Innovation Caucus

# UNDERSTANDING CLUSTER GROWTH POTENTIAL – Part 2: Place Based Innovation in the UK: Case Studies


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## About the Innovation Caucus

The Innovation Caucus supports sustainable innovation-led growth by promoting engagement between the social sciences and the innovation ecosystem. Our members are leading academics from across the social science community, who are engaged in different aspects of innovation research. We connect the social sciences, Innovate UK and the Economic and Social Research Council (ESRC), by providing research insights to inform policy and practice. Professor Tim Vorley is the Academic Lead. The initiative is funded and co-developed by the ESRC and Innovate UK, part of UK Research and Innovation (UKRI). The support of the funders is acknowledged. The views expressed in this piece are those of the authors and do not necessarily represent those of the funders.

## About this Document

This report is the second report for the Understanding Cluster Growth Potential project, the first is Place based Innovation: Synthesis Report

## Disclaimer

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## Contents

## Introduction

This second part of the Place-Based Innovation report contains detailed reports of the nine case studies and is a companion to the Part 1 report, which provides a synthesis of key lessons and themes from this research.

The findings result from applying the framework introduced in the *Understanding Cluster Growth Potential* project (Nelles et al. 2022) in interviews with between 5-10 stakeholders in each case as well as secondary sources where they were available. The methodology for case selection and workflow are described in detail in the Part 1 report. The framework used and the interpretive guidelines that structured how researchers organised and synthesised interview data are reproduced as appendices to this report.

One of the core purposes of this project was to begin to build an evidence base of place-based innovation for use by Government departments and their stakeholders. As such, these case studies are presented here without an analytical introduction so that they can be approached and analysed in support of a broad array of purposes and agendas without being coloured by our reflections. Those interested in our thoughts can consult the Part I document.

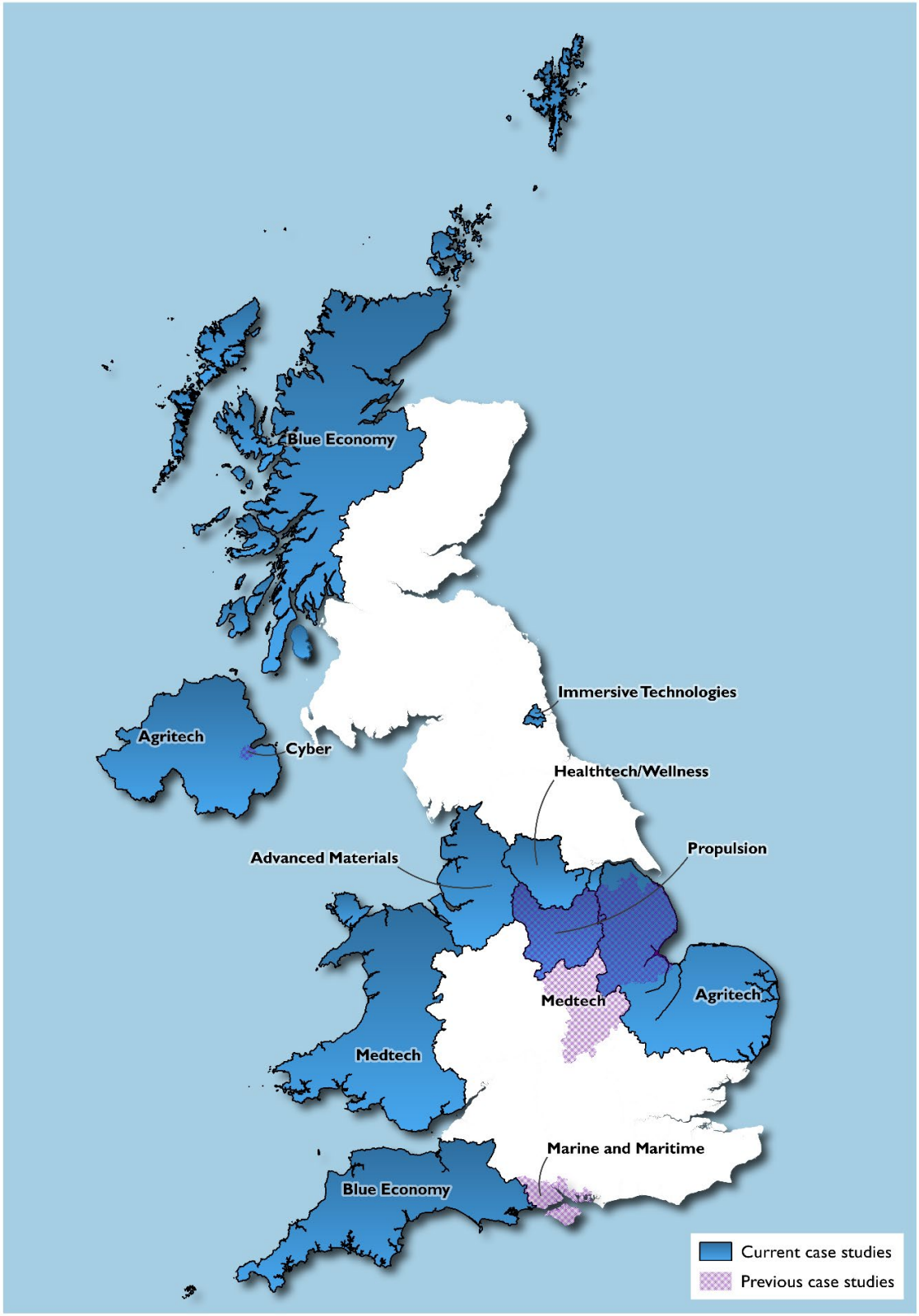


Figure 1: Location of case studies with cases covered in the current document shown in blue and cases conducted as part of the *Understanding Cluster Growth Potential* report in purple checks.

# Methodology

## Case selection and workflow

As in the previous report, we relied on discussions with Innovate UK regional managers to select case study industries and geographies. These conversations yielded nearly 30 candidates, which the research team and Innovate UK partners collaborated to narrow down to nine final case studies. Among the considerations for case selection were some degree of geographical variation, so that the study included cases from as many regions as possible. We also aimed for a diversity of urban-centred versus more distributed cases, which also had the impact of creating a variation in the geographical size of the case study areas. These varied from quite large (e.g., medtech in Wales) to the very small (e.g., immersive technologies in Gateshead). While we also aimed for some variation in the ages and types of industries, the range of differences was limited by pairing similar cases (e.g., agritech in Eastern England and in Northern Ireland). By exploring how pairs of industries have evolved in different parts of the country, we were able to investigate similarities that are related to the focus industry as well as differences that might be attributable to specific local contexts.

We opted for this qualitative approach for several reasons. First, the *Understanding Cluster Growth Potential* report stressed that while quantitative approaches to defining clusters are frequently sought, it is critical to understand that clusters are more than the sum of their statistical parts. This is among the reasons that data-driven approaches to cluster identification are so difficult. The presence of agglomeration of something (an industry, for example) can be relatively easy to detect. The degree to which that agglomeration is resulting in the clustering dynamics that enhance innovation outcomes is much trickier to determine. Even more difficult is determining quantitatively which agglomerations may have the *potential* to develop those dynamics or are earlier in that evolutionary process.

Our approach relied on the observations and experience of (primarily) Innovate UK regional managers, their networks, and local stakeholders. This is particularly useful for pinpointing buzzed about and emerging innovative activities, which we hoped to spotlight in this research. However, it is important to acknowledge that these perspectives are likely to be subjective and may be biased. While we expected that this approach would be effective in identifying areas of developing critical mass and emerging innovations, we knew that the industries and geographies identified were not likely to correctly identify fully realised clusters, either in composition or scales. We argue that this finding, however, is an important part of the assessment process and can help policymakers and their delivery agencies to rethink how to characterise the innovative sectors in place-based economies and their relationships to sectors.

In applying the cluster growth potential framework (Nelles et al. 2022), researchers were instructed to follow the evidence to make an assessment of whether their case studies exhibited all of the cluster criteria and, if possible, to discuss whether clustering was occurring at different scales or within different industrial groupings. In the many cases where specific clusters were not identified, researchers focused on describing the innovation dynamics that they were able to observe and make recommendations to enhance and magnify them.

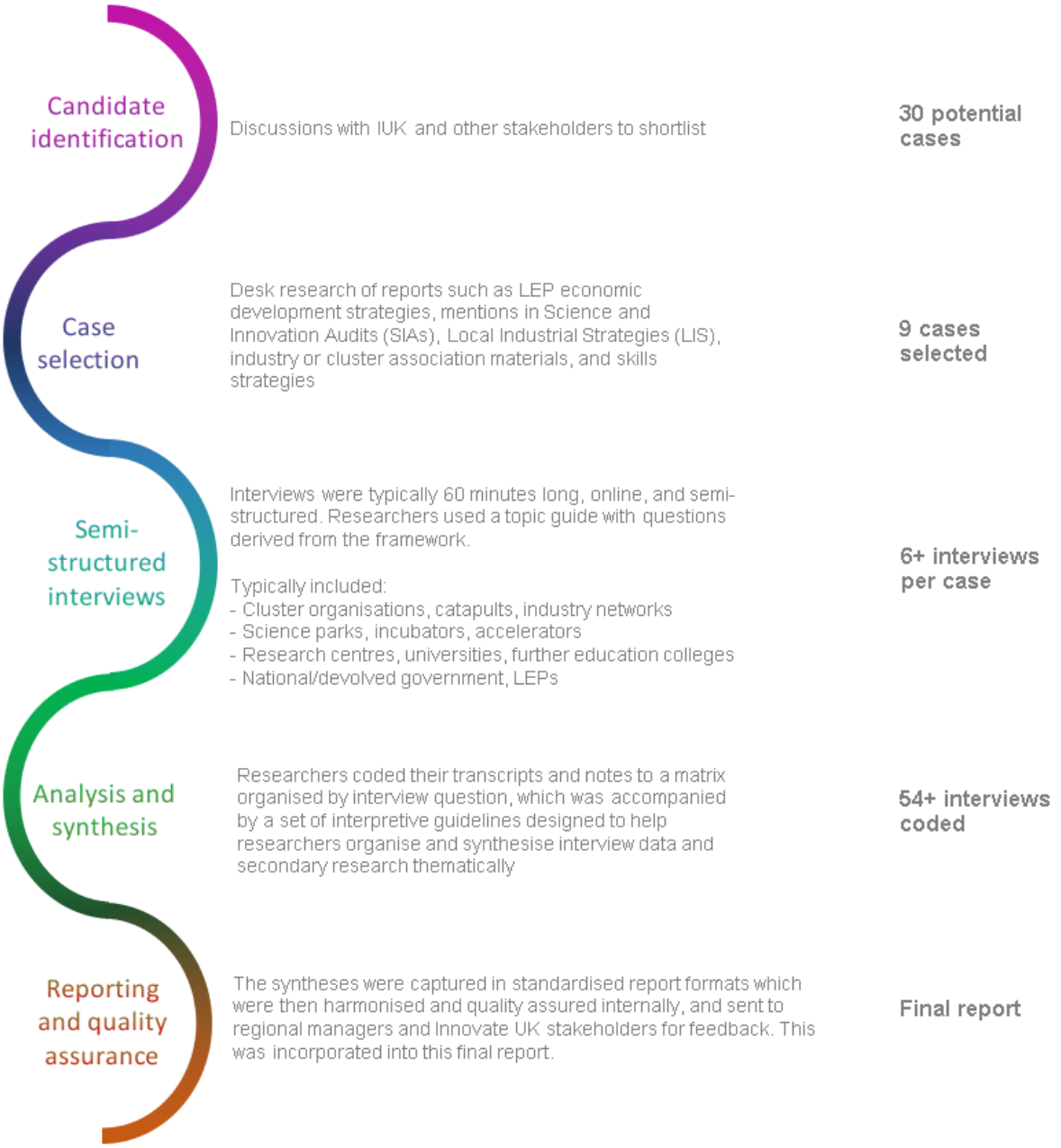


Figure 2: Case study workflow

## Case study methodology

### Case selection

We engaged in extensive discussions with IUK and other stakeholders to develop a shortlist of potential cases. Cases were selected for diversity of geography, types of industry, size, and industry maturity.

### Case study scoping

This involved conducting desk research of reports such as LEP economic development strategies, Science and Innovation Audits (SIAs), Local Industrial Strategies (LIS), industry or cluster association materials, and skills strategies to establish an understanding of the case study and the key players.

### Interview target selection

Based on desk research and inception conversations with regional managers and other stakeholders to identify key organisations and individuals to target with interview requests. Because we were limited to ~6 interviews per case study, our target selection needed to be quite strategic. Where possible and advisable, we interviewed groups of people to extend our resources. We targeted interviewees from the following types of organisations:

- LEPs
- Cluster and/or industry organisations (there may be more than one)
- Research institutions (university or otherwise)
- Science parks
- Further education (usually useful for skills)
- Catapults
- National industry networks
- National/devolved admin government
- Incubators or accelerators

### Interviews

Interviews were typically 60 minutes long, online, and semi-structured. Researchers used a topic guide with questions derived from the framework (see below). Interviewees were all presented with a privacy statement, made aware of how we were going to use the information, and asked to sign a consent form in compliance with Oxford Brookes University ethics procedures. Where permission was granted, interviews were recorded, transcribed, and stored in a secure folder. In all cases, interviewers also took notes, which were used as points of reference and as transcripts for analysis where permission to record was declined.

### Coding and case study synthesis

Once interviews were completed, researchers coded their transcripts or notes to a matrix organised by question. This enabled researchers to organise their thoughts and compile data into relevant categories.

### Case study report

The cluster framework was accompanied by a set of interpretive guidelines designed to help researchers organise and synthesise interview data and secondary research thematically into a final report. These reports were harmonised and quality assured internally and sent to regional managers and Innovate UK stakeholders for feedback, which was incorporated into this final report.

## Framework summary

In the interview and analytical phases of the case study research, researchers used a topic guide and set of interpretative guidelines derived from the cluster framework from the *Understanding Cluster Growth Potential* report. These are reproduced in detail in Appendix 1. The following section summarises the headline categories and objectives.

## Understanding cluster growth potential framework

### Foundations and defining features of the cluster

- Case study characteristics - Establish core industries and what they do.
- Case study history - Outline how industries and places have evolved with key events.
- Geography and size - Establish the geography of the case study and characterise its size.
- Key actors and animators - Determine whether any firms, organisations, or individuals have been core to the evolution of the industry.
- Market potential and innovation opportunities - Discover opportunities for growth and evolution.

### Current capabilities related to innovation opportunities

- Firm sizes and characteristics - Explore the market structure and how that affects the development and potential of the industry.
- Anchor firms - Flag any specific large employers and leading innovative firms.
- Non-firm institutions contributing to knowledge creation - Understand the role of universities, colleges, and research institutions in creating and sharing knowledge in the industry.
- Knowledge sources - Understand where firms are sourcing knowledge and partnering for research and innovation.
- Knowledge flows - Understand how knowledge is transmitted and flows between actors in the cluster.
- Firm network relationships - Understand the culture of collaboration and patterns of knowledge exchange as well as value chain linkages and formal partnerships for research and innovation.
- Convening networks - Survey the organisations and networks involved in convening actors and developing a vision for spatial or industrial development.
- Skills - Understand the characteristics of the talent pool, the role of local higher and further education in skills production, and skills competitive advantages or shortages.
- Support structures - Survey the most significant organisations involved in providing business support including economic development agencies, incubators or accelerators, industry or professional organisations, etc.
- Finance - Understand the main sources of funding and finance and issues with access, growth cycles, and pinch points.
- Infrastructure - Explore the importance of and providers of specialised infrastructure, such as lab space, testing facilities, specialised equipment, etc.

### Innovation opportunities

- Evolution and position of the industry - Evaluate expectations about the development of the industry and assess attitudes about how well positioned it is to take advantage of market opportunities and address challenges.
- Market opportunities - Understand how actors in the industry think market opportunities will evolve over time and what needs to be done to take advantage of these.

- Support required - Evaluate whether the case requires external support to achieve growth and outline what that might involve.
- Resilience - Explore whether there are any threats, pinch points, or bottlenecks that might threaten industrial growth or evolution.
- Leadership - Establish whether there is sufficient leadership convening the industry and relevant stakeholders to think collectively about the future of the industry and its growth potential.

The interpretive guidelines (see Appendix 2) were designed to help researchers think about how to structure, synthesise, and reflect on insights from the interviews into a case study report. This document provides guidance about how to map interview responses for each question in the topic guide thematically to structure the cluster report and offers some thoughts about what kinds of metrics (see below) might bring more detail to each section. Each report provides an overview of the case study, outlines core assets, discusses skills provision and gaps, reflections on patterns and practices of knowledge exchange, and details leadership and convening networks that are contributing to visioning and strategy of place-based innovation. Each case concludes with a discussion of innovation opportunities and support needs.

**Metrics and measurement**

As the project progressed, we grappled with the question of what kinds of metrics we could use to add context to the case studies. The interpretive guidelines that accompanied the *Understanding Cluster Growth Potential* report included a list of metrics that might be useful for such a purpose. While these indicators are still relevant, and we include them where appropriate, we stress that they are not suitable for comparative analysis without addressing substantial methodological issues.

The primary problem of generating comparable data to evaluate case studies relative to one another is that the units being compared - in this case the geographies and (groups of) firms and industries - must be standardised to ensure that the research compares like with like. This is difficult, though not impossible, for a variety of reasons. First, the geographies being compared need to be similar and make sense. In this project, the case study geographies were established prior to engaging in qualitative research and not based on a rigorous analysis of the extent or scale of the industries we were studying. This is why we have case studies that span very large areas (e.g. Wales and Northern Ireland) alongside smaller areas (e.g. Gateshead and Yorkshire). Areas of analysis do not need to be the same size, but they do need to encompass similar phenomena. That is, ideally geographical boundaries should align with the spatial concentration of firms and the networks between them. This exercise is complicated by the fact that the aggregation of innovative activities often does not align with the administrative boundaries or scales at which data is collected. The most sophisticated approaches to cluster identification use methodologies that do not assume specific geographies but construct cluster boundaries using percolation or other methods that assess the similarity of activities/assets between contiguous microscale units (such as postcodes or LSOAs) and based on algorithms specifically designed using proximity and industrial parameters appropriate to the industry.

If comparable geographies need to be determined by the boundaries of industrial concentration and innovation activity, then it is also important to use comparable definitions of industries. In the UK, industries are usually identified by standard industrial classification (SIC) codes. However, many criticise this structure, stating that it hasn't been updated since 2007 and simply doesn't have classifications for new and emerging industries driven by research, development, and innovation (Salmon 2020). Even if SICs did effectively capture the different types of innovative activities that now permeate the economy, we would still have to rely on combining SICs to capture the extent of activities in particular sectors. For example, agritech combines agriculture with biosciences, robotics, data science, remote sensing, logistics, and processing operations (among others). Many of the firms

that contribute to this economy do not consider themselves agritech companies - yet they can be important sources of innovation and points on the value chain. It is, of course, possible to aggregate SICs to construct a reasonable description of the industry. Alternatives also exist, built with machine learning and human expertise, that enable a potentially more accurate mapping of complex industries (Salmon 2021). Other methodologies have also evolved to describe knowledge spaces and explore related variety to capture how new industrial spaces are evolving through recombination (Balland and Boschma 2021, Hidalgo et al. 2018, Whittle and Kogler 2020).

In sum, if comparison of place-based innovation is the aim - on any metrics - the two fundamentals of ensuring that geographies and industries are rigorously defined and comparable is an essential, and not easy, first step.

### Where and how we use data in this report

Given that the methods described above were beyond the scope and resources of this report, we have adopted a light touch approach to data in the report. Because metrics that describe things like industrial growth or employment add important context to the case studies, we have opted to include them where possible. We did not do any of our own data collection or analysis for this report but instead relied upon statistics published in reports we collected during the desk research process or that were shared with us during interviews. While we cite data sources, it is important to note that they are not always reported at the same geographical scales that we are studying (we indicate geographies if they differ from our own) and we cannot verify the accuracy of those figures. As such, we emphasise that these figures should only be used to gain an understanding of the individual cases and not be considered for comparative purposes.

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# Cluster Abstracts

## Eastern England Agritech

The agritech sector encompasses connected technologies originating from a variety of industries and across different platforms designed to aid and transform agricultural activities. In this case, we interpret the geography of "Eastern England" as encompassing a core set of counties - Lincolnshire, Norfolk, Suffolk, and northeastern Cambridgeshire - while acknowledging that agricultural activities, supply chains and synergies also extend south into Essex, west into Hertfordshire and Bedfordshire, and northwest into the East Midlands. Our research suggest that the area has particular specialisms and growth potential in crop and biosciences underpinned by strong research capacity in universities and research centres; food and beverage processing, with a large sectoral presence and recently established research centres; controlled environment farming (including vertical farming); and sensors, robotics, and automation. It is difficult to describe agritech in Eastern England as a cluster, because of the distributed geographies that it inhabits, the wide variety of activities that fall under its umbrella, and the current state of development of synergies between them. The area has many of the raw materials to fuel that growth and to seize emerging market opportunities. The sector will benefit from ongoing national attention to net zero goals, rethinking regulations on gene editing post-Brexit, and investments and initiatives in the space sector, which will likely improve downstream applications. Engaging closely with LEPs, Agritech-E, and research organisations around the area will be crucial to coordinating activities in the cluster and designing effective interventions.

## Northern Ireland Agritech

Northern Ireland has existing strengths in several areas of agritech with potential for future growth including data and digitalisation, earth observation, AI-enabled technologies, optics and sensors, nutrition and food quality, agriengineering, and farm equipment manufacturing. Agritech in Northern Ireland has many of the right ingredients to be a successful cluster but has not, as yet, coalesced as such. While there are strong capabilities, and industrial identities, around agriculture, food and beverage, and agrifood there is not yet clear cluster leadership in agritech. The research infrastructure and support streams are not as numerous as in some other agritech clusters, but it is well-established, well-resourced, and developing and supporting world-leading innovations. While higher education and publicly funded research are spearheading important knowledge generating projects, the role of the further education college, CAFRE, in providing skills, training, business support, knowledge exchange, and promoting innovation adoption should not be overlooked. There is an emerging consensus that the single most impactful intervention to accelerate cluster development would be the creation of a cluster leadership organisation - or the adaptation of an existing structure - to strategise beyond agrifood, advocate more effectively within the fragmented Government structure, increase international visibility, and establish a shared identity for the sector.

## Great South West Blue Economy

The Great South West is an amalgam of three Local Enterprise Partnerships (LEPs) in the South West: Cornwall and Isles of Scilly LEP, Heart of the South West LEP, and Dorset LEP with approximately 700 miles of coastline. Areas of expertise in the Blue Economy are emerging and consolidating around offshore wind, oceanic environment monitoring, autonomous vessels, surveillance and maritime security, and marine science and research. While these may be regarded as core competencies, other related industries are as diverse as boat building (specifically race and pleasure craft) and fitting, satellite applications, digital and data, and logistics. Spatially, Blue Economy activities are distributed across a broad geography with notable concentrations in and around major urban areas and port facilities. Additionally, given the diversity of Blue Economy activities and industries it is hard to describe the

current configuration as a cluster in the technical sense. There are, however, synergies that seem to be evolving between different Blue Economy subsectors described here and it is not too difficult to imagine that with further evolution these industries may converge further and create meaningful spillovers that will act as innovation multipliers. While processes are underway to develop a stronger identity for the sector in the area, there is not yet a collectively shared vision. The area is also facing skills shortages that might constrain growth.

## Blue Economy in the Scottish Highlands & Islands

The Highlands and Islands area is home to emerging expertise in the Blue Economy with a focus on offshore energy, aquaculture, and marine biology, monitoring, and engineering. The various industries that make up the Blue Economy tend to operate in silos and are sometimes competitive over marine resources. As such, this is currently less of a coherent cluster than a set of industries, activities, and assets that could potentially be more effectively connected to maximise opportunities for knowledge synergies. For a large, in many cases remote and sparsely-populated area, the Highlands & Islands has a rich foundation of core assets in the Blue Economy. Industries with large multinational anchor firms and growing international investment, well-established and well-connected research programmes in universities and independent research organisations, specialised infrastructure, and active and engaged supportive organisations mean that the area has a lot of expertise and engagement to build on. While how to best coordinate the Blue Economy in the Highlands & Islands remains an open question, it is clear that the area has a strong foundation to grow various Blue Economy industries. Targeted investment could help to overcome challenges - particularly related to skills - and create conditions to ensure that the benefits of growth are effectively captured in order to fuel the development of local innovation systems.

## Healthtech Yorkshire

Healthtech in Yorkshire comprises both emerging and established clusters. In the West, Leeds has a relatively mature and dense network of firms related to digital healthcare, personalised medicine, tissue regeneration and wound care, and wellbeing (nutrition, wellness, mental health, sleep). These appear to be centred around research centres of excellence as well as strengths in related fintech and software industries and underpinning assets such as IT infrastructure, and a legacy of manufacturing strength. In the South, Sheffield has some large Healthtech anchors and evidence of startup activity, although this is a more recent development than the West. Beyond these two centres, there are other distinct pockets of Healthtech activity, each building on local assets and legacies such as textile industry in Huddersfield which has translated into woundcare technologies, and Bradford establishing a Digital Health Zone linked to the local university and proximate to the Wolfson Centre for Applied Health Research. As such it is not appropriate to view Yorkshire as a Healthtech cluster, although this presents an opportunity, already appreciated by the respective Combined Authorities who are coordinating to better integrate complementary strengths across the region. For example, South Yorkshire has the opportunity to be more applied in the wellbeing space by drawing on the data infrastructure and architecture in West Yorkshire, enabling both regions jointly build digital health solutions.

## Wales MedTech

The Medtech sector encompasses diagnosis and treatment devices to improve health and wellbeing. As such it has links to technologies employed in a range of industries including pharmaceuticals, electronics, manufacturing, software and data analytics, all of which have presence in Wales. In this case we include the whole of Wales while recognising this region may have distinctly separate areas of activity with limited interaction between each other and strong connections to regions outside Wales.

The north of Wales appears to interact with industry in assets in Liverpool and Manchester, and the south of Wales has better infrastructure and network connections with Bristol and surrounds. Therefore it is difficult to describe Medtech in Wales as a cluster, although the area has many of the knowledge and support assets to fuel growth. The sector will benefit from the unique position with strong voice from a national devolved administration, enabling a more direct policy focus on some of the regulatory changes that affect the medical sector post-Brexit, however threading the needle of access to international markets for Wales based firms requires engagement and coordination with those proximate regions such as Northern Ireland and the Republic of Ireland which have seen increased activity due to their access to markets.

## Energy/Propulsion in the East Midlands

The propulsion cluster in the East Midlands, centred around Derbyshire and Nottinghamshire, is an established cluster since important anchor firms have been active in these regions for decades (e.g., Rolls-Royce, Alstom, Toyota). However, the green industrial revolution has brought a new dynamic to this area. Due to the fact that within these regions, a variety of cutting-edge low-carbon propulsion technologies (e.g., electric, hydrogen, alternative fuels, nuclear) are being developed, serving multiple sectors of the economy (e.g., trains, vehicles, aerospace, submarines), a strong regional absorptive capacity has been created in energy research in general, and in propulsion and engine systems engineering, in particular. Although it can be considered as an existing cluster, it has been formed as a set of separated interconnected sub-clusters on a sectoral basis (train cluster, vehicles cluster, etc.) rather than an overall, coherent propulsion cluster. The area is uniquely positioned to play a central role in the research and development of propulsion technologies and engine systems engineering globally, since it enjoys deep and broad abilities and skills across all alternative propulsion technologies, providing efficient low-carbon energy solutions for all means of transportation. The long-term, strong, and continuous commitment of the government to the potentiality of the cluster along with the creation of an organisation that could lead, coordinate, and coherently represent the cluster in its entirety are two of the most important areas of potential support that emerged from our interviews.

## Advanced Materials in the North West

Advanced materials innovation is fundamental to the economic development of the country and its net zero strategy. This has been duly recognised by the UK government which highlights innovation in advanced materials as an area of strength and opportunity for the country in the Innovation Strategy published in 2021. The North West region of England has one of the largest combinations of advanced material development and application companies in the UK, as well as world-leading material science research institutions. The North West can leverage its strong asset base to take advantage of the global focus on net zero and decarbonisation and turn the area into an advanced materials innovation and manufacturing powerhouse. Our research suggest that the sector would benefit from closer collaboration between the various stakeholders and strong leadership that can help formulate and drive the industry strategies. Closer engagement between the different administrative authorities such as LEPs and combined authorities would be essential to the coordination of strategic interventions and other activities aim at realising the objectives of the UKs national innovation strategy and other initiatives.

## Gateshead and Newcastle Immersive Technology Cluster

The immersive technology sector focuses on technologies that can transform users' digital experience by combining the virtual experience with users' sight, sound, and touch. The aim is to create an artificial, simulated environment applicable to a variety of industries and platforms. The immersive technology industry in the North East is currently emerging around Gateshead and its surrounding area alongside

the River Tyne in Newcastle. The Gateshead Council and North East LEP recognise the potential development of the cluster and its application that may spread across the wider local authority areas of North East England, which comprise the urban centres of Tyneside, Wearside, and Teesside and the local authority areas of County Durham, Gateshead, Newcastle, North Tyneside, Northumberland, South Tyneside and Sunderland. Our research suggests that the industry grew from particular specialisms of entertainment and gaming. However, opportunities arising during the pandemic have allowed for a wider range of industries to realise the potential that immersive technologies could bring to business, in areas such as advanced manufacturing, crisis and hazard management, skills training, and education. We see immersive technology in the North East as an emerging cluster, centred on Gateshead, with national and international interconnections due to the virtual nature of immersive technology and the wide variety of applications that it is currently connected to and may connect to in the future. A major strength of the emerging cluster is its high potential opportunity (HPO) status for immersive technology, conferred by the Department for International Trade (DIT). Challenges remain in the limited talent pool, access to funding to scale up firms, and education initiatives affecting the potential that immersive technology offers. Support needs to be given in increasing awareness among existing entrepreneurs on the wide application of immersive technology, as well as among clients who are adopting immersive technology. The sector will also benefit from attracting investors into the region and growing the local private funding community.

# Eastern England Agritech

## Case Study Overview

**Characteristics and history:** Agricultural activity in Eastern England primarily focuses on crops, with livestock (predominantly pork and poultry), and some aquaculture in coastal areas. While most of the activities described in the definition of agritech occur to some degree in Eastern England, stakeholders indicated that the area had particular specialisms in *crop and biosciences* underpinned by strong research capacity in universities and research centres; *food and beverage processing*, with a large sectoral presence and recently established research centres; *controlled environment farming* (including vertical farming); and *sensors, robotics, and automation*. A recent report placed the area's agricultural output at £5.1 billion in 2019, noting that this accounts for a quarter of the English total and that the food chain supports over 150,000 jobs across the region (New Anglia LEP et al. 2021).

There is considerable expertise in the area in related industries such as ICT, space and satellite applications, and artificial intelligence. These certainly have made contributions to agricultural development in the area; however, their applications are much broader than agriculture and significant agriculturally-focused sub sectors have yet to coalesce in this area. Although there are notable complementarities between the areas of excellence noted above (e.g., robotics and automation is used in vertical farming; crops and biosciences are responsive demands to the food processing industry, etc.), this has not translated into significant synergies in the form of strategic partnerships and widespread ongoing collaborative research.

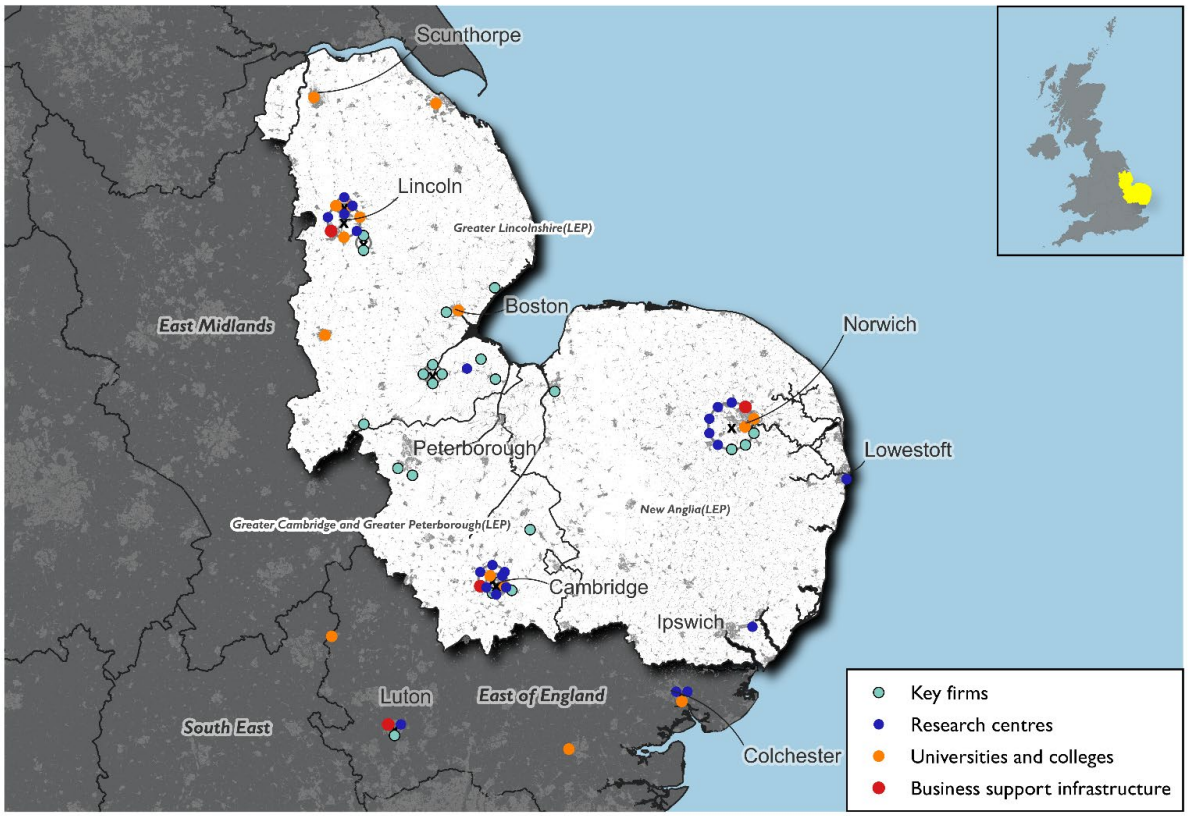


Figure 3: Eastern England Agritech map.

**Geography and size:** This study began from a loose geographical definition of Eastern England with the aim of refining that definition through our discussions with stakeholders. Opinions differ as to the precise geography of agritech in the area, with some adopting definitions that encompass the entire scope of agricultural activities and others that focused on what they perceived as centres of innovation

in and around Lincoln, Norwich, and Cambridge. In this study, we interpret the geography as encompassing a core set of counties - Lincolnshire, Norfolk, Suffolk, and northeastern Cambridgeshire - while acknowledging that agricultural activities, supply chains and synergies also extend south into Essex, west into Hertfordshire and Bedfordshire, and northwest into the East Midlands.[1] That said, this definition is somewhat problematic since some knowledge producing universities and Rothamsted Research (Hertfordshire) is another significant research and business support organisation even though it is located outside of this core geography. Also notable is that this geography does not map neatly to current governance mechanisms such as Local Enterprise Partnerships (LEPs) and Combined Authorities. Core LEPs include Greater Lincolnshire LEP, the Cambridgeshire and Peterborough Combined Authority, and New Anglia LEP, each of which has its own interpretation of the agritech sector and its contribution to its economic development planning.

**Areas of potential future growth:** Agritech was described as a dynamic and growing sector by stakeholders in the area. In terms of areas of potential future growth, stakeholders focused on both core technologies and practices.

- Controlled environment farming - vertical farming and glasshouses for applications locally and in challenging environments in the context of climate change and Net Zero objectives.
- Alternative proteins - experimenting with and producing alternative proteins.
- Farming and food waste reduction and processing - seeking efficiencies in food production to reduce waste, develop more resource efficient crops and processes, and innovation to expand markets for agricultural products.
- Biological crop protections and plant engineering - related to resource efficiency, responding to climate change, and increasing hardiness to pests - includes cell and gene editing (GE) and genetic modification (GM). Changes in UK regulations around GE and GM anticipated after exit from the European Union may create space for significant growth and innovation in this field.
- Satellite applications - remote monitoring of crops and livestock permit precision farming.
- Digitalisation - encompasses a broad set of opportunities around data marshalled from many applications: from predictive and precision farming and supply chain management, to better navigation of logistical and regulatory challenges, among many others.
- Automation - has increasingly been developed for and adopted in farming both in relation to emerging practices (e.g., vertical farming) and to mitigate labour challenges.

The diversity of areas of potential growth is a great asset for agritech as a sector but also highlights how fragmented it is as well. While it is again worth noting that there are synergies between them, many of these are innovations, practices, or technologies that are conceptualised (and funded) as distinctive activities. Importantly, these growth areas can yield benefits for local producers and processors; their primary value will likely come from international markets.

**Reflections:** It is difficult to describe agritech in Eastern England as a cluster, because of the distributed geographies that it inhabits, the wide variety of activities that fall under its umbrella, and the current state of development of synergies between them. While there is no shortage of governance entities and industry associations that champion aspects of agritech, a shared vision has only recently begun to emerge. In 2021, the three LEPs that we have designated as core collaborated

[1] Previous studies have used these more expansive geographies while also acknowledging the difficulty in establishing firm boundaries (see Policy Links 2016). As another example, SQW (2017) uses an alternative definition that excludes Lincolnshire.

on a document to guide investment entitled "Agri-food in Eastern England: An Investment Opportunity", highlighting their intention to work together to grow the sector. However, while the document features core assets in the region and some broad collective objectives, interviews suggested that the LEPs (and industry organisations) were generally pursuing their own strategies, even though they duly acknowledged the benefits and need for collaboration. This is covered in more detail under the heading of governance, below. It is also worth noting that other, overlapping agritech-related clusters are developing on the area's flanks - most notably the Crop Protection cluster in Buckinghamshire Thames Valley, Hertfordshire, Oxford and Thames Valley Berkshire that is being created as a candidate for a high potential opportunity (HPO) zone.

## Core Assets

**Market structure and anchor firms:** Because agritech encompasses so many different elements of the value chain (see Figure 4), it is difficult to provide a thorough accounting of notable anchor firms or a detailed description of the sectors' structures. Some respondents remarked that the area lacks large domestic agritech firms, and is instead dominated by large international players like Syngenta, Bayer, Dow, and Cargill. Others contrasted the structure with the pharmaceutical industry, in which large domestic firms and foreign anchor firms are more embedded in the ecosystem and do more horizon scanning and R&D that engages local SMEs.

Respondents tended to focus on the firms in subsectors of agritech that were most relevant to them. Those focused more on biosciences and technologies noted domestic SMEs such as Tropic Biosciences, Leaf Expression Systems, Colorifix, Phytoform Labs, Olympus Automation Ltd, and Alltech. For instance, those focused more on the food production side were more apt to list large food producers such as Dyson Farming, Gs Growers, Burgess Farms, the Bom Group. On the food processing side, interviewees named several firms including Greenyard, Plant and Bean, Princes, Branston Potatoes, Staples Vegetables, Worldwide Fruit, AH Worth, Bakkavor Plc, FESA, Karsten UK, Pinguin, and Premier Foods. Retailers such as Sainsbury, Waitrose, McCains, and others are not locally based, but exert influence on the value chain.

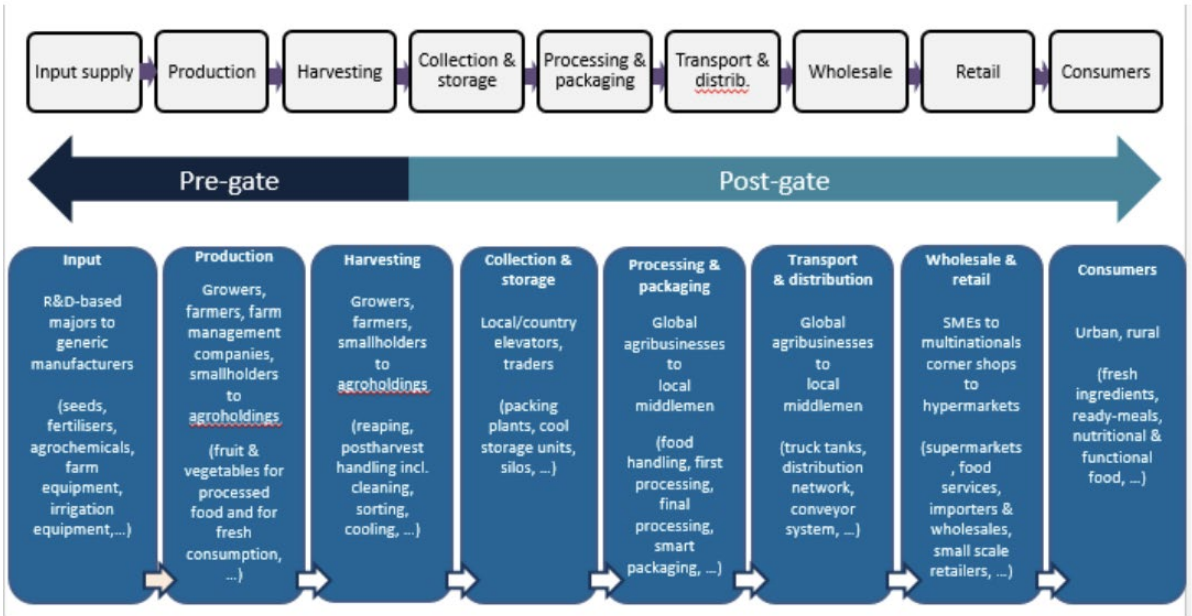


Figure 4: Different elements of the Agritech value chain. Source: Policy Link 2016.

Market structures play a strong role in stimulating demand and creating an environment for innovation. The area undeniably has an impressive roster of companies active and innovating across the value chain and many more SMEs that were not mentioned or in the process of developing, particularly on the technology side of the equation. Interviewees described a community of farmers ranging between established 4th or 5th generation family farms (which can be very large and significant producers) and industrial operations. The former were described as having varying degrees of openness to technological and process innovation and engagement with research infrastructure, while the latter were characterised as having their own internal programmes and not drawing extensively on locally-generated innovations. One respondent noted that with respect to plant sciences, food processors much further along the value chain were significant actors in shaping innovation and demand. In their view, this was creating a structural reorganisation on the production side - with producers aligning with specific processors and clusters of producers and processors in one location forming compressed supply chains - to respond to processor and retailer demands.

This highlights suggests distinctions in the demand profile for different technology types, what drives that demand, and the actors within the market with the capabilities (and willingness) to access innovation or engage in their own development processes. The degree to which firms developing technology have been able to penetrate local markets is unclear from this sample and is an area for future research. However, the markets for those technology solutions are global. This suggests a role for support mechanisms that leverage existing market structures to maximise innovation and adoption locally while recognising that local absorption is not crucial for the development of international opportunities.

**Higher education and training institutions:** Universities and colleges in the area have strong research and training programmes in agriculture, biosciences, and emerging agritech fields due to the area's historical specialisation. Note that each institution has programmes in plant and crop science and biotechnology. Much of the world leading research is conducted in specialised research centres listed in the next section.

- **University of Lincoln** delivers "advanced, multi-disciplinary research and innovation across the entire food chain, providing cutting edge solutions to improve the sector's productivity, sustainability, safety, and resilience, while enabling new product development" (New Anglia LEP et al. 2021). The ***National Centre for Food Manufacturing (NCFM)*** provides training for food industry employees and businesses. The university has a specialist MSc programme in Agri-food technology and hosts the ***Lincoln Institute for Agri-Food Technology (LIAT)***, which supports research in the areas of artificial intelligence, robotics, engineering, crop science, environmental sustainability, food manufacturing, product development and supply chains to support and enhance the future of food and agriculture productivity, efficiency, and sustainability. LIAT engages in several partnerships such as ***Lincoln Agri-Robotics (LAR)***, the world's 'first global centre of excellence in agricultural robotics' (UK Innovation Strategy, July 2021). This initiative brings LIAT together with the Lincoln Centre for Autonomous Systems (L-CAS) to support robotic innovation and technical advancement in agriculture, through a network of academic excellence, industry partnerships, and funding organisations. The university is also host to ***Barclays Eagle Labs Farm***, which provides space to support entrepreneurship and includes a robotics lab, a demonstration packhouse, and a model refrigerated supermarket aisle. The university is also a partner in ***AgriFoRwArdS*** (see below).
- **Lincolnshire Institute of Technology** is a collaboration between the University of Lincoln, employers and colleges across Greater Lincolnshire to meet the higher level engineering, digital and manufacturing skills of the region's agritech sectors. The partnership brings together the University of Lincoln, Grimsby Institute of Further and Higher Education, DN Colleges Group (North Lindsey College), Bishop Burton College (Riseholme College), Boston

College, Grantham College and University Centre, Lincoln College, Lincoln UTC, University Campus North Lincolnshire, Bakkavor Plc, and Olympus Automation Limited, with the support of the Greater Lincolnshire Local Enterprise Partnership, Siemens Energy UK, and CATCH.

- **University of East Anglia (UEA)** hosts an MA in Agriculture and Rural Development and specialisms in health and nutrition, environmental and biological sciences, responses to climate change, understanding consumer behaviour, competition and regulation, and data. It is home to the ***Broadland Food Innovation Centre***, an £11.4m ERDF funded project supported by New Anglia LEP and delivered by UEA, Broadland District Council, and Hethel Innovation. The initiative provides food and drink SMEs and the broader sector with support to grow and test new food items and to develop local supply chains. The initiative also supports a ***Food and Drink Innovation Cluster*** for Norfolk and Suffolk, which aims to facilitate knowledge exchange, R&D collaboration, new business, and supply chain opportunities.
- **University of Cambridge** hosts numerous plant science and agritech departments and programmes. In addition to world-leading departments of Plant Sciences and Genetics the university is also home to the ***Sainsbury Laboratory***, ***Crop Science Centre***, and ***Cambridge Global Food Security Research Centre***. The ***Cambridge Conservation Initiative***, a collaboration between the university and nine leading conservation organisations, leads agritech projects focused on food security and biodiversity. The Computational Biology stream at the ***Cambridge Centre for Data-Driven Discovery (C2D3)*** offers courses in computational biology using mathematical and computational methods to analyse large amounts of complex data and synthesising them into useful system-wide models of biological processes.
- **City College Norwich** is participating in the co-creation of a New Anglia technical curriculum in Agritech (among other subjects) with a coalition of colleges in the area. It works closely with employers and industry associations to fill skills need in the area.
- **AgriFoRwArdS** is a collaboration between the Universities of Lincoln, Cambridge and East Anglia, and focuses on robotics within the agricultural sector. The Centre provides fully funded opportunities for students to undertake MSc and PhD study, to become the next leaders in the agri-food robotics community. In 2021, the programme had £6.9m of funding to support 50 PhDs, all co-sponsored by industry (New Anglia LEP et al 2021).

There are several other universities that contribute to the Agritech economy in the area that, while not physically located within the case study geography, are significant enough to mention:

- **Writtle University College:** Writtle is one of the oldest specialist institutions in the UK and offers a range of land-based, environmental, animal and sport courses at various levels of academic study including postgraduate, undergraduate, further education, short courses and apprenticeships.
- **University of Essex:** The plant group at Essex is working with farmers and growers to find new ways of improving crop yield, thanks to a deeper understanding of photosynthetic and plant responses to the environment. The ***Essex Plant Innovation Centre (EPIC)*** brings together the research skills, expertise and technologies across our science faculty (Life Sciences, Computer Science and Electronic Engineering) together with the Institute for Analytics and Data Science (IADS) and Essex Business School to address the grand challenges facing farmers, technologists and all those in the agricultural and horticultural sectors.
- **Anglia Ruskin University: (**Essex, Cambridge and Peterborough). Hosts the ***Global Sustainability Institute*** and is leading an initiative to create an ***Agri-Food Tech & Sustainability Consortium*** around their new campus in Peterborough.
- **Cranfield University:** (Bedfordshire) The Environment and Agrifood Theme combines

research groups with 50+ years of experience in contributing to societal challenges such as sustainability, enhancing natural capital and future global food systems resilience. Cranfield is also a partner in two Agritech Centres; Agri-EPI and CHAP. University facilities combine research and development capabilities in agriculture, in multiple configurations, to address the importance of soil resources and sensing and analysis of big-data.

**Other research and anchor organisations:** In addition to the research institutions and programmes hosted at universities and colleges (above), the area hosts five of the eight national strategic sites supported by the Biotechnology and Biological Sciences Research Council (BBSRC). These research centres have close connections with one another and with associated universities. However, it is notable that these tend to specialise more on plant and crop science than on enabling agritech technologies, such as data analytics, robotics, machinery, etc.

- **Norwich Research Park** is one of the most significant concentrations of food, genomics, and health technology research in the UK. It is home to over 40 companies that are translating concepts developed through science research into viable commercial propositions. It is a partnership between the John Innes Centre, Quadram Institute, Earlham Institute and The Sainsbury Laboratory; with University of East Anglia (UEA) and Norfolk and Norwich University Hospitals NHS Foundation Trust (NNUH), supported and funded by The John Innes Foundation and UKRI Biotechnology and Biological Sciences Research Council (BBSRC).
- **John Innes Centre** was founded in 1910 and established in Norwich in 1967. It is an independent international centre of excellence in plant science, genomics, and microbiology. Its core departments focus on biochemistry and metabolism, cell and developmental biology, computational and systems biology, crop genetics, and molecular microbiology.
- **The Sainsbury Laboratory** is based at Norwich Research Park and hosts research projects that take fundamental scientific discoveries from the laboratory to the field with the aim of reducing worldwide losses to crop diseases. Current projects include the discovery, engineering and deployment of novel immune receptors in crops, as well as genome editing tools that will enable the generation of novel alleles for crop improvement.
- **Quadram Institute** is an interdisciplinary institute that conducts research at the interface between food science, gut biology, human health and disease, and is based at the Norwich Research Park.
- **Earlham Institute** is based at the Norwich Research Park and has a core mission to unravel the scale and complexity of living systems to understand, benefit from, and protect life on Earth. It brings together multi-disciplinary expertise in the life sciences with engineering, computational science, and biotechnology.
- **Rothamsted Research**[2] is a world-leading, non-profit research centre that focuses on strategic agricultural science to the benefit of farmers and society worldwide. The scientists at Rothamsted use data, expertise, and technologies to improve crop performance, resilience, and value. Its research tackles weed, disease and insect resistance to agrochemicals, improves soil health, enhances natural capital, reduces agriculture's carbon footprint, and adds novel nutritional and bioeconomical value to crops and other products. ***Rothamsted Agritech Business Centre*** is located on the same campus and offers office, lab space, and business support services to agritech and agrifood businesses through an innovation hub and incubation space.
- **NIAB** has several locations in Eastern England including its headquarters in Cambridge and

[2] Rothamsted is technically located outside of the geographical footprint of the area of study but was mentioned so frequently as a partner and knowledge generating asset by actors we interviewed that we have included it here.

the Eastern Agritech Innovation Hub. Its research and support offerings span the crop improvement pipeline; from underpinning research required to develop higher yielding, more climate resilient crops through to the extensive trials data, agronomy expertise and advice needed to ensure these advances are transferred effectively onto farms.

**Support structures and infrastructure:** Much of the innovation and commercialisation process is supported by the numerous universities and research centres. Several of these have dedicated incubation spaces and offer support and technology transfer services (e.g., Rothamsted, Norwich Research Park). Consequently, there are relatively few standalone support structures. ***CERES Agritech*** brings together five leading UK universities (Reading, Hertfordshire, Lincoln, East Anglia, and Cambridge, as well as three research centres (Rothamsted, John Innes, and NIAB) to provide translational funding and commercialisation expertise and drive agritech innovations to market. Other initiatives include six **Food Enterprise Zones (FEZs)**, each of which has a different specialism and aims to support innovative businesses in collaboration with local councils and affiliated research organisations and universities. As with other assets, there is no shortage of initiatives and support across the area. Where respondents felt that there may be gaps was particularly on the financing side, where there is a perception that there are wide differences in access to resources based on area of research (e.g., controlled environment farming is currently attracting a lot of public and private investment while other areas do not receive as much) and a lack of support for SMEs looking to scale. On this latter point, all of the incubation facilities that we interviewed reported being at capacity while fielding frequent requests for support. This suggests that there is an opportunity to either expand existing incubation offerings (which often requires access to lab spaces or test facilities/land) and/or provide related business support in other ways.

**Finance:** Funding and finance are perennial challenges for innovation support. The most frequently mentioned sources of business support were CERES Agritech (listed above) and Innovate UK. However, these were both characterised as "oversubscribed". The 2017 SIA mentions several sources of funding:

- Anglia Capital Group venture capital
- Cambridge Agritech investment syndicate
- Adapt Cocoon Equity

It is perhaps notable that none of these were mentioned by name; only Anglia Capital Group appears to be active. This suggests that angel and venture capital is relatively difficult to access, a sentiment that is confirmed by several people we interviewed. One summarised the situation:

> *Well, you have angel networks, you have VC funds, but you also have high net worth individuals. [But it] takes a long time to see investment return. This was traditionally not an area where a lot of investors were interested, because you know, they need within five, seven years to have the return on investment. [Now] there is a lot more interest in agritech, because of the global challenges and because they also realise this is an exciting area with a lot of technologies. But yes, there are private sources of finance, but not enough. We need to do more education with the finance sector and explain how this market works. You know, what are the kinds of business models and how they can create return on investment.*

As this statement suggests, some observers noted some momentum in investment but also argued that this has not been evenly distributed. Areas such as controlled environment farming (vertical farming) have received more attention than others. One of the area LEPs also noted that while they do not have much funding for agritech themselves, they do try to signpost to different pots of money, such as the EURDF Low Carbon Innovation Fund that supports sustainable agriculture. Their impression was that many companies lacked crucial information about what funding might be available

and that where they were aware of opportunities they did not always have the skills to put together a strong bid, which created an additional barrier to funding innovation.

**Reflections:** Overall, the area has a strong foundation of support organisations and knowledge generating assets across the wide range of types of activities and specialisms in the agritech space. The area is host to world-leading research capacity and innovative research centres. There is a considerable critical mass of firms across all areas of growth potential listed. However, the lack of large domestic leaders on the technology side was noted as a potential weakness in the sector's structure. This was less pronounced on the food production and processing side, although larger actors tended to be international firms. Some strong support structures have emerged in partnerships between universities and from partnerships between local councils and universities. But these are relatively new and may not be established, sufficiently resourced, or numerous enough to effectively support the broad geographies and diversity of industries. There also appears to be high demand for access to funding and finance that is not currently being met by either private sources, existing consortia, or Government. Given the strength of core assets, however, there is no shortage of partners that would lend expertise to the co-design and implementation of support programmes.

## Skills

**Talent pool:** Talent was regarded as a complicated issue in the area, with various different patterns and challenges across the different types of activities. Generally, interviewees reported that the area had a great depth of research and innovation skills, in part generated by the strong research organisations and higher education institutions in the area. There is particular, world-class strength in bio- and plant sciences, and emerging strengths in robotics generated and attracted by research labs and university research groups. Gaps were specifically identified in a few fields such as engineering, bioinformaticians, software engineers, around digital skills more generally, and lower skill gaps on the logistics side (e.g., LGV drivers). A recent report noted that between 2019-2021 there was a decline of more than 100,000 workers travelling from EU8 countries, down 12% (Partridge & Partington 2021). Rising labour costs have increased demand for automation and the technical skills to adopt and implement new systems. The most commonly cited gap, however, was in business skills. As one interviewee put it:

> *We have a lot of researchers and I guess, agronomists, and chemists and you know, product developers, but we don't have people who are implementing this in the business.*

Another noted:

> *The problem that I'm facing at the moment is that I have technical expertise, which is kind of overflowing. I have no business expertise at all [...] And we need if we're going to have a strategy for the UK, we have to be investing in training the next generation of business leaders for this new agri business.*

This shortage of people who can understand not only the science and technology, but also the business models and industry structure and markets, creates barriers to innovation and adopting innovation. It also limits the ability of firms to access resources as dealing with funders also requires specific skillsets. Some respondents reflected that agritech was not attracting business talent because of perceptions that it is not a "sexy" sector and because the science and technology expertise required to succeed in that environment is intimidating. Similarly, even where management talent is attracted to these sectors,

it is often inexperienced as more mature sectors are more effective at attracting more senior C-suite talent.

**Local skills provision:** As noted above, local universities and postdoctoral programmes through research organisations generate world-leading research and innovation talent. While much of that talent is retained locally, because of the prestige of these institutions some of that talent is exported internationally. For similar reasons, these institutions also attract talent from around the world to conduct research. Local colleges were also seen as fertile sources of talent in technical and agricultural technology fields. These colleges were identified as potential sources to feed gaps in digital skills and to inject more workers with the willingness and technical ability to seek out and adopt new technologies in food production. City College Norwich is developing a digital lab that will possibly contribute to these efforts, and colleges across the area are engaged in consultation exercises with local employers to fill skills needs. As the agrifood sector has evolved, colleges and local councils have produced a variety of skills analysis documents (see Easton College et al. 2021; New Anglia LEP 2022; New Anglia LEP 2017), which confirm that many of these skills gaps are well-recognised and being addressed through local skills strategies.

Respondents made two related observations about skills and training needs in the area. First, they noted that the food production and agricultural segments of the agritech market have increasing demands for upskilling. Again, as demands for automation and technologies for crop monitoring, water use control, and other innovations increase, so too will demand for people with the skills to deliver and implement these tools. Part of the equation will be in upskilling the existing workforce of farm managers and farm workers. While the demand may be there, employers do not always have the resources to invest in training or upskilling or the knowledge of what programmes exist or support they might be eligible for. Secondly, there is a growing recognition that training has tended to occur in silos, but that model may no longer be appropriate for an increasingly technologically integrated sector. As one observer argued:

> *You do need people who understand the soil science and can do the agronomy, you do need people who can drive the tractors, you do need people that can harvest and sell on the crops, and they do go past the farm gate. But if you teach all of those things in isolation, you'll never get innovation or a broad understanding, because it was a tractor driver, you need to understand the soil science to understand why you're doing certain things. And you need to understand why you're harvesting at a particular time at a particular quality, because of where it goes out of the farm gate. And I think we've probably for a number of years in education, because that's how qualifications were driven down with very, very narrow occupational routes, we kind of lost some of that breadth.*

Consequently, linking training and upskilling programmes and work experiences may yield innovation benefits and future-proof the agritech workforce.

**Reflections:** The skills profile in agritech in Eastern England is relatively strong. However, this section has highlighted some notable gaps. For the most part, these can be (and are being) resolved by concerted action by local councils, LEPs, and area colleges and universities. As related above, these efforts may benefit from being designed holistically in order to ensure that workers understand the systems within which they are operating and increase opportunities for innovation. Public support may play a role in increasing knowledge about and access to training and upskilling opportunities. There may also be an opportunity to work with higher education and further education colleges in the area and around the country to provide specialised management training to fill the significant gap in business skills identified.

## Knowledge Exchange

**Firm research and development practices:** It is difficult to paint an accurate picture of firm R&D practices across such a wide variety of subsectors and activities. Those we spoke with thought that firms in the area were relatively active in research and innovation activity. Respondents would point to food producers using new equipment or techniques (e.g., automation or sensors or crop imaging) but it was unclear whether this represents real innovation for the producer or was really just a form of technology adoption. On the production side, there were clear examples of innovation occurring where farmers were involved in co-developing tools, around vertical farming, and in creatively using waste products. Even in technology adoption, some people we spoke with described reluctance to make investments. Others suggested that producers didn't always have good access to information about innovations that might benefit their businesses. Another barrier to investing in R&D is who might benefit from that investment. One respondent explained that changes in the breeding cycle (for example) take a long time to show results and that value gets fragmented between different players in the value chain. In these cases, the burden of risk and the bulk of the cost falls on the breeder doing the R&D, while retailers and customers reap a majority of the benefits. Sustaining R&D in this area may require that the different members of the value chain work together to both determine what types of research would make the most difference and to collaboratively fund the work. However, this type of risk-reward structure only affects some areas of agritech - although where it does, it creates constraints on R&D behaviour.

**Knowledge sharing and flows:** With such a wealth of knowledge generating research institutions in the area it is no surprise that the potential for knowledge sharing and flows is relatively high. The research institutions that we spoke with reported high levels of demand from firms and cited frequent interactions between researchers and industry. Generally, those relationships were described as effective collaborations with one respondent stating that research is "translating brilliantly" into the local market. However, others responded that research was not focused on producing solutions for the local market and that they would work with firms wherever made sense for product or process development. Only conversations with individual researchers and their counterparts would reveal what barriers or challenges emerged in these processes and the balance of commercial or collaborative partnerships that are local. Respondents cited various bodies (predominantly the AgriFood Industry Council) as important sources of information flows feeding back intelligence about advances in research and innovation activities to the various different groups of stakeholders. That said, some did highlight that information about activities across the area and different subsectors of agritech could potentially be easier to access and that there was still a need for a potentially national level organisation that could pull together information, and expertise about activities in different places, in one place. While some thought about enhancing this capacity at the regional level, others saw advantages in organising better nationally to support connections between actors domestically and to serve as an interface with global markets.

**Knowledge access and cultures:** Respondents reported few significant barriers to knowledge sharing and that cultures of collaboration are relatively robust. The degree to which this is true will vary by subsector. However, due to the strong communities that exist around research organisations, proprietary projects take place in the context of tight knit networks of researchers, which facilitates broader knowledge sharing. Again, brokers like the research organisations themselves and bodies like the AgriFood Industry Council function as gateways through which firms and other researchers can gain access to knowledge and as disseminators of that knowledge. There was a feeling that more could be done to expand access and give firms and researchers more resources (and incentives) to share or seek knowledge from peers and providers in the area.

> *[We need to support] industry to realise the kind of research base research assets we have, but also some of the innovative companies we have in the region. So actually, whilst we've got the sort of research stuff*

*that many businesses don't know about we've also got companies that the farming community have no idea about that could massively benefit their company, with game changing agritech solutions. So they might just go to the University of Lincoln, which is great, just because we work really closely with them. Because they don't know that there are actually companies in their own county or the next county that are doing some of the stuff that they really need.*

One research organisation reported that they felt that while they built internal networks well, they were not as externally facing as they could be. This is a potential area for improvement.

**Firm network relationships:** The people we spoke with had the most insight about interfirm networks in collaborative projects oriented around research infrastructure. Outside of these, farmers were reported to be quite well networked and frequently working in "clusters" (usually meaning groupings of affiliated operations).

**Reflections:** World-class research organisations are significant assets in innovative regions. However, there is no guarantee that, in the absence of concerted effort, the benefits of that research will be absorbed locally. These centres attract researchers from all over the country and the world, and the results of their efforts are similarly transmitted through national and international knowledge networks. While local firms that are able to access these assets can benefit from collaborations and being early adopters of commercialised researchers, it seems likely that many firms lack the capacity to navigate these relationships and that finite capacity at the research end may limit the potential for partnerships. This may also be an issue on the food production side, where large global firms and processing operations either have their own internal R&D programmes or contain their innovations within increasingly vertically integrated supply chains. Almost all agreed that there was scope to increase knowledge exchange behaviour in the area.

## Networks of Coordination

Agritech in Eastern England has several prominent networking organisations. The principal ones are:

- **Agritech-E:** is a business focused membership organisation, supporting the growth of a world-leading network of innovative farmers, producers, scientists, technologists and entrepreneurs who share a vision of increasing the productivity, profitability and sustainability of agriculture. This organisation was previously Agritech East but has rebranded in order to serve a broader national group of stakeholders. Because this group covers a broader geographical area than others on this list, it has the potential and ambition to function as the cluster organisation and convener for the region.
- **Norfolk and Suffolk Agrifood Industry Council:** A council made up of members of industry, government, and the research community to support the ambition of providing strong and clear leadership for the industry to drive forward the aspiration to be recognised as the UK's leading region.
- **UK Food Valley:** An initiative of the Greater Lincolnshire LEP, UK Food Valley aims to support growth and encourage inward investment through promoting the scale, breadth and importance of the food sector to the area, and by ensuring that existing food sector companies and new investors are supported.

Another network of interest in the area is **TechEast**, a community of startups and scaleups, later stage companies, investors, academia and government in the tech space in Eastern England concentrated in Norfolk and Suffolk. However, agritech companies are not strongly represented

among members. TechEast leaders recognise the importance of the agrifood sector in the area but also reported some difficulties in connecting with more agritech focused groups.

**Reflections:** The area is divided between three LEPs and at least four counties (as we have defined it). Political fragmentation is often a problem in these situations. While the Eastern England geography exhibits some of this, there is also evidence of collaboration and coordination between the different governance entities. For instance, each LEP has its own initiatives and plans around agrifood, highlighting their own strengths and investment priorities. However, each is aware of the interrelationships and interdependencies between geographies and describes regular coordination with counterparts in other LEPs. The recent joint production of an investment strategy for agrifood in Eastern England (New Anglia LEP et al 2021) is testament to that approach. Agritech-E and the Agrifood Industrial Council were also described as cluster convenors, although were seen more as forums through which information about innovation in the area is disseminated rather than strategic leaders. Finally, it is notable that most of the initiatives in the area focus on agri*food* rather than agri*tech*. This may be more than just semantics. In the former, the focus is on the food production, processing, and distribution value chain, in which technology can play an enabling role. In the latter, the technology itself is the focus and of value to international markets, and innovations are co-developed, tested, and adopted by local members of the broader value chain. These differences may be significant in terms of the strategic evolution of the tech side of agritech.

## Discussion: Innovation opportunities and support needs

**Evolution and market opportunities:** In line with the discussion in the previous section's reflections, the evolution of the market will depend largely on the focus of support. It seems likely that it will continue to develop strengths in its three core strengths of controlled environment farming; crop and plant sciences; and robotics, automation, and sensors. There is an opportunity to strengthen support for innovations for international trade as well as localised adoption. As the post-Brexit regulatory environment on cell and gene editing relaxes, public support may contribute to revitalising and enhancing world-leading expertise in this area.

**Resilience:** Brexit has created a number of challenges that can threaten the viability of agrifood activities. As export markets contract and logistical challenges mount, firms require different tools and skills to optimise market strategies. Similarly, labour market shortages have increased costs of production. Finally, climate change and environmental stresses, such as this summer's drought conditions, strain yields and create issues for the domestic food supply chain. Energy issues will also stress producers' bottom lines. Fortunately, all of these challenges also create opportunities, many of which are already being embraced by firms in the area. Innovations using big data and digital tools are helping to navigate logistics networks and are optimising food storage regimes to maintain the quality of foods in transit, in storage, and on shelves. Labour market shortages are encouraging innovations in robotics and automation and accelerating their adoption. Researchers are working on drought tolerant and resistant crops, developing smarter irrigation systems, and learning how to do more with less. The combination of market, regime, and environmental challenges are significant and may change the structure of the agritech sector in the medium term, but can be mitigated through coordinated strategy and support.

**Areas of potential support and intervention:** Agritech in Eastern England has strong foundations. The most significant areas of intervention include:

- Meeting demand for incubation space and business support services for emerging firms: The

strong research capacity in the area already has infrastructure in place to develop market opportunities and to broker relationships between partners locally and globally. However, those running programmes report high demand for access, which suggests that there is a potential pipeline of firms that is not currently being served by existing resources. Intervention might include a mix of additional support to existing programmes[3] or the creation of new entities in collaboration with governance partners.

- Strengthening the innovation pipelines of existing research strength: Increasing how much research is translated locally at scale is another area of potential intervention. While research programmes report a high level of translation already, there is likely scope to increase adoption, co-creation, and scaling. Robotics and automation, and digital and data are the two areas that are most ripe for this as these can be applied across crop types and cost and logistics challenges may be generating increasing demand. Seizing these opportunities and supporting firms that can deliver solutions to do so at scale may be an effective way to both grow the agritech industry and secure food value chains.
- Supporting and developing external markets for technology: Many of the innovations generated within the area have potential applications in international markets. Helping firms develop global networks and to access international markets is another area where firms could use business support.
- Training the next generation of agritech leaders: The lack of experienced, tech-, and market-savvy leaders in the agritech sector is a barrier to growth and innovation. This could be resolved through specialist agritech management training programmes at area universities that provide work experience and exposure to the wide range of technologies employed in agrifood businesses. The importance of food, the imperative to reduce carbon emissions across the value chain through innovation, and connections to next generation technologies such as AI may help attract new talent to the sector.
- Consolidating networks around a strategic vision for the industry: Existing networks appear to be strong and thriving. Encouraging even more collaboration between initiatives can help multiply the impact of investments and ensure that support is available to enterprises across the area. Collaboration on developing an actionable vision for the development of agritech, and particularly going deeper on how the technology aspect of the industry can be supported, is a next step to demonstrate to firms and investors that agritech is a strategic priority.

**Reflections:** Agritech in Eastern England is evolving rapidly and has an excellent potential for growth. The area has many of the raw materials to fuel that growth and to seize emerging market opportunities. The sector will benefit from ongoing national attention to net zero goals, rethinking regulations on gene editing post-Brexit, and investments and initiatives in the space sector, which will likely improve downstream applications. Engaging closely with LEPs, Agritech-E, and research organisations around the area will be crucial to designing effective interventions.

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# Northern Ireland Agritech

## Case Study Overview

**Characteristics and history:** Northern Ireland has strong assets in Agritech. However, it is not, as yet, a fully realised cluster. Part of the issue is a long legacy and clear identity in the Agri*food* sector that, while it embraces technology and innovation, is more focused on Agrifood producers and production. Agrifood, which includes food production and processing, is one of Northern Ireland's most significant industries. The sector is focused predominantly on livestock: cattle (beef and dairy), sheep, and poultry. A recent independent strategic review estimated that it accounted for £1.7 billion of value added to the Northern Ireland economy (approximately 3.5% of GVA) and employs over 600,000 workers in the supply chain (Kendell 2021). Consequently, Northern Ireland has developed Agritech research and development capacity in support of the sector and of technologies and practices to support animal welfare, environmental optimisation and sustainability, food and feed quality, and security. There is a significant and growing Agritech sector in Northern Ireland, and Government departments such as the **Department of Agriculture, Environment and Rural Affairs (DAERA)** and **Department for the Economy (DfE)** are increasingly seeking to leverage technologies in agrifood and to prioritise Agritech. The DfE 10x Economy strategy identifies Agritech as one of the Northern Ireland priority clusters ready to adopt enabling technologies, defining it as: "The application of innovation and enabling technologies to build competitive advantage and transition to net zero across the primary and secondary processing sectors, including genomics, traceability of food, advanced packaging, plant and animal health specialisms, and the application of AI to new agricultural methods" (DfE 2021, 22). However, there is a lack of consensus among stakeholders interviewed about what Agritech is and, consequently, the sector lacks a strong identity. That said, there also appears to be a strong appetite amongst stakeholders to change this by developing a stronger vision for an Agritech sector that encompasses actors across the supply chain and research infrastructure to both support internationally competitive Agrifood production and export expertise and technology abroad.

**Geography and size:** This study explores Agritech across the entire territory of Northern Ireland, but there are important nodes and geographies of activity. Unsurprisingly, the bulk of Agrifood production - farms and food processing - takes place outside of Belfast. The majority of research, innovation, and technology development is centred in universities, research centres, and firms located in the Belfast metropolitan area. Exceptions to this pattern are the **College for Agriculture, Food, and Rural Enterprise (CAFRE)**, which plays an important role in skills provision, industry support, and technology diffusion, and has predominantly rural campuses; and the planned **Agritech Centre** in Craigavon which is envisioned as an innovation hub and investment in Agritech business support (ABC Council 2022). This large geographical area means that agriculture, Agrifood, and Agritech are governed by a patchwork of different regional initiatives and local authorities and strategies at different scales.

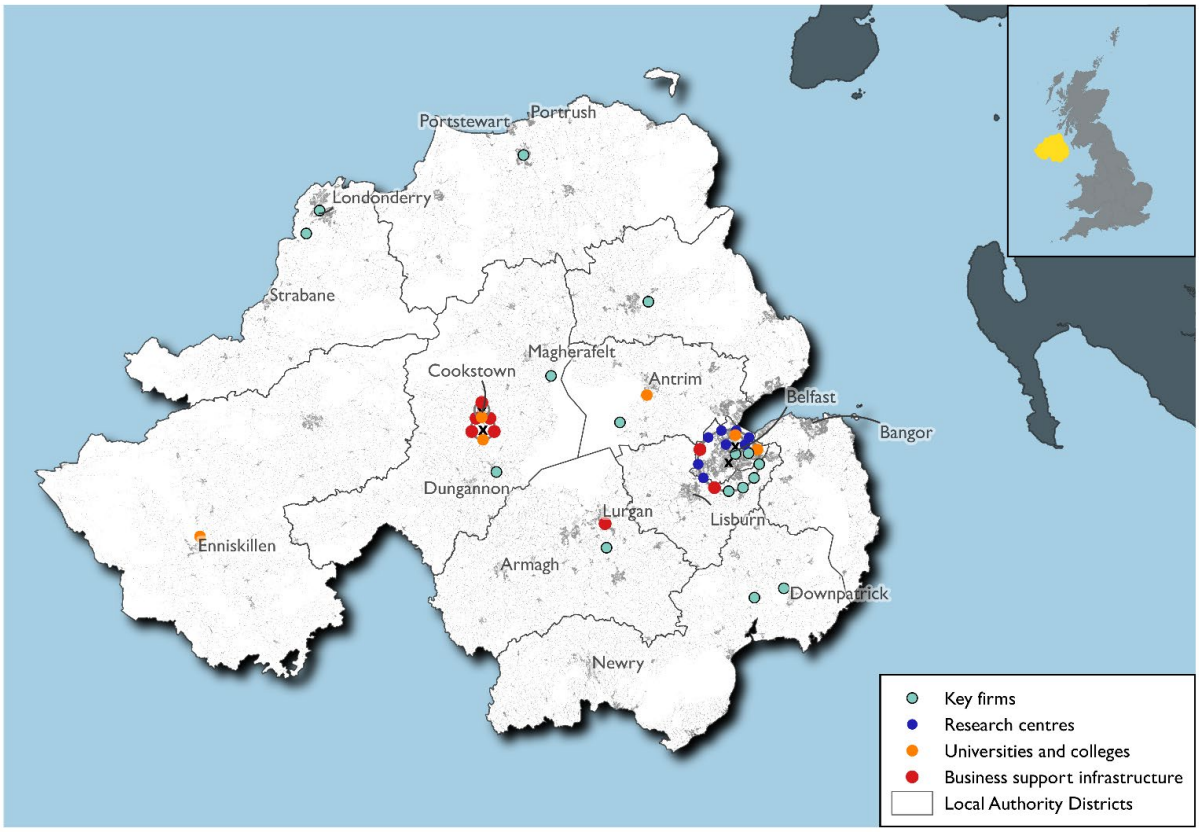


Figure 5: Northern Ireland Agritech map.

**Areas of potential future growth:** Northern Ireland has existing strengths in several areas of Agritech with potential for future growth. Note that many of these areas of expertise and technologies are already being combined in innovative ways and growth in this sector can be encouraged by leveraging these synergies:

- Data and digitalisation - Northern Ireland has established strength in ICT, cyber security, and data analysis; expertise that is currently being used to digitalise the Agricultural sector. Innovations are emerging in this area to process data to monitor crops and livestock, assess animal health, optimise nutrition from feed to final product, manage energy and fuel use, monitor the security and integrity of the food supply chain, and ensure environmental sustainability.
- Earth observation - Increasingly, satellites are being used to produce imaging of crops, livestock, and landscapes. The sector continues to benefit from advances in satellite networks, quality, and latency of images and on the data processing and translation required to interpret and apply insights from these images.
- AI-enabled technologies - The use of artificial intelligence and automation is also increasing in the Agrifood sector. AI is being used to detect and predict animal health issues and monitor animal welfare, as a tool to enable dynamic approaches to feeding, resource management, and to enhance sustainability. There is also increasing scope for innovation in automation of agricultural equipment.
- Optics and sensors - Earth-based video, imaging, and activity tracking technologies provide more targeted monitoring of agricultural assets, supply chains, and processing.
- Nutrition, health, and food quality - Bio- and nutritional sciences are being used to understand the nutritional implications of animal and crop care practices through to the consumer and in terms of environmental impact. Northern Ireland has also developed world-

class food testing and quality assurance systems to detect and reduce contamination and counterfeiting in the feed and food supply chain.

- Agriengineering - Modern farming and food processing requires appropriate facilities. There is an emerging expertise in agricultural building design, engineering, and materials to optimise productivity and animal welfare and reduce environmental impact.
- Farm equipment manufacturing - Northern Ireland is a world leading manufacturer of equipment such as slurry tankers and delivery systems, All-terrain vehicle (ATV) equipment, livestock and crop handling equipment, mobile bulk and wet processing equipment with agricultural applications. Innovation in this area involves improving efficiency, adopting automation and utilising data generated, incorporating new materials, and reducing environmental impact.

**Reflections:** As the rest of this review will show, Agritech in Northern Ireland has many of the right ingredients to be a successful cluster but has not, as yet, coalesced as such. While there are strong capabilities, and industrial identities, around agriculture, food and beverage, and Agri*food* there is not yet clear leadership or vision in Agritech. The sector can build on strong foundations of expertise in ICT, data, and digitalisation, which is bringing new innovations and increasing productivity in traditional agriculture and food processing sectors. As in other clusters, enabling technologies such as satellite, autonomation, and AI are being applied to generate insights and improve outcomes. Growth potential lies at the intersection of these technologies and areas of expertise, to create technologies and practices to improve Agrifood production in Northern Ireland and feed into global markets.

## Core Assets

**Market structure and anchor firms:** The structure of the Northern Ireland agricultural sector creates an interesting opportunity landscape for innovation. Certain segments of the market - most notably, poultry and pork - are very vertically integrated, which means that there is greater transparency and control over the supply chain. Beef and dairy have been described as quite fragmented, although these sectors are united by large cooperatives in which farmers own the processors. There are also lots of smaller and lifestyle farming operations that fragment the landscape. These structures create both barriers and opportunities for innovation and adoption of Agritech.

There were few large anchor firms mentioned in the Agritech space, most notably because the most innovative companies tended to be SMEs. The one major exception was Moy Park, a large food processing company that was frequently mentioned as adopting cutting edge technologies in relation to precision feeding, animal welfare, and reducing environmental impact.

Firms mentioned by interviewees include the following, although a more comprehensive list can be found in the InvestNI "Northern Ireland Agri-Tech: Creating the Future Through Farming" summary document (InvestNI 2018):

Data analytics and AI
  - Analytics Engines
  - Foods Connected
  - CropSafe
  - Unitas Software
  - Farm Compare
- Sensors and optics
  - Crop Hound

    - CattleEye
- Machinery and agriengineering
    - SlurryKat
    - Moore Concrete
    - Erth Engineering
    - Machine Eye
    - Fleming
- Biology, food/feed quality, and testing
    - Randox Food Diagnostics
    - Devenish Nutrition
    - Finnebrogue
    - McDon Substrates

These firms are among the most visible actors in the Agritech sector because of either strong local adoption, international market penetration, or both. Several interviewees noted that it was difficult to create a comprehensive list of notable companies because of silos and differences between agricultural markets that mean that there are few actors with a clear vision of the entire sector.

**Higher education and training institutions:** Northern Ireland has a relatively small number of higher and further education institutions involved in researching and providing skills in Agritech. However, these are very active and world-renowned programmes.

- **Queen's University Belfast** offers numerous Agritech related educational programmes that produce expertise in biosciences, data, and nutrition. It also hosts globally-recognised research centres, such as the ***Institute for Global Food Security***, which investigates climate change, food production, supply chains, and fraud. The ***Institute of Electronics, Communication and Information Technology*** (ECIT) focuses on big data, cybersecurity, and scaleable computing. These two initiatives are among the partners in a new ***Global Innovation Institute***, which combines expertise in data and food science and health to generate innovative solutions for health, food production, and the environment. The ***Northern Ireland Technology Centre*** (NITC) also contributes to the Agritech economy through work on advanced manufacturing, packaging, and design. A new ***Advanced Manufacturing Innovation Centre*** (AMIC) is also being established at the university in partnership with **CAFRE** and with investment from the Belfast City Deal. The university also houses ***AgriFood Quest***, a membership organisation supporting the Agritech sector (see support structures).
- **Ulster University** hosts the ***Food and Drink Business Development Centre***, which offers specialist programming and training for food and drink businesses and supports them in research and innovation. It has related course offerings such as advanced certificate in Management Practice (Developing Leaders in Agri-Food) designed to equip farmers with cutting edge business management skills. It also has strong programmes in nutritional education and environmental science.
- **College for Agriculture, Food, and Rural Enterprise** (**CAFRE**) is one of the most important sources of skills and training in Northern Ireland Agritech. It is a further education college that also performs numerous other important convening and industrial support functions (see support structures). The entire college offering is geared around agriculture, horticulture, food processing, and equine. The college has specialised ***Agricultural Education Facilities*** delivering training, specialised facilities, and knowledge transfer activities in dairy, beef and sheep, machinery, and veterinary nursing. It also hosts ***Food Educational Facilities*** that include the Food Innovation Centre, Food Technology Centre, Food Packaging Centre, Food Business Incubation Centre, and Science Laboratories.

- **South West College** hosts the ***InnoTech Centre***, which provides business services to agricultural businesses.

**Other research and anchor organisations:** There are several research and knowledge-generating anchor organisations in Northern Ireland that have either an Agritech focus or include Agritech development among their areas of expertise. These are also quite internationally active and are well-connected with the higher education research networks described above.

- **Agriculture Food Biosciences Institute (AFBI),** sponsored by DAERA, is a leading provider of scientific research and services to government, non-governmental organisations and commercial organisations. It is a founding member of the UK-wide network of ***Centre of Excellence in Livestock (CIEL)*** and participant in international research initiatives from EU Horizon projects and beyond.
- **Centre for Advanced Sustainable Energy Research** (CASE) - is an industry-led sustainable energy research centre. It does Agritech research related to anaerobic digestion and alternative energy. It is a partnership between Queen's University Belfast, Ulster University, AFBI, and InvestNI.

**Support structures and infrastructure:** There are several organisations that support Agritech and innovation in agriculture more generally. Here it is difficult to overstate the significance of **CAFRE** and its wide portfolio of programmes and business support offerings. So while the list of support structures here is not long, those initiatives that do exist are very well-established, respected, and effective.

- **College for Agriculture, Food, and Rural Enterprise** (**CAFRE**) is technically a further education college, but is funded by DAERA to deliver education and training as well as a vehicle to deliver agricultural programmes and policy. Among these missions is to support Agrifood and Agritech businesses with innovation and business development, which it does through a suite of support services, specialised facilities, specialist teams, technology demonstration programmes, as well as farm and business facing networking and knowledge sharing initiatives. One respondent at **CAFRE** reported that they maintain regular contact with over 3,000 farms in Northern Ireland, many of which are involved in business development groups that support peer to peer learning.
- **AgriFood Quest** is a membership-based, industry-led innovation centre that supports the Agri-food sector in Northern Ireland. It has more than 30 industry members, who work with universities and other organisations in the region to drive innovation.
- **Centre of Excellence in Livestock** (CIEL) is a network of centres of excellence based in GB that has a presence within AFBI. While to date its engagement with the sector has been limited to specific projects, its services, expertise, and networks of universities are available to companies in Northern Ireland.
- **InnoTech Centre** provides research, development and innovation services to businesses, with the agricultural sector a major focus. The centre is part of the South West College, where it is based on the Cookstown Campus. It carries out a range of knowledge transfer, CPD and education activities and supports Agritech companies within the Knowledge Transfer Partnerships (KTP) and Innovation Boost programmes through which companies employ graduates to develop new products under the supervision of College academic staff.
- **InvestNI**, the economic development arm of the Department for the Economy (DfE) was also identified as playing a significant role in business development through funding (see finance), industrial promotion efforts, and other business support programmes.

**Finance:** The future of the public funding and finance landscape for Agritech in Northern Ireland was described as "bleak" and as "a challenging environment" by one respondent because of political complexities and government financial constraints. However, those interviewed complimented investment in research and innovation, education and training offerings, and business support by Government to date - particularly DAERA and InvestNI. Similarly, there has been relatively steady public support for technology adoption and innovation. Some interviewees commented that firms did not always have the expertise or time necessary to complete funding applications but that knowledge about available resources was relatively high due in part to the support and information clearing role that **CAFRE** plays. Commentators suggested that there were several sources of private business finance but that the sector has a preference for grants and other non-repayable sources of funding - something they referred to as a "grant culture". As one noted: "I think there needs to be a little bit of resetting of industry expectations, that it can't always be a grant, and that sometimes the more beneficial support is non-financial or repayable". There are therefore potential opportunities to use the strong business development influence of **CAFRE** and InvestNI to try to shift this culture, where appropriate.

**Reflections:** Agritech in Northern Ireland is building on a very strong set of assets. While the research infrastructure and support streams are not as numerous as in some other Agritech clusters, it is well-established, well-resourced, and developing and supporting world-leading innovations. One advantage of this smaller pool of assets is that actors tend to be well connected and information flows relatively well. While higher education and publicly funded research are spearheading important knowledge generating projects, the role of **CAFRE** in providing skills, training, business support, knowledge exchange, and promoting innovation adoption should not be overlooked.

### Skills

**Talent pool:** The Agrifood sector in Northern Ireland is growing, with attendant implications for talent and skills. DfE estimates that the demand for new workers in the sector could grow by 1,000 annually, with up to 10,000 new workers required in the next decade (DfE 2021, 24). A 2018 report noted that Agrifood has relied heavily on migrant workers (NIFDA 2018) while the recent independent review of the sector affirms that access to labour remains a crucial vulnerability, stating bluntly that "There is a real risk that Agri-food will end up limited, not by lack of product development but by the number of workers it can recruit" (Kendall 2021, 13).

There is growing demand for digital skills. As one respondent commented:

> *One of the things we've found we don't have the skills for is digitalisation. We don't have the skills for digital manufacturing. And that covers the whole of Agritech. So, you know, we've got efficient agriculture, Agrifood industry, lots of entrepreneurs, good technically competent people who know their products and processes. But in terms of applying digital technology, or advanced technology, though, we're not there. We're not there.*

This need is certainly not unique to the Agritech industry and digital skills figure prominently in the 10X industrial strategy (DfE 2021).

**Local skills provision:** Northern Ireland has a strong Agritech skills pipeline in Agrifood through **CAFRE**, Agribusiness through **Ulster University**, and in digital skills, data, and technology through **Queen's University Belfast**. Together, these fill the bulk of the mid- to high-skills needs. Each of these institutions is aware of emerging and future skills challenges and are developing and adapting

programmes to enhance digital and data capabilities. **CAFRE** is aware of this need and is in the process of incorporating digital and innovation skills components to ongoing course refreshes. However, it recognises that it does not have the near, or even medium, term capacity to pivot its programming quickly. One respondent suggested that strengthening skills and training collaboration between **CAFRE** and the universities could help to fill some of these gaps. This is also consistent with the 10X strategy, which suggests that meeting these needs will require working collaboratively across Government and making a joined up approach to (digital) skills a central part of its talent strategy.

**Reflections:** Very few of the interviewees stressed that skills were a crucial limitation to Agritech growth. This is in part because labour force contraction has primarily affected the supply of lower-skill migrant workers and not the more innovative segments of the economy. The Northern Ireland skills provision ecosystem for higher skilled workers in Agritech and Agrifood was very highly regarded. That said, interviewees did flag concerns about the availability of digital skills and a need to coordinate efforts to ensure that these skills needs do not constrain the growth of the sector.

## Knowledge Exchange

**Firm research and development practices:** Agritech firms in Northern Ireland were regarded as quite innovative, with many globally-recognised names in their markets. For instance, the large food and feed processing firm Moy Park was frequently mentioned as very actively engaged in horizon scanning and new technology adoption. That many of the firms listed above incorporate cutting edge technologies - such as AI - into their products and services speaks to vibrant R&D practices.

**Knowledge sharing and flows:** interviewees reported really strong relationships between higher and further education institutions in the region. Several initiatives, such as the **Centre for Advanced Sustainable Energy Research** are the result of partnerships between the universities and research organisations. While existing research partnerships testify to the existence of knowledge flows between higher and further education institutions, one respondent reported that the universities were sometimes perceived as more competitive than cooperative. Both universities reported strong relationships with industry, however characterised these as predominantly bilateral rather than networks through which knowledge created was shared more broadly.

Knowledge exchange from research and business to farms and farmer is quite strong due to **CAFRE**'s strong networks and brokerage role, which was thought to enhance and increase technology adoption. The mechanism of these flows was described by one actor:

> *The universities do a lot of research, they come up with ideas, or commercial businesses launch new products and then **CAFRE** takes these, we apply it and see if they work. And if they work we show the farmers or approve the applications. So we're actually just doing sort of a knowledge transfer rather than the research. Yeah. So it goes two ways, either from universities or from commercial businesses, and we're trying to translate.*

The role that **CAFRE** plays in mediating between technology and equipment firms and Agrifood production entities is relatively unique. While it does not do blue sky research, it does engage in technology and product testing at its demonstration facilities and consults on business and product development.

Knowledge flows between businesses in Agritech generally are difficult to gauge. However, knowledge exchange is strong on the Agrifood side. **CAFRE**'s business development group (BDG) model, which is based around facilitated peer-to-peer learning, engages over 3,000 farmers. A recent paper tracked

performance of participants in the sheep and dairy BDGs and found that BDGs increased their gross margin by £109.10 and £17.10 per head respectively compared to farmers that are non-members of the BDGs (Adenuga et al. 2021, 949).

**Knowledge access and cultures:** As described above, **CAFRE** is instrumental in facilitating knowledge sharing and championing peer-to-peer learning, both locally and abroad. Some secrecy and reluctance to share technology and practices was reported in larger food and feed processing firms. However, it is unclear whether these are widely held attitudes that are blocking innovation potential, or whether these practices sensibly protect competitive advantage.

**Firm network relationships:** While a relatively strong ecosystem of firm interaction seems to have developed around **CAFRE** and its activities on the Agrifood side, the links between firms involved in technology development in Agritech are more difficult to assess. Interviewees described a few isolated attempts to bring these firms together that were thought to have generated some interest in developing specialised tech-focused groups; however, without an animator momentum stalled.

**Reflections:** Agritech in Northern Ireland is characterised by some very strong and robust knowledge exchange networks and practices between firms and research on the Agrifood side, primarily animated by **CAFRE**. Universities reported frequent connections and knowledge exchange and collaboration with industry, although these were more likely to be bilateral, thereby potentially limiting diffusion. Networks between technology firms appear to be weaker overall than in food production and processing, although it is difficult to confirm by how much. There is an opportunity to build and strengthen networks outside of the Agrifood part of the sector.

## Networks of Coordination

While there are several networks active *within* the Agritech sector in Northern Ireland, there is not (yet) one that covers, develops strategy for, and connects the entire sector. A common theme is that advocacy networks in Agrifood are quite well-developed, but that there is no analogous group uniting technology companies. Agrifood actors include the **Ulster Farmers Union**, the **Northern Ireland Food and Drink Association** (NIFDA), **Animal Health and Welfare NI (AHWNI)**, and the **Northern Ireland Grain Trade Alliance**. Many of these bring together farmers, processors, vets (where applicable), and relevant government departments.

The Kendall report (2021) outlined a "Dutch diamond" strategy, jointly developed by **Queen's University Belfast** and **AFBI**, which emphasises the importance of bringing together stakeholders - from government, research, the knowledge base, and civil society. Working together across divisions was seen as particularly important for Government, where responsibility for supporting various dimensions of Agrifood and Agritech is split between **DAERA** and **DfE** with little coordination between activities.

The diamond model was widely cited in our interviews and there is strong support for an initiative that would put the proposal into action. However, there was less agreement about who should lead it and whether a leader would, in fact, step forward.

> *There's no obvious candidate. That's not a role for governments. I mean, I don't think the universities would tolerate one being elevated to that level over the other, you know, we're not gonna have that. I don't see any [prominent business actors] stepping up.*

Initiatives such as **Agrifood Quest Competence Centre** - which unites 30 businesses with researchers at **Queen's University**, **Ulster University** and the **Agricultural and Food Biosciences Institute (AFBI)** - facilitate and enable innovation and are potentially well-positioned to span the Agrifood/Agritech divide and bring together diverse stakeholders. **CAFRE's** role as a broker has been well-documented in this report and its already deep networks could potentially be broadened even further to facilitate a convening and strategic role. However, neither organisation has expressed an interest in being the leading cluster organisation. One respondent suggested that the diamond should be interpreted more as a "way of working" and not something that needs to be led by or embodied in a legal entity.

**Reflections:** The lack of a central convening entity has diluted the effective development of a genuine Agritech cluster. While Agrifood has a relatively strong identity and set of linking networks, by contrast Agritech suffers from an identity crisis. One solution is to abandon the idea of Agritech as an organising principle, and build out the diamond practice through Agrifood organisation (or network) that would expand to encompass a broader technology community. Another is to develop a cluster organisation to strategise, convene, and advocate for the broader community of Agritech firms and research institutions. In either case, the cluster champion will have to be cohesive and enjoy enough support to effectively bridge the **DAERA-DfE** divide. Until the question of cluster coordination, leadership, and direction is resolved, the sector will continue to be fragmented and innovative potential restrained.

## Discussion: Innovation opportunities and support needs

**Evolution and market opportunities:** The Agritech sector in Northern Ireland is likely to continue to grow, leveraging its strong research base and diverse group of innovative firms. Firms across the spectrum are likely to continue to integrate expertise in AI, digital and data analytics, and materials and manufacturing to increase the effectiveness of machinery and processes and to optimise animal welfare and reduce environmental impact. In the medium-term, there will be opportunities to continue to link up regional ambitions to lead on Net Zero through Agritech development and implementation.

**Resilience:** Brexit has had a high-profile impact on the Northern Ireland economy and will continue to affect all sectors, including Agritech. This is most likely to affect Agrifood production and is not having significant direct labour impacts on innovation. Indirectly, labour shortages and increased labour costs may reduce firms' abilities to invest in innovation but may accelerate their openness to adopting automation and other labour reducing technologies. The removal of European funding and free circulation of research and innovation professionals may constrain knowledge creation and exchange. Climate change is less of a threat to this livestock-based ecosystem, although regulations to curb carbon emissions from agriculture could further stimulate Agritech innovation if encouraged with public funding. Relatedly, as the impact of food supply chains on climate change becomes more evident, individuals are beginning to adapt their diets to consume fewer animal products. While it is difficult to predict the impact of these changes on demand in the medium and long term, these trends may constrain growth in Northern Ireland's predominantly meat- and dairy-based Agrifood sector.

Areas of potential support and intervention:

- Establish a cluster identity and leadership: Northern Ireland has almost all of the pieces in place to boast an Agritech cluster, but lacks clear leadership, governance, and most crucially, a shared identity. This research revealed a consistent theme that while the region has well-

established strengths in research, knowledge diffusion, support structures and infrastructure, its identity is stronger in the Agrifood space than in Agri*tech*. However, the tech side of Agritech is a growing part of the scene and could potentially thrive more with better connections, clear visioning, and development strategy. This will potentially be very important for the sector to respond to and leverage likely growing investment in Net Zero initiatives and food supply chain resilience.

- Develop a clearer understanding of the local Agritech supply chain and impact in international markets: Similarly, the agrifood sector has a better grasp on its local and international supply chain and potential opportunities and challenges for market development. The Agritech sector as a whole does not. The development of international markets was identified as an issue for the cybersecurity industry in Belfast and the Agritech sector likely faces similar challenges. An initiative to map and strategise around increasing international market penetration for Agritech solutions (and not just agrifood products) may multiply growth potential.
- Develop international markets: Going beyond mapping and strategy, resources might be effectively used to support international market development, increase global partnerships, and enhance knowledge exchange.
- Strongly support innovations towards Net Zero agriculture and consider diversification scenarios: Securing the resilience of such a vital sector should be a central concern for Government and for industry bodies. These actors would ideally work together to determine how to collectively achieve environmental sustainability goals without dampening existing growth.

**Reflections:** The group of activities that constitute the Northern Ireland Agritech sector has a lot of strengths and the sector as a whole is likely to experience significant growth. There is an emerging consensus that the single most impactful intervention to accelerate cluster development would be the creation of a cluster leadership organisation - or the adaptation of an existing structure - to strategise beyond agrifood, advocate more effectively within the fragmented Government structure, increase international visibility, and establish a shared identity for the sector. Discussions suggest that actors within the region would strongly support such an initiative but that defining the collective goals and identity around which to do strategic planning will not be simple.

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# Great South West Blue Economy

## Case Study Overview

**Characteristics and history:** The Blue Economy in the Great South West is centred around and has derived from the long maritime history of the coastal parts of the area. The maritime economy initially developed around ports with deep sea littoral access in Plymouth and South Devon focused on shipping and naval activities. These maritime assets and activities spawned the development of a broader infrastructural, research, and institutional landscape that includes the Met Office (Exeter); UK Hydrographic Office (Taunton); Falmouth Marine School (Falmouth); Centre for Environment, Fisheries and Aquaculture Science (Weymouth); HMNB Devonport (Plymouth); National Marine Aquarium (Plymouth); Plymouth Marine Laboratory (Plymouth); and several world class research programmes at universities around the coast (discussed in more detail below).

While marine and maritime generally comprises a mature set of industries, what is emerging in the area under the umbrella of the Blue Economy revolves around the application of new technologies and their deployment on established infrastructure. Areas of expertise are emerging and consolidating around *offshore wind*, *oceanic environment monitoring*, *autonomous vessels*, *surveillance and maritime security*, and *marine science* and research. While these may be regarded as core competencies, other related industries are as diverse as boat building (specifically race and pleasure craft) and fitting, satellite applications, digital and data, and logistics.

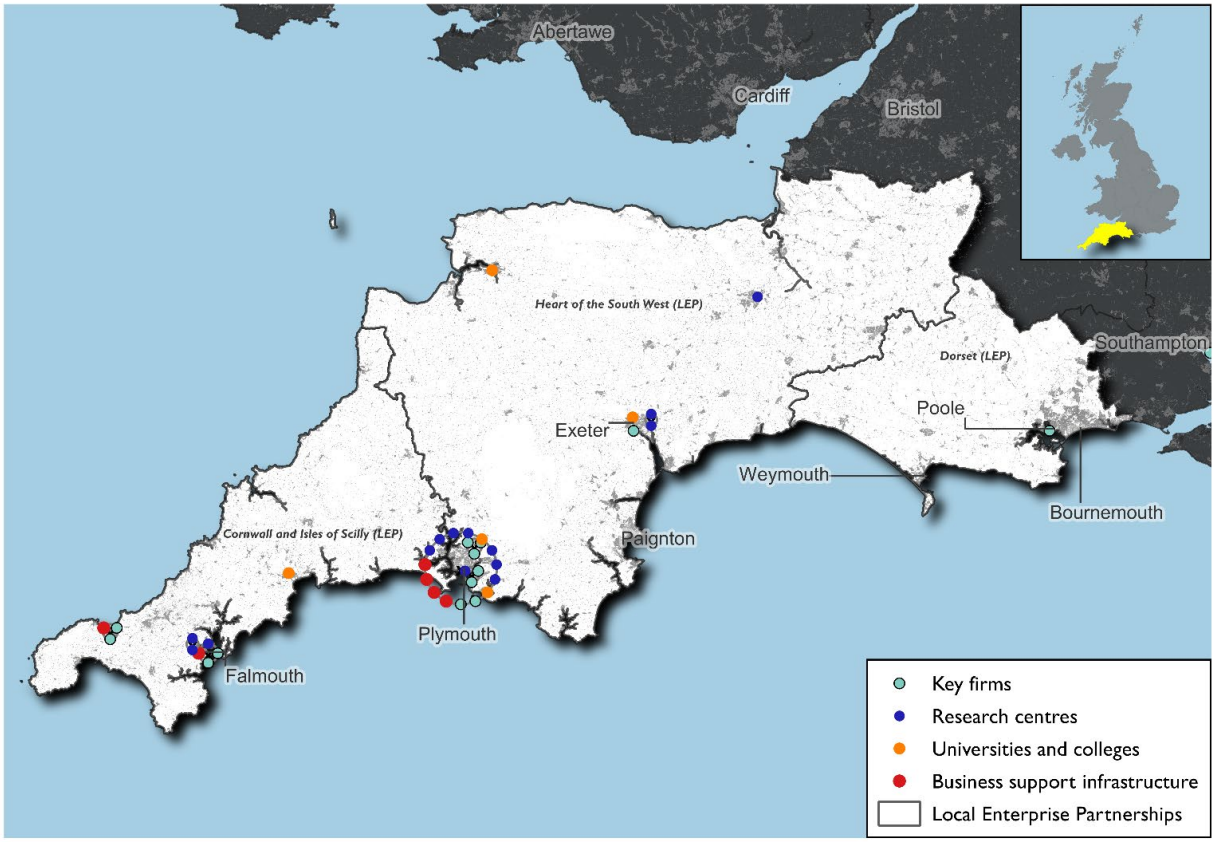


Figure 6: Great South West Blue Economy map.

**Geography and size:** For the purpose of this study, we have adopted the geography of the Great South West. This geography is an amalgam of three Local Enterprise Partnerships (LEPs) in the South West: Cornwall and Isles of Scilly LEP, Heart of the South West LEP, and Dorset LEP. The area boasts almost 700 miles of coastline, although the Blue Economy activity discussed in this report is located

primarily along the south coast with concentrations around Plymouth, Exeter, Falmouth, and Weymouth.

It is notable that "the Great South West" is the most recent geography associated with the Blue Economy, and that it is not the only one. For instance, both Ocean Futures and Maritime UK SW expand the region to include Bristol. However, a previous initiative, the South Coast Marine Cluster (SCMC) extended the area to include the Solent to the east. The SCMC previously united partners across the south coast area but did not include the Solent LEP, which chose to partner with Maritime UK instead. Ultimately, the LEPs in the South West opted to organise around the current geography. While actors in the South West and in the Solent recognise that the other has Blue Economy ambitions they maintain that synergies are currently weak and that activities and strengths are different enough to support independent USPs.

Areas of potential future growth:

Currently, the Blue Economy is in a growth phase with notable activities in three core areas:

- Offshore renewable energy - The area hosts a variety of offshore renewable energy projects centred primarily on tidal/wave and wind. The Celtic Sea off the coast of Cornwall will be the site of a large floating offshore wind (FLOW) project and is expected to produce 5.0GW by 2030 (rising to 20.0GW by 2045).
- Marine autonomy and robotics - The construction of autonomous maritime autonomous systems to function as platforms (for sensors or other robotics) or crew transfer vehicles is an emerging area of innovation.
- Digital oceans - This involves hardware, such as sensors and communication systems, to improve connectivity between systems active in marine environments, transmit data, and software to process data and ensure systems are secure.

It is worth noting the degree to which these activities can be complementary. As one observer commented:

> *Floating offshore wind requires autonomy and geospatial data to exist and to bring down costs, which is the major challenge for offshore floating offshore wind at the moment as a nascent industry. The biggest, early adopter of hydrogen powered vessels and electrical powered vessels is likely to be offshore wind. So, we're in a position where we have expertise around clean maritime potential port facilities around clean maritime and a key customer.*

Other areas that may have strong growth potential, but that emerged less clearly in the course of this research, include aquaculture (fish and shellfish farming) and maritime net zero (clean ocean technologies such as charging infrastructure, synthetic and e-maritime fuels, blue hydrogen, batteries and alternative fuel programmes, low-carbon vessel design, etc.). The suite of activities classified as maritime net zero are featured prominently in the Ocean Futures visioning documents (Ocean Futures 2022). However, only offshore renewables (which they include in this category) appeared to be sufficiently advanced. Given that other studies show that marine and maritime clusters around the country are also focusing on alternative fuel and vessel design and blue hydrogen, including their neighbours in the Solent, it might be worth concentrating on the specific areas where industry has evolved sufficient critical mass to be competitive.

**Reflections:** Spatially, Blue Economy activities are distributed across a broad geography with notable concentrations in and around major urban areas and port facilities. Additionally, given the diversity of Blue Economy activities and industries it is hard to describe the current configuration as a cluster in the technical sense. There are, however, synergies that seem to be evolving between different Blue Economy subsectors described here and it is not too difficult to imagine that with further evolution these industries may converge further and create meaningful spillovers that will act as innovation multipliers. For instance, sensors are going to be critical for monitoring and securing offshore wind. Floating offshore wind assets are moored far from shore and so autonomous monitoring, using drones or marine vessels, will also be useful for maintaining turbines. Sensors and robotics are critical to autonomous vessel operation. Communicating across long distances and harsh maritime environments, defending assets from cyber attacks, and processing data from sensors will all require advanced digital capabilities. At this point, these kinds of synergies are evident and increasing, but it is unclear how much collaboration is currently happening between firms in the area, how ready existing technologies are for deployment, or whether connections are being made effectively. This is also complicated by the fact that collocation between different centres of excellence appears to be relatively weak. For instance, floating offshore wind is centred in Cornwall while the development and testing of autonomous vessels and robotics predominantly happens in Plymouth. That said, there are several initiatives that are trying to bring Blue Economy stakeholders together to forge those connections and develop a vision. The Great South West group of LEPs and Maritime UK SW are leading organisations that are coalescing around the Ocean Futures vision. Celtic Sea FLOW envisions a floating offshore wind cluster, and presents a slightly more targeted proposal. While progress is being made, it appears as though geographic dispersion, governance complexity, and industrial silos remain barriers to unlocking the greater potential of the Blue Economy in this region.

## Core Assets

**Market structure and anchor firms:** The nature of Blue Economy activities means that there are few anchors that genuinely underpin the entire breadth of the sector. Large marine and maritime firms tend to be connected to the defence industry such as Babcock, BMT, and Thales. A&P/Appledore shipyards and Pendennis shipyards concentrate on commercial ship building and maintenance activities, while firms like Princess and Sunseeker build smaller pleasure craft. A large offshore wind consortium, Celtic Sea Flow, currently dominates the offshore wind industry.

A variety of firms smaller to medium sized firms were mentioned in our research, predominantly in the realms of marine engineering, surveying, and autonomous vessel development: Frontier Technical (sustainable energy technologies), M Subs Ltd (manned and unmanned underwater vehicles), Mayflower Autonomous Ship (automated research vessel), Silicon Sensing (inertial sensors), Marine Tech Systems (autonomous offshore survey), Hydro Surv (marine data processing systems), USS Unmanned (unmanned surface vessels), Sulmara Subsea, Fugro (marine survey training), AutoNaut (unmanned surface vessels), Blue Screen IT (maritime cybersecurity), and Sonardyne (underwater acoustics). This list is by no means exhaustive, but captures many of the firms that are most active in partnering in governance networks and for innovation.

**Higher education and training institutions:** The Great South West has several important universities and further education colleges that feed into the Blue Economy in the area:

- **University of Exeter** has a strong programme in marine education, training, and research. Exeter Marine unites researchers interested in marine environments and science and has several partnerships with stakeholders in the area. It also hosts specialised infrastructure such as the ***Dynamic Marine Component Test Facility (DMaC)***, offshore and marine energy

facilities such as ***FaBTest*** (a nursery and test facility), offshore wave buoys that provide data to researchers and test facilities, and a high performance computer cluster for data analysis. It is a partner in ***Marine-i***, an EU-funded programme designed to help germinate the marine technology sector in Cornwall and the Isles of Scilly and includes partners such the ORE Catapult, Cornwall Council, University of Plymouth, Cornwall Marine Network and Falmouth Marine School. Other partnerships include work with the Plymouth Marine Laboratory on microplastic pollution, with the Met Office on predictability of extreme weather events (PREDEX), and Cefas on aquaculture topics and doctoral training partnerships. The university is also home to the ***Centre of Future Clean Mobility***, committed to leading on the next generation of clean mobility across all modes of transport. It is also a partner in the planned ***Marine and Environmental Science Accelerator*** (see below).

- **University of Plymouth** also has a strong research, education, and training offering in marine and maritime. It hosts maritime studies and navigation, marine autonomy, and maritime science degree programmes as well as the world-leading research at the ***Marine Institute*** with over 3000 researchers and students. This research is largely focused on the sustainable use of the marine environment with thematic emphasis on topics as diverse as marine biology and biogeochemistry to shipping and maritime business. The Marine Institute is one of the partners in the Marine Research Plymouth group (see below). It hosts the ***Supergen Offshore Renewable Energy Hub*** (an EPSRC-funded project on innovation in offshore renewables), the ***One Ocean Hub*** (a marine conservation research group), and ***Cyber-SHIP Lab*** (a hardware-based, fully configurable maritime IT&OT cyber security research platform), among other initiatives.
- **Cornwall College** hosts the ***Falmouth Marine School*** delivering courses in boatbuilding, marine engineering, marine science, and watersports. As part of the Marine-i partnership, the school is coordinating a marine technology focused graduate placement scheme and provides mentoring support.
- **Plymouth City College** provides the only foundation degree in marine autonomous systems.
- **Petroc College** hosts the South West Institute of Technology centre, which houses two state-of-the-art facilities – the Engineering facility includes cleanroom fabrication capabilities; electronics design, manufacture and testing laboratories; additive technologies (3D); and production robotics; whilst the Digital Science suite contains a bespoke area for developing virtual environments; a large space for drone experimentation; and the latest specification networking, software, and data engineering facilities.

**Other research and anchor organisations:** The area has a rich array of other research engaged institutions across a wide range of Blue Economy themes. While it is tempting to divide these into silos focused on aspects of marine environment/biology and other marine technologies (autonomy, energy, digital, etc.) there appear to be strong partnerships across those divides - a phenomenon that is particularly evident in the Marine Research Plymouth partnership.

- **National Physical Laboratory (NPL)** is the UK's national metrology institute and has partnered with Lloyd's Register to establish the ***Maritime Assured Autonomous Testbed (MAAT)*** (see below).
- ***Plymouth Marine Laboratory (PML)*** is widely regarded as a world-leading research organisation in the area of marine research. It hosts the ***Smart Sound Laboratory*** - a facility for testing autonomous vessels, buoys, and other monitoring devices - as well as marine biological lab and observatory facilities. It also maintains a state of the art research vessel. It is a core member of Marine Research Plymouth.
- **Marine Biological Association (MBA)** conducts marine biology research "from the seashore to the seafloor". The organisation has a strong track record of delivering projects for industry, government agencies, and other stakeholders and provides advice and services to a wide

range of industries.

- **UK Hydrographic Office** is a world-leading centre for hydrography, specialising in marine geospatial data to support safe, secure and thriving oceans. It partners frequently on marine and maritime projects and hosts students from university programmes from around the region.
- **Met Office** provides data and expertise to firms in the area that are working in the maritime environment. Ocean Futures described the Met Office's contribution to stakeholders in the area as facilitating the management of an interface between emerging maritime capabilities and the marine environment (Ocean Futures 2022).
- **Thales Centre for Marine Autonomy** was established by Thales UK for the development, assessment and certification of autonomous systems at a waterfront facility in Plymouth. It offers a secure location to conduct a full evaluation cycle for multi domain platforms.
- **Marine Research Plymouth** is a partnership between the Marine Biological Association, Plymouth Marine Laboratory, and the University of Plymouth. The partnership is built around a shared vision to harness the expertise of the UK's largest concentration of marine science researchers and cutting-edge facilities.

**Support structures and infrastructure:** The area is also home to a wide range of support structures and infrastructure, often supported by joint investments between universities, research organisations, and local government authorities. The degree of co-investment in facilities, initiatives, and projects can make it somewhat difficult to determine who leads these initiatives and how they relate to one another.

- **Cornwall Floating Offshore Wind Accelerator (Cornwall FLOW)** is a partnership between Celtic Sea Power, the ORE Catapult, and universities of Plymouth and Exeter to reduce the carbon intensity of floating offshore wind projects, generate evidence to shorten project timelines, and build a sustainable industry.
- **Oceansgate Marine Enterprise Zone** is a world class hub for marine industries located in Devonport, Plymouth, with opportunities for research, innovation and production in a collaborative environment. It has been envisioned as the site for the ***Ocean Futures Innovation Centre***, which will house the Smart Sound Plymouth and Connect control centre as well as Maritime Assured Autonomous Testbed (MAAT) and Requirements for Operational Assurance of Data Standards (ROADS) project teams, and the ***Ocean Futures Prototyping Centre***. The site already hosts the Marine Business Technology Centre (MBTC).
- **Marine Business Technology Centre (MBTC)** is an ERDF-funded gateway for firms hoping to access and develop leading edge marine technology based at the Oceansgate Marine Enterprise Zone. Its focuses include marine autonomy, clean propulsion, advanced materials/manufacturing, environmental modelling and monitoring, and digital ocean technologies. Led by Plymouth City Council, it partners closely with the universities of Plymouth and Exeter, PML, and MBA. Among other projects, the MBTC coordinates access to the ***Smart Sound Laboratory*** test facilities. Within the Smart Sound envelope also sits the ***Future Autonomous at Sea Technologies (FAST)*** infrastructure cluster.
- **Cornwall Marine Network** was established in 2002 by local marine businesses to give identity to, and improve the economic prosperity of, businesses in the marine sector. The organisation provides expert specialist support which helps member companies to grow, by improving marketing, skills, bringing innovation to market and improving productivity in the workplace.
- **Marine and Environmental Science Accelerator** is a partnership between the universities of Exeter and Plymouth which brings together three projects and has a proposed £128.3m plan to level up and supercharge the economy: The Environmental Intelligence and Net Zero Solutions Hub, Maritime Autonomy Testbed (MAAT), and the South West Technopole.

- **Plymouth and South Devon Freeport** is a planned development that will leverage investment and the world class manufacturing, marine and defence innovation assets to support further innovation and research.
- **ORE Catapult** is involved in supporting firms developing offshore renewables and is a partner in several research projects.

**Finance:** Blue Economy firms face many of the same issues as those in other places: a lack of angel investors and early stage funding, a lack of funding sensitive to the particularities of the industry (e.g., longer development and return on investment timelines), wariness about engaging in commercial or private sources of finance, and a weakness of knowledge about skills to access different funding streams. An additional set of constraints in the Great South West are its peripheral location relative to centres of funding and finance and uncertainty related to the transition away from European funding.

On access to angel investment, one respondent noted that while the British Business Bank has resources to support angel networks, only existing networks are eligible. Since there are none in the South West, this funding doesn't benefit firms in the area.

Challenges vary by different subsectors in the Blue Economy. Firms in the offshore renewables supply chain find it particularly difficult to secure sustained investment:

> *Yeah, I suppose for small companies, it's finding investment. So, you know, finding the right angel investors, finding the right sort of entrepreneurs, who are prepared to make those commitments, because often those investors want a very quick return. And, you know, renewables is not a quick return market.*

One respondent commented that support will often come from high net worth individuals, but that they rarely have the resources to continue the needed levels of investment over the longer term. As interest in renewables increases, there is a hope that institutional investors will begin to take an interest in these projects (and their ecosystems).

One university, which was heavily involved in collaborative projects supported by ERDF funding, noted some pros and cons to shifting to SDF and other UK sources of funding. While they celebrated that some of the more onerous eligibility requirements attached to European funding would liberate them to do more interdisciplinary projects they also noted that they were anticipating far less support than in the past.

Given the centrality of higher education institutions in leading bids and partnering in networks supporting research, innovation, and firms, the potential for a contraction in supporting resources could be a threat to growth.

**Reflections:** The Blue Economy in the Great South West has a very rich pool of assets. While marine and maritime is dominated in some ways by large defence primes and boatyards, this obscures a broad and growing ecosystem of firms emerging and coalescing around the themes of offshore renewables, automation, and digital. There is incredibly strong research capacity, both in higher education and other research organisations, doing world-renowned work in a wide range of areas. While the more recent work on robotics, automation, data, and materials is starting to translate to the market it was unclear from our research whether and how a similar process was underway for marine biology and sciences. There is no shortage of stakeholders with an interest in and capabilities to engage in cluster growth and, as the networks section reflects, no shortage of initiatives to leverage synergies and drive firm development. However, resources appear to be a constraint - both in fuelling firm growth and collaborative programmes, and in creating a sustained revenue stream to fund governance activities.

## Skills

**Talent pool:** Most respondents characterised the area as having a strong foundation of marine and maritime skills, but also some emerging areas of need. Workforce surveys have identified issues with recruitment, with key anchor firms including Babcock International and Princess Yachts indicating areas of high demand in engineering and non-engineering roles and SMEs reporting difficulty in scaling because of recruiting challenges.

Sectoral surveys such as the State of the Maritime Nation (Maritime UK 2022) highlight skills challenges across the sector, many of which hold true in the Great South West: An ageing workforce, an increase in demand for engineering and digital skills across the economy, and recruiting challenges have exacerbated these difficulties. These are largely echoed in the local skills strategies (see, for example, Heart of the South West 2022). Skills shortages are likely to be particularly acute in the offshore renewables sector, where the Celtic Sea Power project is slated to expand rapidly increasing demand for labour across its supply chain. It, along with other maritime firms in the area, reports difficulties recruiting people with key skills, from welders to project engineering.

One respondent drove home the diversity of skills needed, stating:

> *Really, we don't need PhDs. But master's degrees would not be unhelpful. But it's also going to be from engineering, environmental, environmentalists, marine biologists, operations, mariners, and I could go on and on. So it's sort of quite broad. But in terms of more precision of what kinds of skills we're going to need, we don't know yet.*

Celtic Sea Power is aware of the potential limits that skills shortages may place on its growth and reports working closely with local further and higher education providers to plan for the future. They noted that given project timelines, they need people in school now developing the qualifications and skills so that they are online when they are needed in the future.

Against this background it is also important to note that attraction and retention are an issue both for Blue Economy sectors and the Great South West economy as a whole. Young people graduating from university or college often don't stay (or don't stay long) and rising housing costs make it more difficult to attract external talent. These are important factors to consider when investing in local skills pipelines.

**Local skills provision:** Colleges and universities in the area have increasingly developed training programmes to support emerging Blue Economy industries. Ocean Futures lists some of the core offerings that will provide graduates to fuel growth (summarised briefly here):

- **City College Plymouth** is developing facilities to deliver new university- level courses on marine autonomy with higher-level pathways.
- **South Devon Marine Academy** forms part of South Devon College and is a state-of-the-art facility providing many full-time courses on offer from Level 2 and 3 courses in Marine Engineering, Maritime Skills alongside apprenticeships in Boat Building, Warehousing and Composites to degree-level qualifications in Marine Technologies, Coastal Engineering and more. It also offers short courses aimed at adults for reskilling or updating training.
- **University of Exeter** provides courses at undergraduate and postgraduate levels across science and engineering disciplines relevant to the marine and maritime sectors, such as ecology, data technologies, engineering, renewable energy and materials technologies.
- **University of Plymouth** has the first and largest Marine Institute in the UK, representing over 3000 researchers and students.
- **Bournemouth University** offers courses in Engineering Marine Technologies and Marine Ecology which build on Foundation courses in marine, coastal or freshwater conservation.

- **Falmouth Marine School** has training programmes in boatbuilding, marine engineering, marine science, and watersports.

These programmes also feature industry partnerships, work placement opportunities, access to shared infrastructure for learners, and apprenticeship offerings. However, skills gaps persist, sparking discussion about the responsiveness of the FE and HE sectors to industry needs, with even universities acknowledging that they can do better. While each of the LEPs has published LSIPs and action plans involving consultations with HE, FE, and industry there is still a sense that these efforts are currently falling short, have not yet borne fruit, or, as the previous commentator suggests, are not effective mechanisms to address local skills provision challenges.

**Reflections:** Despite a strong marine and maritime heritage and a number of skills pipelines through local FE and HE, skills shortages are likely to constrain growth in Blue Economy industries. These shortages will be particularly pronounced in the skill sets, such as engineering and digital, that are in high demand across sectors in the Great South West in which the Blue Economy is competing with manufacturing and aerospace. This is partly a qualification supply issue that can be alleviated with increased investment in a development of tailored training offerings and enhanced access to industrial experience. However, the twin problems of human capital retention and the attractiveness of employment in the Blue Economy also remain challenges.

## Knowledge Exchange

**Firm research and development practices:** Since floating offshore wind, marine robotics and autonomy, maritime defence, and digital oceans industries are currently in a period of rapid development, firms in the area tend to be highly research active. While it is difficult to make statements across the entire spectrum of activities in the Blue Economy, the trend appears to be that research, science, and development is relatively strong and occurring in firms (from tiny micro enterprises to large primes), there may be more difficulties in translating those innovations into the market, scaling production, and fuelling the next generation of innovations. Similarly, while the world-class research organisations in the area are very active in partnering with and supporting firms, it is unclear how many discoveries are effectively commercialised. There appears to be great potential, given the area's research strengths, but there may be challenges involved in unlocking it for economic growth.

**Knowledge sharing and flows:** There are many partnerships between world-class research labs and centres on collaborative research projects to support business in the area. The Marine Research Plymouth consortium is one localised research and knowledge exchange network. All of the universities and many major labs are members of governance networks such as Ocean Futures, the MBTC, and Oceansgate projects. Again, the perception is that there are strong partnerships between universities and labs on research but that they are less effective at working together on commercialisation and industry support.

That inter-university/research centre collaboration on economic development may not be as strong as some observers would like may have geographical dimensions. All of the major universities are highly engaged in their localities and have strong track records, and continuing intentions, to support the industries in their ecosystems. As one university described their relationships with firms:

> *The work that we do with businesses it's all the stuff that you would expect. We sometimes will get [firms saying] we have a pretty good idea of what the problem is, and we need help with the solution. And that's then connecting them with an academic to help them develop that technical solution.*

> *Sometimes it's about the university being aware of new technologies, or new innovations, and then holding events and kind of quasi training events to bring businesses together, to help to explain to them what the new, you know, kind of what the opportunities, you know, through this new technology or innovation might be. And there's a big part of that, because, again, if you're an SME, you might have less time to spend on that kind of innovation. So sometimes it's about [generating a demonstration effect]. So we've run [the immersive technologies] project for a year and a half. And it's only when we've written the case studies of how we've helped the first tranche of businesses that the other businesses start saying I didn't really understand what immersive was or could do for me, but now I understand it, can you help me? And then that then grows, it creates that ecosystem between the university and the businesses because you then have academics that have created relationships with businesses. That then sparks an idea in an academic to say, actually, I've got a research question, which I need an industry partner to help with. Would you like to be part of that? They say yes. And then you know, it kind of grows from there and, you know, goes into knowledge transfer partnerships, and it goes into industrial research. And, and, you know, there's definitely evidence of that.*

Many of the projects and facilities listed as flagship Blue Economy programmes for the universities above (Marine-i, FaBTest, etc.) were created to provide infrastructure and services to support local firms, increase knowledge exchange from researchers to the market, and to enhance innovation. Notably, many of these programmes have been supported by ERDF funds which, once depleted, will need to be replaced to sustain this degree of activity.

In sum, there appears to be scope to strengthen jointly supported commercialisation activities that link stakeholders across the area and integrate more localised projects to reach firms across the geography. However, this activity may be contingent on continued public investment in established infrastructures.

**Knowledge access and cultures:** The knowledge exchange environment is relatively open. While firms certainly guard their proprietary information, there appears to be a willingness to collaborate and share knowledge as evidenced by relatively high levels of firm participation in various accelerator and business development initiatives (such as the MBTC). The fact that Thales has opened a marine autonomy testing facility is further evidence of firms', even large primes, commitment to sharing resources and supporting innovation more broadly.

**Firm network relationships:** While it is difficult to comment on firm network relationships across such a diverse range of industries and activities, there are at least increasing opportunities for firms to meet, interact, and share knowledge. Accelerator and business development programmes, shared infrastructure, and evolving network activities all multiply the potential for interaction and opportunities to collaborate. Activities convened by industry leaders (see the following section) are increasing around the Ocean Futures initiative, the development of the Freeports, and in the development of the Celtic Sea Power cluster (value chain).

One commentator reflected that the large firms in the area appear to have well-established lines of communication:

> *It's very clear that those sorts of communication links were already there, or they were quite strong. So whether that's with the Navy with the likes of Babcock, or Thales, or these other sort of larger organisations, it was already there. So that communication path was already established, which I think is quite rare. And certainly, those businesses were also the ones that were helping to build the demand.*

It is likely that this is less true across the breadth of the SMEs in the area - who are less likely to be collaborating or competing for large government contracts or as deeply engaged in governance networks because of their long tenure in the area and status as large employers. While this research

did not reveal a lack of interfirm partnerships to be a particular weakness, there was a perception that these could be further encouraged and reinforced where possible.

**Reflections:** Knowledge exchange in the Blue Economy industries studied happens predominantly around university and public research labs and their associated public-facing projects. This process appears to work quite well with two caveats. First, it is unclear how well the commercialisation pipeline is working as a result of those partnerships and whether that success is shared evenly across Blue Economy subsectors. There may be scope for support to improve those results and increase interdisciplinary/intersectoral synergies. Secondly, because of that orientation, the R&D landscape appears to be relatively fragmented. While university and public research from different parts of the Great South West come together in a few locations it is unclear how well knowledge flows between places. This has resulted in the emergence of local specialisms, which is positive, but may be limiting knowledge exchange between subsectors with potential for synergies (e.g., automation and offshore energy). That much of the visible knowledge exchange in Blue Economy industries is driven by universities and labs is an asset, but one that may be challenged as the EU funding that has supported it to date is running out. Whether partnerships will continue with new funding streams, find ways to sustain themselves, or peter out remains uncertain.

## Networks of Coordination

Aside from the LEPs, which all have an interest (to varying degrees) in the marine and maritime, there are four main governance networks dedicated to developing a vision for and strategies for growing the Blue Economy in the Great South West.

- **Great South West** is the 'powerhouse' brand to promote the LEP areas of Cornwall and the Isles of Scilly, Heart of the South West and Dorset. It aims to deliver £45bn of economic benefit and become the leading region for the green and blue economy in the UK.
- **Maritime UK South West** is a public-business-research partnership which brings together the breadth of ocean economy to create a world leading ocean technology cluster. It enables innovation and collaboration, provides business and skills support, and drives strategic development and investment.
- **Ocean Futures** is a private-public-research partnership that has a united goal to create a global centre of excellence and supercluster in testing, development and manufacture of autonomy, digital and clean ocean technologies for the rapidly growing global ocean economy.
- **Celtic Sea Cluster** is this initiative of Celtic Sea Power, a consortium of Welsh Government and Cornwall & Isles of Scilly Local Enterprise Partnership (CIOSLEP), Celtic Sea Power, Marine Energy Wales, and the Offshore Renewable Energy Catapult (ORE). Celtic Sea Cluster has set out a clear regional strategy in consultation with a wide-range of regional stakeholders to deliver social and economic benefits to Cornwall, South Wales and the greater South West through working groups on: Supply Chain, Innovation, Workforce, Grid and Ports. The Cluster also provides a hub for regional activity and invites local businesses and stakeholders to sign up for updates on floating offshore wind as it develops.

These are just some of the most prominent initiatives that have explicitly stated a desire to seed, support, develop, and/or grow the Blue Economy (cluster) in the South West. These initiatives are coloured by the recurring theme of mild regional fragmentation, which has meant that stakeholders have not yet coalesced around a single dominant strategy. For the most part, these initiatives do not

compete with one another conceptually. They all seem to embrace a pan-South West geography and champion the idea of working across LEP boundaries. However, they also do not appear to speak to or engage with one another explicitly. For example, Ocean Futures has emerged as an offshoot of Maritime UK South West and has a proposal for Blue Economy development that is meant to both galvanise actors in the region and attract the attention of, and funding from, Government. While name recognition is high, only the Heart of the South West LEP is listed as a partner and core documents from other networks do not mention it. This may be because it is relatively new, but some respondents suggested that it was seen as more of a Plymouth initiative. The nascent ***Marine and Environmental Science Accelerator*** seeking funding for a suite of business support and R&D solutions similarly only lists the Heart of the South West LEP in its documentation as a partner (alongside universities).

The Celtic Sea Cluster (CSC) initiative has also proposed a regional strategy focused on the development of a value chain for the floating offshore wind industry. Notably, CSC styles what they are doing as "cluster development" but sees its efforts as separate from other initiatives in the region:

The short answer is no, we don't see ourselves as part of a Blue Economy cluster, we see ourselves as an energy cluster. And we just happen to be the closest I would say, to us to the offshore oil and gas sector. And that's because really, we've got the same, we've got the same skill sets required and similar sort of mentalities, build big things offshore, we see the maritime and marine supply chains and the businesses as key elements of our supply chain.

This rejection of the Blue Economy framing for the area sets CSC apart. Other respondents described Celtic Sea Flow as a significant development but one that is not (currently) very well integrated with other governance networks.

**Reflections:** The abundance of governance initiatives demonstrates that there is both a lot of interest in and leadership around the Blue Economy. A core challenge for growth will be to bring partners together to integrate visions and establish complementary objectives and/or divisions of labour. Another challenge will be to ensure that partnerships are not in name only and that synergies translate across subsectoral and geographical boundaries. What emerges in the future will be in no small measure determined by which initiatives are successful in securing funding, and how sustained those flows of resources are.

## Discussion: Innovation opportunities and support needs

**Evolution and market opportunities:** The area has proven and emerging strengths across a range of Blue Economy activities that will continue to offer opportunities for innovation and growth. Each of the core areas - *offshore wind*; *oceanic environment monitoring*; *autonomous vessels*; *surveillance and maritime security*; and *marine science* - are independently plugged into growing markets but also have great potential for cross-sectoral synergies (as described above). From this perspective, if it can encourage these connections, the region is well-positioned to multiply innovation capacity and develop world-leading industries.

**Resilience:** Blue Economy industries look to have a good growth trajectory generally, and those in the Great South West are no exception. With increased and sustained interest in Net Zero and environmental stewardship agendas, the likelihood of increased ocean-based activity (e.g., aquaculture), and rising labour costs, higher demand for alternative energies, automation, and environmental protection skills seem likely. Key challenges for this area include (1) skills shortages, which can constrain growth; (2) a contraction in funding related to lapsing EU support; and (3) competition from

other areas of the UK on core competencies. Several other coastal areas in the UK have or are building out strategies around Blue Economy industries. Activities around automation, alternative fuels, and blue hydrogen are particularly common. Focusing on key strengths rather than trying to support every type of activity can help mitigate this risk.

**Areas of potential support and intervention:** Overall, the Blue Economy in the Great South West appears to have a bright future. With support in the following areas, it can increase its growth potential.

- Ensuring that businesses have the skills they need to succeed: stakeholders should build on efforts already underway to anticipate the skills needed in the medium and long term and establish programmes to provide them. This is not just about qualifications, but ensuring that graduates (and those being retrained) have industry-ready skills. Another part of the equation is attraction and retention, which involves providing high quality of life to workers through affordable housing and vibrant communities.
- Replacing and growing funding streams for R&D and collaborative innovation: many of the region's successes have been publicly funded through EU resources. As those wane, it will be important to replace these with UK funding streams to ensure that existing collaborations can continue and grow. Currently, domestic and local funding is not expected to be able to sustain existing initiatives, creating a risk that successful programmes will lapse and progress will be stalled. The region has a wealth of ambitions and has mobilised the partnerships to progress them, but will require significant investment to translate those ambitions into reality.
- Coming together around a common vision for the Blue Economy: many visions and many leaders have emerged to drive Blue Economy initiatives. While there are many commonalities and overlaps between them, it does not yet appear as though there is a clear leader or division of labour. As each one seeks funding for its programming, there is a risk of confusion about who does what and how support will be distributed, as well as of competition spreading resources too thinly. There is an opportunity for stakeholders to come together to clarify how each initiative relates to others and set up clear partnerships between them - or else consolidate efforts.
- Building links between subsectors: partnerships between universities and research labs appear to be quite strong, but there is considerable scope to prioritise building links between the subsectors of the Blue Economy in both research and practice. While this is likely happening already, more effort could be made to link activities across geographies and across specialisms to seek unique synergies that will underpin the region's competitive advantage. Ocean Futures has already outlined the link between automation, offshore energy, and digital communications - these connections should be further encouraged and expanded where possible.
- Focusing on areas of strength: the Blue Economy is gaining popularity around the world and is seen as a strategic asset by many (frequently disadvantaged) coastal communities. The region should work to define, publicise, and grow areas of unique expertise rather than compete with other coastal areas (such as the Solent). This effort is already underway through Ocean Futures and others' planning processes. As part of this process, the region should seek to coordinate with neighbours and competitors around the country to discover how connections might complement and strengthen each other's efforts and build the UK Blue Economy into a world leader.

**Reflections:** The Blue Economy in the Great South West is well-positioned to grow and, if supported, has great innovation potential. It has developed a strong reputation for research excellence in marine and maritime and is in the process of successfully pivoting to take advantage of a confluence of expertise in

related Blue Economy industries. Governance across subsectoral and geographical boundaries remains an important challenge and will be instrumental in securing public support at the levels needed to sustain growth.

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# Blue Economy in the Scottish Highlands & Islands

## Case Study Overview

**Characteristics and history:** Blue Economy is a term that is increasingly being used in Government and governance organisations to encompass the ensemble of Scotland's extensive marine and maritime resources. Marine Scotland estimates that Scotland's marine assets extend over 617,000 km2, or roughly seven times its land area (Marine Scotland 2022). Its Blue Economy vision document is not specific about what sectors and activities are included but defines this economy as "the marine, coastal and the inter-linked freshwater environment of Scotland, the different marine and maritime sectors it supports, and the people connected to it". Other initiatives, such as the MAXiMAR consortium formed in 2015 as part of the SIA consultation process, and Highlands and Islands Enterprise (HIE), are more specific. MAXiMAR (2019) focused their analysis on aquaculture, wave and tidal energy, and marine biotechnology, which were described as the most highly innovative sectors of the region's marine economy. More recently, HIE has been refreshing their strategic priorities to include:

- Marine energy and renewables: floating offshore wind, wave and tidal energy, alternative (marine) fuels (e.g., hydrogen)
- Aquaculture: Finfish, shellfish, and seaweed farming
- Marine biotechnology and bioprocessing: extractives from marine products and waste processing
- Marine environmental services: marine monitoring around coastal erosion, fish stocks, ocean temperatures and acidification, pollution, etc.
- Decommissioning of existing offshore fossil fuel installations and infrastructure and, in future, of renewable energy assets being upgraded or replaced

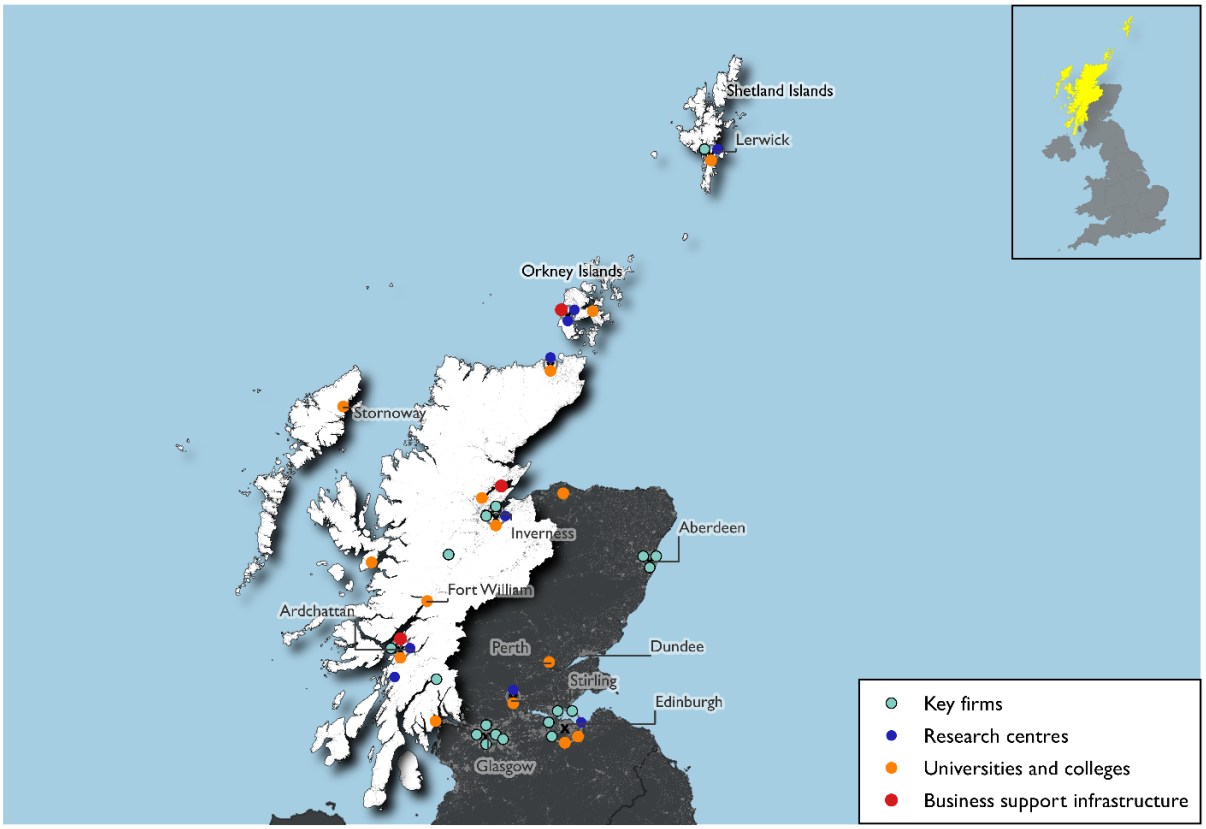


Figure 7: Blue Economy in the Highlands and Islands map.

It is notable that these areas of expertise build on legacies of, but do not include, industries that have for a long time anchored the Highlands & Islands economy and are still operating but are either viewed as less innovative, such as fisheries, or in the process of being dismantled, such as offshore oil. This is not surprising as the idea of a Blue Economy is closely tied to concepts of sustainability.[4]

The Government of Scotland's Marine Economic Overview (2022) estimated the significance of the marine economy in the Highlands and Islands was £704 million in GVA, £1,640 million in turnover and employed over 22,200 people in 2019. This represented modest growth from the 2016 – 2018 figures. It estimates that the Highland & Islands represented approximately 15% of marine economy turnover in Scotland and 29% of employment.

**Geography and size:** Definitions of the Highlands & Islands geography vary, but for the purposes of this study we adopt HIE's definition. This area includes Shetland, Orkney, Caithness and Sutherland, the Outer Hebrides, Moray, Inner Moray Firth, Argyll and the Islands, and Lochaber, Skye, and Wester Ross (see Figure 7).

This area is immense (over 400,000 km2 of landmass) and fragmented, covering more than half of Scotland's landmass and encompassing nearly 100 inhabited islands. However, the area is sparsely populated with only 469,500 inhabitants (HIE 2019) and facing challenges of gross population decline even though some parts are gaining inhabitants.

**Areas of potential future growth:** The Highlands & Islands area has a rich legacy in marine and maritime and, as HIE's strategic priorities (above) attest, no shortage of vibrant industries with significant growth potential. Three of these stood out as particularly innovative.

- Offshore energy - The area is currently in a transition away from oil and gas exploitation towards offshore renewables. Where the region had previously focused on wave and tidal energy, offshore wind (both fixed and floating) is growing quickly. In 2021, the UK accounted for over 20% of total operating wind energy capacity and increased its capacity 8% over the previous year (The Crown Estate 2021). Beatrice and Moray East, off the Northeast coast of Scotland is among the largest operating sites in the country, both of which will be eclipsed in size by planned floating offshore installations (see ScotWind 2022). A recent article reported that jobs serving offshore wind development have increased about 16% (Reed 2022). This growth is being supported by the Scottish Government's strong policy targets on renewable energies. Because of its natural advantages, the Highlands & Islands area will be home to a large proportion of offshore renewable energy development in Scotland.
- Aquaculture - Aquaculture is big business in Scotland, generating over £560 GVA in 2019 and accounting for over 11% of marine economy GVA (Government of Scotland 2022). Over 200,000 tonnes of salmon are farmed every year and the supply chain consists of over 3,600 Scottish businesses (Salmon Scotland 2021). While finfish aquaculture is the largest segment of this market, both shellfish and seaweed farming are emerging and growing markets. Innovations to increase the productivity of finfish and to scale shellfish and seaweed production will be real areas of growth.
- Marine biology, monitoring, and engineering - Offshore infrastructure and installations require detailed data and monitoring to function effectively. Considerable expertise has developed in sensors, data collection, and analysis of ocean environments for both environmental modelling and industrial applications. As offshore investment in aquaculture

[4] This was reflected in the Blue Economy vision document in the statement that "The blue economy approach requires a transition from 'environment versus economic growth' (the prevailing status quo in Scotland and globally) to 'shared stewardship' of natural capital that is facing common pressures".

and energy increases, environmental regulations tighten, and climate change changes the marine environment, there will be greater demand for technology solutions that are sensitive to or can enhance our ability to support the sustainable use of ocean resources.

Significantly, there are also segments of the Blue Economy that could potentially be more joined up. Respondents reported that while each of these individual sectors is evolving, there are few formal relationships and synergies between them, particularly in industrial research and innovation. The marine biology, monitoring, and engineering segment of the Blue Economy could represent an opportunity to bridge energy and aquaculture innovation systems by providing technology solutions to shared concerns (e.g., sustainability and operations monitoring). This may result in important knowledge exchange and provide information feedback to bring these industries together to counter common threats to the environments in which they operate and their supply chains.

**Reflections:** While the Blue Economy label has strong buy-in at the policy level, it is less clear that this identity is shared by marine and maritime stakeholders in the Highlands & Islands area. The various industries that make up the Blue Economy tend to operate in silos and are sometimes competitive over marine resources. As such, this is currently less of a coherent cluster than a set of industries, activities, and assets that could *potentially* be more effectively connected to maximise opportunities for knowledge synergies[5]. Another element is that respondents often perceived clusters to be very small and localised - for instance different actors expressed an aim to grow very specialised but small scale clusters around research organisations in Shetland, Oban, and Orkney. This, combined with the large geography and industrial silos, makes constructing a cluster at the Highlands & Islands scale quite challenging. Apart from the cluster question, a common challenge for many of these industries, and for economic development policy, is also ensuring that the benefits from these largely extractive industries are better captured locally through supporting the development of a vibrant innovation system and supply chain.

## Core Assets

**Market structure and anchor firms:** In the Highlands & Islands case, the two largest industries - offshore energy (renewable and otherwise) and the salmon farming segment of aquaculture - are dominated by large multinationals.

In offshore wind, firms like Shell, BP, SSE, Total Energies, Ocean Winds (EDP Renewables and ENGIE), Orsted, Floating Offshore Allyance, and Falck Renewables are the core developers currently working in partnership or competition with Scottish and UK companies such as ScottishPower Renewables. Developers are supported by an ecosystem of Scottish suppliers (Offshore Wind Scotland lists 800 supply chain stakeholders in the DeepWind Cluster) including innovative companies such as Global Energy Group (wind and tidal turbine manufacture and assembly), ACT Blade (wind turbine blades), and Xodus Group (energy consultancy). Scottish companies are also involved in providing support, crew, and maintenance services, many of which have pivoted from petroleum industry support functions.

Salmon aquaculture is similarly dominated by a few multinationals based in Norway, Chile, and Canada such as Mowi (Norway), Scottish Sea Farms (Norway), Bakkafrost (Faroe Islands), and Cooke Aquaculture (Canada). This industrial structure is the result of significant consolidation and foreign

[5] Respondents had different views on the feasibility of this type of thing

direct investment over the past 30 years. As with offshore energy, the salmon farming industry has attracted international investment and attention due to its natural geographical advantages: Scottish waters are one of the few places favourable to salmon aquaculture. The Scottish supply chain and support ecosystem is relatively large and decentralised and consists primarily of SMEs.

Supply chains in both industries share some broad similarities that have important implications for the cluster development potential of the Highlands & Islands area. First, while Scottish supply chains - for manufacturing, construction, maintenance in offshore renewables and construction, processing, and logistics in aquaculture - are substantial, they are often measured at the national level. That is, many of the firms that support these industries are based or headquartered in the Southern parts of the country and outside of the Highlands & Islands. Second, because of the multinational nature of both industries, supply chains are genuinely global. For instance, most offshore wind manufacturing is located overseas. This also applies to research and development. The farming and energy installations are supported by Scottish enterprise, but many of the innovations that sustain their competitiveness are developed at company headquarters and through global innovation networks. While innovation does happen locally, and localised research and innovation partnerships do occur, it's just one, sometimes quite minor, pipeline into the industry. The challenge within this industrial structure, then, is to grow the share of local firms benefiting from foreign investment and to connect to pipelines of international research.

And I think that would be my big message for Innovate UK, that the cluster is not, it's not a geographical cluster, it's an intellectual cluster, or it's a supply chain cluster. And probably at least 50% of the supply chain for [fish]farming in the highlands, is in the central belt of Scotland, or it's in England or it's in Wales.

Firms in marine biology, monitoring, and engineering, and in the other segments of aquaculture, all tend to be SMEs. These include firms like Ocean Ecology, Ocean Kinetics, Gael Force Fusion, and Cuan Tec.

**Higher education and training institutions**: Because of the sparsely populated nature of the Highlands & Islands area there are not many higher education and training institutions. The **University of Highlands and Islands** (UHI) is a hybrid university and further education college. It is composed of 12 colleges and research institutions spread around the Highlands and Islands, Moray and Perthshire regions of Scotland. It hosts a Marine and Environmental Science research group that focuses on research themes around understanding environmental change, people and the environment, energy and national resources, water quality, energy innovation, and hosts the **Environmental Research Institute** (ERI), **North Atlantic Fisheries College Marine Centre**, **Aquaculture Hub**, and **Institute for Biodiversity and Freshwater Conservation**. The UHI Tern Campus hosts the **PowerHouse**, which aims to become a centre of excellence for floating offshore wind and green hydrogen and offers training modules for the renewable energy industry. The **Scottish Association of Marine Science** (SAMS) is the country's oldest independent marine science organisation and is a leading partner in UHI (based at the European Marine Science Park in Oban). SAMS also delivers a Marine Science BSc; Aquaculture, Environment, and Society MSc; Algal Biotechnology, Biology, and Ecology MRes and PhD. It also hosts the Culture Collection of Algae and Protozoa and the Scottish Marine Robotics Facility.

Universities outside of the Highlands & Islands make significant contributions to the research landscape and are often involved in partnerships with researchers at the various marine and maritime research groups and centres. While it is unusual, in a study such as this, to cite knowledge generating and training institutions outside of the study area, because of the lack of population density and higher education in the Highlands & Islands, other Scottish universities also fill the skills gap and, more frequently, play crucial roles in research networks. The **University of Stirling** hosts the Institute of Aquaculture,

which does research and offers undergraduate and postgraduate degrees. It also operates the ***Marine Environmental Research Laboratory*** (MERL). The **University of Edinburgh** provides MScs in Marine Systems and Policies as well as Aquaculture Genetics and Health. **Heriot-Watt University** hosts the Centre for Marine Biodiversity and Biotechnology and provides MSc programmes in Maritime Logistics and Business and Marine Renewable Energy. The university also supports the **International Centre for Island Technology** based at the Orkney Research and Innovation Campus that specialises in areas of interest to islands including marine resources and coastal zone management, renewable energy, waste minimisation, fish stock habitats and technologies, marine and coastal estates and conflict, biodiversity and marine conservation, and diving science.

**Other research and anchor organisations:** While the higher education offering in the Highlands & Islands is dominated by UHI, there are several other research organisations that contribute to the Blue Economy research and innovation ecosystem.

- **Scottish Association for Marine Science (SAMS)** is an independent marine science organisation, delivering marine science for a productive and sustainably managed marine environment through innovative research, education and engagement with society. SAMS has a diverse marine research and teaching portfolio that is global in outlook, project locations and relevance, and delivered by a highly skilled team working in partnership with academic, business, government, regulatory, voluntary and civic society colleagues. Its main facilities are located at the **European Marine Science Park** in Oban. SAMS offers state of the art facilities for marine robotics, research vessels, sampling equipment, analytical services, a research aquarium, research seaweed farm and hatchery, experimental artificial reef, coastal ocean modelling system, and scientific diving services.
- **Sustainable Aquaculture Innovation Centre (SAIC)** is based at the Stirling University Innovation Park, and so is located outside of the Highlands & Islands area. However, it has close links with the aquaculture industry and researchers working in the area. Its mission is to transform aquaculture by unlocking sustainable growth through innovation excellence. SAIC works to reduce the environmental footprint and increase the economic impact of aquaculture. It supports world-class research and collaborations with industry as well as offering skills and training programmes (MSc, PhD, innovation and leadership development). It also offers funding and business networking support.
- **The PowerHouse** is a relatively new applied research centre dedicated to developing floating offshore wind and green hydrogen technologies located on the Cromarty Firth. It aims to become a global centre of excellence and renewable energy innovation. The centre will also act as a specialist educational hub to deliver training modules from STEM activities for school pupils to continuous professional development (CPD) for workers interested in joining the renewable energy industry, throughout the Highlands and beyond, to ensure people across the region have the skills and experience to take advantage of these nationally significant projects being constructed in the region. This initiative is connected to the Opportunity Cromarty Firth consortium.

**Support structures:** Support structures in the Highlands & Islands Blue Economy typically take the form of innovation campuses where research, specialised infrastructure, business, and business support are collocated. These often involve partnerships with or house university research centres and programmes or independent research organisations, and are supported by governance networks (such as HIE) and demonstrate an ecosystem that strongly links knowledge creation, firms, and supportive structures.

- **European Marine Science Park (EMSP)** - was developed by HIE in partnership with Scottish Development International and the Scottish Association for Marine Science (SAMS). EMSP is SAMS' principal research centre. It is located in Argyll and has world-class facilities for marine

science research and blue economic business growth. In addition to SAMS' research and academic programmes, EMSP is home to incubator, specialised lab, and business development space. Business support services at EMSP are provided through HIE and include expert advice and support, funding and investment, and networking facilitation.

- **European Marine Energy Centre (EMEC)** is the world's first and leading facility for demonstrating and testing wave and tidal energy converters – technologies that generate electricity by harnessing the power of waves and tidal streams – in the sea. EMEC is also pioneering the development of a green hydrogen economy and smart local energy systems. Its operations are spread over five sites across Orkney. EMEC provides a wide variety of services in addition to testing including certification, numerical modelling and data collection, environmental services, regulatory consulting, business services (including bid writing consultations), and technology assessments. EMEC clients include Alstom, Magallanes REnovables, ScottishPower Renewables, Nautricity, and others.
- **Orkney Research & Innovation Campus (ORIC)** is a joint venture between Orkney Islands Council (OIC) and HIE, creating an improved home for Orkney's wide range of clean energy and low-carbon expertise. ORIC aims to strengthen Orkney's global lead in the field of renewables research and innovation, providing purpose-built business and educational facilities within Stromness, where much of the sector's activity is currently focused. One of EMEC's sites is based at the campus and it is also home to Heriot-Watt's International Centre for Island Technology. Robert Gordon University is also a partner.

**Finance:** The deep and well-connected nature of the Blue Economy support structures in the Highlands & Islands means that there are numerous organisations that are spreading word about and supporting firms and researchers in accessing funding from various sources. On the economic development side, funding from Scottish and UK public streams and regional deals (such as the Islands Deal) has been important in enabling the development of support structures and facilities and will remain critical in expanding capacity and sustaining funding to research and development. This research did not reveal clear bottlenecks with firm financing and we recommend further follow up with firms to establish what the issues are, if any, in each of the industrial segments we have identified.

**Reflections:** For a large, in many cases remote and sparsely-populated area, the Highlands & Islands has a rich foundation of core assets in the Blue Economy. Industries with large multinational anchor firms and growing international investment, well-established and well-connected research programmes in universities and independent research organisations, specialised infrastructure, and active and engaged supportive organisations mean that the area has a lot of expertise and engagement to build on. On the research and support side, there are clearly strong links between organisations across the broad geography. What is less clear is how that is both contributing to the development of a collective - meaning at the Highlands & Islands scale - identity around the Blue Economy, or whether the localised connections (and agendas) and industrial silos are more compelling foundations for place-based development.

## Skills

**Talent pool:** Talent was described as a perennial problem but there are several interrelated dimensions to the skills challenge. Most of the industries in the Blue Economy have been traditionally labour-intensive but, with the adoption of technologies are now transitioning to being less labour-intensive and more highly skilled. While there are local skills providers (see below), the perception is

that as industries grow they will be reliant on attracting talent from other parts of the country and internationally. As many of the multinationals mentioned above have vast resources and global networks, at least some of the skills needed will be met through workers attracted from abroad and through their own (re)training programmes. This option is only really available to the largest and best resourced firms. Furthermore, attracting skilled labour is easier said than done. Some respondents report that housing costs are rising due to a number of factors, including the increase of second home ownership and people working from home in more attractive locales in the Highlands & Islands. Attracting and retaining people in sometimes remote locations can also be challenging.

The nature of skill needs varies by industry and firm, and there is a perception that human resources will be a significant constraint on growth across the board.

These sectors are at different stages of maturity. So those with predominantly the larger businesses transition faster, they invest in transition sooner, and to a greater scale, I think. So if we look at for example, oil and gas, they are transitioning to renewables, they are transitioning their workforce to renewables. So when they are taking on undergraduates, the type of the training pathway is similar, but slightly different, for example, and if we look at even aquaculture and actually some of the supply chain within that we are much more looking at people who can work automated systems - strong in technology, computer science, for example, and biology, - because it's no longer a manual job. And we are seeing both vocational and academic pathways adapting to respond to what the industry needs. I think in some of the newer sectors, such as moving bioprocessing, probably, and definitely seaweed farming, for example, we've a way to go. Quite a way to go.

Training, retraining, sourcing labour from other parts of the country (and the world), and issues around lifestyle, attractiveness, and retention will remain important for all skills and qualifications. But, if done effectively, could help turn around stagnating population growth and meaningfully impact prosperity.

**Local skills provision:** Because the skills required for many of these evolving industries are quite technical and specialised, firms tend to rely on Scottish and even international labour markets to fill gaps. Consequently, there is a complex relationship between the local labour force and Blue Economy industries that create accessibility challenges. One observer commented that, on the higher skill end, local workers often choose to go away to university or college in other parts of the country. The word choice is deliberate here, as there are several programmes being delivered by universities and their Highlands & Islands based research centres that provide training - in higher educational and vocational levels - to contribute to and connect with Blue Economy industries. The perception is that younger people do not always want to stay in the Highlands & Islands for their higher or further education and that there can be some difficulty in re-attracting them. Retraining local workers for jobs in Blue Economy industries appears to be an important emerging issue. This is already happening in the oil and gas industry as workforces are being re-skilled for offshore renewables. However, many of these industries are more automated and less labour intensive than in the past, and are increasingly requiring digital and other skill sets. The PowerHouse is one example of an initiative that is focusing on increasing inclusiveness and ensuring that local residents can get qualifications for and access jobs in these growing industries.

There are also specific skills initiatives growing around particular industries. UHI is involved in a collaborative effort to establish a skills strategy for the energy industry. The initiative is reportedly cataloguing the skills needed in 5,000 different job types and modelling predicted need as well as time to train people to meet those needs[6]. This will be shared among education providers to respond to critical demands. Skills providers also report meetings with stakeholders in the area and in Government

[6] These estimates were not public at the time of writing.

to share information and plan for growth, suggesting that there is a collective effort underway to fill gaps with Scottish talent.

**Reflections:** As some industries are projected to grow very rapidly over the next decade, skills constraints are front of mind. Several initiatives are underway to respond to these evolving needs, but most respondents lack confidence that it is possible to meet skills needs locally. It is also clear that ensuring a sufficient skills base is about more than just filling training needs, but is also tied to the area's ability to offer an attractive, and affordable, lifestyle. While emphasis on attraction, and sourcing labour from a national pool, is understandable, attention should also be paid to ensuring that the existing workforce is not left behind and that support enables local residents to participate in these growing industries.

## Knowledge Exchange

**Firm research and development practices:** The Blue Economy industries that are the focus of this report are quite research and development intensive. The growth and competitiveness of all of these industries is reliant on advancements in materials or manufacturing of equipment, maintenance and monitoring, or related to understanding biological systems, animal welfare, or the health of the oceanic environment, all of which require strong and sustained research and innovation efforts.

The large multinationals maintain global research programmes and are plugged into international pipelines of knowledge exchange. They also maintain relationships with the Scottish (though not always "local") research community. Some firms have strong relationships and engage in collaborative research with, or take advantage of, research and innovation funding provided by research centres in the Highlands & Islands. However, those that do participate in those structures and relationships are a subset of the active firms in these industries.

**Knowledge access and cultures:** Research performing organisations have very strong relationships with one another and there appears to be a tradition of working together, where appropriate, on collaborative projects or initiatives. Researchers were careful to stress, however, that they did not prioritise research relationships in the Highlands & Islands and that they frequently worked with partners from other parts of the country and world. Firms engaged in accelerator or innovation parks reportedly engaged in network relationships and were likely more open to knowledge sharing with peers. Respondents noted that there were not many cross-industry interactions or partnerships for knowledge sharing, but suggested that this was because of a lack of obvious overlaps between certain activities. The closest synergies were likely in marine biotechnology and aquaculture, where research on the marine environment (etc.) and innovations in feed and waste management fed directly into the aquaculture industry.

**Firm network relationships:** As suggested above, industries appear to operate in silos with very few notable inter-industry interactions. However, firm networks are relatively strong (a) within their own industries, and/or (b) within their own areas. Each industry has one, or several, associations that facilitate networking between members, which typically include firms, research, and government agencies (see below for a selection of these). Networking also appears to be strong within specific localities and nodes in the Highlands & Islands area. Innovation campuses, such as EMSP and ORIC, function as "cluster" conveners and bring together tenants and firms in their broader areas to share information about opportunities and events. These nodes often have specific industrial and thematic focuses around which networking is reportedly most synergistic. However, these geographically

concentrated groups of firms are relatively small and respondents struggled to ascribe concrete innovation outcomes from network relationships at that scale.

The question of industrial silos and geography is a particularly interesting one for this area, and opinions differ about what a Blue Economy strategy should aspire to in terms of connecting different actors. As one person noted:

> *I think where [the previous cluster strategy] tried and failed was to say that all parts of the Highland coast were part of the same cluster. And they're not. There are pockets of expertise. And they are different. Trying to mush everything into one thing doesn't make sense.*

This highlights some of the geographical and industrial barriers that governance networks must grapple with as they encourage knowledge sharing and firm networking.

**Reflections:** Knowledge exchange is relatively strong but suffers from several challenges (that may not be worth attempting to surmount). Research partnerships are strong but not primarily anchored in the Highlands & Islands. Industrial associations span the large geographical distances, but also tend to function at the national scale, even if a large proportion of activities occur in the Highlands & Islands area. Nodes of vibrant network activity have emerged around specific research centres but are small and specific. Meanwhile, many remain sceptical about the value of pushing an agenda that seeks to maximise inter-industry and inter-local relationships across the Highlands & Islands.

## Networks of Coordination

There are several notable networks, past and present, that bring together and coordinate actors in the Blue Economy in the Highlands & Islands. As noted above, some of these networks are industry specific and function at a broad national scale, some are industry specific and are more locally focused, and some focus on all Blue Economy industries at the Highlands & Islands scale. While the ecosystem of governance actors is relatively rich, the challenge is whether a Blue Economy vision is appropriate for the area or whether it may be more effective to concentrate on strengthening sub-clusters by industry.

- **Highlands and Islands Enterprise (HIE)** is the economic and community development agency for the north and west of Scotland. HIE supports businesses, communities and social enterprises through a range of services, including advice, funding, events and property. The organisation is also active in developing strategies for the Blue Economy sector (as a participant in MAXiMAR and through its own internal strategies) and backing these with investments (such as in EMSP and other initiatives).
- **MAXiMAR Consortium** was convened in 2015 to shape the science and innovation audit in the Highlands & Islands. It included Highlands and Islands Enterprise (HIE), EMEC, Wave Energy Scotland, UHI, IBioIO, Heriot-Watt University, SAMS, Marine Scotland, Marine Alliance Science Technology Scotland, SAIC, National Oceanography Centre, and the University of Stirling. While the initiative generated several reports on strategy and skills, and two (unsuccessful) bids for Strength in Places funding, it is currently inactive.
- **SAIC Consortium** is a free network for aquaculture professionals and academics to connect, collaborate, and get advice on funding opportunities. It includes over 280 businesses and organisations, from SMEs to large multinationals, and from cutting-edge research institutes to Scotland's oldest universities.

- **Scottish Offshore Wind Energy Council** is a partnership between the Scottish public sector and the offshore wind industry. Its mission is to coordinate and grow the sector, ensuring the Scottish offshore wind industry is more sustainable, competitive, and commercially attractive, both domestically and in the global offshore wind market.
- **DeepWind Cluster** is a supply chain cluster and the largest offshore wind representative body in Europe with over 800 members from industry, academia, and the public sector. The main purpose of the DeepWind cluster is to help its members achieve greater benefits from the current and future development of offshore wind in the UK and internationally. It specialises in fixed and floating offshore wind in deeper waters, usually considered to be greater than a 40m depth. The organisation originally covered a geographical area that stretched along the Scottish coastline from Wick in the far north to Montrose in the north east. Due to the introduction of the 25GW ScotWind offshore wind leasing round, DeepWind's ports and harbours members now extend around the North Coast, Northern Isles, Western Isles and West Coast as far south as Campbeltown in Argyll & Bute, and across to Hunterston PARC (Port and Resource Centre) in North Ayrshire. This now encompasses 25 ports and harbours members and represents coverage of over 70% of the Scottish coastline.
- **Salmon Scotland** represents every company farming salmon in Scotland along with companies from across the Scottish salmon supply chain, championing the sector's interests. It also works with its members, the UK and Scottish governments and regulators to help shape the regulatory environment so both Scotland and its members can thrive.
- **Opportunity Cromarty Firth (OCF)** is a consortium leading a bid in the current competition for Green Freeport status, which could "revolutionise" the Highland economy and stimulate major new manufacturing activity locally and elsewhere in Scotland and the UK. The consortium is backed by port owners Port of Cromarty Firth, Global Energy Group, Port of Inverness and The Highland Council alongside a dozen regional businesses, public sector organisations and academic bodies. OCF believes the creation of such a zone on the Firth would maximise local and Scotland-wide benefits from a pipeline of renewable energy projects, placing the Highlands at the heart of the drive towards net-zero and will drive job creation.
- **Blue Economy Cluster Builder** was a 3 year programme to communicate and raise awareness of the benefits of the Blue Economy in Scottish SMEs and enable them to take advantage of new opportunities, which included an online tool. While this focuses on the Blue Economy broadly, it was organised for the whole of Scotland.

**Reflections:** Of all the networks, HIE is best placed and most active in convening actors around a Blue Economy agenda in the Highlands & Islands. The struggle is how, and in what way, to construct a shared vision and stimulate innovation synergies across industrial silos and a large territory.

## Discussion: Innovation opportunities and support needs

**Evolution and market opportunities:** Offshore renewables will be a huge growth sector for the Highlands & Islands. At first, growth will occur around installing and scaling offshore energy infrastructure, which will require a rapid increase in manufacturing, servicing, and installation capabilities. Over time, there are ambitions to link in more advanced manufacturing, and green hydrogen processing and transport, potentially creating opportunities for firms engaged in service vessel design and operation, and particularly robotic and autonomous platforms and monitoring systems. Aquaculture will remain a significant contributor to regional GVA. Market opportunities will be in areas of animal welfare, remote maintenance and monitoring. Marine engineering is poised to

grow as a sector to support these two industries, while marine biotechnology will be integral to ensuring the sustainability of operations and creatively managing waste materials.

**Resilience:** Although several of these industries are poised for growth, they each face challenges. Labour markets are uncertain and skills shortages remain a significant risk to development. The housing market, and related demographic changes, are a key factor in understanding evolving risks. First, the increase in remote work and higher demand for homes in picturesque coastal areas are raising home prices and making attracting workers more challenging. This will likely require more, and quite rapid development, to house labour demand. Secondly, as more people have migrated to the area in search of more attractive places to live and work, resistance to offshore development is rising. It is already becoming more difficult to approve new farming operations and the increase in activities related to scaling offshore wind may also create local conflicts.

Areas of potential support and intervention:

- Establish and execute a cluster strategy, or several: Blue Economy activity in the Highlands & Islands area could be coordinated and constructed around a cluster strategy. However, there is probably no one "right" way to do that. One option would be for HIE to lead a consortium of stakeholders from across industries to devise collective goals and strategies to address common challenges. These might include skills shortages, housing development, managing the impact of growth (and potential resistance), and ensuring that growth is inclusive. There are potential benefits to increasing inter-industry links, possibly around adapting enabling technologies such as robotics, automation, satellite infrastructure, and data analysis tools to different activities in the maritime environment. However, the legacy of the MAXiMAR process left some stakeholders in the area wary of attempts to bring industries together or treat them equally. Some have suggested that focusing on narrower, more localised, and industry-specific clusters may be a more effective approach. Any effort to work across industrial boundaries will have to overcome this reluctance.
- Skills: This report has established that skills are likely to be a constraint to growth. Several efforts are currently underway to assess labour needs and devise strategies to attract and retain talent. These should be supported and encouraged to share findings more broadly to inform a coordinated response. Efforts should also be increased in linking business, education and training stakeholders, and relevant departments in the devolved and national administrations to support labour strategies and ease migration and immigration where appropriate.
- Housing: Growth and growth pressures are likely to be very unevenly distributed across the area. Some communities will experience greater pressures than others. While expanding housing stocks to accommodate a larger workforce will be vital, this should be executed in collaboration with existing communities and with sensitivity to the community character, natural beauty of the area, and impacts on existing industries (such as tourism).
- Balancing industry, sustainability, and natural amenities: Most of the industries that anchor the Blue Economy in the Highlands & Islands are there because of the unique maritime natural advantages of the area. While the area would benefit greatly from growth, it is important to take factors such as sustainability and social licence into consideration.
- Capturing the value of growth: Both offshore energy and aquaculture are, as currently configured, largely extractive industries. That these are dominated by large multinationals and consortia creates advantages in attracting investment and to support rapid scaling. While some benefits will always accrue to local supply chains there is a risk that the benefits of growth - both material and in terms of innovation advances - are realised elsewhere. These industries have already stimulated the development of a constellation of businesses but there is potential to create a larger critical mass of firms at the cutting edge of innovation. This will likely be facilitated by more aggressive identification and support of emerging firms,

support to do collaborative R&D with the large multinationals, and strategies to mitigate the disadvantages of remoteness and facilitate access to global markets so that firms can grow locally.

- Support cutting edge research: While remote, there are many research centres, institutes, and institutions doing cutting edge research, offering important testing facilities and infrastructure, and supporting business development. These would benefit from funding to expand their capacities and particularly to support their impact on local business development.

**Reflections:** While how to best coordinate the Blue Economy in the Highlands & Islands remains an open question, it is clear that the area has a strong foundation to grow various Blue Economy industries. Targeted investment could help to overcome challenges - particularly related to skills - and create conditions to ensure that the benefits of growth are effectively captured in order to fuel the development of local innovation systems. Ensuring that growth is equitable, sustainable, and widely supported will be at the forefront of any place-based strategy (or strategies).

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# Healthtech Yorkshire

## Case Study Overview

Characteristics and history: The region is primarily divided into two clusters: West and South Yorkshire, with West Yorkshire known for its Medtech sector, and South Yorkshire known for health and wellbeing. Several interviewees repeatedly echoed the sentiment that "the region is most definitely two clusters rather than one cluster." However, there are pockets of distinct activity throughout the region, localised near universities.

West Yorkshire is home to four key subsectors: digital healthcare, personalised medicine, tissue regeneration and wound care, and wellbeing (nutrition, wellness, mental health, sleep). To some extent activity seems to localise around university strengths and local industrial underpinnings. For example, Huddersfield traditionally has a strong textile manufacturing background and its university has strengths in industrial textiles, which underpins the Healthtech sector for areas such as tissue regeneration and wound care. Bradford has a digital health enterprise zone, and there is a distinct grouping of digital health and Medtech between Kirklees and Bradford, particularly on the edge of Leeds. Bradford has a focus on data analytics. The growing digital sector in Leeds, with firms developing mobile apps for managing health conditions, links to physical medical devices and dovetails with clinical systems. The telecommunications infrastructure in Leeds has led to fintech and IT specialisation in Leeds, which in turn support the digital health sector in the area.

South Yorkshire is better known for Health and Wellbeing, with an emphasis on wellbeing. The Health and Wellbeing sector, which contributes 12% of South Yorkshire's GVA and employs one in six people (South Yorkshire MCA, 2021) is at an earlier stage of the cluster development journey compared to West Yorkshire, but its strength in manufacturing has translated into some Medtech manufacturing as well. Interviewees highlighted that the health and wellbeing sector in South Yorkshire is bigger than the manufacturing sector - it's the second largest sector in the region with about 1,815 businesses in this space (South Yorkshire MCA, 2021). In South Yorkshire the strength and relatedness of manufacturing and Healthtech, particularly medical technologies for health and wellbeing which involves manufacturing of physical devices and implants using advanced materials, is epitomised by the institutionalised regional support from the Advanced Manufacturing Research Centre (AMRC) and the Advanced Wellbeing Research Centre (AWRC).

The region is characterised by its strong manufacturing base and legacy, which has increasingly been integrated into the Healthtech sector, creating resilience within the region. Despite this expertise, the region also faces challenges: "Yorkshire and the Humber have some of the worst figures in the English regions with regard to the health of its population." (University of Huddersfield, 2023)

However, the region is not one homogenous cluster of activity. Instead, it is made up of a number of distinctly different areas within Healthtech, located in different areas of the Yorkshire region, each with their own strengths and challenges. Herein lies the opportunity - to develop a region that collaborates to draw on complementary strengths as well as pool resources to address some of the shared challenges, such as awareness of funding programmes that have recently moved from a regional to national level.

**Geography and size**: The geography and size of the Yorkshire region presents both challenges and opportunities for the development of Healthtech. Historically, the region has been made up of several somewhat overlapping Local Enterprise Partnership (LEP) and Mayoral Combined Authorities

(Sheffield City Region and South Yorkshire Combined Authority, West Yorkshire LEP and Combined Authority, York and North Yorkshire LEP, and the Hull and East Yorkshire LEP). Interviewees placed the emphasis for Healthtech almost entirely on West and South Yorkshire, which is supported by the figure below.

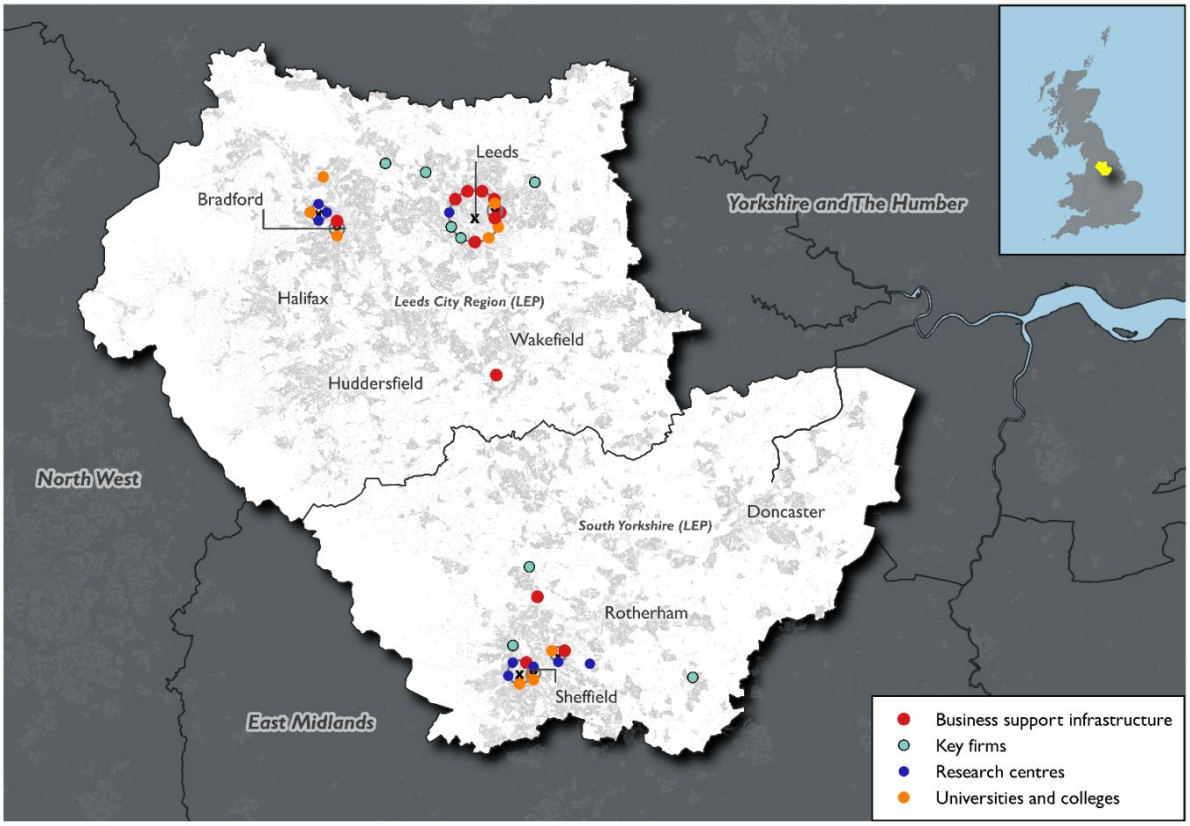


Figure 8: Healthtech Yorkshire map.

Figure 8 shows that within West and South Yorkshire, there are several distinct pockets of activity. West Yorkshire is made up of five boroughs in the Combined Authority - Leeds, Bradford, Huddersfield, Wakefield and Calderdale (Halifax). Each of these areas has its own distinct identity and strengths. This fragmentation can make it difficult to create a cohesive narrative and to coordinate efforts towards Healthtech cluster development. However, the Olympic Legacy Park in South Yorkshire provides an interesting case that highlights the potential to act locally but think globally, helping to bring people together and create a more cohesive narrative. Interviewees argued that the grand societal challenges around health are not unique to one specific area, but are instead present throughout the region, nation and indeed the globe. By forming a shared vision of the common challenges to be addressed, but leveraging local strengths in addressing them, the Yorkshire region can overcome some of the current fragmentation across a Healthtech sector with diverse activities.

There appear to be differing views on the apparent size and fragmentation of the region. Some believe that it makes it difficult for businesses to recruit people and for logistics, while others suggest that it could be an advantage as talent flows across the entire area, providing opportunities for knowledge spillovers and related activity.

**Areas of potential future growth**: As the world becomes more digitised, opportunities will increasingly arise not only in digital health, but in integrating digital health into other sectors of Healthtech. The complementary capabilities between South and West Yorkshire make the region a strong contender for growth in the digitalisation of Healthtech. By working together these regions can

leverage their strengths to drive innovation and development in the areas of implant technology and digital health, ultimately improving patient outcomes and the overall healthcare system.

West Yorkshire is known for its expertise in developing implants, such as those used in orthopaedics and spinal surgery. However, the region lacks expertise in materials and producing at scale, which are crucial aspects of implant development. South Yorkshire, on the other hand, possesses a wealth of expertise in materials and scale production, making it an ideal partner for West Yorkshire in the development of implant technology. By working together, these two regions can combine their strengths to create more advanced and effective implants for patients.

In addition to its expertise in materials and scaled production, South Yorkshire also boasts a wealth of digital assets, such as digital health platforms and telemedicine solutions. However, a key challenge for the region is a lack of data to support the development and deployment of these digital health solutions. This is where West Yorkshire comes in, as it is home to the Leeds Care Records, a comprehensive electronic health record system that can provide the data needed to support South Yorkshire's digital health efforts. Furthermore, West Yorkshire has the governance structures, such as trusted research environments, in place to ensure that the data is used responsibly. By working together, South and West Yorkshire can leverage their digital assets and data to create innovative digital health solutions that can be scaled nationally and globally.

**Reflections:** While this region does not have a highly integrated cluster in the typical sense, partly due to its geographical layout, there appears to be significant potential to leverage the complementarities of different Medtech and Healthtech strengths in each place to create greater innovation potential. With the healthcare system, and the technology sectors that it relies on, poised to grow, these industries and their expertise are likely to be more in demand.

## Core Assets

**Market structure and anchor firms**: Interviewees noted that you need larger firms to conduct capital intensive research and development and generate significant employment, and smaller companies to supply them. The Yorkshire region has successfully attracted large firms several times. For example, the Leeds LEP attracted LabCorp, a global diagnostics and drug development company, which has recently doubled in size, retaining and creating almost 300 highly skilled scientific and healthcare jobs in the city, and is creating a new 100 bed facility for clinical trials (Yorkshire Post, 2021). Interviewees suggested that international firms from the Nordics (e.g. VAR Healthcare - see Digital Health (2022a)) and Israel (Digital Health, 2022b) chose Leeds as their UK base rather than London. This is due to the critical mass in Leeds, and support in the region including investor networks, incubation support, and accelerator programmes.

Interviews suggest that for smaller firms, it's a question of how you influence and utilise large firms to support those startups and spinouts. West Yorkshire, in particular, has a strong environment for early-stage growth in the Medtech sector. Leeds, for example, has a strong track record in this area by attracting companies like Johnson & Johnson. Additionally, the city has a diverse digital sector, with digital health being one of the key areas of focus. Anchors such as Channel 4 and the big 4 consulting companies provide a reservoir of digital talent that can spill over into digital health firms. Four of the largest digital health providers to the NHS are based in the region: TPP, EMIS, Mastek and BJSS. They

have strong ties to institutional anchors in Leeds, with NHSX and NHS Digital based out of the city region. For example, BJSS is a spinout from NHS Digital, and the former leaders of NHS Digital and Mastek, creating a supportive environment for the development of digital health solutions. In addition, Pharmacy2U is the UKs biggest pharmacy, offering online prescriptions and pharmacy services since 1999.

The market in South Yorkshire is also strong, with anchor firms such as Swann Morton, which develops surgical equipment, and Canon, who have invested £15m into the Olympic legacy site AAI diagnostic research centre (Canon Medical, 2022). Canon Medical have also partnered with the AWRC (Insider Media, 2022) who have supported over 28 startups through their accelerator programme in Sheffield (Sheffield Hallam University, 2021).

In terms of new healthtech firms, "startups more often than not originate from universities but not exclusively - we see some clinical entrepreneurs developing companies all over the region". In this sense, "universities are at the heart of the cluster".

**Higher education and training institutions:** The role of higher education and training institutions cannot be overstated in the development of the Yorkshire Healthtech cluster. In Yorkshire and Humber, there are 12 universities and 34 Further Education Colleges, which cover 10% of the UK graduate population. The University of Leeds, with the Centre for Health, Technologies and Social Practice is at the heart of the West Yorkshire cluster, focussed on surgical tools and implants. However, this is by no means the whole of the story. Leeds Beckett University does a lot of work in its own right (Centre for Health Promotion Research). Interviewees note that this is mostly focussed on digital health. The University of Bradford, together with the University of Leeds, conducts research into health and wellbeing through the Wolfson Centre for Applied Health Research.

South Yorkshire has strengths around key university based institutions such as AMRC (Sheffield University) and AWRC (Sheffield Hallam University). The two universities develop many bids together, benefitting jointly from large sums of industry money. Other research centres include the Health Research institute (Sheffield Hallam University).

**Support structures and infrastructure:** In addition to the anchor firms and higher education and training institutions, there are also support structures in place to drive the growth of Healthtech in the region. These support structures include the Nexus in the centre of Leeds, associated with Leeds university, Leeds Beckett University's new Leeds Health and Social Care Hub (see Leeds Beckett University, 2022), Bradford University's Digital Health Enterprise Zone, and Sheffield's Olympic Legacy Park, and Huddersfield Health Innovation Campus.

The Yorkshire and Humber Academic Health Science Network (YHAHSN), Medilink, and Association of British Healthtech Industries (ABHI) all work together to create a triangle of academia, commercial, and local and regional government, which helps to support the growth of the Healthtech cluster. The YHAHSN runs an accelerator programme called Propel, which helps international firms bring their digital health innovations to the UK and understand the NHS. This helps companies to build their value proposition and stress test their products in a trial setting. Many innovators choose to come to West Yorkshire to test their innovation in the real world and then scale beyond that, using the data from West Yorkshire.

Access to data in NHSX and NHS digital is a key reason for locating in the region. Leeds Care Records, for example, provides access to 2.3 million patient records, which is likely to be expanded to 8.1 million across Yorkshire (Humber and North Yorkshire Health and Care Partnership 2023). This is one of

the largest healthcare datasets in the country. The Born in Bradford dataset, which is connected to the University of Leeds and University of Bradford, has led to strength in areas such as health analytics, particularly at the Wolfson Centre for Applied Health Research in Bradford. The Bradford Institute for Health Research, established by the Bradford Teaching Hospitals NHS Foundation Trust, has an out-patient facility for researchers to conduct clinical research.

Innovation Hubs, led by the YHAHSN and ICSs in both West and South Yorkshire provide a gateway for innovation and entrepreneurs into the healthcare system. These hubs are key to matching between NHS and care system needs and what is provided in the market. They work with companies to develop the products and services that are needed.

Embedding Healthtech innovation in the NHS is slow and difficult, but with the headquarters for NHSX and Digital, the Leeds Teaching Hospital Trust, and the Sheffield Teaching Hospital there is a tangible regional advantage to improving this journey for firms in the cluster.

**Finance:** Interviewees noted that one of the biggest complaints among companies, particularly smaller ones such as SMEs and microenterprises, is related to finance. They said that from the proof of concept stage to further down the journey, finding adequate funding can be a major obstacle. In a recent report, access to finance was identified as a risk by over 10% of respondents (West Yorkshire Combined Authority, 2019). The report identifies 10 investors active in digital health, with over 33 fundraisers across Healthtech in West Yorkshire.

There are also some new initiatives worth exploring. For example, Northern Gritstone, which is a partnership between Sheffield, Leeds, and Manchester University, provides finance for spinouts. Sure Valley recently launched a new funding programme in the region (Yorkshire Post, 2022). Additionally, the YHAHSN (2023) highlights the numerous funding programmes available.

In West Yorkshire, interviewees highlighted that there is an active investment network that can provide additional opportunities for companies. Additionally, investment in the Healthtech sector is global, as investors from all over the world are attracted to companies that address global problems. For example, interviewees described how a recent delegation from Singapore was interested in investing in the region 'because the problems they address are global.'

However, there are also changes to international funding sources. It is important to note that EU funding for the innovation support programmes is coming to an end. Although the UK has its own funding programmes, such as the Strategic Priorities Fund and Shared Prosperity Fund, and devolved funding from the presence of a mayor, some interviewees expressed concerns about the uncertainty currently associated with innovation funding. In response, InnovateUK has funded a joint initiative between the CPI and the ABHI to help Healthtech companies navigate EU regulations.

Overall, while funding can be a challenge for Healthtech companies in Yorkshire, there are a number of new initiatives and opportunities available that can help companies navigate these challenges. It is important for Healthtech companies to stay informed about new funding programmes in the rapidly changing landscape, which may require support from network and support organisations.

**Reflections:** The region boasts a large number of assets that make it very attractive for Healthtech cluster development. The region has significant strengths in research and several specialised research centres engage in both knowledge exchange and business support activities. Many startups are spin outs from that research infrastructure. The market for Healthtech is global in nature, with local companies often seeking to obtain US FDA approval and setting their sights on a global impact. While attractive for the potential to scale, it also reflects a significant challenge in the UK Healthtech sector as a whole: "businesses are always saying it's easier to sell abroad than it is into the NHS and social care system - this is one of the biggest barriers that needs to be broken down. The problem in those systems is their capacity to articulate their need and then finding innovations that match that." The Yorkshire region, and West Yorkshire in particular, has an established advantage in access to resources that help to overcome these challenges.

## Skills

**Talent pool**: The Yorkshire region has a strong talent pool for Healthtech due to the related fintech and IT sectors, the large NHS presence, and a legacy manufacturing industry. As businesses look to expand in this area, they are increasingly turning to the region's universities as a source of skilled workers.

> *It's a challenge everywhere. But we have the universities. We're a net importer of graduates - one of the only importers outside London. We also retain a lot.*

Several interviewees stated that West Yorkshire has better retention rates for its graduates than other comparable cities. Companies are able to attract and retain top talent, which allows them to build and maintain a skilled workforce over the long term. This is a key factor in the success of the region's Healthtech sector, as it allows companies to focus on developing cutting-edge technologies and products without worrying about losing key employees.

In addition to its strong talent pool, the Yorkshire region offers a diverse range of skills and capabilities (Leeds City Region, 2022). "Both West and South Yorkshire have different but complementary skills and capabilities and there is scope to bring those together". This diversity allows companies to tap into a wide range of expertise, which in turn helps to drive innovation and growth.

Despite the many benefits of the Yorkshire talent pool, there are still high value jobs that cannot be filled without talent external to the region. A recent report suggested that access to local talent was the most important issue for Healthtech firms (West Yorkshire Combined Authority, 2019). However, this is not necessarily a negative for the Healthtech sector. In fact, it presents an opportunity for the region to continue to attract top talent from around the world, further strengthening its position as a leader in the Healthtech industry, and demonstrating to local skills providers the demand for courses to develop this talent locally.

**Local skills provision**: In Yorkshire, local skills provision is driven by the LEPs and the Mayoral Combined Authorities (MCAs) across both South and West regions. In West Yorkshire, for example, the Digital Skills Academy was established as a leadership initiative to address crucial shortcomings in the region's digital skills.

One key aspect of skills provision in West Yorkshire is the consortium of colleges that sits on the decision-making committees. These colleges are in a position of influence when it comes to shaping the skills through course provision in the region.

In Sheffield, there are recent improvements in skills provision as well. For example, the University Technology College, which is part of the Olympic Legacy Park, both develops and markets the skills and jobs in the sector. Five years ago, appropriate technical courses related to Healthtech were unavailable in the region, but that is not the case anymore. Recently, sector-specific courses such as Sheffield Hallam's MSc in AI and data, which focuses purely on Healthcare, are increasingly plugging the training gaps. Interviewees said that this is especially important for the Medtech sector, as the sector-specific knowledge is complicated and fragmented compared to sectors like Agritech.

To address this, skills provision needs to be made more responsive to the needs of the region, making it more self-reliant. One way to achieve this is through programmes funded by industry and steered by groups that include anchors such as Canon and the NHS. The University Technology College, for example, has programmes of this kind, which aim to develop talent that is responsive to the needs of the cluster. With the right approach, local skills provision in Yorkshire can help to address the region's challenges and create a more vibrant and sustainable economy.

**Reflections:** While there is generally a strong skills ecosystem, interviewees still highlighted that the Yorkshire region struggles to attract the right people for the right jobs. When high value jobs are created, it draws in external people: "Skills are always the key driver for firms looking to expand in a region". Improved skills provision, which is very much on the radar of higher and further education providers and their stakeholders, would make the region more self-reliant.

## Knowledge Exchange

**Firm research and development practices**: Research and development (R&D) is a key part of knowledge exchange in Healthtech. Firms work with healthcare providers to research and develop new products and technologies that can be used to improve patient care. An interviewee described how a firm partnered with Sheffield Children's Hospital in South Yorkshire to develop an offering, and a lot of the R&D was done with the hospital. Once the innovation was developed and implemented, it was evaluated with the hospital and the data collected was used to scale up and spread the product across the rest of the NHS.

The Leeds teaching hospital and Sheffield teaching hospital, and Sheffield Children's hospitals are all research active. However, interviewees noted that Sheffield has yet to invest in research as much as Leeds.

**Knowledge sharing and flows:** In Yorkshire, there are various institutions and initiatives that facilitate the sharing of knowledge and the flow of information between different organisations and individuals. The AWRC provides a platform for firms to connect with academic researchers and experts, allowing for the sharing of knowledge and the development of new ideas.

In Leeds, the Combined Authority brings together different stakeholders, including the NHS, local government, and businesses, to work towards a common goal of improving the health of the population. Additionally, NHSX, which is based in the region, aims to drive innovation and digital transformation in the NHS.

DataCan is another organisation in the region that brings together cancer data for better cancer diagnostics. This initiative allows for the sharing of data and expertise among different organisations,

enabling the development of more effective cancer treatments. Additionally, Leeds care records is an international exemplar of bringing together patient data for better whole-life outcomes.

Further, collaboration between academia, industry and local and regional government is encouraged via Medilink, ABHI, and YHAHSN which creates an excellent environment for startups and high growth firms in the region. This collaboration allows for the sharing of knowledge and resources, and provides a supportive environment for the development of new ideas and technologies. In West Yorkshire, the Leeds Academic Health Partnership brings together the universities, NHS, council and colleges, as well as industry and third sector organisations.

Finally, Both South and West Yorkshire have Innovation hubs. The South Yorkshire hub makes up for the lack of an Academic Health Partnership in the region - it brings together the Integrated Care System to address some of the challenges.

**Knowledge access and cultures:** Interviews suggested that there was a culture of knowledge sharing both between firms and between industry, universities and the NHS. Examples of employment mobility between the NHS and private enterprise was described in a positive light and academic interviewees were actively engaged with private enterprise to both foster startups and to discuss applications of their research.

**Firm network relationships:** West Yorkshire is a very well connected cluster:

> *Everybody knows everybody. Everybody works together. Because it is so well connected, there isn't really a need for a networking service because any access connects one to everybody else. Companies from the Nordics choose this region because the network is so strong and there is a full suite of support.*

In contrast, South Yorkshire has traditionally been more fragmented and poorly connected in terms of its Healthtech sector. Interviewees note that actors in the sector may not be aware of each other's existence, and there is a lack of collaboration and cooperation among companies and organisations. However, interviewees believe that South Yorkshire is similar to where West Yorkshire was only 5 years ago, offering an optimistic path to improved connectivity in the region.

**Reflections:** The Yorkshire region has strong research infrastructure and Medtech/Healthtech are a highly R&D dependent set of industries. Researchers and firms are linked through a variety of platforms and initiatives that facilitate knowledge sharing. However, networking relationships differ across parts of the region. Where West Yorkshire benefits from being a "small world" in which informal interpersonal relationships play an important role, interviewees in South Yorkshire reported less of this kind of activity. In this case, it is helpful to have formal organisations performing that bridging role in networks and encouraging interaction.

## Networks of Coordination

Governance in Yorkshire is complex at first sight, with numerous LEPs and MCAs. Some of these cover overlapping geography. There appear to be current efforts to coordinate between MCAs, particularly with regard to Healthtech, and this is supported by nationwide efforts for increased coordination through Integrated Care Systems.

Integrated Care Systems partnerships were recently established on a statutory basis (NHS England, 2023) throughout England. This formalises the joining up of health care services and includes all upper-tier local authorities, together with a broad alliance of local partners. In West Yorkshire, partners include national partners such as Healthwatch, and voluntary, community and social enterprise sector organisations, and benefitting from local Healthtech innovation is considered throughout their recent 5-year plan (West Yorkshire and Harrogate Health and Care Partnership, 2019). In South Yorkshire, the Integrated Care System's 5-year plan (South Yorkshire and Bassetlaw Integrated Care System, 2019) is less explicit about Healthtech innovation but frequently anticipates the role that the Innovation hub will play to identify and address unmet needs (see South Yorkshire Integrated Care System, 2023).

The new development of separate ICSs would benefit from involvement from Yorkshire wide actors. The YHAHSN, spanning both South and West Yorkshire, is ideally placed to bring these together.

**Reflections:** Despite the proliferation of research networks and support structures, there are no Medtech/Healthtech organisations covering the entire Yorkshire area. Given the growing significance of these industries, there may be a role for the LEPs/Combined Authorities to come together to lead an effort to convene activities and coordinate their evolving Healthtech strategies.

## Discussion: Innovation opportunities and support needs

**Evolution and market opportunities:** Innovation in the field of digital health is rapidly growing, offering new opportunities for healthcare providers and patients alike. One such opportunity is the use of large datasets to predict and diagnose health issues. By analysing vast amounts of data, healthcare providers can gain valuable insights into the health and wellbeing of their patients, allowing them to provide more personalised and effective care.

For South and West Yorkshire, there is potential for complementary evolution within digital health. South Yorkshire, for example, has the opportunity to be more applied in the wellbeing space by drawing on the data infrastructure and architecture in West Yorkshire, to jointly build digital health solutions.

Interviewees highlight that the LEP in South Yorkshire is beginning to recognize the potential of digital health, based on the journey that West Yorkshire has been on and the scale of assets they have in their region.

However, in order to fully realise the potential of digital health in these regions, support and investment are needed. This includes funding for R&D, as well as the infrastructure and training necessary to implement and maintain these solutions. Additionally, collaboration between healthcare providers, researchers, and industry leaders is crucial to ensure that digital health solutions are effective and accessible to all.

**Resilience:** The West and South Yorkshire Healthtech clusters are both built on strong legacies of manufacturing, with significant industry anchors and excellent research capabilities which suggest that both clusters are likely resilient and able to continue their development

**Areas of potential support and intervention:**

- **Build on the success of the Olympic Legacy Park**: One of the keys to unlocking potential in the Yorkshire region, with pockets of differing activity throughout the region, is to take a lesson from the Olympic Legacy Park, which demonstrates that acting extremely locally while addressing a large national and global problem can provide a vehicle to make meaningful progress. The challenges that are faced locally in Yorkshire are of interest nationally and globally, and the Olympic Legacy Park serves as a testbed for ideas that can be scaled.
    - The growth of the Olympic Legacy Park is founded on addressing grand challenges, rather than focusing on a particular technology or sector. This approach enables interdisciplinary, multisector innovation and may provide a clue for how the Healthtech cluster in Yorkshire may continue to evolve. Instead of focusing on underlying capabilities or regional specialisations, the region can focus on addressing shared societal challenges.
- **Encourage inter-regional collaboration:** While there are opportunities to integrate and collaborate between South and West Yorkshire to create a complementary cluster, it is possible that the two regions will compete on certain attractive sectors such as digital health, and therefore stop collaborating. Leadership from both regions is needed to continually foster and coordinate to create regional collaboration rather than devolving into regional competition. Innovate UK should participate in new initiatives to look at the region as a whole and there is an opportunity to bring together under one banner numerous different areas with different political leadership. A vision is needed to bring everything together and create more links to South Yorkshire.
- **Encourage interfirm collaboration and networking:** The region should also provide awareness of new programmes and support small/new firms with the capacity to apply. A Healthtech catalyst can bring together investors and businesses, and UKRI can complement this by deepening the relationship with the academic health science networks to direct support to where it's needed.

**Reflections:** There is a lot of potential for Yorkshire to become a leader in the field of Healthtech, but it will require a concerted effort to articulate and champion particular societal challenges to create a strong, attractive cluster for further innovation. The support structures are in place, and it is up to the region to leverage its unique strengths and work together to achieve this goal.

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## Wales Medtech

### Case Study Overview

The Medtech sector encompasses diagnosis and treatment devices to improve health and wellbeing. As such it has links to technologies employed in a range of industries including pharmaceuticals, electronics, manufacturing, software and data analytics, all of which have presence in Wales. In this case we include the whole of Wales while recognising this region may have distinctly separate areas of activity with limited interaction between each other and strong connections to regions outside Wales. The north of Wales appears to interact with industry in assets in Liverpool and Manchester, and the south of Wales has better infrastructure and network connections with Bristol and surrounds. Therefore, it is difficult to describe Medtech in Wales as a cluster, although the area has many of the knowledge and support assets to fuel growth. The sector will benefit from the unique position with strong voice from a national devolved administration, enabling a more direct policy focus on some of the regulatory changes that affect the medical sector post-Brexit, however threading the needle of access to international markets for Wales based firms requires engagement and coordination with those proximate regions such as Northern Ireland and the Republic of Ireland which have seen increased activity due to their access to markets.

**Characteristics and history:** According to the 2019 study (NESTA 2019), the Welsh population considered "Making the UK's population healthier" the most important area for innovation, and, after climate change, they perceived most innovation activity to be addressing this area. Medtech, medical devices that enhance diagnosis, treatment and monitoring of patients, has a vital contribution to make to innovation that addresses societal needs in Wales.

The sector has developed into established clusters of excellence in high-growth markets including, in-vitro diagnostic, single use technology and wound care" (Welsh Government 2021, 3). Interviewees differed in their opinion of key Medtech activity in Wales, emphasising the importance of digital, diagnostics and devices as core sub-sectors. This illustrates the breadth of activity that falls under the Medtech sector.

A wide range of niche specialisations within the Medtech sector appear to be localised around a variety of anchors. For example, electronics manufacturing of devices is localised around Siemens-Healthineers in the North (Welsh Government 2022a), while ophthalmic activity appears localised around the OpTIC Innovation Centre at Wrexham Glyndŵr University (Welsh Government 2022b). Other activities appear to be co-located with related clusters of activity such as the specialisation in semiconductor manufacturing in the South-East cluster. For example, GlucoRX has recently launched a world first, non-invasive glucose monitoring device using engineering expertise from Cardiff university (Medtech News, 2022).

Medtech activity is underpinned by a legacy of electronics manufacturing. For example, Siemens has operated out of Llanberis since 1992, and currently employs around 400 people at its 36-acre site (BBC 2022), and Wales is home to the "world's first semiconductor cluster" (Welsh Government 2017).

**Geography and size:** Medtech is an important and dynamic sector in Wales making up 60% of companies within the life sciences sector in the region. Medtech firms (approx. 200 firms) include large multinational as well as small and medium enterprises (Welsh Government 2021). Although med-tech companies supply local and national supply chains, the bulk of sales is export focused.[7]

[7] 75% of the life sciences market in Wales is export focussed, amounting to about £980 million p.a. (Welsh Government 2022c).

The Medtech sector appears clustered in two distinct regions in the North and South-East of Wales, coalescing around transport networks (the M4 and A55 motorways). Each cluster has better transport infrastructure linking to proximate neighbouring English areas of industrial activity (Liverpool and Bristol respectively) than they have to one another. The map below highlights how these two regions are divided. The majority of Medtech activity occurs in the South of Wales.

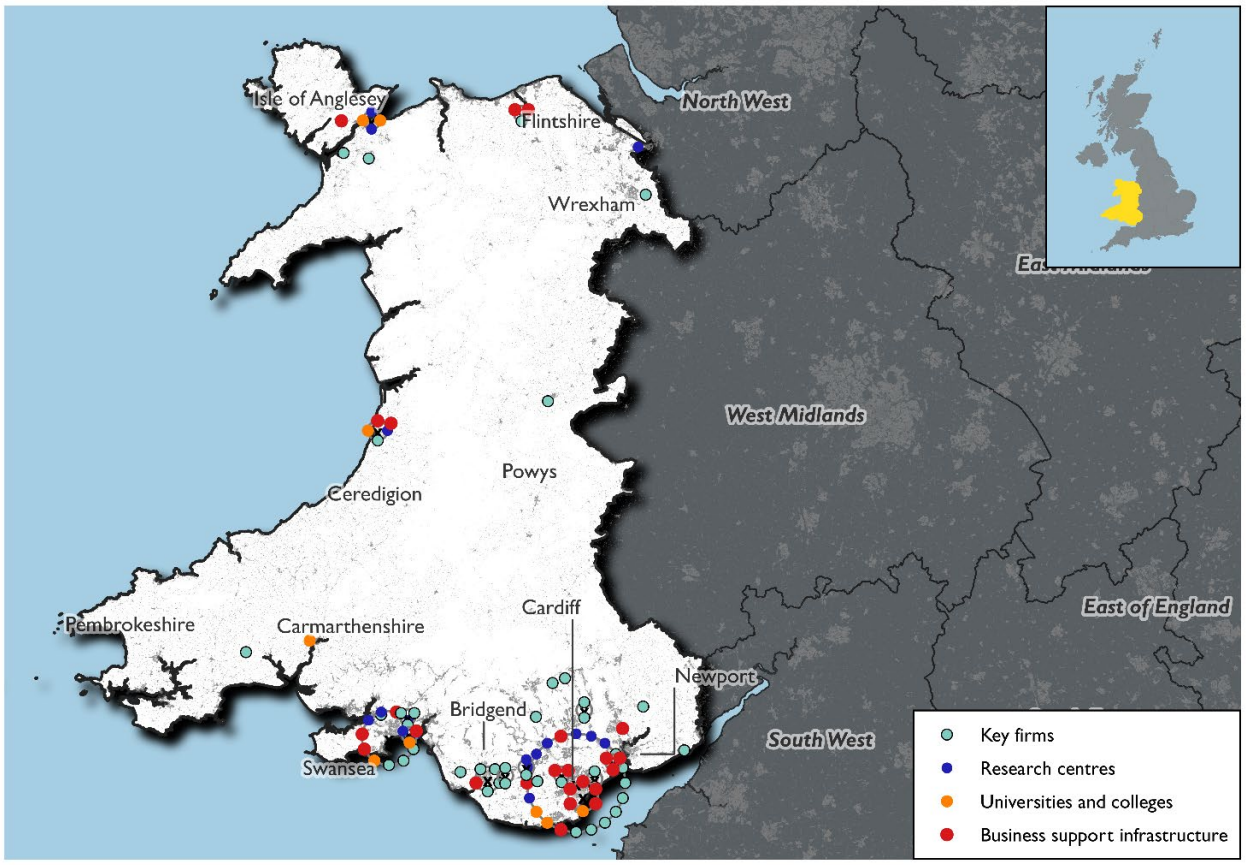


Figure 9: Wales Medtech map.

**Areas of potential future growth:** With an ageing population in Wales, the UK and globally, interviewees noted that the potential for future growth for Medtech activity lies in tackling problems related to healthy ageing such as dementia and cancer. The opportunity for Wales lies in leveraging their established, world class research capabilities. Examples include diagnostic and monitoring devices that incorporate research from the neuroscience capabilities at the Brain Research Imaging Centre in Cardiff University, and the Rutherford Cancer Centre which is one of the only centres in the UK with proton beam technology.

**Reflections:** The fact that activity in Medtech is geographically divided between southern and northern parts of Wales creates interesting challenges for cluster dynamics and development. While there is evidence of research linkages between the two regional subclusters, we know less about whether similar relationships exist between firms. The fact that it is physically easier to travel to England than between cluster poles creates both challenges and opportunities that will need to be considered in any evolving cluster strategy.

## Core Assets

**Market structure and anchor firms:** Medtech in Wales has focused on national EU and US markets and has been guided and governed by the regulation and market size in each. Interviewees highlighted that Wales is only 6% of the UK market so often it is not viable to sell only to Wales, even as an initial market. Further, they noted that despite being highly navigable with only 7 NHS trusts, these are difficult to sell into, although the small size of the Welsh environment is attractive for collaboration in research and development. As a result, most Medtech firms are exporting companies, and international medical regulations are therefore as important as national regulations. Interviewees noted that companies take clinical trials anywhere they can get done, as they do with manufacturing. For example, although a Fujifilm mobile x-ray machine project with ambulances was placed into NHS trials (FujiFilm 2021), manufacturing was subsequently lost to China.

Although large international Medtech firms feature prominently in both the North and South-East clusters, less than 10% of Medtech firms are MNCs - most are SMEs. Interviewees noted that these typically require more guidance in accessing business support and funding, and often lacked awareness of opportunities and programmes available.

In addition, the Covid pandemic has brought to the fore a new SME anchor with approximately 150 employees (Wales 247, 2020). Lighthouse Lab in Newport is a specialist COVID-19 lab that processes 10,000s of tests a day, providing a service on which many Medtech customers can build.

**Higher education and training institutions**: Wales has a number of world class universities in both the North and South. Each has centres of research supporting specific activities within Medtech. These are primarily centred around **Cardiff University** with the ***Brain Research Imaging Centre (CUBRIC)***, the ***Wound Healing Research Unit***, ***Wales Cancer Research Centre***, ***Cardiff Medicentre***, the ***Dementia Research Institute*** and the ***Cardiff School of Sport and Health Sciences*** which prides itself on its reputation for internationally excellent research. **Swansea University** is also an anchor, with the ***Centre for Innovative Ageing***, the ***Centre for Ageing and Dementia Research (CADR)***, ***Centre for Nanohealth***, ***Joint Clinical Research Facility***, and the ***Institute of Life Sciences***.

Other notable research institutions include **Cardiff Metropolitan University's *RobotiCare Lab*** for healthcare, hospitality and tourism, the ***Centre for Excellence in Rural Health Research*** at **Aberystwyth University**. **Bangor University** hosts the ***Wales Centre for Behaviour Change.***

According to interviewees, "the new medical school at Bangor University in North Wales will be significant. It will join the clusters together." It is expected to open in 2025 (Nation Cymru, 2021).

**Other research and anchor organisations:** Wales has a number of collaborative research centres that are key developers and/or adopters of Medtech. These are often the result of close partnerships between universities and healthcare providers. Notably, sometimes these networks are geographically agnostic – e.g., include universities from around Wales, such as the Wales Institute of Cognitive Neuroscience (WICN) – and other times these networks are more geographically concentrated, such as the **All-Wales Intensive Learning Academy** centred on Cardiff and Swansea.

**Welsh Wound Innovation Centre (WWIC)** – located in Pontyclun, WWIC is the first national wound healing centre world-wide and is the flagship facility for clinical innovation in Wales. The centre is experienced in undertaking multiple stages of clinical trials investigating both medical devices and pharmaceuticals related to wound healing, from First-in-Human trials, large-scale RCT's to Post-Market Surveillance studies.

**Wales Institute of Cognitive Neuroscience (WICN)** – based in Bangor, this was established by a £5.2m grant from the Welsh Assembly Government (WAG) to support the development of world-

leading expertise in cognitive and clinical neuroscience within Wales at Bangor, Cardiff, and Swansea Universities.

**All-Wales Intensive Learning Academy for Innovation in Health and Social Care** is a world-class teaching and research base to equip existing and future leaders with the ability to deliver innovation across health, social care, and the third sector. It is a multidisciplinary partnership between **Swansea University**, **Cardiff & Vale University Health Board**, the **Bevan Commission**, and **Cardiff University**.

Finally, there is some evidence of Medtech linkages with other Medtech regions. For example, **AMRC Cymru** in Chester is part of the **University of Sheffield Advanced Manufacturing Research Centre** and a member of the **High Value Manufacturing (HVM) Catapult** (AMRC, 2023).

**Support structures and infrastructure**: According to interviewees, the attraction for large Medtech firms to establish in Wales is largely driven by financial incentives. Similarly, they conceive of 'business support' as funding. Nonetheless, there are numerous support structures in place in Wales that offer attractive reasons to conduct innovative activity.

A number of incubators and accelerators associated with universities exist across Wales. **Wales Data Nation Accelerator** is a pan-Wales initiative to accelerate new insight, foresight and intelligence from diverse data assets for societal, health and economic impact. **Accelerate** is a collaboration between Cardiff University (CIA), Swansea University (HTC), University of Wales Trinity Saint David and Life Sciences Hub Wales. It helps innovators in Wales to translate their ideas into solutions, enabling them to be adopted in health and care. The ***Institute of Life Science*** (ILS) is part of Swansea University, it helps innovative organisations to grow quickly, while Cardiff University has made a £300m investment in a new Innovation Campus which includes **spark**, a space for start-ups and spinouts. **Cardiff University** also hosts ***Cardiff Medicentre***, a business incubator for biotech and Medtech start-ups. Aberystwyth University hosts ***AberInnovation*** which provides state-of-the-art facilities and expertise for the life science sector. Startup support also comes from regional anchors such as the ***Innovation Village***, opened by GE Healthcare.

These university related institutes are underpinned by knowledge assets such as the **Next Generation Data Center**, Europe's second largest Tier 3 data centre, the **SAIL Databank**, a world-leading health dataset, and the UK's **Intellectual Property Office**, located in Newport, providing advice and expertise needed for market entry. The **Surgical Materials Testing Laboratory** provides medical device testing and technical services to the Welsh NHS, enabling the NHS to better evaluate potential Medtech offerings.

Beyond startups and spinout support, science parks include **Cardiff Edge**, **Cwmbran Medipark**, and the **Life Science Wellbeing and Sport Campuses Project** which will expand Swansea's Institute of Life Sciences ecosystem. **M-Sparc** is a dedicated science park operated by Bangor University.

**Finance:** Interviewees highlighted a particularly transactional view of the cluster, with financial incentives likely being the only attraction for large multinationals to move to the cluster.

Funding for **Accelerate** is coming to an end after 4 years. It remains uncertain if it will be replaced with UK funding. The Life Sciences Research Network has provided the **Bridging Fund** since 2015 to commercialise projects, although it is not currently open for applications. Interviewees noted that many health programmes are advertised as UK wide "but the fine print indicates they are only 'Department of Health' funding which is England only." For example, England only programmes include National Institute of Health and Care Research (NIHR) accelerated access collaborative funding. As a result, interviewees felt that organisations are also not applying for funding - they submit fewer

applications - perhaps due to a lack of confidence or lack of awareness brought about by the changing environment. Nonetheless, funding resilience is expected through initiatives such as the **Cardiff Capital Region City Deal,** a catalyst for regional growth. It is a ring-fenced £1.2bn investment fund.

**Reflections:** The international and export focused orientation of the predominantly small and medium firms in the Welsh Medtech sector creates a relatively unique dynamic. This makes the sector relatively resilient to changes in the national market and a success story for the international reach of UK-based science and research. This sector is supported by very strong research intensive universities and specialised centres as well as incubation and business development offerings. These appear to be well-networked and collaborative initiatives; however, formal networks are sometimes limited to within their own subcluster. Finance does not seem to be a barrier to growth, although lapsing EU funding may have impacts on institutions' abilities to continue research streams and services.

## Skills

**Talent pool:** Interviewees noted that capacity is a challenge in Medtech. Although the flow of skills has increased, further investment is needed to grow the talent pool. The region has 18,000 graduates with degrees in Medtech-related subjects (DfT n.d.).

Regional Skills Partnerships (RSPs) are in place to provide regional employer-led labour market intelligence, setting priorities for Welsh Government across the areas of employability and skills. The RSPs are:

- North Wales Regional Skills Partnership (NWRSP);
- South East Wales Cardiff Capital Region Skills Partnership (CCRSP); and
- South West and Mid Wales Regional Learning and Skills Partnership (RLSP)

Medtech research talent is supported through **Sêr Cymru**, "a multi-million pound funding programme to bring scientific talent into research posts in Wales". It has produced a talent pool capable of research in areas including biotechnology and life sciences. The programme has supported research chairs, rising stars, research fellowships, PhD and post-doc studentships. This programme, which has generated more than £180 million in research grant income, has increased Wales' research outputs, efficiency and impact. Substantial investment in the programme has been received from: Welsh Government, Higher Education Funding Council for Wales (HEFCW), Welsh Higher Education Institutions (HEIs), European Regional Development Fund, European Commission Horizon 2020.

**Local skills provision:** Thirteen training institutions and universities located in Wales offer courses and programmes in life sciences, with between 12,000 (Wilson 2022) and 59,000 (DfT n.d.) students studying relevant programmes. As listed above, all of the major universities (and many of their specialised research centres) offer medical and Medtech related courses and training opportunities. Bangor University has also announced a new medical school.

Interviewees noted that "FECs play a key role in apprenticeships and mainly the previous polytechnics." The Welsh government manages an approved Welsh Apprenticeship Framework combining practical training in a job with study. Frameworks are available across 23 sectors, one of which is 'Life Sciences'. Within this sector there are:

- Level 2/3 Apprenticeships in Laboratory & Science Technicians, suitable for roles of Laboratory Technician (multiple settings)

- Level 2/3 Apprenticeships in Polymer Processing Operations, suitable for roles of Polymer / Composite Operator, Production Operator, and Production Technician.
- Level 4 Apprenticeships for Life Science and Related Science Industries, suitable for roles including: Life Science Technician; Chemical Science Technician; Food Science Technician, and Process Development Technician.

**Reflections:** Wales has a significant foundation of talent in Medtech and has a strong ecosystem of higher and further education offerings for training. However, interviewees had the impression that the labour pool would need to expand to accommodate additional growth.

## Knowledge Exchange

**Firm research and development practices**: Medtech companies in Wales vary from large corporate multinationals, which interviewees suggest generally "have their own R&D department" to smaller start-ups built around innovation arising from the Welsh academic research base, such as MedaPhor and Cyden. Interviewees described situations where large Medtech firms had entered into research agreements with universities but were frustrated by the mismatch in priorities and ownership of the output.

**Knowledge sharing and flows:** There are numerous organisations set up to ensure the flow of knowledge between universities and industry. OpTIC Technology centre is a business and technology centre in North Wales. The Centre for Nanohealth at Swansea University is a purpose built open access facility providing a technology and innovation base for industry and academia. The Centre for Photonics Expertise (CPE) draws on a team from four Welsh Universities and aims to accelerate business growth by working together with industry supporting the development of processes, products or systems. Wales Centre for Batch Manufacturing, established by University of Wales Trinity Saint David, and is a core component of the University's SA1 Swansea Waterfront development, "driving innovation, creativity and entrepreneurship among companies engaged in new product development and low-volume manufacture" including medical devices.

There is limited evidence of knowledge sharing and flows that are institutionalised beyond Wales North and South clusters. An exception may be the **Health Data Research UK (HDR UK) Wales and Northern Ireland,** a collaboration across Swansea University and Queen's University Belfast, which aims to unite the UK's health and care data to enable discoveries that improve people's lives.

Finally, the **Life Sciences Research Network**, led by Cardiff University, aims to work closely with national and international research organisations as well as companies to develop science leading to new treatments. The **Ser Cymru** programme supports three National Research Networks. These help academia, businesses, industrial partners and government cooperate together.

**Firm network relationships**: Interviewees highlighted that "information still seems to lie in people's heads" and that collaboration is slightly different for different products, leading to fragmentation. Nonetheless, Wales has a devolved health system (7 NHS trusts) which is significantly smaller than England and more open to collaboration and demonstration to promote adoption. This results in lower requirements to have multiple conversations to reach the local market for both trials and embedding innovation and possibly less of a need to rely on formal networking organisations to engage in knowledge exchange. That said, some interviewees reflected that creating a tool listing Medtech assets and market participants to facilitate information sharing and make the research and innovation activities of the sector more visible to improve matchmaking.

**Reflections:** Despite the proprietary nature of much of the work in the Medtech sector, collaboration and efforts to stimulate knowledge flows appear strong. What is not clear is the impact of the geographical separation of North and South clusters on knowledge exchange. While this may be partly mitigated by strong sectoral networks operating across the entire Welsh geography, there may be an opportunity to organise more cross-cluster collaboration. There may also be opportunities to leverage the easier horizontal linkages into England to extend the reach of each cluster.

## Networks of Coordination

Although Wales, and the NHS in Wales is devolved, the Office of Life Sciences, at a UK level, has articulated a vision through its innovation strategy which is followed in Wales. To support this, the Welsh Government has created bodies in the form of several network organisations to handle engagement and foster collaboration.

**MediWales** is the life science network and representative body for Wales, providing advice, support and business opportunities for its members, whilst promoting collaboration within the life science and health technology community in Wales.

**Digital Health Ecosystem Wales** connects developers and digital health companies with the NHS and charities as a user test base. Health and Care Research Wales is a networked organisation, which brings together a wide range of partners across the NHS in Wales, universities and research institutions, NIHR, local authorities, and others.

**Health Technology Wales** (HTW) is a national body working to improve the quality of care in Wales. HTW collaborates with partners, like **NICE** (National Institute for Health and Care Excellence), across health, social care and the technology sectors to ensure an all-Wales approach.

The **Life Sciences Hub Wales** is a wholly owned subsidiary of the Welsh government, aiming for collaboration between industry, health, social care, and academia.

**Reflections:** Networking occurs at various scales and within different industrial silos across Wales. One advantage of a devolved administration, such as Wales, is that it has many of the levers necessary to be a strong organising force and champion for its leading sectors. As noted above, the Welsh Government has fulfilled this role through strong support for a network of organisations that shape and deliver policies related to Medtech. However, a gap remains for leadership to emerge from within the industry.

## Discussion: Innovation opportunities and support needs

**Evolution and market opportunities:** An ageing population coupled with steady investment into health care services and technologies suggests that the Medtech sector in general has solid growth potential and Wales is well-positioned to contribute. However, regulations in Medtech determine markets. England is the biggest UK market. It is therefore important for clarity and engagement in the development of new UK Medtech regulations in light of Brexit. If these regulations are carefully crafted, firms may, by complying with UK regulations, simultaneously meet the requirements for EU and US

markets. Beyond regulations, there are opportunities to develop gateways into the EU market. For example, some large Welsh based firms have established sister operations in the Republic of Ireland.

**Resilience:** As above, exiting the EU may have a significant impact on the Medtech industry in Wales. If firms are forced to tailor products and services to conform to more than one set of regulations it is possible this may have implications in their resource allocations to smaller markets. This may result in firms leaving Wales and may result in poorer supply relationships with UK procurers.

**Areas of potential support and intervention:**

- **Enhanced networking and matchmaking:** A desire was mentioned for a catalogue that facilitates introductions and strengthens the Medtech network, as well as facilitating local procurement.
- **Continue supporting the extant firms:** to act as anchor firms to support new firm entrants. This includes regulation, export, staff/training, paying for trials, finance (e.g. underwriting R+D)
- **Support to access funding and encourage companies to seek support:** This leadership sits with the Welsh government to encourage and support companies to apply for funding. Continuation funding is a challenge.
- **Innovation in navigating TRLs and market access:** A continuous emphasis on finding ways to speed up the route to market is desired. Integration between NHS and social care was mentioned as an opportunity to improve access to market and embedding of Medtech across the space.

**Reflections:** The growth of the Medtech sector will depend in part on evolving regulatory development following Brexit and may be strengthened by bridging the divisions between the North and South clusters. There appear to be opportunities for linkages with neighbouring clusters of activity in Liverpool and Bristol respectively, which may provide some complementary pools of talent and capabilities and present a more integrated region which requires greater political consideration as changes are rolled up, in turn increasing the resilience of the extant Medtech sector.

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# Energy/Propulsion in the East Midlands

## Case Study Overview

**Characteristics and history:** The propulsion cluster in the East Midlands is centred on Derbyshire and Nottinghamshire. "Transport equipment", which covers the production of aerospace, automotive, and rail transport vehicles, is a very important sector for the whole of the East Midlands, since it is the second largest manufacturing sector in the region (Make UK, 2022). Particularly for Derbyshire and Nottinghamshire, the Transport Equipment manufacturing sector is 40% more productive in this area than elsewhere in the UK, hosting a large number of globally significant employers (Department for Education, 2017). Derbyshire and Nottinghamshire place a strong emphasis on their low carbon economy, as shown by their increasing R&D Investment in Low Carbon and Environmental Goods and Services (LCEGS), with the Alternative Fuels sub-sector performing significantly above average in terms of market size and the Nuclear sub-sector showing stronger growth than the UK average (D2N2, 2021).

The area is historically connected with Britain's Industrial Revolution as some of the country's first factories and mills were located there. Additionally, Derby has always been important for the railways: The Derby Locomotive Works started building steam engines there in 1840, and the nationalised British Rail located its R&D department there. Moreover, it hosts the largest concentration of Rolls-Royce employees in the UK; a community that settled in this region before World War I. In addition, Derby has always been a railway hub.

There is a strong innovation and manufacturing cluster around propulsion and engine systems engineering that contributes to sectors related to transport. In particular, there is significant expertise concentrated in this region in the automotive, rail, aerospace, and nuclear-powered submarine industries, creating interconnected sub-clusters within the broader propulsion cluster. To support the activities of these industries, an important number of firms have centred around this area, supplying propulsion equipment, transport equipment, maintenance services, and more. Interviewees stressed the high level of talent and expertise of employees concentrated in the region, an argument supported by the high salaries observed in districts in Derby (Department for Education, 2017).

**Geography and size:** Arguably, the propulsion cluster in Derbyshire and Nottinghamshire is part of a bigger cluster that includes thousands of firms and extends to the whole of the Midlands. Some of the interviewees emphasised that as far as the automotive cluster is concerned, the West Midlands hosts a significant proportion of the innovation and manufacturing activities of the Midlands, including electric propulsion activities. However, although electrification ventures are also important in the East Midlands, Derbyshire and Nottinghamshire seem to be very well positioned to develop strong regional competitive advantage in the other alternative technologies, such as hydrogen, nuclear, and alternative fuels, specialising in providing efficient low-carbon energy solutions for trains, aerospace, submarines, and vehicles.

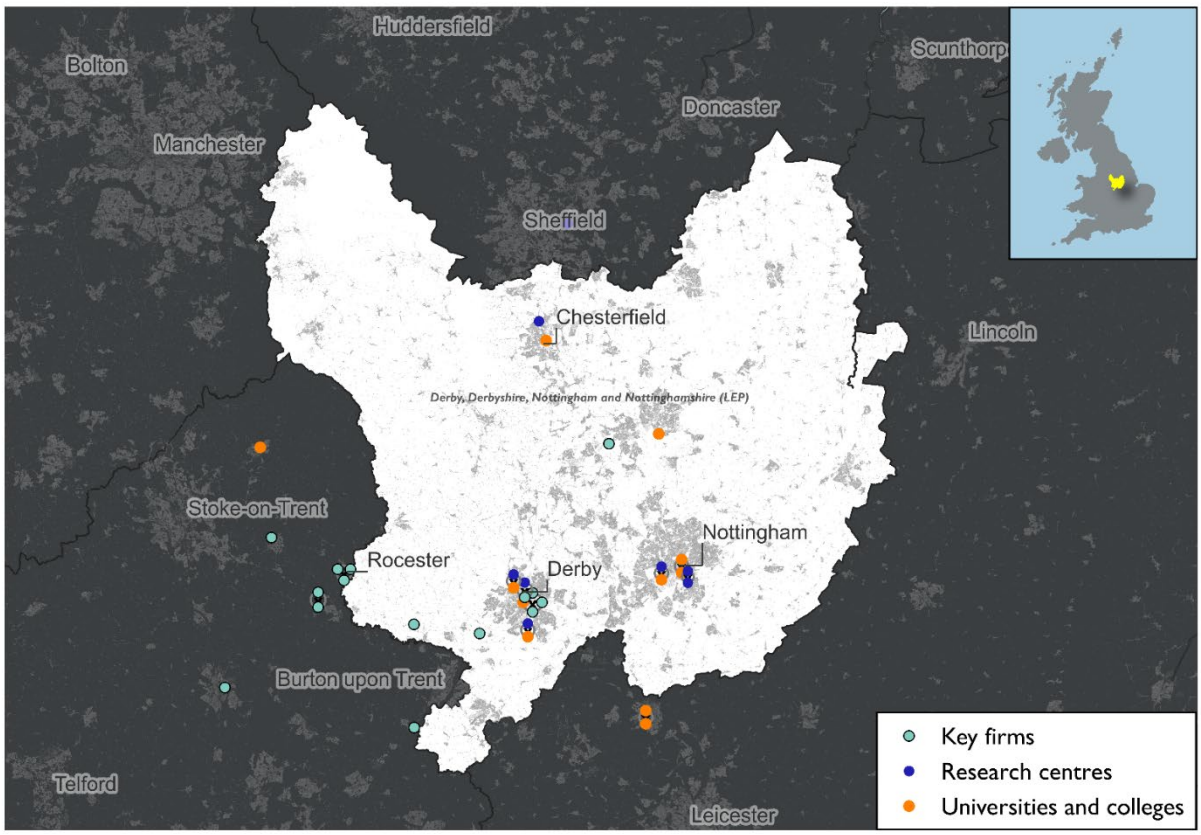


Figure 10: Energy/Propulsion in the East Midlands map.

**Areas of potential future growth:** Interviewees unanimously agreed that the cluster's innovation activities primarily focus on developing technologies that will contribute to the decarbonisation of transport (i.e., low-carbon transport). To achieve this goal, a series of alternative technologies has started to replace internal combustion engines, with each technology at a different stage of development and diffusion and in a different field of application. Electric propulsion is definitely the primary alternative technology, and its level of development and diffusion reveals that it is already too significant to be overtaken by other technology in the near term. As one interviewee eloquently noted, "the train of electrification has already departed". Apart from activities related to electrification, important investments have been made in this region in other technologies such as hydrogen, fuel cells, biofuels, and nuclear energy (i.e., nuclear reactor cores for submarines). More specifically, interviewees emphasised the above-average concentration of innovation and manufacturing activities related to hydrogen. All major private companies working in propulsion have dedicated significant resources to hydrogen (e.g, Alstom, Toyota, Rolls-Royce, JCB), as, in certain applications, such as long-distance journeys with trains, aviation (where batteries could be too heavy), or heavy vehicles, the use of hydrogen seems very promising. According to interviewees, other satellite sub-clusters that could affect the growth of the propulsion cluster are the digital smart control systems relevant to energy management and the electric charging infrastructure and systems. Finally, there was a strong consensus that synergies and complementarities among the propulsion technologies can substantially boost the overall growth of the cluster as well as the export potential for the region, contributing to national and international energy transition objectives.

**Reflections:** The propulsion cluster in the East Midlands, centred around Derbyshire and Nottinghamshire, is an established cluster since important anchor firms have been active in these regions for decades (e.g., Rolls-Royce, Alstom, Toyota). However, the green industrial revolution has brought a new dynamic to this area. Due to the fact that within these regions, a variety of cutting-edge low-carbon technologies (e.g., electric, hydrogen, alternative fuels, nuclear) are being developed, serving multiple sectors of the economy (e.g., trains, vehicles, aerospace, submarines), a strong regional absorptive capacity has been created in energy research in general, and in propulsion and engine systems engineering, in particular. Apart from knowledge synergies currently achieved among these technologies, this area is competitively positioned to successfully adapt or even lead the way to any potential technological trajectory of energy systems that may emerge in the medium-to-long term.

## Core Assets

**Market structure and anchor firms:** Some of the most important global firms in the propulsion industry operate within the Derbyshire and Nottinghamshire propulsion cluster.

**Rolls-Royce -** this firm's long-lasting presence in Derby can be considered as a primary catalyst for the cluster. According to the 2022 EU Industrial R&D Investment Scoreboard (Grassano et al., 2022), Rolls-Royce was the fifth R&D spender globally in the Aerospace & Defence industry, spending €964.3 million in R&D in 2021. Derby hosts the largest concentration of Rolls-Royce employees in the UK and its academy recruits over 200 apprentices each year. The primary innovation and manufacturing activities of Rolls-Royce within Derby relate to civil aerospace and nuclear reactor cores and propulsion components for the Royal Navy's nuclear submarines.

**Alstom** (formerly Bombardier) - Derby hosts Alstom's activities related to the design and manufacture of its trains. Alstom, as a leading global player in the Industrial Engineering industry, spent €585 million in R&D in 2021 (Grassano et al., 2022), with significant resources spent on low carbon technologies to power trains, including hydrogen and battery solutions for sustainable transport on non-electrified lines.

**Toyota** - has been active in this region since 1989. Toyota's manufacturing plant, located in Burnaston, Derbyshire, is one of the UK's largest vehicle manufacturing plants. Toyota is the largest Japanese R&D spender and the fifteenth R&D spender worldwide, with €8,691 million in R&D expenditures in 2021 (Grassano et al., 2022). Apart from electrification,Toyota is investing heavily in hydrogen technologies.

**JCB** - is located in Staffordshire next to Derbyshire, and is a major construction vehicle manufacturer with important investments in hydrogen, electric motors, and hydrogenated vegetable oil and with €98.2 million spent in R&D in 2021(Grassano et al., 2022).

Other noteworthy firms related to the cluster are Porterbrook, a rail network company located in Derby, Caterpillar's Stafford-based facility for the manufacture of the company's largest and most powerful diesel engines, and Horiba Mira in Nuneaton Warwickshire, a global provider of automotive engineering, research, and test services.

**Higher education and training institutions:** Derbyshire and Nottinghamshire host three important universities and several further education colleges. All three universities seem to acknowledge the history and potential of the region generally in engineering and, particularly, in aerospace, automotive, and rail, providing many undergraduate and postgraduate programmes and research activities within these fields.

The **University of Nottingham** offers highly ranked studies in Aerospace, Electrical and Electronic Engineering, and Mechanical, Materials and Manufacturing Engineering. Concerning its research activity in the relevant fields, the University of Nottingham is home to the Institute for Aerospace Technology, a major centre for aerospace research, where researchers and academics in collaboration with private companies strive to produce useful knowledge in the fields of aerospace electrification and future propulsion. Additionally, the university hosts the ***Power Electronics, Machines and Control Research Group***, an internationally renowned research group in Electrical and Electronic Engineering, delivering influential teaching, research, and industrial collaborations in subject areas such as Power Electronic Systems, Electrical Machines, Electrical Motor Drives and Systems, and Power Electronic Integration.

The **University of Derby** offers high-quality undergraduate and postgraduate studies in Electrical and Electronic Engineering, Mechanical and Manufacturing Engineering, and undergraduate courses in Motorsport Engineering. It hosts the ***Rail Research and Innovation Centre***, which provides collaborative research and innovation projects within the Derbyshire and Nottinghamshire rail supply chains and access to its facilities that address infrastructure related to rail composite design and manufacture, rail data analytics and artificial intelligence, and decarbonisation rail solutions. Another relevant research centre within the University of Derby is the ***Institute for Innovation in Sustainable Engineering (IISE)***, which focuses on issues related to sustainable engineering solutions across various business sectors, placing important emphasis on the regional dimension of their research impact.

Finally, **Nottingham Trent University** also offers undergraduate and postgraduate studies in Engineering, including Aerospace Engineering, with important research output in sustainability and low carbon strategies.

**Other research and anchor organisations:** Derbyshire and Nottinghamshire regions are home to some nationally important organisations that significantly contribute to the development of the cluster.The most noteworthy are:

- **The Energy Research Accelerator**: an Innovate UK- funded organisation that brings together universities, the government, and industry to develop low carbon technological innovations.
- **The Low Emission Vehicle Enterprise and Learning Network**, which delivers skill development, knowledge transfer, and business networking in low carbon transport technologies.
- **The Nuclear Advanced Manufacturing Research Centre (Nuclear AMRC)**: part of the Catapult network, Nuclear AMRC is a centre led by industrial members to support companies in the nuclear sector to develop and test new technologies and to be better networked.

**Support structures and infrastructure:** Nottinghamshire County Council, Nottingham City Council, Derby City Council, Derbyshire County Council, D2N2 LEP, Low Carbon Business Network, East Midlands Chamber Sustainability Forum, Midlands Engine's Green Growth, and the Midlands Net Zero Hub are all aware of the importance of this cluster for the region, and strive to contribute to the transition to a low carbon economy by working with and educating local businesses, developing appropriate business networks, facilitating and supporting investments in energy projects, and coordinating the various stakeholders that could exert an influence on the cluster's dynamic. Moreover, the Rail Forum, a national industry body that provides networking opportunities to its members who belong to the whole rail industry, is located in Derby.

The most important infrastructure related to innovation that can be used by the firms of the cluster in the region is the shared infrastructure of the local universities. Most noteworthy are the shared infrastructure of the ***Rail Research and Innovation Centre*** and ***Institute for Innovation in Sustainable Engineering*** at the University of Derby and those of the DER-IC (Driving the Electric Revolution Industrialisation Centres) and ***Institute for Aerospace Technology*** hosted at the

University of Nottingham. Additionally, the Nuclear AMRC is building a new research facility on Infinity Park, Derby, focusing on the later-stage development of new technologies related to the nuclear supply chain. Finally, we have to refer to two important energy projects that could prove to be game-changers for the region in the long run. The first is the East Coast Hydrogen launched in North East England which will give the ability to Derbyshire and Nottinghamshire to pipe in green and blue hydrogen from the coast by 2030. The second is the fusion power plant that will be constructed at West Burton, Nottinghamshire, and will be the first commercially feasible fusion power station. This project, expected to be operational by early 2040, though not considered as directly related to propulsion, will attract the best engineers in energy systems worldwide, probably leading the knowledge capacity of the region in Energy Engineering to the highest levels.

**Finance:** With respect to finance for growth or innovation, interviewees felt that, in general, firms have relatively good access to finance. However, a large portion of this finance comes from the government while private equity financing seems to prefer the Golden Triangle (i.e., Cambridge, London, Oxford) to the East Midlands. Nevertheless, a series of initiatives is in motion within the region that will facilitate access to better and easier finance, targeting primarily at SMEs and start-ups, which typically face greater difficulties in securing finance than larger firms.

**Reflections:** Interviewees revealed no disagreements about the significance of the assets related to the innovation activities of the propulsion cluster in the regions of Derbyshire and Nottinghamshire. To emphasise the innovation potential of the cluster for the UK, one of the respondents that we interviewed from a university informed us that the first two UK beneficiaries of Horizon 2020 (the EU's research and innovation funding programme from 2014-2020) in the Green Transport Research category were Rolls-Royce and the University of Nottingham. Additionally, several interviewees underlined the presence of an important mass of SMEs, operating mostly around the anchor firms of the region. Finally, it is worth mentioning that according to a respondent, local universities are characterised by a higher degree of specialism in engineering (although lacking emphasis on nurturing university spin-offs), providing important collaborative, networking, and shared infrastructure opportunities to local SMEs.

## Skills

**Talent pool:** Derbyshire and Nottinghamshire regions have a relatively large pool of skilled labour that can support the propulsion cluster. The main skills required are generally related to engineering, including mechanical, electrical, electronics, and systems engineering, while the most specialised engineering category is engine systems engineering. Other high-tech skills that are strongly related to industry needs are digital skills (including software development and cybersecurity) and data analytics. Concerning some other technical skills that are critical to the cluster, respondents emphasised shortages in welding and ultrasonic testing. Additionally, several interviewees stressed that although the region does focus on engineering skills provision, it still suffers from skills gaps in engineering. According to D2N2 (2021), the LCEGS sector (Low carbon and environmental goods and services) experiences significant skills gaps in production engineers and technicians in the region. Finally, some interviewees identified critical shortages in management and finance, skills that could facilitate the growth of the cluster.

**Local skills provision:** As already mentioned, local universities (i.e., the University of Nottingham, University of Derby, Nottingham Trent University) embrace the history and the potential of the

propulsion cluster in the region. This manifests in the high level of course offerings (accompanied by state-of-the-art facilities) in engineering, and extra attention devoted to aerospace, automotive, and rail, that have created a strong international reputation for propulsion and engine systems engineering. Additionally, the regional further education colleges (i.e., Derby, Chesterfield, Buxton & Leek College, Nottingham, and West Nottinghamshire Colleges) seem to take into account the regional competitive advantage in propulsion and engine systems engineering, making efforts to provide more relative skills. An important insertion into the skills production system will be the recently approved East Midlands Institute of Technology (IoT), operated by the University of Derby, Loughborough College, Loughborough University, and the Derby College Group. Another noteworthy addition to this endeavour is definitely the Nuclear Skills Academy, a partnership between the University of Derby and Rolls-Royce, supported by Nuclear AMRC, the National College for Nuclear, and other experts that started to operate in September 2022, offering more than 200 apprenticeships.

**Reflections:** There was a consensus among respondents that although the skills provision in the area for the cluster is important, it is inadequate to fill the existing gaps, a phenomenon that will increase in the future because technological change and industry needs evolve faster than educational, training, and academic transformations. Propulsion innovation activities are present worldwide and therefore, everyone competes for the same talents. Technological and climate change combined with an ageing workforce have resulted in significant shortages in skills that are related not only to engineers and scientists but also to technicians. Particularly for technicians, the gap is wider, a situation that calls for an upgrade of the role of colleges and apprenticeships in providing a relative workforce. Skills provision is a complicated economic and social process and, thus, a collaboration of all major regional stakeholders is required to improve it, leveraging mechanisms such as the identification and monitoring of the current and future skills needed for a low carbon economy (D2N2, 2019).

## Knowledge Exchange

**Firm research and development practices:** As presented above, most of the R&D activities are performed by the anchor firms of the cluster: Rolls-Royce, Alstom, Toyota, and JCB. However, as one respondent stressed, it is important to differentiate Rolls-Royce and JCB from Alstom and Toyota, because the latter's R&D departments are not located in the region (i.e., Alstom and Toyota). These differentiations could have an important effect on the depth and breadth of knowledge and on the level of knowledge tacitness that resides in the region. In any case, the knowledge that arrives at their local premises from abroad is extremely important for the cluster.

**Knowledge sharing and flows:** Concerning knowledge sharing and flows, a conclusion that can be drawn from the interviews is that knowledge sharing among the cluster's firms is primarily realised through supply chain relationships. Other important channels of knowledge transfer are the numerous research collaborative projects orchestrated by the local universities and the collaborative, innovative, government-funded projects run by public organisations and local authorities (e.g., Innovate UK) that have achieved an important level of knowledge exchange among the participants.

**Knowledge access and cultures:** Some interviewees emphasised that, according to their perceptions, there exists a strong willingness for collaboration among the members of the cluster, acknowledging the importance of collaboration for innovation in high-tech sectors. Nevertheless, all the interviewees that expressed this kind of opinion were from an academic context, and, consequently, their opinion is mostly formed by the firms that participate in the universities'

collaborative projects. However, we cannot make any firm conclusions about firms' collaborative behaviour outside of the academic context.

**Firm network relationships:** It seems that the majority of firm network relationships can be considered supply chain relationships, having the anchor firms of the cluster as the central nodes of the network. Because of their long presence, their supply chain relationships could be better described as strategic partnerships, and this is particularly true for Rolls-Royce, due to the sensitivity of information around nuclear, which requires more stable firm relationships. Apart from these, the cluster's firms can be engaged in collaborative innovation activities through their participation in the local universities' research projects and the public organisations', local authorities', and support structures' networking initiatives, often backed by governmental funding.

**Reflections:** A significant amount of R&D expenditure is on propulsion technologies in the region, primarily coming from the anchor firms of the cluster. These anchor firms have created a structure of knowledge flows with other local companies, mostly based on supply chain linkages. Additional important contributions to the knowledge transfer within the cluster come from the universities' collaborative projects, the local authorities and support structure initiatives for networking and cooperation, and the government-funded collaborative projects. Nevertheless, we believe more collaboration and open innovation strategies are needed in order to cope with the challenges and uncertainties that characterise the rapid transition to a low carbon economy.

## Networks of Coordination

Although a specialised organisation dedicated to the development of the propulsion network that might be perceived as a unified cluster does not exist, there are plenty of networks whose contribution is very important for the current and future potential of the cluster; for example, forums and alliances engaged in the development of the rail, aerospace, nuclear, and automotive sectors (e.g., Rail Forum, Midlands Aerospace Alliance) and networks related to low carbon economy (e.g., Low Carbon Business Network, Midlands Engine's Green Growth, Sustainability Forum of East Midlands Chamber, Midlands Net Zero Hub) and to productivity, manufacturing, and competition (Make UK, LEP's Manufacturing Advisory Panel). Additionally, city and county councils and the LEP also provide unquestionable support to all these kinds of activities.

**Reflections:** Most of the interviewees acknowledged that a variety of associations across the different sectors are actively engaged in the region. However, as one respondent noted, there are so many diverse though complementary and reciprocally interrelated activities that are taking place in parallel in this area that the need for a coordinator that could lead the network is clear. This leader would ideally perceive the propulsion cluster as an interrelated, loosely or tightly coupled network of activities built on the knowledge base of propulsion and engine systems engineering that expands in every aspect of transportation and will establish an overarching narrative for the cluster, forming potential trajectories and venues for the future. The recently approved combined authority (Mayoral Combined County Authority) for Derby, Derbyshire, Nottingham, and Nottinghamshire could provide the opportunity for the establishment of a support structure that will lead the coordination and the whole propulsion cluster, aiming at transforming this area into a global centre for excellence in energy transition, adequacy, and efficiency.

## Discussion: Innovation opportunities and support needs

**Evolution and market opportunities:** All interviewees agreed that Derbyshire and Nottinghamshire are uniquely positioned to play a central role in the research and development of propulsion technologies and engine systems engineering globally. The cluster enjoys deep and broad abilities and skills across all alternative propulsion technologies (i.e., electric, hydrogen, alternative fuels, nuclear), providing efficient low-carbon energy solutions for all means of transportation; that is vehicles, trains, aerospace, and submarines. The opportunities for the cluster could be characterised as more than great.

However, the uncertainty for the future of the cluster remains high. First, all the relevant technologies are still changing fast, have important challenges to deal with such as cost effectiveness, energy efficiency, and sustainable production (e.g., materials used in batteries). Second, the application of these technologies in the various types of transportation is to a large extent in flux and there are still a lot of important but unanswered questions concerning the right combination of the different technologies for all the possible cases of each means of transportation (e.g., long vs short journeys with airplanes, trains within vs outside of the electrical grid, micro-nuclear potential applications, heavy vs light vehicles, rural vs urban areas). Third, the level of infrastructure that could support the development of the propulsion technologies (e.g., recharging and refuelling infrastructure, grid expansion) is critical. Nevertheless, the cluster is gifted with some of the key industrial protagonists worldwide, which, combined with the contributions of a critical mass of SMEs, local universities, research centres, and support structures, creates a rich and strong ecosystem capable of confronting challenges emerging from technological, environmental, and social change as well as global competition.

**Resilience:** The most important vulnerabilities that the cluster must confront are common to the whole of UK manufacturing and are related to current and future skill shortages, supply chain difficulties, manufacturing costs, and energy prices. Additionally, as emphasised by several interviewees, it is of paramount importance for the region to provide a business environment conducive to entrepreneurship, innovation, and inward investments. Particularly for the propulsion cluster, as there is not yet any established technological paradigm for many applications, it is critical that the relevant actors have the ability to participate in the shaping of these paradigms, or at least to adapt to any potential technological trajectory that may prevail or emerge, avoiding lock-in situations while being open to global knowledge developments. Nevertheless, as one respondent aptly noted, as long as these particular big players remain in the region, their capacity signals a very optimistic outlook for the cluster.

**Areas of potential support and intervention:** Probably the most significant area of potential support concerns the strong and continuous commitment of the government to the potentiality of the cluster that can be achieved by long-term planning and by the formulation and implementation of policies based on evidence and dialogue among stakeholders. Interviewees also stressed the importance of establishing an organisation that could lead, coordinate, and coherently represent the cluster in its entirety, aiming at the elimination of fragmentation, overlapping, and barriers to information sharing, at the enhancement of collaboration, and at the creation of a shared identity among the cluster's members. For many of the respondents, the recently approved Combined Authority seems to be a great opportunity to undertake this coordinating role. Finally, it is worth referring to a respondent's opinion about possible interventionist initiatives, that there is a significant export potential for the cluster that is not capitalised on, and that, therefore, more support is needed for this.

**Reflections**: Although the road to efficient low-carbon propulsion solutions for each means of transportation (i.e., vehicles, trains, aerospace, and submarines) is not precisely defined, Derbyshire and Nottinghamshire have strong foundations to grow in all alternative propulsion technologies (i.e., electric, hydrogen, alternative fuels, nuclear). Establishing an organisation that could lead, coordinate, and coherently represent the cluster in its entirety along with the long-term, strong, and continuous commitment of the government are two of the most important areas of potential support for the growth of the cluster.

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# Advanced Materials in the North West

## Case Study Overview

**Characteristics and history:** The North West region of England is considered by many to be the birthplace of the Industrial Revolution and has remained an industrial powerhouse during all six waves of innovation cycles. The region generates about 9% of the UKs GDP, has one of the largest aerospace sectors in the UK, and the largest digital economy in the UK after London and the South East (Office of National Statistics, 2022). The region boasts a conurbation of some of the world's best assets in advanced materials research and manufacturing. It is home to major firms such as Jaguar Land Rover, BAE Systems, Unilever, Tata Steel, Siemens, Pilkington, and Victrex. Due to the size of the area and its connections to neighbouring regions, the Advanced Materials industry is well served by world renowned research centres and institutes within the University of Manchester, University of Liverpool, University of Central Lancashire, University of Chester, University of Lancaster, Leeds University, and Sheffield University. The University of Manchester, for instance, has 10 separate institutes dedicated to various aspects of material science. This is in addition to the Henry Royce Institute for advanced materials research and innovation. There is a dedicated materials innovation factory and a Digital Innovation Facility within the University of Liverpool purposely developed to foster collaboration between academic and industry researchers and to drive advanced materials innovation. Other independent research and innovation centres in the area include Sci-Tech laboratories Daresbury and the Knowledge Centre for Materials Chemistry (KCMC). Whereas the size of the Advanced Materials industry and its related research facilities in the area cannot be understated, there is an acknowledgement of the lack of collaborative efforts among the various stakeholders to identify and drive a common agenda for the North West Advanced Materials industry as a whole. In its current form, only the few major companies in the area that operate in the Advanced Materials industry are obvious but these are supported by a vast supply chain of related firms that can be difficult to identify and classify as Advanced Materials companies. A strong leadership that can provide the much-needed coordination among stakeholders is critical to the development of the industry to allow the North West to drive innovation and enhance the competitive advantage of the UK.

**Geography and size:** The North West region of England, where this study is based, covers Greater Manchester, Liverpool City Region and 23 other local authority districts. It also has strong economic connections to neighbouring government office regions such as the North East, Yorkshire and West Midlands. Even though the majority of the large firms in the Advanced Materials industry in this area are based around the Mersey basin, companies operating within the Advanced Materials industry can be found in most parts of the North West. Whilst some of the larger firms undertake research, innovation and technological developments in-house, a significant proportion of such activities are based in universities and independent research centres. Even though the different political and administrative boundaries do affect the governance of some of the processes around the funding of research and development, as well as access to certain facilities, companies in these areas tend to work with other institutions and firms across such boundaries and beyond. It was, however, evident from the interviews that cross-boundary interactions between the various local administrations were virtually non-existent. In fact, one respondent likened the relationship between Liverpool City Region and Greater Manchester combined Authority to the rivalry between Manchester United FC and Liverpool FC. Instead of the two largest combined authorities working together to create a recognised identity for the Advanced Materials Science industry in the North West, they seem to be competing for superiority.

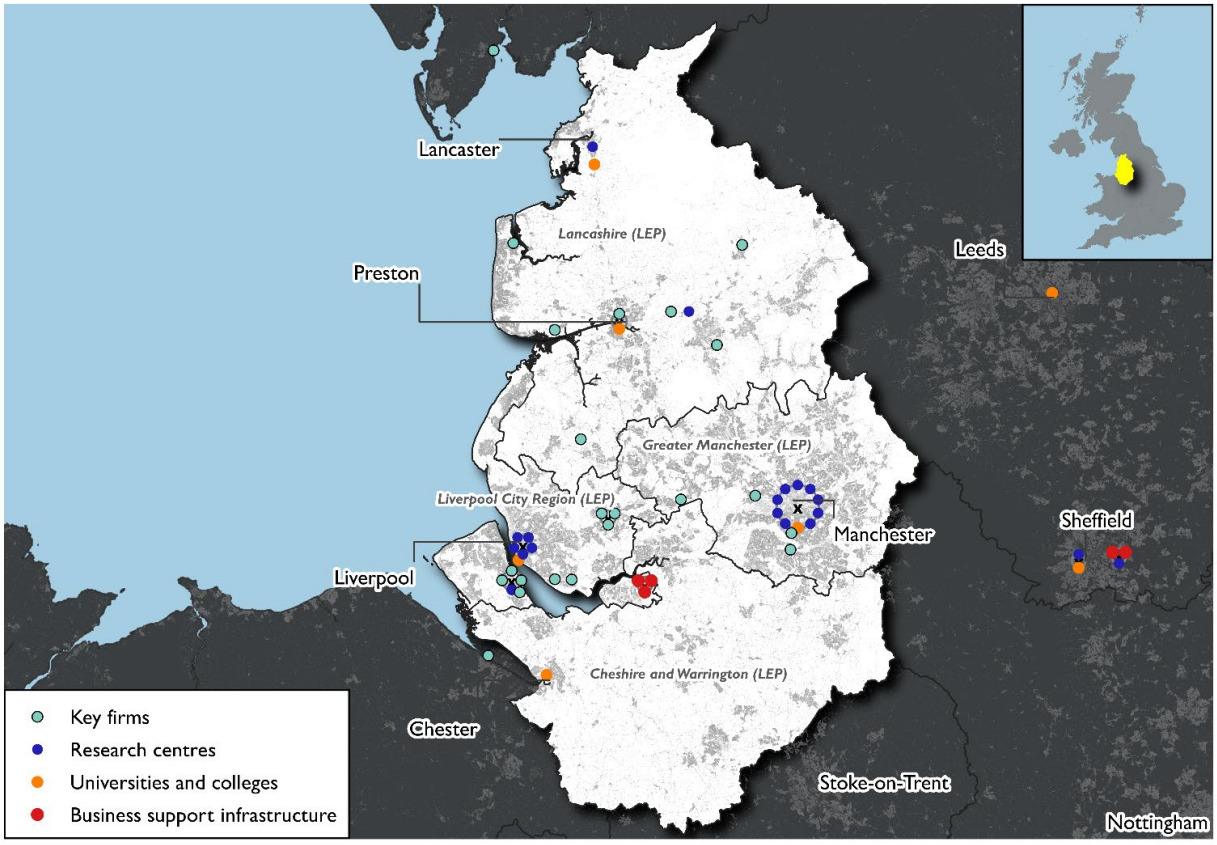


Figure 11: Advanced Materials in the North West map.

**Areas of potential future growth:** The Advanced Materials industry in the UK contributes about £14.4 billion in gross value added to the economy. Given the number of people employed in the industry, its gross value added per employee is 25% more than the UK average (BIES, 2022). The Advanced Materials industry in general is well placed to drive what has been dubbed the "next Industrial Revolution", driven by the sustainability agenda and net zero objectives. There is an ongoing greater focus on advanced material research and innovation within government policy initiatives. The UK Advanced Materials industry was highlighted as one of the 7 technology areas of UK opportunity and strength in the 2021 Innovation Strategy (BEIS, 2021). To this end, the government is investing £95 million through the Henry Royce Institute in advanced materials research and innovation (BIES, 2022). As societies move towards a green economy, demand for sustainable advanced materials will continue to grow. There are firms and institutes in the Advanced Materials industry that are already at the forefront of this change; however, most of these institutions and firms are not collaborating, and progress is very minimal and at smaller scales. A clear indication of the UK Government's commitment to net zero targets, elimination of fossil fuels and decarbonisation was highlighted as being critical to investments in material research and development at the firm level. Specific areas of potential growth include:

- Data and digitalisation
- Intelligent Materials
- The creation of materials for the renewable energy sector and decarbonisation, including materials for long range battery technology and conductors
- The development of lightweight and sustainable materials.

**Reflections:** The Advanced Materials industry in the North West has all of the necessary characteristics and basic ingredients to develop into an innovation powerhouse. It has a strong asset base that is rooted in well-established material science research institutions and has one of the largest conurbations of material development and application companies in the UK. The innovation potential of the industry is hindered by the lack of leadership that can coordinate the activities of the various stakeholders and players in the industry through well-defined objectives. Knowledge transfers between actors in the industry are limited and developments in areas such as big data, digitalisation, and the application of artificial intelligence and machine learning are inadequate.

## Core Assets

**Market structure and anchor firms:** The lack of a clear network of firms and the sheer size of the geography of the North West make it very difficult to obtain a comprehensive list of firms operating in the Advanced Materials industry in this area. According to the Greater Manchester Innovation Plan (2022) there are over 4000 advanced manufacturing companies in greater Manchester alone with about 180 firms specialising in advanced materials. However, most of the interviewees acknowledge that the bulk of the Advanced Materials companies are based within Liverpool City Region. This suggests that there are hundreds more firms in the region specialising in advanced materials. Majority of the large and significant Advanced Materials firms such as NSG Pilkington, Unilever and Johnson Matthey are located around Liverpool. Thera are also many more firms that feed that form part of the industries supply chain and operate in related activities.

Whilst some respondents felt that the presence of large corporations such as Unlivelier, NSG Pilkington, Victrex, and Johnson Matthey among others do drive other firms into the area to form part of the supply chain and drive innovation, other respondents felt the future of the innovation and growth of the industry lies with the many SMEs operating at various stages of the industry.

**Higher education and training institutions:** The North West region has several research-intensive universities actively working in material science. It is also well positioned to benefit from some of the leading universities in material science in neighbouring regions that also undertake material science research and offer both undergraduate and graduate-level degree programmes. This cluster of institutions includes:

- **The University of Manchester** offers many undergraduate and postgraduate programmes in various aspects of material science and boasts expertise in textiles and paper, corrosion and corrosion prevention, metallurgy, biomedical materials, and polymers. The university has a materials science department and 10 institutes dedicated to materials science research. These include the National Graphene Institute and the Graphene Engineering Innovation Centre. It is also home to the world-renowned ***Henry Royce Institute***. This Institute, which focuses mainly on material science research and innovation, is a partnership between the National Nuclear Laboratory, the UK Atomic Energy Authority (UKAEA) and 6 of the UK's leading Universities (**Imperial College London, Oxford, Sheffield, Manchester, Leeds** and **Cambridge**). The Royce is mainly funded by the EPSRC and provides expertise and specialised equipment and facilities to companies of all sizes, other academic institutions and the general public involved in material science research and innovation.
- The **University of Liverpool** is home to the ***Materials Innovation Factory (MIF),*** which opened in 2017 in collaboration with Unilever, is open to academics and other companies seeking to leverage the expertise of academics and other experts in a well-equipped purpose-

built environment to scale their research and development activities. The MIF is well-equipped with material science robotics and analytic equipment capable of handling multiple workflows. Areas of expertise at MIF include organic and inorganic materials, nanomedicines, genomic sequencing and high throughput formulation. MIF also hosts the ***Leverhulme Research Centre for Functional Materials Design,*** and the ***Digital Innovation Facility***: though not necessarily focused on material science, this is a necessary platform for the integration of robotics, autonomous systems, data analytics and artificial intelligence in the development and application of advanced materials. The University of Liverpool also offers various undergraduate and postgraduate degree programmes in materials science and its related disciplines.

- The **University of Central Lancashire** has the ***Research Centre for Smart Materials*** and the ***Functional Materials Group*** with expertise in graphene, nanocomposites, films, fibres, biomaterials, alloys, polymers, and gels among others. Academics in these centres work collaboratively with partners from industry and other academic institutions in the Chemical and Advanced Materials industry.
- The **University of Chester** is home to ***The Smart Composite Group*****,** an innovation hub that explores and develops multifunctional materials for industrial application. The centre has expertise in finite element modelling, composite machining and joining, and multifunctional composite and digital manufacturing of composites.
- The **University of Lancaster**'s ***Material Science Institute*** (MSI) offers a wide range of facilities and equipment for the analyses and characterisation of materials, additive manufacturing of materials and nanoscale device fabrication to industrial partners and collaborators from other institutions working in the material science sector. They offer placement opportunities, internships, and equipment training. MSI is currently working with Bruker UK Ltd and LMA Ltd to pioneer nanoscale property mapping of subsurface and buried layers of materials.

Outside of the boundaries of the North West region, but easily accessible to businesses and academic collaborators in the North West, is the **University of Sheffield's *Department of Materials Science and Engineering*.** The Department has several facilities and the equipment to facilitate chemical and material science research which is accessible to public and private sector organisations as well as academics from other institutions. For instance, their ***Materials for Innovative Disposition from Advanced Separations*** (MIDAS) facility is well equipped for research and development in the management and disposal of radioactive wastes. Other facilities include the ***X-ray Power Diffraction Research*** facility, x-ray absorption and emission spectroscopy equipment, and the ***Sheffield Tomography Centre***.

**Other research and anchor organisations:** In addition to these universities and institutions, other organisations support materials science innovation in the North West through the provision of specialised lab equipment and collaboration facilities. Notable among these are:

- **Sci-Tech Daresbury** in partnership with **Science and Technology Facilities Council** (STFC): has over 30 companies working in various aspects of materials innovation and development from the same location.
- **The Knowledge Centre for Materials Chemistry (KCMC)** is another organisation which supports knowledge transfers between academia and industry to drive innovation in materials chemistry through the facilitation of research and development collaborations. KCMC has facilities in both Liverpool and Manchester.

**Finance:** Materials innovation is a complex process, goes through multiple development cycles, takes several years, and requires some level of funding certainty to ensure that the innovation cycle, where successful, is complete. In this regard, companies, especially large companies, tend to rely on internal funding for their materials research and innovation. Whilst some respondents were quick to acknowledge the role of the EPSRC and Innovate UK in providing funding for materials research and innovation, most of the interview respondents indicated Innovate UK funding does not provide the certainty required to ensure the completion of the innovation cycle. As one respondent put it:

*If I apply for an Innovate UK programme… maybe we get the funding, maybe we don't… but when we do get the funding it runs to a point and it stops, the tap gets turned off... you may then have to win another competition in order to continue. There is no guarantee of follow up funding.*

The above sentiment was echoed by another respondent who highlighted that "*…Innovate UK are funding some very interesting work below TRL level but then it dies*" due to the lack of follow up funding. There is also a lack of awareness among SMEs about funding opportunities available through research councils and other outlets. Those who are aware of these opportunities highlighted challenges with navigating UKRI and Innovate UK funding application processes as barriers to accessing funding.

**Reflections:** The Advanced Materials Science industry in the North West has some of the best core assets in the country. There are world-renowned and well-equipped research and innovation centres in Manchester and Liverpool and other parts of the region as indicated above. There are several world-leading companies in materials development located within the regions. There are also a substantial number of SMEs working within Advanced Materials Science and supported by many more other companies that form part of their supply chain. In terms of asset base, the North West has a competitive advantage in materials innovation over other regions in the UK.

## Skills

**Talent pool:** The Advanced Materials industry in the North West has many academic assets in this area and there is a steady supply of talent. However, in recent years there have been recruitment challenges in getting appropriately skilled personnel in areas where they are needed. Some of the interviewees who work directly in this area highlighted issues relating to competing demands for skills from other sectors, especially in technology and digital fields. One interviewee highlighted a case where a PhD graduate was offered a £40,000 starting salary to work with them in Warrington, but a week before he was supposed to start working with them, he turned the job down in favour of another role in the banking sector in London, for a salary close to £100,000. One interviewee described the situation as "difficult for a company like Tata Steel to outbid a company like IBM or a Bank in the city of London when it comes to talents in AI, machine learning and most of the digital areas".

Other interviewees felt that although the university assets in the area are producing a lot of graduates with the necessary qualifications to work in the industry, most of these graduates are moving out of the area to other parts of the UK and abroad. They believed that this was partly due to the lack of closer relationships between universities and companies in matching talented graduates to opportunities available in businesses. A much closer relationship between universities and companies to understand their talent needs and skill gaps will go a long way to improve employability, and also

ensure that employees with the appropriate skills are made available to the industry. Some of the interviewees also highlighted their commitment to and investments in apprenticeship in various parts of the company to drive productivity and R&D.

**Local skills provision:** Whereas most of the interviewees acknowledge the importance of a sufficient pool of local skills and talents to materials science innovation, they didn't see the unavailability of local talent as a significant limitation to growth or innovation. Companies are prepared to recruit from anywhere in the UK and in some situations from other countries depending on the level of skills and experience required. Others took the view that the relatively low cost of living in the North West compared to London and the South East has some form of comparative advantage when it comes to accessing talent from other parts of the UK. Interviewees were mainly concerned with the number of graduates and the suitability of talents across the UK to be employed in materials science and digitalisation programmes.

**Reflections:** There were divergent views on the availability of relevant skills and talents in the industry. Respondents based in universities and research centres felt there is adequate talent available for firms to work with. On the other hand, respondents from industry suggested that there were difficulties in finding people with certain specialised skills. Respondents felt some of the university programmes were very generalised within Advanced Materials Science and that greater collaboration between universities and industry is required to ensure personnel with the appropriate skills are available when needed. Despite these divergent views, none of the interviewees had a strong inclination that innovation is being restrained because of the lack of people with relevant skills. The availability of local talent did not appear to be a significant issue so long as talent was available in the UK.

## Knowledge Exchange

**Firm research and development practices:** Compared to some of the other industries, the Advanced Materials industry is by default R&D intensive. The surge towards a green economy and sustainability mean that organisations are constantly looking for the next material that will give them a competitive edge. Research and innovation centres in the North West have seen significant increases in the use of their facilities, whilst some of the larger firms in the area like Unilever and Johnson Matthey have collaborated with universities in the area to set up R&D and innovation centres. Some of the respondents indicated that they have created in-house incubators and have deployed data analytics and machine learning as part of their research and development of new materials.

**Knowledge sharing and flows:** The presence of research and innovation centres such as the STFC labs at Sci-tech Daresbury, the Material Innovation Factory, the Royce Institute and the KCNC centres have improved collaboration between academia and industry. Universities are seeing greater willingness from their industry partners to collaborate on various R&D projects. Some of the interviewees from industry indicated they have increased the network of universities that they

collaborate with in recent years and set up several collaborations with start-ups. Academia-industry collaboration is not limited to universities in the North West region: some of the companies in the North West have formed partnerships with universities in other parts of the UK, and vice versa.

**Knowledge access and cultures:** At the firm level, there is an appetite for collaboration between firms, especially between SMEs and large corporations. Some of these collaborations have been facilitated by the materials labs, and innovation and research centres located across the North West. Companies are prepared to consult for other companies and share information on areas like supply chain information when they are not direct competitors. However, in general, there are limited collaborations between firms. This is partly due to the lack of a recognised network or governing body where a comprehensive list of companies working in materials in the North West can be accessed for collaborative opportunities. One interviewee noted that:

> *There are a huge number of SMEs [in the industry in the North West] and part of the challenge is actually being able to identify all of the SMEs or the ones that are relevant, because we are happy to collaborate with SMEs as long as we know that they exist*

**Firm network relationships:** The lack of openness makes it difficult for companies to overcome similar challenges that they may be facing in isolation. Interviewees noted that the limited flow of knowledge is not necessarily due to the unwillingness on the part of the companies to share knowledge, but to the lack of leadership and organisation in creating a collaborative culture and environment. There are also adversarial relationships between academia and industry when it comes to intellectual property rights. Some of the respondents indicated that there are certain universities that they do not and will not work with because, irrespective of how much money the companies invest in their joint ventures, such institutions always want to solely own the rights to any intellectual property that may arise from their activities. Other respondents indicated that universities are not doing enough to identify collaborative opportunities within the industry, especially with SMEs.

**Reflections:** The North West has very impressive sets of innovation assets in advanced materials, considering the wealth of expertise available in the various academic intuitions and research centres across the region, the number of companies and the spectrum of advanced materials related activities in which they are engaged. The presence of key research and innovation centres has resulted in increased connections between academic experts and the industry. There are opportunities to drive materials innovation through networking and coordination of the activities of firms that can benefit from working in the same spaces.

## Networks of Coordination

There are no recognised governed networks within the Advanced Materials industry in the North West and the industry lacks the necessary leadership to collaborate and champion its activities. This is partly because of the segmented nature of the industry. Different companies focus on distinct aspects of materials, and it is sometimes difficult to achieve an appropriate level of critical mass where governance can be useful. The closest to a recognised network is the Materials Research Exchange spearheaded by Innovate UK KTN which holds networking events to enhance collaboration and knowledge transfer. While one respondent commended the ability of the KTN to bring potential partners together once they have a good understanding of the relevant issues and challenges, there were suggestions that the activities of the KTN need to be significantly enhanced if they are to act as a governing organisation for knowledge transfer and networking.

**Reflections:** The innovation and product development potential of the Advanced Materials industry in the North West is significantly constrained by the lack of a recognised governing structure and network that will bring firms together and coordinate their activities. A common theme among respondents was "the lack of leadership". The Advanced Materials industry in the region is not new; it has been there for a while and will probably continue to be there, but there is very little focus on enhancing the image of the North West as the centre of materials innovation in the UK. Resolving issues around cluster coordination, leadership and networking has the potential to accelerate Advanced Materials Science research and innovation in this area.

The *Innovate UK Plan for Action* for UK business innovation published in 2021 recognises the need to create a collaborative environment where people and organisations can come together to make effective use of the resources available and drive innovation (Innovate UK, 2021). What is perhaps even more important is ensuring such opportunities are well-streamlined; easy to understand and navigate; and well-communicated to stakeholders. A strong regional and sectoral leadership to promote and implement the activities linked to such strategies is also essential to the realisation of the aims and objectives of such initiatives.

Given the size of the material industry in the North West and the geographical spread of firms within the industry, a cluster leadership which is independent of the various political and administrative institutions is necessary to facilitate cross-boundary networking between firms, academia, and industry experts; and coordinate the activities of national and regional initiatives.

## Discussion: Innovation opportunities and support needs

**Evolution and market opportunities:** The Advanced Materials industry is currently in a good place in terms of its growth potential and market opportunities. The North West is home to many energy storage and generation companies that will all require some form of new materials as the country and the world in general move towards net zero and the green economy. There are opportunities for the use of big data, artificial intelligence, machine learning and robotics as part of new materials research, innovation and production. These developmental opportunities have the potential to improve the innovation capabilities of the Advanced Materials industry in the North West if the necessary steps towards cluster development and coordination of assets are put in place.

**Resilience:** Feedback from interviewees indicated that the UK lacks a clear and coherent national materials strategy. There appear to be some strategies available at the sub-industry group council level, but what informs such strategies is not clear. There are challenges in getting the right talents in the areas of digitalisation and the use of big data. Demand for talent in these areas remains very competitive and most often, material science companies in the North West are unable to compete with other organisations in other industries in other parts of the country. Another challenge to the industry is the level of R&D investment. Compared to other countries such as Germany and the USA, R&D investment in the UK is very low. This has the potential to put UK companies on the back foot in materials innovation.

**Areas of potential support and intervention:**

- Establish a cluster (or clusters) with clear purpose and identity: In the Advanced Materials industry, this can be very challenging because there are different segments of materials science, and it is necessary to identify how best to focus the cluster activities to achieve the

best possible impact(s). In the North West, there are many assets, players and actors in the Advanced Materials industry. However, the activities of stakeholders such as local administrative authorities, LEPs and research councils that support the industry are not well coordinated. It can be difficult for firms to navigate the various pathways available for support. The establishment of a cluster can certainly help direct and coordinate the activities of stakeholders to strengthen collaborations, networking, and knowledge transfers.

- Enhance the reputation of the region as a centre of excellence for materials science: When we talk about material science innovation, the North West is not the first area that one thinks about, even though it has arguably the best collection of material science assets in the country. The North West needs to develop a notable identity in materials science research and innovation that is recognisable not only in the UK but internationally. The establishment of a recognised cluster can help in this development, but it will also require a platform for the various stakeholders, especially the local and combined authorities in the region, to work together.
- Reconsider funding regarding innovation cycles: The funding of materials innovation needs to be reviewed in recognition of the life cycle of new materials innovation and development. There are suggestions that potentially good innovative products are not being developed because funding for such projects, when obtained from research councils, tends to be on a short-term basis with no guarantee for the next stage of product development. Such developments tend to terminate below TRLs. This approach to funding is stifling innovation in materials.
- Develop a national materials strategy: The development of a clear and coherent national strategy for materials development is required to generate the necessary private sector investment and interest in materials innovation. For instance, firms are not likely to invest in the research and development of new materials if they are not confident that the country is committed to its net zero objectives. Most of these organisations are already working on valuable products that require little to no R&D spending and will not seek to invest in new materials if they are not confident that it is the right direction to take.

**Reflections:** The Advanced Materials industry in the North West has the necessary core assets to develop into a recognised materials research and innovation powerhouse for the country. However, the industry is very segmented and lacks the appropriate leadership to collaborate with the activities of the industry as a whole. The development of any form of a cluster has to be pitched at a point where critical mass can be achieved. At the same time, administrative boundaries possess another challenge to the development of a recognised North West materials cluster that has the support of all stakeholders. For any such cluster development to be successful, there needs to be a recognition that the stakeholders and partners should clearly understand the purpose and motivation for the development of any cluster or clusters in the North West. The leadership of such clusters (s) and the process around its activities must remain open, transparent, and collaborative across the various political and administrative structures within the region.

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# Gateshead and Newcastle Immersive Technology

## Case Study Overview

**Characteristics and history:** The North East immersive technology industry is centred around Gateshead and its surrounding area alongside the River Tyne in Newcastle. The North East of England has been strong in the creative sector since the 1980s, when regional TV programming spilled over to support a wider range of industries, including video gaming and technology. Immersive Technology has historically developed through a small network of creative businesses. The North East houses the largest hub of Virtual Reality companies in Europe, a community that is close-knit and collaborative in nature. In 2014, the companies came together to organise an international virtual reality conference and expo, VR2GO, which unveiled opportunities for the North East to be internationally recognised as an important immersive location.

Since then, the North East and Tees Valley Digital Catapult (NETV), a UK organisation that contributes to the development of advanced technology in the region, has identified immersive technology as a main focus for development. The main actors in the immersive technology industry are a strong network of small and medium enterprises (SMEs); Gateshead Council; North East Local Enterprise Partnership, and NETV Digital Catapult. Currently, the cluster's assets and activities are centred in PROTO, the first digital production facility in Europe. PROTO's purpose is twofold: to provide a shared workspace for immersive companies that are mostly SMEs to collaborate; and to provide immersive technologies for these companies that are otherwise only accessible by larger companies.

In general, immersive technology is still at an early stage in its growth. Nonetheless, respondents of the study explained that the immersive technology industry has had an exponential growth through the pandemic. The past three years have allowed for a wider range of industries to realise the potential that immersive technologies could bring to business. In Gateshead, immersive SMEs are looking at the application of their technologies beyond the limited area of gaming and entertainment. Due to the limitless application of immersive technologies, its application and platforms can be used across multiple industries. Currently, immersive technology enterprises are engaging with the use of immersive technologies in areas such as *advanced manufacturing, crisis and hazard management, skills training,* and *education*, besides the more obvious routes of *games and entertainment.*

**Geography and size:** The North East of England comprises the urban centres of Tyneside, Wearside, and Teesside. Based on the North East LEP, this covers the local authority areas of County Durham, Gateshead, Newcastle, North Tyneside, Northumberland, South Tyneside and Sunderland. The area boasts 8,600 square kilometres (sq km) of land, although the Immersive Technology activities discussed in the report are currently located primarily in Gateshead and Newcastle. While immersive activities may have spillovers in the wider digital economy of the North East, the development of PROTO, the first digital production facility of its kind in Europe, in Gateshead has resulted in a concentration of immersive activities where the building is located and in its surrounding areas.

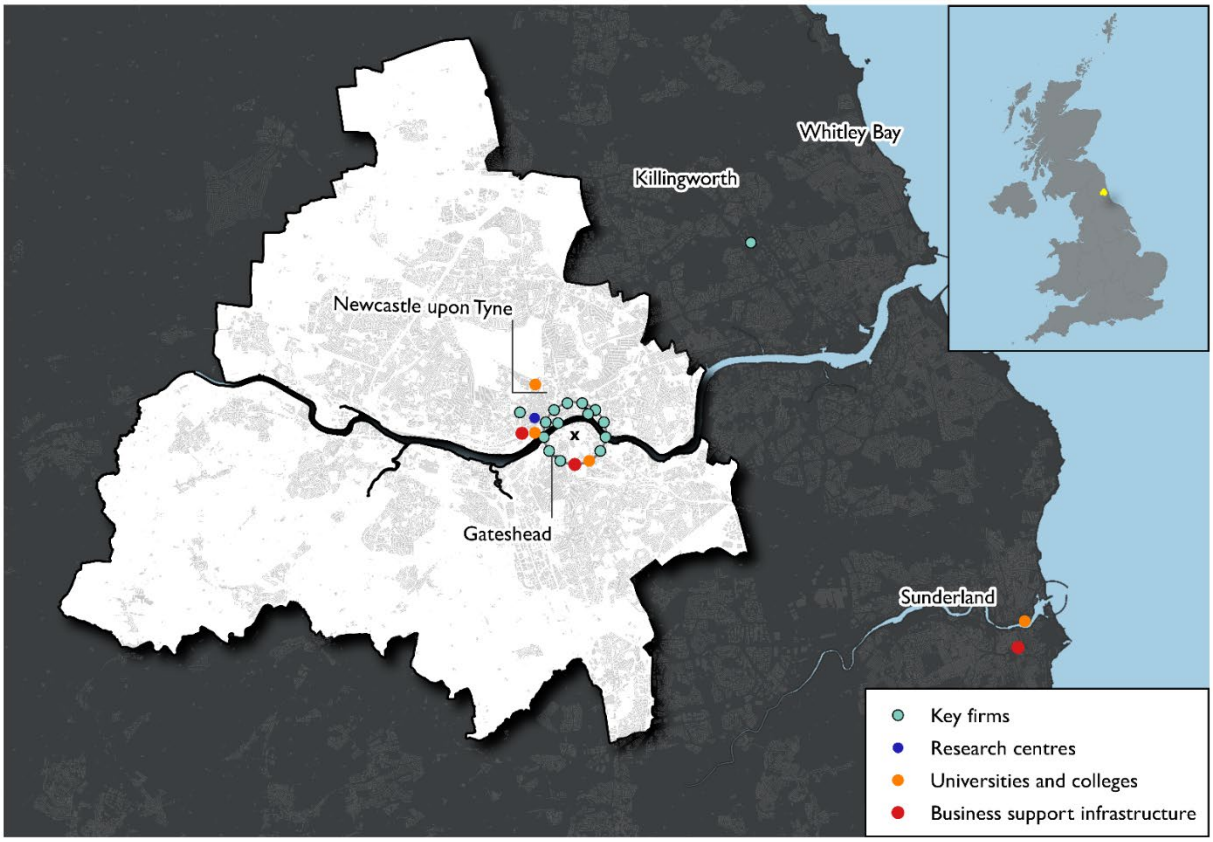


Figure 12: North East Immersive Technology Cluster map.

**Areas of potential future growth:** Internal indicative estimates by Gateshead Council suggest that the potential of embedding immersive technologies across a broad range of industries and applications could increase the UK's productivity by 4%. For the North East region, this could lead to a GVA of up to £159 million. In order to meet the challenges of slow adoption of immersive technologies by non-immersive companies, the development of Immex City in Gateshead aims to support SMEs to sell into a broader range of industries.

Currently, the Immersive Technology cluster is in a growth phase, with the adoption of immersive technologies in games development, software development, fintech, cyber security, space, artificial intelligence, BIM, cleantech and data science. There are notable activities in two core areas:

- **Creative Industries (including gaming and entertainment):** The measurement of gaming and entertainment in the North East could be done through the proxy of the Information and Communications sector, which was worth £2.2 billion in 2019. Gateshead is the centre of gaming and entertainment in the North East, with many creative businesses calling Gateshead Quays their home.
- **Advanced manufacturing:** The North East Manufacturing sector was worth upwards of £7.9 billion in 2019. The main challenge of manufacturing in the North East is in increasing the productivity level, which has varied between 3% to 15% lower than the national average in the past few years. Gateshead Council has identified immersive technology as a potential solution to bringing productivity levels back up in manufacturing, through the reduction of training costs and increasing output efficiency through the use of immersive technologies.

Other areas that are emerging as adopters of immersive technologies in the region include:

- Design, inspection and maintenance of assets
- Health and safety training
- Education
- Electrification and digitisation

**Reflections:** Spatially, the NEIT activities are concentrated in a small geography, although, given that immersive technologies can be applied through digital methods, its reach has no boundaries. Synergies with various sectors are increasing with more awareness around the adoption of immersive technologies. External to gaming and entertainment, opportunities continue to increase in areas of advanced manufacturing through electrification and digitisation; design, inspection, and maintenance of assets; health and safety training; and education.

## Core Assets

**Market structure and anchor firms:** There is no one anchor firm in the immersive technology industry. Instead, the industry is made up of a small cluster of SMEs who are centred around PROTO. Based on interviews, the majority of the SMEs are micro-sized. They are collaborative on knowledge exchange with each other and communicate well, given that many are being housed under PROTO, alongside authorities within the immersive technology industry. There have been a few firms who managed to grow its size by being acquired by larger, international firms. However, the challenge that remains among the micro firms is in scaling up their operations and services.

**Higher education and training institutions:** The North East has several important universities and further education colleges, although skills development specific to immersive technologies has come directly from the entrepreneurs and collaborations with local authorities. This research found skills shortages as a particularly important challenge in the cluster. Currently, stakeholders in the cluster are collaborating in developing skills training and education programmes on digital and technology that would feed into Immersive Technology. Education institutions that were mentioned in this study include:

- **Gateshead College:** working closely with businesses and authorities in the immersive technology industry to respond to the growth in demand for digital and tech skills since long before the pandemic. Gateshead College's Level 3 Emerging Technologies course provides students with access to PROTO's specialist kit. This collaboration allows for the education of young people interested in immersive professions to work with new technologies as they emerge, alongside tech-based start-ups. Gateshead College has engaged with 400 students across different courses, including healthcare, performing arts, dance, education and sport, to develop digital skills that include immersive technologies.
- **Sunderland University:** has a collaboration with PROTO enabling students to access PROTO's specialist kit for the creation of immersive games and content. Sunderland also has a ***Digital Incubator*** which supports skills development by connecting students and graduates with local immersive businesses to work on live projects and R&D.
- **The North East Futures University Technical College:** has IT, computing and healthcare science courses for 14 to 19-year olds that are co-funded by North East-based Accenture, Hewlett-Packard, Sage and Ubisoft.
- **Newcastle University:** houses the ***Digital Cultures Centre***, which focuses on innovative engagements within digital public spaces. As part of this, their UKRI-funded project, 'Next

Generation of Immersive Experiences', introduces innovative digital creative methods, such as changing working processes and practices using AR, into cultural organisations.

- **Teesside University:** has programmes in Immersive Technology that are a unique and important asset in talent development specific to the spaces of immersive. The university also has expertise in immersive technologies and an in-house student digital production studio called ***TUCan***. TUCan is run by experienced academic staff working with graduates to create R&D solutions and products in the areas of animation, immersive technologies, film production, app development, 360, artificial intelligence, and data analytics.

**Other research and anchor organisations:** While the wider North East has a rich involvement with research in digital technology, the study has found that there are several anchor organisations that are catering to the specific needs of immersive technology. It should be noted that these anchor organisations are involved with wider partnerships in the digital technology area, as well as industries in the region that are using the platforms and applications of immersive technologies, such as advanced manufacturing, health and life sciences, energy, and education, among others.

- **PROTO** is an immersive technology facility that is owned by Gateshead Council, and partly funded by the North East LEP, the European Union's European Regional Development Fund, Growth Deals, and the North East Tees Valley Digital Catapult. Based in the Baltic Quarter, Gateshead, the area has a United Kingdom Science Park Association status, housing 40 creative tech, digital and design companies. PROTO is the first digital production facility of its kind in Europe, developed especially with animators, film makers, and game developers in mind. PROTO currently houses the North East and Tees Valley Immersive Lab, a test bed of research in immersive. PROTO was developed to provide access to expensive leading edge hardware and software for businesses, with the hope that providing affordable access to these technologies could assist the growth of start-ups and allow existing businesses to understand the potential of immersive technologies and conduct research and development in new products and practices using immersive. The types of technologies that PROTO has include mixed reality green screen (LIV), haptic gloves (Manus), motion capture suits (Perception Neuron), pupil tracking, and holographic display hardware (The Looking Glass/Hololens).
- **National Innovation Centre for Immersive Technology** is an ongoing project, an ambitious project which aims to grow the cluster by providing access for entrepreneurs to a commercial workspace, R&D lab space, and an immersive visitor attraction centre (Invest North East England, n.d.).
- **TusPark** is a nationally- and internationally-connected incubator located in the city centre of Newcastle. It offers its members access to affordable office space, workshops, and a network of digital and technology entrepreneurs.

**Support structures and infrastructure:** The North East has a great range of assets and infrastructures that support the growth of the immersive technology cluster. These assets and infrastructures are also jointly funded by different authorities, including the Gateshead Council, the North East LEP, Digital Catapult North East and Tees Valley, among others. Co-investment assists in providing support to the businesses in the region and assists in collaborations among the actors in the cluster. The assets and infrastructures include:

- **PROTO -** has assisted in accelerating the growth of the cluster by allowing SMEs to have access to technologies that are usually only available to large firms. PROTO as a building is also home to many businesses in the area as well as several authorities, making it easier for knowledge sharing to occur.

- **North East and Tees Valley Digital Catapult –** The NETV Digital Catapult is a satellite centre of the national Digital Catapult.
- **Gateshead Council** - plays a key role in aligning the NEIT industry's strategy and vision to the overall economic and social goals in the region. Gateshead Council has been instrumental in supporting the aims that the NEIT businesses have as well as finding out new opportunities.
- **Dynamo North East -** a volunteer-led group that aims to grow the North East IT economy through collaboration, innovation and skills. It hosts regular events and an annual digital conference and runs several digital clusters and special interest groups to champion specialities like cybersecurity, digital construction, shared service operations, and fintech.
- **NOVA (North East Game Collective) -** a collective of game companies in the North East. The collective hosts meet-ups, conferences, podcasts, and provides online support for designers, developers, gamers, and studios of all sizes.
- **Sunderland Software City (SSC) -** is part of the NETV Digital Catapult and is a key delivery organisation for North East and Tees Valley. It supports technology start-ups as well as large businesses through regular meet-ups.
- **Innovation Supernetwork -** exists to connect businesses in North East England with the opportunities, finance and support needed to innovate and grow. Supported by 60 partners, including all five regional universities and high-profile organisations across the public and private sectors, it brings together the innovation ecosystem to support economic growth.

**Finance:** Immersive technology firms face the same issues as those in other places: a lack of growth and scale up funding. The firms interviewed have grown organically but remain at a micro- or small-sized scale. A potential constraint in attracting funding could be the cluster's current focus on applied immersive technologies, predominantly in gaming and entertainment. Interviewees explain that there is a cluster-wide collaboration for increasing awareness of the potential that immersive technologies could bring to different industries. This could be integral to attracting funding due to recognition of the untapped potential that immersive technologies could bring to the productivity levels of multiple industries.

Through the Digital Catapult, there is currently a startup programme that has recently funded six new startups in the region. The Venture Fest, where immersive technology firms can go if they wish to secure private investments, also runs annually. There have been some talks to establish an angel investors' network, although at the time of writing this network did not yet exist. While Gateshead Council has been instrumental in providing funding support for the cluster, it should be mentioned that a lot of the funding secured to build the infrastructures in the cluster came from sources that can no longer fund the cluster, such as Northern IT Research (which has since wound up) and the European Union.

Nonetheless, the North East is the only region that has a high potential opportunity (HPO) status for immersive technology, conferred by the Department for International Trade (DIT). The status means that the DIT recognises the national and international significance of the immersive technology industry and will support inward investment opportunities to the region. The immersive technology industry was given HPO status due to the national significance of its digital innovation in manufacturing, the potential for collaborations between universities and SMEs, the availability of R&D assets in the region, and its access to skilled workers. Because of the immersive technology industry's HPO status, companies seeking a UK base in this industry will be brought to the North East cluster. This could generate a lot of interest from the finance community and attract further investment.

**Reflections:** The NEIT industry has a great potential in terms of a growing market, strong assets and infrastructures, and a supportive network of actors. While the industry is currently composed of micro and SME firms, there is a strong drive by various actors to help the industry grow, specifically with a focus on scaling up firms.

### Skills

**Talent pool:** The North East has approximately 32,500 employees in the digital and tech sector, while 5 of its world class universities offer educational courses that are aimed at the immersive technology sector (Invest North England, 2021b). Despite this, a prominent challenge identified by respondents is the limited talent pool for the wider digital industry in the North East. Respondents described a lack of access to skills that could slow down the growth of the immersive technology industry. This could be related to the wider skills shortage faced in the North East. As one respondent said:

> *Some of the entrepreneurs that have started businesses here; we need to make sure that we continue to retain them in our region. I think that's something that we've talked about, maybe not too much. But it's something that we've heard a lot about, right? That kind of talent leaving. They come into the region studying here and then leaving for opportunities further afield.*

Specific to immersive technology is the lack of a talent pool in the region that could cater to the industry. As respondents explained, due to the unique nature of the cluster growing from a small group of SMEs, rather than stemming from university spinouts or startups, the local educational institutions currently need to catch up with providing the right skills training that could cater to the immersive technology industry. The North East has a limited talent pool for immersive technical roles such as design architects, 3D artists, software developers, software engineers, XR gameplay and tools engineers, and system validation engineers. Respondents also identified the need for talent that have the drive to think of immersive technologies beyond the limited spaces of immersive gaming and entertainment.

**Local skills provision:** Based on Invest North East England, the region has nearly 6,000 computer science university students, which is the highest proportion of any other English region (Invest North East England, 2021b). There are also 32,500 people employed in the region's digital sector, with respondents claiming that talent in the industry tends to be loyal, based on lower staff shortages or turnover compared to other parts of the UK. To overcome skills shortages in the immersive sector, authorities and companies are working together with local educational institutions such as Gateshead College and Newcastle University to develop courses, skills programmes, and apprenticeships. Local skills provision by higher education institutions in the region have also been listed under the section of "Higher education and training institutions."

**Reflections:** Although there are a large number of employees in the North East digital and tech sectors, skills shortages continue to be a challenge for the immersive technology sector. These shortages are more pronounced in ensuring that potential employees have flexibility and creativity in seeing the potential application and adoption of immersive technologies. The immersive technology industry is also unique in that the cluster emerged from the pool of entrepreneurs themselves, rather than stemming out of university research, start-ups or spin-outs. Currently, collaborations between entrepreneurs, authorities, and local educational institutions have been instrumental in cultivating skills relevant to immersive technologies.

Efforts should be put into place to retain talent by increasing the attractiveness of employment in the cluster.

## Knowledge Exchange

**Firm research and development practices:** This study did not capture that the firms in the immersive technology industry are research active, given that the majority of them are micro- or small-sized. However, the world-class facilities of PROTO have allowed these firms to have access to expensive technologies which they would not otherwise have had access to. This access has allowed for creativity in identifying potential platforms in which immersive technologies can be applied.

**Knowledge sharing and flows:** Respondents express that there are many collaborations between stakeholders in the cluster, although much has to do with raising awareness of the potential that immersive technologies could bring to multiple industries. The study did not capture whether these collaborations generate income or not. Furthermore, collaborations between firms, authorities, and local educational institutions have been growing to support the development of skills specific to immersive technologies and to grow the local talent pool in the immersive technology industry.

There are also a variety of business networks in the immersive technology sector that are active in supporting one another through collaborations. These include:

- **VRTGO LABS -** bringing together companies, academics, freelancers and the authorities to collaborate on the commercial application of immersive technologies.
- **Digital Catapult North East Tees Valley -** focusing on supporting businesses in the digital and tech sector in the North East and Tees Valley, and encouraging collaboration through different types of events.
- **Dynamo -** a volunteer member group of firms and other types of institutions that are focused on growing the North East's digital and technology industries.
- **Digital Union -** the largest network of representatives of digital companies in the North East.
- **Innovation SuperNetwork -** 50 partners and over 5,000 members that come together sharing ideas, knowledge, funding and business opportunities to support innovative businesses in the North East

**Knowledge access and cultures:** Based on respondents, the knowledge exchange environment of the immersive technology industry is relatively open. As one respondent said:

> *They all collaborate with each other, particularly at the outset to a certain degree. Quite a few times you get new startup companies in the space that benefit from being plugged into the cluster, and from some of the people in the space who were the new authorities and the visionaries. They get a lot of support from each other.*

While firms certainly guard their proprietary information, there appears to be a willingness to collaborate and share knowledge as evidenced by pre-COVID frequency of firm meetups and collaboration events.

**Firm network relationships:** Respondents describe the pre-COVID environment of the cluster as being a lot more active in bringing firms together. There is therefore an opportunity to increase firm network relationships by going back to the pre-COVID activities in bridging gaps between different stakeholders in the cluster. Nonetheless, respondents have described collaborative efforts to grow the cluster as integral to the cluster's success. Collaborations have continued to happen in terms of

knowledge sharing, although there is an opportunity to facilitate more formalised collaborations through innovative projects, especially in the areas of R&D.

**Reflections:** Knowledge exchange happens at the industry level with multi-stakeholder collaboration being key to the success of the cluster's growth. However, there is room to increase awareness of adoption of immersive technologies, which remains a challenge. The growth of the cluster is dependent on cross-sectoral application of immersive technologies. There is a danger that entrepreneurs in this area are only focused on the narrow scope of creative industries. There is a challenge to ensure that they are aware of the business potential that immersive technologies could bring to different industries, and to market themselves as providers of solutions for these different industries.

## Networks of Coordination

There are three main governance networks dedicated to developing a vision and strategy for the growth of the sector:

- **Gateshead Council -** is instrumental in promoting the growth of the immersive technology industry. Together with Invest North East England, they have led the vision and strategy of developing the immersive technology cluster, as well as helped in obtaining the High Potential Opportunity (HPO) status of the cluster from the DIT. They currently continue to contribute in developing the vision and strategy for the cluster, providing support through collaborations with the industry.
- **The North East and Tees Valley Digital Catapult -** supports the competitiveness and growth of digital and technology entrepreneurs in the region. They provide small-scale funding to businesses, have invested in assets in immersive technology, and also provide support for innovation among SMEs.
- **North East LEP -** has a strategic economic plan which includes the tech sector as one of the key sectors for growth in the North East. Immersive technology has become one of the key areas of specialism in this space. Through the ***North East Evidence Hub***, they provide useful data to support the need for growing immersive technology in the region. While instrumental in investing in key assets in the cluster such as PROTO, the North East LEP also provides R&D funding for SMEs in the region.

The three governing bodies are in constant communication with each other and do understand the vision and strategy for the growth of the immersive technology industry. They have a cohesive understanding of the cluster and are working well together to drive the synergies of the multiple stakeholders involved in the cluster.

**Reflections:** The governance of the immersive technology sector shows a recognition of the potential that the cluster may bring to the region. Different governance authorities have similar visions of how the cluster should grow and are constantly in communication with one another. The challenge remains in working together with the industry, especially in attracting large businesses to invest in the cluster and to support further development of the micro- and SME-sized firms in the cluster.

## Discussion: Innovation opportunities and support needs

**Evolution and market opportunities:** The immersive technology industry has accelerated its growth throughout the pandemic with the support and collaboration of stakeholders in the sector. This has allowed for the identification of opportunities to expand and scale up based on increasing awareness of the adoption of immersive technologies. The core areas of *creative industries* and *advanced manufacturing* will remain strong, although there are considerable opportunities for cross-sectoral synergies, especially through activities such as *design, inspection and maintenance of assets; health and safety training; education;* and *electrification and digitisation.* With a greater focus on ESG efforts and sustainability, immersive technologies have a great potential to cross different sectoral boundaries. Efforts should be placed on increasing awareness of the value of adopting immersive technologies and cross-sectoral synergies should further be encouraged.

**Resilience:** Globally, the adoption of immersive technologies is growing at an accelerated rate, and the North East will continue to benefit from this. The key challenge remains in the areas of (1) skills shortages, (2) access to private growth/scale funding, (3) increasing awareness among entrepreneurs of the cross-sectoral application of immersive technologies, and (4) increasing awareness among businesses of the value of adopting immersive technologies.

**Areas of potential support and intervention:** Overall, the immersive technology industry has great potential for growth. With support in the following areas, it can increase its untapped potential:

- Building links between different industries that can apply immersive technologies: Currently the resilience of the cluster could be dependent on increasing awareness of immersive technologies' applications in different sectors. An education initiative is needed to, firstly, increase awareness among those working in the cluster of the untapped potential that immersive technologies could bring in areas such as *design, inspection, maintenance of assets; health and safety training; education; and electrification and digitisation with a focus on sustainability*. Secondly, in a similar vein is the need to increase awareness among businesses in different sectors of the benefits that immersive technologies could bring to their businesses, in the same areas mentioned above. Conversations between these different stakeholders should be encouraged and facilitated where possible.
- Growing local private funding community: One of the core barriers for the growth of the cluster is access to funding to scale up the firms in the cluster. Support needs to be given in assisting entrepreneurs to prepare for private investment pitches, to be aware of their business cases, and to understand where the opportunities lie in emerging technologies. Efforts should be made in attracting investors into the region for immersive technology by creating awareness of the benefits of immersive technologies as a business solution.
- Increasing education initiatives and the potential of immersive technologies: Currently, many of the entrepreneurs in the cluster are still focused on creative industries and solutions. However, immersive technology solutions cut across multiple sectors. For example, there is an untapped potential that immersive technologies could bring in providing solutions for ESG, sustainability, or Net-Zero initiatives. The lack of understanding about immersive technologies does not only reside with entrepreneurs, but also among different industries in terms of knowing how immersive technology adoption could be beneficial to their businesses. Encouraging support in this direction could assist in opening markets and attracting investment into the region.

**Reflections:** The immersive technology industry has built its reputation as an important immersive technology environment not only for the UK, but also Europe. Its international reputation should be exploited to ensure the growth of the cluster. The challenge remains in skills shortages and the lack of funding for scaling up SMEs in the cluster. Currently, the strength of the cluster is in its multi-stakeholder collaboration that has been instrumental in the cluster's growth and success. This collaboration should continue to be encouraged and supported to ensure the sustainable scale up of the cluster.

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# Appendix 1: Cluster Growth Potential Framework

## Part 1 - The foundations and defining features of the cluster

In this section, we aim to understand the history and main features of the cluster

| QUESTIONS | PROMPTS / SUPPLEMENTARY QUESTIONS |
|---|---|
| **Q1 – Cluster characteristics**<br>How would you characterise what this cluster is and does? | • What kinds of activities is this cluster engaged with?<br>• What does it make/sell/provide? For whom?<br>• Is there a specialist market(s) that this cluster has a competitive advantage in? Please elaborate.<br>• What role does this cluster occupy in national/global production and supply chains? Does it provide goods/services to end users, intermediary goods/services, does it rely on inputs from elsewhere?<br>• What technologies (if any) form the basis of the cluster's competitive advantage?<br>• Would you consider this cluster:<br>  ▪ emerging?<br>  ▪ developing?<br>  ▪ mature? |
| **Q2 – Cluster history**<br>How has this cluster evolved? | • Why is the cluster there? Is it possible to identify any key catalysts or drivers in its emergence?<br>• (How) does this cluster represent a change in path from previous industrial structures in the region?<br>• Describe any key moments/events (if any) that catalysed cluster growth or evolution. This might be changes to the industry, knowledge base, technologies, regulations, or changes in the market that created opportunities for local firms; or it could be the arrival of a new firm/lab/support organisation; or any other notable event. |
| **Q3 – Geography & Size**<br>How would you define the cluster in terms of where it is physically located/concentrated and its size? | • How would you define the geography of this cluster?<br>• In your own words explain how you would describe the area that it occupies (this might be with reference to specific administrative units or something more vague such as "the area around X" – the description does not have to be precise but specific reference points are useful).<br>• In your view, has the cluster reached a critical mass? How so?<br>• Approximately how many firms are currently active locally in the industries you consider to be part of the cluster? Note that this does not have to be precise, and an estimate will do (i.e. tens, a hundred, closer to a thousand?)<br>• If that is difficult, would you characterise the cluster as large? Small? On what basis are you making this assessment? |
| **Q4 – Priority firms and people**<br>What firms, or people, are the key actors in the cluster? | • List any 'anchor' firms or key individuals that you consider to be foundational to the emergence and growth of the cluster" – they may be large, customer firms; large employers who train their people well; or important movers and shakers in the market.<br>• What makes those firms and people the most important?<br>• Are there many second-generation firms of the same entrepreneurs |
| **Q5 – Market potential and innovation opportunities**<br>What are and where are opportunities for growth and innovation? | We explore this question in more detail later in the interview but at this stage it is useful to get general impressions of cluster growth potential:<br>• What broad opportunities are there for cluster growth?<br>• Are there triggering factors to be alert to |

## Part 2 – Current capabilities related to innovation opportunities

This section explores different aspects of the current cluster to explore advantages and understand potential gaps.

| QUESTIONS | PROMPTS / SUPPLEMENTARY QUESTIONS |
|---|---|
| **Q6 – Firm sizes and characteristics**<br>Can you characterise the mix of firms that currently populate the cluster in terms of size, age, etc.? | • Are firms that have entered the cluster as it has grown mainly:<br>  a. small or start-up companies;<br>  b. spin-out companies from universities;<br>  c. spin-off companies from other companies;<br>  d. companies that started in other industries but have diversified into this industry;<br>  e. companies that have relocated from other regions;<br>  f. branches of companies headquartered in other regions<br>  g. other?<br>• What are the synergies within the business community that make it possible to work together as a cluster? |
| **Q7 – Firms (or businesspeople) contributing knowledge**<br>Which firms (or businesspeople) are most active in contributing to the development and dissemination of knowledge in the cluster? | • How innovative are they? Are they active in R&D?<br>• How have they generated the new knowledge? How have they shared it?<br>• Do the leaders in the cluster have a culture of 'openness'? How so? |
| **Q8 – Non-firm institutions contributing knowledge**<br>What role do local universities or colleges play in developing and disseminating knowledge in the cluster? | • Specifically which universities and colleges, and which departments, institutions or leaders?<br>• What kinds of knowledge are they involved in creating?<br>• How has this influenced cluster development and innovation. |
| **Q9 – Knowledge sources**<br>Are firms actively seeking out local or external sources of knowledge for their innovation processes? | • Are there any significant sources of external knowledge that are core to the cluster's success? Think of key strategic partnerships, universities/colleges/labs in other places.<br>• If the answer to the previous question is that the strengths of the local HEI knowledge base are not that relevant to the local business cluster, explore whether there are other sources being drawn on, e.g. consultancies, professional advisors, a cluster management network, or whether non-firm sources of knowledge are not as important for this cluster's development |
| **Q10 – Knowledge flows**<br>How is knowledge disseminated and transmitted in the cluster? | • How accessible is the knowledge to firms in the area? Do actors share knowledge frequently or easily?<br>• Is knowledge shared through any cluster wide activities? Is it 'managed'?<br>• Are there actors that are left out of or have difficulty accessing knowledge exchange networks? Who, and why? |
| **Q11 – Firm network relations**<br>Would you say that a culture of collaboration and/or knowledge exchange between companies and with other organisations (e.g., universities, etc.) has developed within the cluster | How do actors typically interact with one another?<br>a. supply chain linkages with other local companies inside the cluster<br>b. supply chain linkages with companies outside the cluster<br>c. informal networks between companies inside the cluster<br>d. formal networks/associations<br>e. collaborations with local universities or research centres<br>f. collaborations with universities or research centres in other regions<br>g. other? |

| QUESTIONS | PROMPTS / SUPPLEMENTARY QUESTIONS |
|---|---|
| **Q12 – Cluster development networks**<br>Are there key people or networks (formal or informal) related to cluster development, management, strategy, best practices? | • Who leads those networks/initiatives?<br>• Do any events/initiatives stand out as important for cluster development? Please describe them and how they influenced cluster growth. |
| **Q13 – Skills (Talent pool)**<br>Does the cluster have a competitive advantage in specific skill sets? | • What skills are most important to innovation in the cluster?<br>• How easily are these positions filled?<br>• What labour force skills do the businesses require and are there common skills shortages issue that the cluster can strategise on? |
| **Q14 – Skills (Sources)**<br>To what extent are skills locally developed versus sourced externally? | • What local education or training programmes are most important for skills development (if any)?<br>• If skills are sourced externally, where from? |
| **Q15 – Support structures**<br>What are the key supporting organisations and their roles in the innovation process? | Name the most significant actors and classify them, if possible/applicable, by the following categories:<br>a. incubators/accelerators (public or private)<br>b. cluster development organisations<br>c. economic development agencies/departments<br>d. industry/professional associations<br>e. charitable and civic organisations<br>f. other? |
| **Q16 – External finance for growth or innovation**<br>What have been the most important sources of financing for the growth of the businesses? | • What finance sources (public or private sector) have been most important?<br>• To what extent are these sources local? If they are not, how easily can firms in the cluster to these sources, for instance, via well-connected individuals?<br>• How accessible are these for firms in the cluster? |
| **Q17 – Infrastructure**<br>Is any specific or specialised (public or private) infrastructure a significant source of competitive advantage? | Probe for the relevance of:<br>a. specialised lab equipment<br>b. testing facilities<br>c. transportation infrastructure<br>d. communication networks<br>e. other? |

## Part 3 – Innovation opportunities

Looking forward, what opportunities are there for future cluster growth and how well is it positioned to capitalise on these?

| QUESTIONS | PROMPTS / SUPPLEMENTARY QUESTIONS |
|---|---|
| **Q18 – Evolution**<br>How do you think the cluster will evolve in the medium- to long-term? | If not mentioned probe in relation to:<br>a. size and composition;<br>b. technological focus;<br>c. markets (including downstream applications) |
| **Q19 – Market opportunities**<br>How do you imagine that the market opportunities for this cluster will evolve over the medium- to long-term? | What domains of activity might become more/less important and how well positioned is the cluster to capitalize on these? |
| **Q20 – Support**<br>Will the cluster achieve the vision by itself or might it need some support? | If not mentioned probe in relation to:<br>1. research and development capabilities (public or private);<br>2. supply of labour with relevant skills and provision of relevant training;<br>3. sources of funding for new or existing companies;<br>4. other support from national or local government/economic development agencies;<br>5. access to new customers or suppliers (local, national, or international);<br>6. local leadership or strategic vision.<br>7. Importance of the infrastructure? |
| **Q21 – Resilience**<br>What contexts, if any, threaten cluster evolution along the lines described above? | Focus on pinch points, bottlenecks, vulnerabilities (if any). |
| **Q22 – Leadership**<br>Does the cluster have strong leadership and a strategic vision for its development over the medium- to long-term? | To what extent are leading actors thinking collectively about opportunities? |

**WE HAVE COME TO THE END OF THE INTERVIEW, DO YOU HAVE ANYTHING YOU WOULD LIKE TO ADD REGARDING THE CLUSTER, ITS DEVELOPMENT AND OR FUTURE PROSPECTS WHICH HAVEN'T BEEN COVERED?**

**---------- END ----------**

# Appendix 2: Interpretive Framework

This document situates the questions from the topic guide in a framework to write up case studies. For each bullet point, summarize findings that emerged from the questions indicated.

The sections in the suggested framework are:

- Cluster overview;
- Core assets;
- Skills;
- Knowledge exchange;
- Governance networks; and
- Discussion: Innovation opportunities and needed support

**Some notes on applying the framework:**

As interview qualities and case contexts will differ, not all questions will be relevant in each case. Similarly, information relevant to the topic heading may have been discussed in response to questions not listed. *Please consider this a set of guidelines and not a rigid framework.*

Note that data from secondary sources mentioned in the interviews should be included where appropriate to add detail and should be cited.

Also note that some findings will be repeated across bullets. Skills, for example, tend to come up in several places. This is to be expected and should be considered indicative of significant themes - where a consensus has emerged about either core strengths or areas that might benefit from intervention or support.

In each section, we have included some metrics that might be useful for situating the cluster. This data can be collected for the ecosystem more generally or, where feasible, for the cluster/relevant sectors. Where possible, comparisons should be made over time (rather than with other clusters) to establish rate of change and growth potential. We recommend that all data be interpreted in the context of the qualitative findings. Slowing growth on some metrics could indicate that the cluster is changing technological trajectories because it is highly innovative and that measures need to be adapted or expanded.

Each section concludes with a "self-assessment" section where investigators can synthesize their observations using the guidance provided.

## Cluster overview

**Overview metrics**

The most useful metrics here will establish basics about the business base of the cluster these can include:

- Number of firms in industries related to the cluster, and growth over time;
- Data on entrepreneurship and startup rates;
- Data on average ages of firms, firm lifespans, and churn.;
- Total employment in the cluster and changes over time;
- Where relevant, these metrics can be disaggregated by industry or sector to demonstrate emerging areas of growth.

- Characteristics and history: Q1 (How would you characterise what this cluster is and does?) and Q2 (How has this cluster evolved?).
- Geography and size: Q3 (How would you define the cluster in terms of where it is physically located/concentrated and its size?) and Q6 (Can you characterise the mix of firms that currently populate the cluster in terms of size, age, etc.?).
- Areas of potential future growth: Q5 (What are and where are opportunities for growth and innovation?)
- **Reflections**: Reflect on the extent to which this is a cluster based on the findings presented in this section. Does the level of activity in this area seem significant? How established is the cluster? Does it have growth potential? Is there a coherent shared vision for the future of the cluster - if yes, describe.

## Core assets

**Core assets metrics**

Metrics in this category will capture fundamentals about cluster assets. Note that some of these categories do not lend themselves well to quantification (e.g., infrastructure does not have an easy or generic metric).

- Additional data on the business base, such as firm sizes, prevalence of foreign owned firms;
- Research funding to universities and colleges (e.g., HERD, total funding from government, etc.);
- Number of firms in relevant incubator or accelerator programmes;
- Data on firms participating in government R&I funding programmes;
- Data on VC deals or private equity rounds, where appropriate.

- Anchor firms: Q7 (Which firms (or businesspeople) are most active in contributing to the development and dissemination of knowledge in the cluster?) and Q4 (What firms, or people, are the key actors in the cluster?).
- [Use sub-bullets to list different key actors and roles]
- Higher education and training institutions: Q8 (What role do local universities or colleges play in developing and disseminating knowledge in the cluster? Specifically, which universities and colleges, and which departments, institutions or leaders?).
- [Use sub-bullets to list different key actors and roles]
- Other research and anchor organisations: Q8 (Are there any significant government labs and research organisations? Government actors?).
- [Use sub-bullets to list different key actors and roles]
- Support structures and infrastructure: Q15 (What are the key supporting organisations and their roles in the innovation process?) Q17 (Is any specific or specialised (public or private) infrastructure a significant source of competitive advantage?)
- [Use sub-bullets to list different key actors and roles]
- Finance: Q16 (What have been the most important sources of financing for the growth of the businesses?

**Reflections:** Reflect on the extent to which the assets listed are suitable for the direction of evolution and to deliver on the development vision for the cluster. What are the main gaps and

opportunities? Which actors could or should be supported or involved in co-designing initiatives to address these gaps?

## Skills

**Skills metrics**

These measures focus on the quality and composition of the talent pool.

- Educational attainment and qualifications profile (this is usually available at the regional scale but may be difficult to disaggregate by relevant sectors);
- Occupational profiles;
- Labour demand statistics and job projections;
- Graduate retention rates;
- Average job tenure;
- Graduation rates from relevant/specialised degrees or training programmes;
- Job creation targets.

- Talent pool: Q13 (Does the cluster have a competitive advantage in specific skill sets?)
- Local skills provision: Q14 (To what extent are skills locally developed versus sourced externally? What local education or training programmes are most important for skills development (if any)? If skills are sourced externally, where from?)
    - [Use sub-bullets to highlight specific programmes or initiatives]
- **Reflections**: Reflect on the skills status quo and on existing and emerging gaps. Consider which types of programmes should be emphasised (e.g., specialist skills training for the cluster, general skills that could be developed, leadership or management skills training, etc.) and which institutions are best suited to delivering these. Also note differences in timelines in terms of programme implementation and workforce impacts. What interventions are needed in the short term, and what options exist or could be created, and how do these differ from longer term needs?

## Knowledge exchange

**Knowledge exchange metrics**

Knowledge flows and networks are very difficult to measure in clusters and so qualitative methods will generally provide more targeted insights. Because not all forms of knowledge exchange are reported or available by sectors or at relevant geographies, measures may not capture the vigour or vibrancy of knowledge flows and diffusion in a region. Where geographies align, the UK Innovation Survey and Innovate UK have data on:

- Business collaboration practices;
- Collaborative research;
- Sources of innovation.

- Firm research and development practices: Q7 (Which firms (or businesspeople) are most active in contributing to the development and dissemination of knowledge in the cluster? How innovative are they? Are they active in R&D?) and Q9 (Are firms actively seeking out local or external sources of knowledge for their innovation processes?)
- Knowledge sharing and flows: Q10 (How is knowledge disseminated and transmitted in the cluster?)

- Knowledge access and cultures: Q10 (How accessible is the knowledge to firms in the area? Do actors share knowledge frequently or easily? Is knowledge shared through any cluster wide activities? Is it 'managed'?) and Q7 (Do the leaders in the cluster have a culture of 'openness'? How so?) and Q11 (Would you say that a culture of collaboration and/or knowledge exchange between companies and with other organisations (e.g., universities, etc.) has developed within the cluster?)
- Firm network relationships: Q11 (How do firms typically interact with one another?)
- **Reflections**: Reflect on the practices of knowledge production and exchange as well as cultures associated with sharing knowledge. Are there any gaps, challenges, or bottlenecks? Particularly explore whether there are barriers to knowledge exchange specific to certain segments of the economy (e.g., between higher education and firms, between firms of different sizes, between firms in different sectors, etc.).

## Governance networks

**Network metrics**

As with knowledge exchange, networking practices are difficult to measure and are more effectively assessed using qualitative methods. Some potential indicators may be insightful, if available:

- Existence of relevant local networking groups and highly connected individuals;
- Number of members in cluster associations;
- Attendance at networking events;
- Number of related networking events.

- Cluster development networks: Q12 (Are there key people or networks (formal or informal) related to cluster development, management, strategy, best practices? What are their roles?) and Q22 (To what extent are leading actors thinking collectively about opportunities?)
    - [Use sub-bullets to highlight key networks/actors, if more than one]
- **Reflections**: Reflect on the state of evolution of cluster development networks and leadership. Are the networks that presently constitute the cluster suitable for the direction of evolution? Note any gaps but also the nature of the relationship between cluster organizations and leaders, if more than one is currently active. Do cluster leaders and their networks have a coherent vision for cluster evolution and are they able to articulate coherent goals? What is the primary focus of their development efforts and their ambitions - is it localised, enabling cluster growth, or externally oriented seeking connections to national or global networks? Do the existing networks have the capacity to enact their visions?

## Discussion: Innovation opportunities and needed support

**Metrics**

Relevant metrics are comparable to those typically sought by Innovate UK for assessing the scale and growth rate of innovation opportunities, the market access through innovation, and the additionality of public support.

- Size and growth rate of the domestic and global markets that the cluster aligns to;
- Evidence of the suitability of the cluster's innovation capabilities to the needs of the future market;
- Data points showing firms have skin in the game and could go further, faster with public support

Conclude by assessing the future potential of the cluster.

- Evolution and market opportunities: Q18 (How do you think the cluster will evolve in the short- to medium-term?) and Q19 (How do you imagine that the market opportunities for this cluster will evolve over the medium- to long-term?)
- Resilience: Q21 (What contexts, if any, undermine cluster evolution along the lines described above?)
- Areas of potential support and intervention: Q20 (Will the cluster achieve the vision by itself or might it need some support?) Is there a clear case for intervention?
    - [Use sub-bullets to list multiple areas]

**Concluding Reflections:**

Given the findings of the preceding sections, how well equipped is the cluster (in terms of assets, skills, knowledge base and knowledge exchange, and governance networks) to leverage and evolve to seize future market opportunities and manage challenges? If you have insight into national growth priorities and policies, please comment on how well cluster ambitions and assets align with these.

Reflect on priority areas for support and what might be needed in terms of programming or resources to enable, or steer, cluster activities. Which actors will be central to those efforts, either from within the cluster or through partnerships across Government departments.

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