Pull together best local skill and knowledge in one centre



Theme (1b) Connected, integrated products and supply chain and business models

Opportunity and feasibility assessment

- A: Lightweight, high spec/high performance materials
1. Lightweight structures and components
 2. Manufacture & assembly of high-performance materials
- B: Connected, integrated products and supply chain and business models
3. Sectoral leadership
 4. Connected supply chain

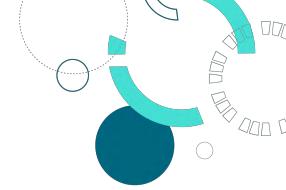


Opportunity assessment	
5	Very substantial and persistent improvement in Northern Ireland global advanced manufacturing competitiveness
4	Substantial medium term improvement in Northern Ireland global advanced manufacturing competitiveness
3	Short term improvement in Northern Ireland global advanced manufacturing competitiveness
2	Minor and temporary improvement in Northern Ireland global advanced manufacturing competitiveness
1	No improvement in Northern Ireland global advanced manufacturing competitiveness or negative impact

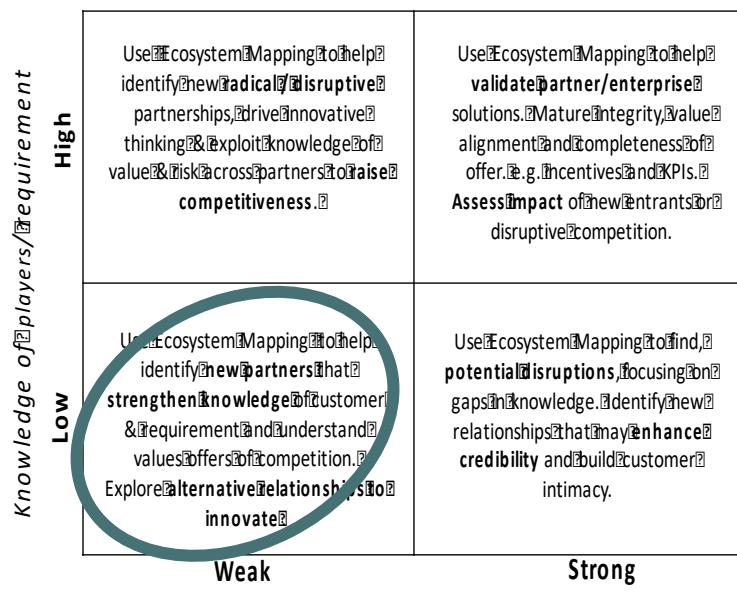
Feasibility assessment	
5	Capability already exists and in widespread use
4	Capability already exists and can be readily adopted by the supply chain
3	Capability required is available and can be adopted with concerted investment by government and industry
2	Capability required is identified but it is uncertain whether concerted investment by government and industry will realise
1	Capability required is unavailable in UK and no means is identified to obtain it

Key: Line represents high to low score **range** from delegates' views. Circle represents **weighted average** from delegates' views.

Figure 11: Connected, integrated products and supply chain and business models opportunity and feasibility assessment



Current competitive position



Current competitive position

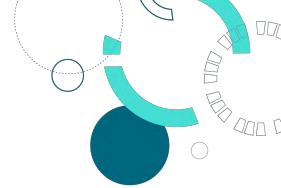
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Mapping as determined by workshop delegates' combined view.

Figure 12: Connected, integrated products and supply chain and business models, current competitive position

Ecosystem discussion

See [theme \(1a\)](#) for ecosystem discussion, which took place in whole theme groups.



Roadmap headlines

Table 2: Connected, integrated products and supply chain and business models roadmap headlines

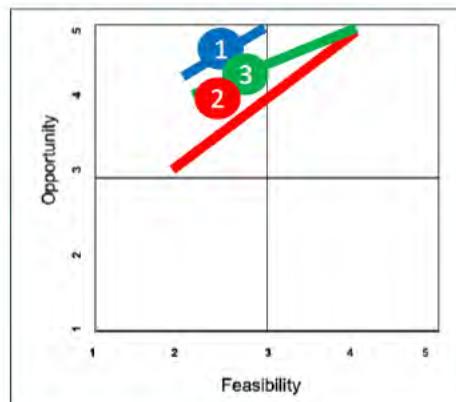
Topic roadmap	Pitch	Skills that need to be developed	Role of AMIC	Equipment needed (AMIC investment)	Immediate actions for AMIC
Sectoral leadership	Establish AMIC as sector and thought leader for advanced manufacturing in Northern Ireland	Clear understanding of current and emerging skills demand for industry to support case for funded skills development framework	Strategic alignment and integration of the advanced manufacturing landscapes	Facilities/IT infrastructure/hosting spaces	Development of sustainable commercial model to underpin the ambition
Connected supply chain	<ul style="list-style-type: none"> • Create a cohesive strategic system and plan for partnership-based growth • This is an important action to protect and scaffold existing capability towards future markets and efficient processes • We will develop a clear vision for NI manufacturing supply chain landscape, back this up with data and planning, effective brokering and capability sharing, to maximise outcomes 	<ul style="list-style-type: none"> • Strategic partnership-building skills, including finance • Modelling and analytics skills • Shared service skills (tech, data, SME) 	<ul style="list-style-type: none"> • Creation of data, maps and models for supply chain working • Reduce required investment and risk in early lifecycle product development (small business) • Support business plans and identify partnerships and knowledge sharing across markets • AI for 'back office' supply chain activities 	<ul style="list-style-type: none"> • Focused facilities for R+D → lower barriers to entry for supply chain (e.g., structural testing) • Sectoral leadership and steering • Supporting sectors transition to vision • Tiger-team support 	<ul style="list-style-type: none"> • Inventory or map of capability • AMIC organisation structure to facilitate sharing and partnership • Framework, templates and processes for creating partnerships • Confirm business plan



Theme (2): Manufacturing decarbonisation

Opportunity and feasibility assessment

1. New manufacturing power sources
2. Circular economy
3. Renewables including hydrogen



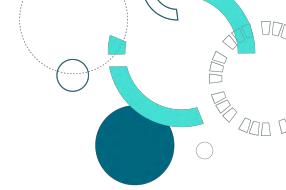
Opportunity assessment	
5	Very substantial and persistent improvement in Northern Ireland global advanced manufacturing competitiveness
4	Substantial medium term improvement in Northern Ireland global advanced manufacturing competitiveness
3	Short term improvement in Northern Ireland global advanced manufacturing competitiveness
2	Minor and temporary improvement in Northern Ireland global advanced manufacturing competitiveness
1	No improvement in Northern Ireland global advanced manufacturing competitiveness or negative impact

Feasibility assessment	
5	Capability already exists and in widespread use
4	Capability already exists and can be readily adopted by the supply chain
3	Capability required is available and can be adopted with concerted investment by government and industry
2	Capability required is identified but it is uncertain whether concerted investment by government and industry will realise
1	Capability required is unavailable in UK and no means is identified to obtain it

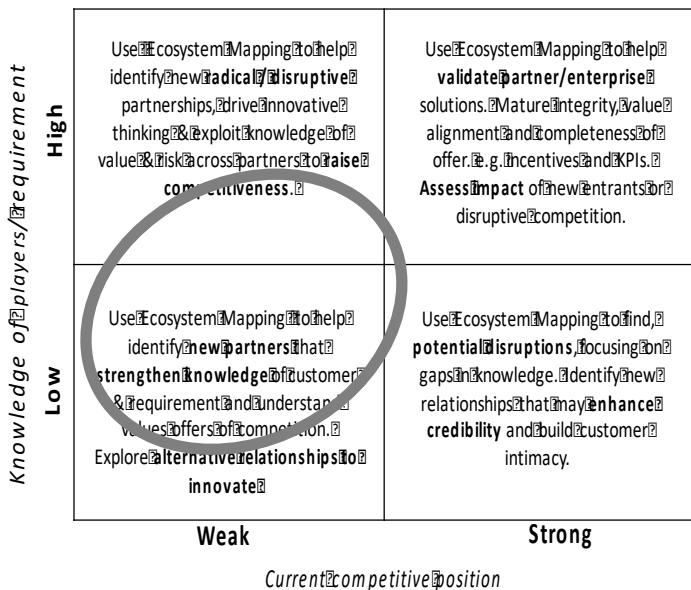
Key: Line represents high to low score **range** from delegates' views. Circle represents **weighted average** from delegates' views.

Figure 13: Manufacturing decarbonisation opportunity and feasibility assessment

It is noted that these topics are assessed as presenting a scale of challenge that suggests significant investment at a UK ecosystem level, which also offers the potential of a pioneering role for Northern Ireland.



Current competitive position



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Mapping as determined by workshop delegates' combined view.

Figure 14: Manufacturing decarbonisation current competitive position

Ecosystem discussion

Value creation

Hydrogen opportunities include:

- Raised hydrogen proportion in natural gas
- Conversion of rainwater to hydrogen

The applications highlighted were:

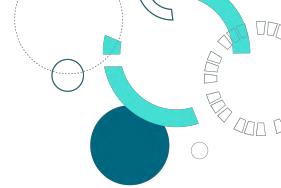
- Zero-carbon transport systems (e.g., hydrogen-powered buses)
- Hydrogen as an alternative fuel for manufacturing/process heating
- Potential small scale domestic applications

Role of AMIC

- Link to government Net Zero policy agenda:
 - Set targets based on 'green growth' and climate change act
 - Demonstrate raised productivity from green initiatives
- Build momentum:
 - Create awareness of local strengths
 - Market and public education
 - Establish partnerships (e.g., Glen Dimplex) for factory power schemes

Key industries (based on top voted ecosystem members)

Aerospace; automotive/transport; electrical; energy; polymers



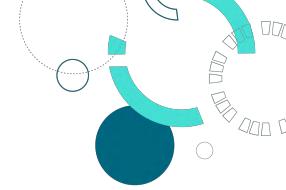
Roadmap headlines

Table 3: Manufacturing decarbonisation roadmap headlines

Topic roadmap	Pitch	Skills that need to be developed	Role of AMIC	Equipment needed (AMIC investment)	Immediate actions for AMIC
New manufacturing power sources (e.g., hydrogen, biofuels, electric)	AMIC should provide a service to industry to assist transition away from fossil fuels and ensure a secure and sustainable supply of energy for the NI manufacturing sector	Education programmes on sustainability and energy	Modelling and systems design, proof of concept, networks for clusters, carbon tracking tools, e.g., CASE would be a good partner	To be determined	Set up team with appropriate skillset
Circular economy	Northern Ireland should self-position as an exemplar of the circular economy through re-using, sharing, repairing, refurbishing and recycling existing materials and products for as long as possible	<ul style="list-style-type: none"> • Engineering • Materials • Cyber • Analytics • Supply chain 	<ul style="list-style-type: none"> • AMIC should be the convener and the Centre of Excellence for materials and processing • A certification hub 	<ul style="list-style-type: none"> • State-of-the-art plastics processing equipment (full list available). Rapid prototyping capability. • Equipment for healthcare product sterilisation. • Analytical equipment. • Certification lab • Robots and automation equipment 	<ul style="list-style-type: none"> • Start information-sharing initiatives between companies • Consolidate equipment and capability requests across areas of interest • Respond to Department for the Economy's Circular Economy Consultation (later this year)



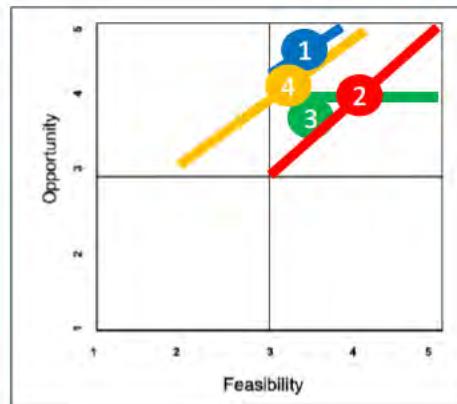
Topic roadmap	Pitch	Skills that need to be developed	Role of AMIC	Equipment needed (AMIC investment)	Immediate actions for AMIC
Renewables (including hydrogen)	To enable development in new and emerging energy market in order to reduce carbon emissions, meet government Net Zero targets and move toward energy independence	<p>Increased skill requirements needed within:</p> <ul style="list-style-type: none"> • Production • Supply Distribution • Service • Test • Data analytics 	<ul style="list-style-type: none"> • Development of fuel cell and other H₂ storage capabilities • Modelling/simulation of new designs • Engine management development and evaluation of emissions 	<ul style="list-style-type: none"> • Demo/prototype production equipment • Software for modelling, design and energy requirements 	<ul style="list-style-type: none"> • Build AMIC – the facility is key to this programme



Theme (3): Testing and simulation services

Opportunity and feasibility assessment

1. Digital simulation of design, manufacturing and installation
2. Digitisation/capture of test data
3. Materials evaluation and testing
4. Data handling for testing and analytics services



Opportunity assessment	
5	Very substantial and persistent improvement in Northern Ireland global advanced manufacturing competitiveness
4	Substantial medium term improvement in Northern Ireland global advanced manufacturing competitiveness
3	Short term improvement in Northern Ireland global advanced manufacturing competitiveness
2	Minor and temporary improvement in Northern Ireland global advanced manufacturing competitiveness
1	No improvement in Northern Ireland global advanced manufacturing competitiveness or negative impact

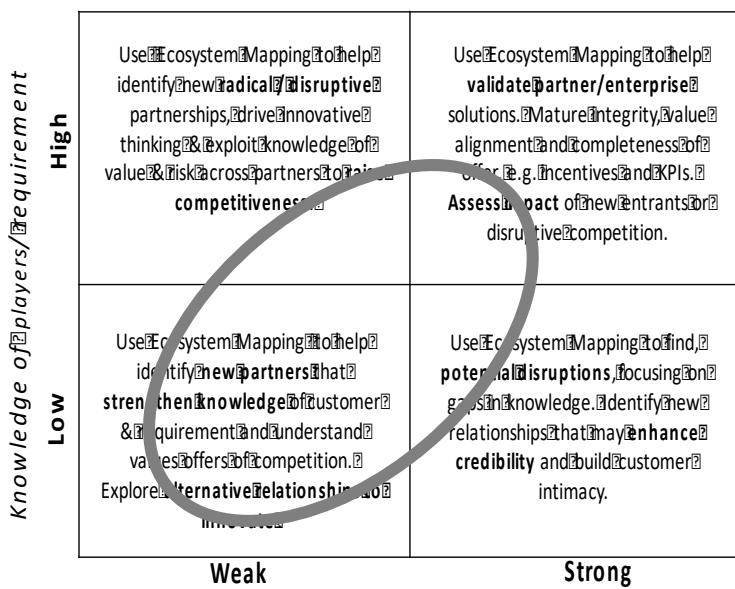
Feasibility assessment	
5	Capability already exists and in widespread use
4	Capability already exists and can be readily adopted by the supply chain
3	Capability required is available and can be adopted with concerted investment by government and industry
2	Capability required is identified but it is uncertain whether concerted investment by government and industry will realise
1	Capability required is unavailable in UK and no means is identified to obtain it

Key: Line represents high to low score **range** from delegates' views. Circle represents **weighted average** from delegates' views.

Figure 15: Testing and simulation services opportunity and feasibility assessment



Current competitive position



Current competitive position

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Mapping as determined by workshop delegates' combined view.

Figure 16: Testing and simulation services current competitive position

Ecosystem discussion

Value creation

- World-class companies are looking to innovate and invest, but there is a 'Brexit risk' around the transfer of standards and regulations from EU to UK
- NI is a consumer presently rather than a provider of digital solutions
- There is a lack of certified simulation and test capability
- Analytics services are not generally available to manufacturing from local companies, although some consultancies may offer
- Cross-platform integration and action-based analytic services for manufacturing may be opportunities

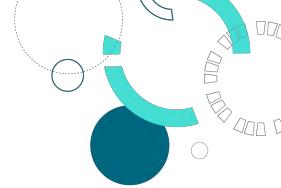
Role of AMIC

AMIC should generate value from relevant academic digital technical expertise through in-house business support services:

- Awareness raising
- Develop and disseminate case studies and support cross-sector knowledge transfer
- Identify and bring in best practice from outside Northern Ireland
- Factory layout and simulation
- Support standards development
- Start-up support

Key industries (based on top voted ecosystem members)

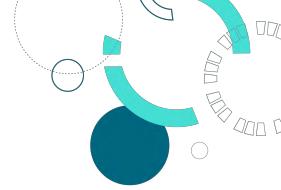
Aerospace, construction, electrical, electronics, health and life sciences, materials handling



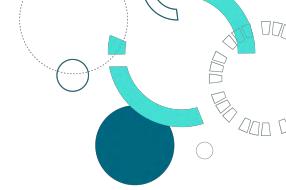
Roadmap headlines

Table 4: Testing and simulation services roadmap headlines

Topic roadmap	Pitch	Skills that need to be developed	Role of AMIC	Equipment needed (AMIC investment)	Immediate actions for AMIC
Digital simulation of design, manufacturing, and installation	Make digital simulation of design and manufacture the first gear of your business system to automate procurement, manufacture and enhance innovation and efficiency throughout your organisation	<ul style="list-style-type: none"> • Software training • Turning theory into practice • AR/VR • Digital twin technologies 	<ul style="list-style-type: none"> • Knowledge and technology transfer • Product and manufacturing test beds • Access to expertise 	<ul style="list-style-type: none"> • Access to SIM software • IoT • AR/VR 	<ul style="list-style-type: none"> • Industry and AMIC collaboration to scope requirements for digital twin
Digitisation/capture of test data	Save time, increase quality and make money by capturing test and simulation data in process and in service	<ul style="list-style-type: none"> • Business skills: business case development (data) • Tech skills: sensors, comms networks, storage (futureproofing & curation), cyber security, integration, installation 	<ul style="list-style-type: none"> • Promotion and awareness, convening stakeholders, independent of vested interests • Portal to capabilities – national & international 	<ul style="list-style-type: none"> • Test beds • Demo equipment 	<ul style="list-style-type: none"> • Establish knowledge observatory • Matchmaking for funding • Access to existing facilities (test beds) e.g., HVMC • Sharpen up industry requirements • Create/fund team to deliver



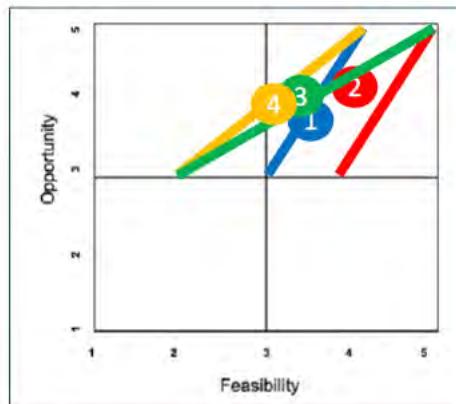
Topic roadmap	Pitch	Skills that need to be developed	Role of AMIC	Equipment needed (AMIC investment)	Immediate actions for AMIC
Materials evaluation and testing	The start of the process to capture data from materials and manufacturing processes and transforming it into actionable knowledge and IP, optimising profit and reducing environmental and monetary costs of manufacturing industry	<ul style="list-style-type: none"> Materials testing and certification processes, methodologies and data analysis and interpretation Specialist knowledge in characterisation and ability to transfer skills from niche areas from academia to industry 	Linking needs from different sectors and transferring knowledge of common use – developing awareness of available facilities and capabilities	<ul style="list-style-type: none"> Custom-made testing equipment – destructive & non-destructive – test development & screening Manufacturing equipment to assess the effect of defects induced by manufacturing processes Material design & simulation capability – equipment for development and testing of new materials at TRL >4-6 	<ul style="list-style-type: none"> Generate engagement and synergies by identifying key stakeholders Involve supply chain
Data handling for testing & analysis	Develop a solution to handle data from testing and analysis to give the right information to the right people at the right time to enable better real-time decisions	<ul style="list-style-type: none"> Digital thread design – planning Data scientist 	<ul style="list-style-type: none"> Facilitate core team Develop data analytical skills AMIC to be Centre of Excellence 	<ul style="list-style-type: none"> Analytic software Test databases Offline test environments 	<ul style="list-style-type: none"> Launch core team Develop ‘art of the possible’ and communicate accordingly



Theme (4): Robotics, automation, and digital manufacturing

Opportunity and feasibility assessment

1. Robotics, digital innovation, automation – strategic network
2. Digital manufacturing test bed
3. Supply chain digitalisation
4. Intelligent automation including robotics and AEVS

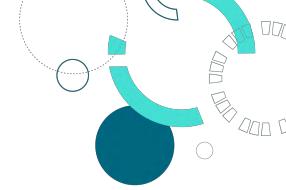


Opportunity assessment	
5	Very substantial and persistent improvement in Northern Ireland global advanced manufacturing competitiveness
4	Substantial medium term improvement in Northern Ireland global advanced manufacturing competitiveness
3	Short term improvement in Northern Ireland global advanced manufacturing competitiveness
2	Minor and temporary improvement in Northern Ireland global advanced manufacturing competitiveness
1	No improvement in Northern Ireland global advanced manufacturing competitiveness or negative impact

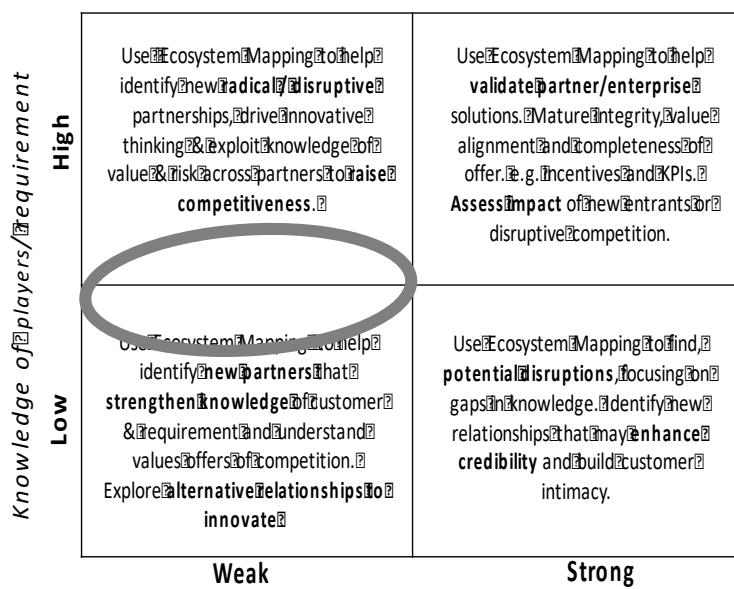
Feasibility assessment	
5	Capability already exists and in widespread use
4	Capability already exists and can be readily adopted by the supply chain
3	Capability required is available and can be adopted with concerted investment by government and industry
2	Capability required is identified but it is uncertain whether concerted investment by government and industry will realise
1	Capability required is unavailable in UK and no means is identified to obtain it

Key: Line represents high to low score **range** from delegates' views. Circle represents **weighted average** from delegates' views.

Figure 17: Robotics, automation and digital manufacturing opportunity and feasibility assessment



Current competitive position



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Mapping as determined by workshop delegates' combined view.

Figure 18: Robotics, automation and digital manufacturing current competitive position

Ecosystem discussion

Value creation

The journey to global competitiveness may be a major, multi-project effort for companies. Future-proof, scalable solutions are required but may be impeded by lack of capital for investment.

Role of AMIC

Building confidence and commitment to de-risk investment (particularly for SMEs):

- 'Honest broker' with equipment suppliers
- Training and capability building (including apprenticeships)
- Differentiate from other centres, recognising that 'local is better'
- Understand and maintain knowledge of leading global capability

Key industries (based on top voted ecosystem members)

Applies cross sector

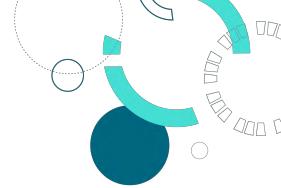


Roadmap headlines

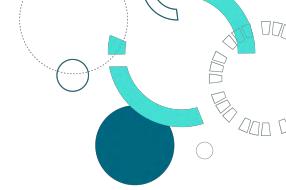
Table 5: Robotics, automation, and digital manufacturing roadmap headlines

Topic roadmap	Pitch	Skills that need to be developed	Role of AMIC	Equipment needed (AMIC investment)	Immediate actions for AMIC
Robotics, digital innovation, automation – strategic network	Network to convene industry-academic policy stakeholders in manufacturing to explore new technology so Northern Ireland can exploit its strengths and trends	<ul style="list-style-type: none"> Business development skills Business strategy Public affairs and communications 	<ul style="list-style-type: none"> AMIC facilitate and brand the network Employ network leadership to build relationships Convene advisory board every month 	<ul style="list-style-type: none"> Website – social media Communications and marketing for case studies Define metrics and KPIs 	<ul style="list-style-type: none"> Obtain funding to employ a network lead Identify candidates for advisory board
Digital manufacturing testbed	Development and implementation of open digital platform on industry-informed hardware demonstrator to provide proof-of-concept test environment and generic 80% framework with provision for specific industry use cases	<ul style="list-style-type: none"> Software developers/solutions architects/engineers Support systems/Python experts/network engineers/ experts Data scientists/cloud computing expertise/cyber security skills IoT engineers/Edge engineers 	<ul style="list-style-type: none"> AMIC funding, AMIR partner use cases, thought leadership; hardware provision exploitation, networking, access to subject matter experts 	<ul style="list-style-type: none"> IT and network infrastructure Edge, IoT servers Cyber systems Sensorisation 5G/WiFi 	<ul style="list-style-type: none"> Business case development Specific workshop on theme Straw man of test bed environment Integration considerations Lessons learned from similar institutions Define success 'Estonia' planning⁶

⁶ See, for example, how [digital innovation](#) in Estonia is developing along with [digital society](#)



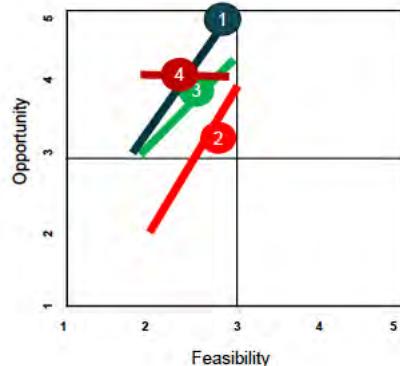
Topic roadmap	Pitch	Skills that need to be developed	Role of AMIC	Equipment needed (AMIC investment)	Immediate actions for AMIC
Supply chain digitalisation	Decrease time to market and increase market share through total digital control of full product life cycle	<ul style="list-style-type: none"> • Digital, manufacturing expertise and supply chain/purchasing expertise • Good communicators → marketing 	<ul style="list-style-type: none"> • Engage with industry • Build capability + expertise 	<ul style="list-style-type: none"> • Computer software • Computing power • Supplier databases 	<ul style="list-style-type: none"> • Begin immediately → immediate demand
Intelligent automation including robotic systems AEVs, etc.	Developing the relevant NI capability and demonstrators of intelligent automation/robotic solutions including pre-production piloting facilities for manufacturing solutions	<ul style="list-style-type: none"> • Manufacturing automation • Intelligent system integration skills: advanced comms (4G/5G), IoT sensor technology, computer science • Cloud/IoT, machine learning/AI, real-time control and optimisation 	Working in consultation to develop and deliver all the above. Connectivity with other aligned innovation centres. UK (MTC/AMRC), global (US etc.), Germany (i.e., Fraunhofer)	State-of-the-art technology stack associated with intelligent automation theme	<ul style="list-style-type: none"> • Recruit engineering team and team lead to drive initiative <p>Build a consortium to pursue grant funding (Innovate UK, Horizon Europe)</p>



Theme (5): Food and drink processing

Opportunity and feasibility assessment

1. Service for skills and knowledge transfer
2. Lightweight sustainable packaging, processes and components for agile, lean waste reduction
3. Digital innovation support ecosystem
4. Automation and digital integration with easy-to-use data analytics for decision making

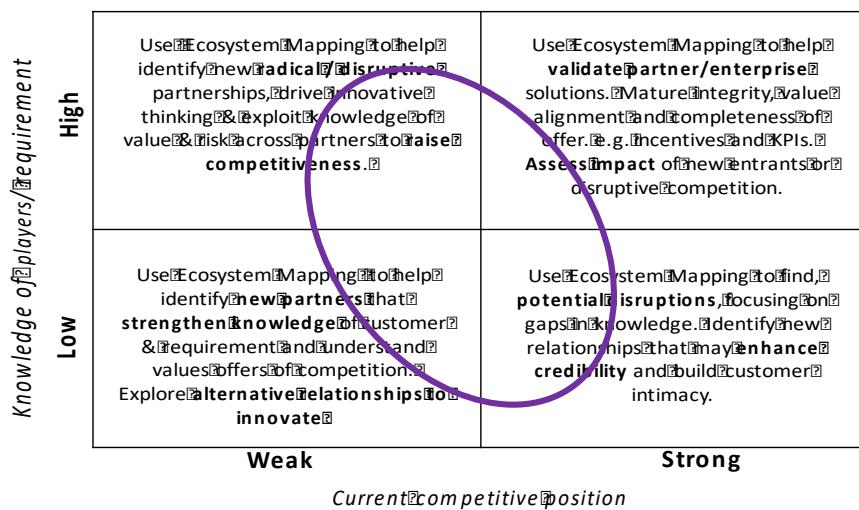


Key: Line represents high to low score **range** from delegates' views. Circle represents **weighted average** from delegates' views

Figure 19: Food and drink processing Opportunity and Feasibility assessment

It is noted that these topics are assessed as presenting a scale of challenge that suggests significant investment at a UK ecosystem level, which also offers the potential of a pioneering role for Northern Ireland.

Current competitive position



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Mapping as determined by workshop delegates' combined view.

Figure 20: Food and drink processing current competitive position



Ecosystem discussion

Value creation

- There is an opportunity to disrupt the competition by building relationships that support customer ‘mass’, credibility and sustainability goals through high value, fast-changeover, low carbon-footprint products
- Industry has some big players, competitive in the UK and Ireland, but the average agri-food company comes from a small (low) base and knowledge of advanced manufacturing
- The innovation ecosystem (linking business/academia/government/civic society) for agri-food in Northern Ireland is fragmented currently; however, there is a thriving knowledge-based economy with ‘spires of excellence’, which can elevate food and drink further

Supply chain

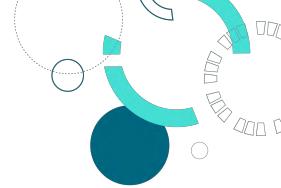
- Highly segmented industry with many complex processes
- Weaknesses: energy costs; economy of scale; geography (fuel, isolation); government position
- Strengths: flexible/niche; customer intimacy; adaptability in engineering/production; ‘field to fork’, offering a strong line in sustainability and food security

Role of AMIC

- Driven by the needs of the agri-food sector to resolve current perceived lack of academic interest in industry
- Facilitate benchmarking, collaboration, knowledge transfer, best practice sharing and networking with industry, including from outside food sector (e.g.: aerospace and transport)
- Make innovation from around the world accessible for NI agri-food companies
- Inform government policy
- Facilitate access to government funding
- Given many different processes and segments within and across agri-food, consider a focus on people rather than processes (would require a highly specialised talent development programme)

Key industries (based on top voted ecosystem members)

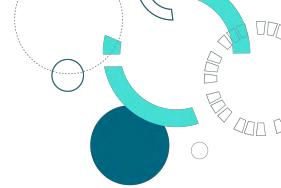
Dairy processors, drinks manufacturers, meat processors, poultry processors, ready meals producers, automation providers, energy OEM, ICT and analytics providers



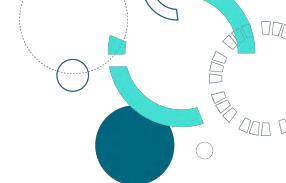
Roadmap headlines

Table 6: Food and drink processing roadmap headlines

Topic roadmap	Pitch	Skills that need to be developed	Role of AMIC	Equipment needed (AMIC investment)	Immediate actions for AMIC
Service for skills and knowledge transfer	To catalyse industrial knowledge transfer and skills development for advanced manufacturing within NI food and drink industry	<ul style="list-style-type: none"> Processing/packaging technologies, raw materials, and best practice processing Digital/analytics, IoT and factory of the future 	AMIC to act as capability enhancement facilitator Footprints in regional Centres of Expertise Key role is coordination and collaboration	<ul style="list-style-type: none"> Knowledge of processing/packaging technologies Knowledge of raw materials/ingredients and best practice processing Digital/analytics – sensors/IoT/ Factory of the future and data capture 	Map our hub and spoke model Build the collaborative network
Lightweight sustainable packaging, processes, and components for agile, lean waste reduction	Driving sustainability through packaging, its contexts, and precursors	Skills gaps in life cycle assessment packaging technology and polymer scientists	Demonstrator lines (including waste streams) smart packaging, cross-sector network	<ul style="list-style-type: none"> Packaging demonstrator lines Digital and data capability for material segregation Pilots: repulping/material recovery/waste stream utilisation/composting 	Ensure that this area is mapped/gap analysis carried out across NI Feed this into the Belfast Region City Deal and other city deals and coordinate approaches across the centres



Topic roadmap	Pitch	Skills that need to be developed	Role of AMIC	Equipment needed (AMIC investment)	Immediate actions for AMIC
Digital innovation support ecosystem	A Centre of Excellence for automation and digital ecosystem	Competing in a small pool for automation, digital and software engineers and for data analytics skills	Will be a core conduit for agri-food businesses to exploit digital and automation technologies, avoiding a fragmented approach	Digital – 5G networks, IoT, Edge computing capabilities, sensors Automation – relevant automation, cutting-edge new technologies (robotics, etc.)	<ul style="list-style-type: none"> Engagement with industry and funding bodies Completing full business case
Automation and digital integration with easy-to-use data analytics	<ul style="list-style-type: none"> The creation of a Centre of Excellence which supports rapid automation Feasibility studies for industry with the agri-food and drink sector 	<p>Short term – basic skills across operatives and engineering</p> <p>Medium term – data analytics and advanced manufacturing knowledge</p>	Industry partner, providing alignment with industry, academia and government	<ul style="list-style-type: none"> A physical centre with demo plant Meeting rooms Test robot with vision system and range of grippers VR headsets Modelling software 	<ul style="list-style-type: none"> Establish the business partners, process systems, hardware, and software to determine the size of the Centre of Excellence in turn establishing the capital investment Locate local to partnered industry submitting planning applications liaising with environmental bodies and establishing a construction phased plan and as timeline for partnering with industry



4. Composites roadmap update

The National Composites Centre conducted an update of the national strategy during the first half of 2022, which included a regional consultation for Northern Ireland. A summary of this report, including the companies consulted and the approach adopted is available in annex 4, available on request.

The key elements of the strategy, which are broadly aligned with the findings of this wider roadmap, may be summarised as follows.

4.1 Key sectors for the UK economy and the associated vision(s)

Aerospace

We develop high impact, sustainable composite solutions to solve the aerospace sector's challenges.

Surface transport

We accelerate high value composite technology to enable the UK Surface Transport Sector to go beyond Net Zero.

Defence and space

We are an independent authority for Composites in Defence & Space, enabling the UK to grow prosperous and enhance security.

Energy

We accelerate net-zero energy generation and distribution.

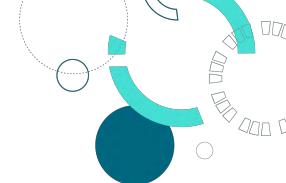
Construction and infrastructure

We accelerate the commercial adoption of transformational engineering solutions in the construction and infrastructure sector.

4.2 Key themes emerging from local consultation

Several local companies were consulted through structured interviews, the following being in common with this study: CCP Gransden; Collins; Denroy; Spirit AeroSpace; and Thales.

Key themes identified are listed below, in rank order of the number of companies mentioning them. Text in red indicates that the theme was also identified as high priority across this study.



Trends and drivers/market needs

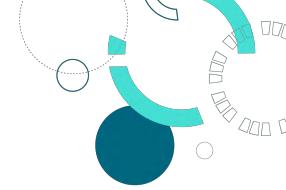
- **Sustainability** (end of life; operational Net Zero)
- Harsh environments (composites in marine; extreme environments; high temperature; FST compliance; impact and damage tolerance)
- Cost effectiveness composite manufacturing (high volume manufacturing; rapid prototyping)

Products, services, and solutions

- **Digital** (digital manufacturing; in-service digital)
- Integrated structures and multifunctional solutions (SHM/asset management; functional coatings and finishes; multifunctional composites (thermal management, etc.)
- **Skills, tools, and supply chain support provision** (skills and workforce development; software and licensing; secure facilities)
- **Verification and validation** (material characterisation and qualification; product certification support)
- Composites repair

Technologies, capabilities, and enablers

- Life-cycle assessment (LCA)
- Design for sustainability
- Biomaterials
- Hosted virtual desktop (HVD) (**Collaborative design tools, data analytics and predictive digital twins**)
- Automated deposition and preforming (automated fibre placement, Filament winding, etc.)
- 3D textiles and preforming
- Liquid resin infusion (LRI) processing (novel resin systems and LRI process optimisation)
- Thermoplastic processing (TP)
- Novel network device interface (NDI) technologies and techniques
- Composite joining



5. Conclusions

From the stakeholder interviews and workshop discussions, IfM Engage has made the following observations:

The Northern Ireland economy is dominated by SMEs who need to significantly increase their innovation capability and who may be reluctant to engage beyond a 'local' support centre.

Whilst there are notable exceptions, Northern Ireland's advanced manufacturing is seen by delegates as having a relatively weak global competitive position and low knowledge of international players and requirements.

Food and drink processing share many of the same development priorities as other industries, particularly regarding skills and knowledge transfer, digital manufacturing, and automation

There are many regional initiatives so the innovation support landscape may be seen by some as complex and in need of effective integration.

The role of AMIC as an incubator as well as capability builder remains to be further developed:

- Priorities for capability building might include Convener and direction setting; Linking to other UK and international facilities; Influencing policy development and focus on mid technology readiness level and larger companies
- Priorities associated with incubation might include skills delivery, engagement and signposting and a focus on high technology readiness level and smaller companies

A parallel exercise specific to composites, conducted by the National Composites Centre, has shown good alignment with the general themes and priorities identified in this study.



6. Recommendations & actions proposed

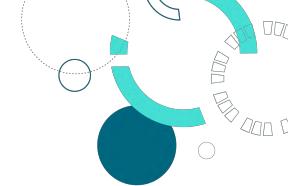
Recommendations focus on clarifying AMIC's roles and proposing a delivery model. Actions proposed consist of early priorities for AMIC as identified by workshop topic groups.

6.1 Recommendations

Recommendations for AMIC that grew out of the workshop align with IfM's observations in section 5. This is illustrated in table 7.

Table 7: Observations and recommendations to AMIC

Observation (IfM Engage)	Recommendation (workshop output)
The Northern Ireland economy is dominated by SMEs who need to significantly increase their innovation capability and who may be reluctant to engage beyond a 'local' support centre.	As it represents the largest capability and investment, AMIC may consider acting as a capability enhancement facilitator , building consensus on priorities for the development of new technologies and building of innovation capability: <ul style="list-style-type: none">• Convener and direction setting• Link to other UK and international facilities• Focus on mid TRL, larger companies and innovation ready SMEs• Influencing policy development
The role of AMIC as an incubator as well as capability builder remains to be further developed.	Other local facilities may engage to provide additional capacity and capability in a range of areas including: <ul style="list-style-type: none">• Skills delivery• 'Incubation'• Focus on high TRL and smaller companies• Engagement and signposting
There are many regional initiatives so the innovation support landscape may be seen by some as complex and in need of effective integration.	
Whilst there are notable exceptions, Northern Ireland's advanced manufacturing is seen by delegates as having a relatively weak global competitive position and low knowledge of international players and requirements.	
Food and drink processing share many of the same development priorities as other industries, particularly regarding skills and	Food and drink processing should be fully integrated with AMIC development programmes, particularly regarding skills, digital and automation and be



Observation (IfM Engage)	Recommendation (workshop output)
knowledge transfer, digital manufacturing, and automation.	helped to take full advantage of knowledge sharing with other sectors

AMIC may consider acting as a '**capability enhancement facilitator**' with other NI facilities. In this role it would help build consensus on priorities for the development of new technologies and innovation capability. It would link to other UK and international facilities, and, it is recommended, focus on mid TRL, larger companies and innovation ready SMEs. In such a model, other local facilities (and AMIC itself) could provide skills delivery, start-up incubation, and engagement and signposting, with other local facilities focusing on high TRL and smaller companies.

In addition to leading on the development of capability AMIC can have an important role in improving understanding of the global competitive position and priorities, especially by SMEs.

6.2 Summary of actions for AMIC

Table 8 indicates the immediate actions recommended to AMIC by the theme groups. Many actions were recommended by multiple groups, as shown in the table.

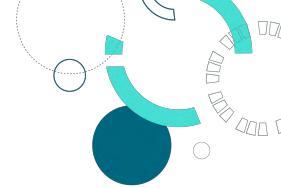
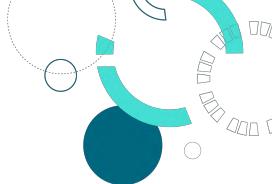


Table 8: Actions for AMIC showing source in theme groups. Red font shows text added or amended with input from the food and drink sector workshop

Action theme	Specific action	Strategic theme				
		1. Lightweight, high spec/high performance materials	2. Connected, integrated products and supply chain and business models	3. Manufacturing decarbonisation	4. Testing and simulation services	5. Robotics, automation and digital manufacturing
1. Accelerate the delivery phase of AMIC, as per approved plan	1. Get started with AMIC development recommendations URGENTLY					
	2. Establish implementation team, business model and associated business plan, in concert with relevant funding bodies					
	3. Confirm wider governance, stakeholder management and network role					
	4. Set up consortium for funding management and match making					
	5. Build AMIC partnering and information sharing capability					
2. Confirm capability development requirements	1. Map existing capabilities and associated supply chain					
	2. Confirm capability needs and make appropriate links to existing facilities (e.g. HVMC)					
	3. Build AMIC 'horizon scanning' capability					
3. Implement early projects	1. Respond to circular economy consultation					
	2. Develop Digital Manufacturing testbed workshop and environment					
	3. Scope requirements for 'digital twin'					

Appendix 1: Participating organisations

Ecosystem category	Organisation	Sector	Interviews	Pre work	Workshop (1)	Workshop (2)
Industry	Advanced Systems Group	Electrical				
	ASG Whale	Specialist Products				
	Avondale Foods	Ready Meal processors				
	BioTactics	Crop protection				
	BT	ICT and analytics providers				
	Catagen	ICT and analytics providers				
	Causeway Sensors	Photonics				
	CCP Gransden	Aerospace				
	CDE Global	Construction				
	CforC	Consultants				
	Collins Aerospace	Aerospace				
	Dale Farm	Dairy Processors				
	Deli Lites	Ready Meal Processors				
	Denroy	Polymers				
	Doherty & Gray	Meat, Poultry and Pig processors				
	Dunbia	Meat, Poultry and Pig processors				
	Eakin Healthcare	Health and Life Sciences				
	FC Robinson	Meat, Poultry and Pig processors				
	Glanbia Cheese	Dairy Processors				
	Glen Dimplex	Electrical				
	Gourmet Island	Meat, Poultry and Pig processors				
	Graham Construction	Construction				
	Greiner	Polymers				
	Harlequin Manufacturing Ltd.	Polymers				
	Hyster Yale	Materials Handling				
	James Docherty Meats	Meat, Poultry and Pig processors				
	Jans Group	Polymers				
	Keystone Group	Construction				
	Kingspan	Polymers				
	Linamar	Automotive/Transport				
	Magellan Aerospace Ltd.	Aerospace				
	McColgan	Ready Meal Processors				
	MJM Marine	Marine				
	Moteam	Automation providers				
	PAC Group	Automation providers				
	Randox Laboratories Ltd.	Health and Life Sciences				
	RLC	Aerospace				
	Ryobi	Automotive/Transport				
	Seagate	ICT and analytics providers				
	Spirit	Aerospace				
	Terex Materials Processing	Materials Handling				
	Thales	Aerospace				
	Thompson Aerospace	Aerospace				
	Whites Speedicook	Millers				
	Wrightbus	Automotive/Transport				
Trade Association	ADS					
	Makers Alliance					
	MANI					
	Manufacturing NI					
	Matrix					
	NIPA					
Government funding and innovation agencies	DAERA					
	DFE					
	Health Innovation Research Alliance NI					
	HVMC					
	Invest NI					
	NIFDA					
Academia	University of Ulster					
	Queen's University Belfast					
Support and facilitation	AMIC Office					

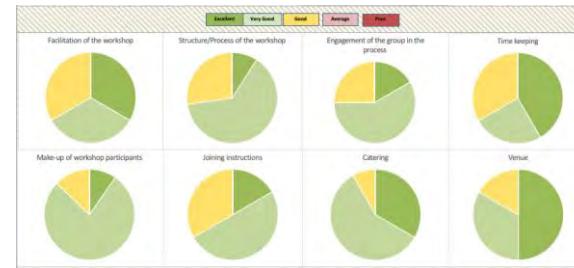


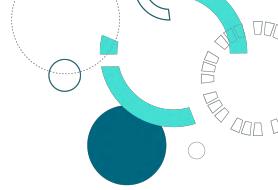
Appendix 2: Delegate feedback

Mechanical, electrical, healthcare & process industries workshop



Food & drink processing industries workshop





For more information about this report:

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Institute for Manufacturing: IfM

The IfM is part of the University of Cambridge's Department of Engineering. With a focus on manufacturing industries, the IfM creates, develops and deploys new insights into management, technology and policy. We strive to be the partner of choice for businesses and policy-makers, as they enhance manufacturing processes, systems and supply chains to deliver sustainable economic growth through productivity and innovation.

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