

# Chapter 5

## Prime Capability 3 - Advanced Manufacturing, Chemistry and Materials

**'Britain is extraordinarily well-placed to benefit from this new industrial revolution. We are an open enterprising economy, built on invention, innovation and competition. Our universities and research institutions are among the best in the world. ... We have many industries - from financial services to advanced manufacturing, from the life sciences to the creative industries - which are world leading. To benefit from the opportunities before us, we need to prepare to seize them.'**<sup>1</sup>

*Industrial Strategy - Building a Britain fit for the future<sup>1</sup> page 7*

### **The North West Coastal Arc Clean Growth & Sustainable Partnership and UK strategy documents**

Advanced materials are a key tool for advanced manufacturing and are named as one of the UK's Eight Great Technologies. UK businesses that produce and process materials have a turnover of around £170 billion per annum, represent 15 per cent of the country's GDP and have exports valued at £50 billion. There is particular interest around additive layer manufacturing also known as '3D printing'. This new technology is possible not just because of advances in IT but also because of advances in the materials that go into the process.

The UK Chemistry Growth Strategy Group (CGSG) has committed to the following vision 'By 2030, the UK chemical industry will have further reinforced its position as the country's leading manufacturing exporter and enabled the chemistry-using industries to increase their Gross Value Added contribution to the UK economy by 50%, from £195 billion to £300 billion.' Analysis completed by Chemistry Innovation highlight three areas as priorities: raw materials for the 21st century; smart manufacturing processes; and design for functionality. The scale of each area's contribution was assessed within the 2013 Chemistry Innovation Strategy<sup>18</sup>.

**Moving towards a regenerative circular economy. Raw materials:** The potential longer term benefits of using biomass or waste as raw materials reach £8 billion. There is also potential for using new technologies to replace scarce metals, as defined in the Industrial Biotechnology Innovation and Growth Team Report.

**Design for functionality:** A further £10 billion opportunity is identified for formulated products with designed-in functionality. Currently, the formulated products market in the UK is worth about £180 billion a year, and the UK is recognised as a strong player globally.

That advantage needs to be better coordinated and developed, to enable growth in both domestic and global markets. A conservative estimate of the potential benefit of intervention on materials chemistry (to create substitutes for materials currently imported) stands at £5 billion. Chemical products designed for a 'circular economy' offer additional potential: about £1 billion is currently achievable through design for waste management and recycling, and this figure could grow up to tenfold by 2020. The Industrial Strategy highlights the importance of raising the resource productivity of businesses, including through the promotion of recycling and strong secondary materials markets where products are designed with recyclability in mind.

This is also a time of rapid change in manufacturing. The full integration of digital capabilities in manufacturing - referred to as 'Industry 4.0' - and adoption of new materials and manufacturing processes, will drive high productivity growth in businesses able to adopt them. The 'Made Smarter Review 2017'<sup>15</sup> was built around this concept and focuses upon a need to equip the UK with the means to fully embrace the next industrial revolution through a series of recommendations around Adoption, Innovation and Leadership activities designed to make the UK a leader in industrial digitalisation technologies and skills.

The 2013 report Emerging Trends in Global Manufacturing Industries (United Nations Industrial<sup>16</sup> Development Organisation) identified 'sustainability' as one of eight megatrends influencing the future of Advanced Manufacturing. Innovation around advanced manufacturing, chemistry and materials, by extending the life of materials and products, lowering carbon intensity and increasing the recovery and reuse of high value elements, will improve the resource use efficiency of manufacturing, whether energy, water or other natural resources. As such, this capability has natural and fundamental linkages to Environmental Industries, Technologies and Services (especially resource use efficiency, recycling and waste management: Chapter 3), and Future Energy Systems (reduced greenhouse gases emissions and energy use: Chapter 4).

**The Government's Industrial Strategy identifies Clean Growth as one of the Grand Challenges to put the UK at the forefront of industries of the future.**



The NWCA boasts a rich industrial heritage and is often quoted as 'the birthplace of the industrial revolution'. The manufacturing assets, skills base and research excellence that have evolved here over generations, today provide the innovation capacity needed to develop the new tools to deliver key elements of the 'Industrial Strategy' in the context not only of the 'The Clean Growth Strategy'<sup>2</sup> and the 25 Year Environment plan<sup>6</sup> but also the Future of Mobility Grand Challenge in the Industrial Strategy. As already highlighted in the Wave 1 Sheffield City Region and Lancashire SIA<sup>17</sup>, our region has particular strengths in aerospace and automotive manufacturing (5.1.1 and 5.1.2 respectively), and so is intimately linked to the drive towards low carbon transport highlighted in the Clean Growth Strategy. Beyond that, these major sectors have been the stimulus for a diverse and innovative supply chain, often of SMEs, across many types of advanced chemicals and materials (5.1.3). This audit has further clarified the potential of that supply chain to deliver materials and know-how that could contribute to the productivity, efficiency and sustainability in sectors beyond aerospace and automotive.

### 5.1.1 Aerospace

The UK Aerospace industry has an annual turnover of £31 billion and its productivity has grown by 30% in the last five years. With an 18% global market share (largest in Europe and second only globally to the US) the sector employs at least 128,000 directly and 140,000 indirectly. Almost a decade's worth of work is in hand with an order book of more than 13,000 aircraft worth up to £195 billion to the UK. (Information courtesy of ADS group)<sup>19</sup>. In aerospace, the fundamental drivers remain the rapid international growth of markets, fuelled by increasing demand for air travel and the need for modern aircraft in both civilian and defence sub-sectors. As a result, opportunities lie in the processing of advanced lightweight materials, and expertise in how best to exploit these.

### Global Centre of Excellence in Glass for R&D, Innovation and Training (Glass Futures Ltd)

Glass Futures Ltd is a new collective comprising a number of the world's largest glass industry companies in partnership with leading glass research universities including Liverpool, Nottingham, Swansea and Cambridge and Liverpool City Region's Metro Mayor, and St Helens Council. With a primary hub based at Pilkington's St Helen's site, the group's vision is to revitalise the domestic glass industry and diversify its application across other sectors to drive national economic and productivity growth.

### 5.1.2 Automotive

The Automotive sector is equally important to UK PLC employing at least 169,000 people directly and a further 78,000 across the supply chain. Manufacturers claim that 80% of a vehicle can be made on UK soil with more than 2,000 automotive suppliers (including 18 of the world's top 20) situated here. The sector has an annual turnover of £71.6bn and annually adds approximately £12.4 billion to the UK economy. The Made Smarter Review 2017 identified Automotive as a key sector for growth with clear opportunities presented through the adoption of innovation and digitalisation within manufacture. The production of connected and autonomous vehicles is also predicted to grow with an estimated 25,000 new jobs forecast to be created<sup>20</sup>.

In parallel to the Clean Growth agenda, the automotive sector clearly has a significant role to play in the UK Industrial Strategy's<sup>1</sup> Grand Challenge around the Future of Mobility, which aims to put the UK at the forefront of the design and manufacturing of zero emission vehicles, with all new cars and vans effectively zero emission by 2040.

Aligned to this ambition will be £1bn support over 10 years for the development of low carbon power trains, grants for the purchase of low emission vehicles, investments in electric vehicle charging infrastructure and an Automotive Sector Deal setting out how government and industry will work together to achieve this strategic mission.

### 5.1.3 Cross-cutting advanced chemicals and materials

This is part of a UK manufacturing sector that relies on chemistry to generate £600 billion of annual aggregate sales<sup>23</sup>. With an annual turnover of £60 billion the sector is consistently the UK's biggest manufacturing contributor to the national balance of payments, posting an annual £5 billion trade surplus. It supports 500,000 jobs and contributes 6.8% of UK manufacturing GVA. From a global perspective, world chemicals turnover was valued at €3.4 trillion in 2016, of which the UK contributed 7% of total sales. However, since 2012 the UK's chemicals imports have risen faster than exports, reducing the traditional surplus in chemical and pharmaceuticals from around £0.5 billion per month to around £0.3 billion per month<sup>18</sup>.

The NWCA's strength in aerospace and automotive has acted as a stimulus for a strong and innovative community of businesses, often SMEs, across the range of advanced chemicals and materials.

Table 5.1  
**Advanced Manufacturing, Chemicals and Materials Research and Innovation Assets**

Asset	Location	Aerospace	Automotive	Advanced Chemicals & Materials
Advanced Manufacturing and Research Institute	N Wales	✗	✗	✗
Advanced Manufacturing Centre for Skills Development and Employer Engagement	Lancs	✗	✗	✗
BEACON Biorefining Centre of Excellence	N Wales			✗
The BioComposites Centre	N Wales			✗
Built Environment & Sustainable Technologies Institute at Liverpool John Moores University (LJMU)	M'side			✗
Centre for Global Eco-Innovation	Lancs	✗	✗	✗
cTAP (Collaborative Technology Access Programme)	Lancs			✗
Engineering Innovation Centre	Lancs	✗		✗
Environment Centre for Wales at Bangor University	N Wales			✗
Glass Futures	M'side			✗
Hartree Centre	Ches	✗	✗	✗
Institute for Risk & Uncertainty at Liverpool University	M'side	✗	✗	✗
Lancaster Leadership Centre	Lancs	✗	✗	✗
Lancaster Product Development Unit	Lancs			✗
LCR4.0	M'side	✗	✗	✗
Lloyd's Register Foundation	M'side	✗	✗	✗
Low Carbon Eco-Innovatory	M'side	✗	✗	✗
Manufacturing Technology Centre (MTC@LJMU)	M'side			✗
Materials Innovation Factory	M'side			✗
Northwest Advanced Manufacturing Research Centre	Lancs	✗		✗
Optoelectronic Technology Incubation Centre	N Wales		✗	✗
Quantum Technology Centre	Lancs		✗	✗
Sci-Tech Daresbury	M'side	✗	✗	✗
Sensor City, Liverpool	M'side	✗	✗	✗
Unilever R&D	M'side			✗
The Virtual Engineering Centre	M'side	✗	✗	✗



### Sub-sectors of advanced manufacturing and chemicals

The UK plastics industry consists of approx. 6,200 firms with an annual turnover of over £23.5 billion and employing approx. 170,000 people. In 2015 the UK exported £7.5bn of plastic and plastic products making it one of the UK's top ten exports. The use of plastics globally has increased 20-fold in the last 50 years and is expected to double again in the next 20 years (The New Plastics Economy, Ellen MacArthur Foundation (2016). By 2020 it is expected that the global plastics industry will be worth in excess of £500 billion. The UK Plastic Industry's 'Strategic Vision for Growth' identified key objectives for future growth including, 'improving the Industry's skills base and educational support' and 'accelerating the sustainability of the plastics industry and its alignment to the circular economy', both closely aligned with the objectives of this Science and Innovation Audit. The growing concern over plastic pollution provides a very strong link to Environmental Industries, Technologies and Services (Chapter 3).

The global ceramic composites market was valued at £1.7 billion in 2016 and is projected to reach £5.6 billion by 2026. The market is expected to expand at an estimated compound annual growth rate (CAGR) of 9.65% from 2016 to 2026 due to increasing demand for lightweight and high-performance ceramics that substitute metals and other conventional materials. Technological adaptiveness and R&D are critical factors for companies in this market because of intense competition, rapid change in technology, and customers with evolving demands. A significant amount of energy is consumed during ceramic composite production and technology providers are making efforts to develop energy-efficient production processes to reduce both greenhouse gas emissions (Chapter 3) and overall cost.

The global market for high performance metals alloys was estimated at £5.9 billion in 2016, growing at a CAGR of 4.7% over the forecast period (2016-26). The industry is likely to grow due to increasing demand for the high-performance alloys in critical applications across multiple sectors. One example is the growing demand for light materials in the aerospace industry which is expected to drive rapid market growth over the next decade.

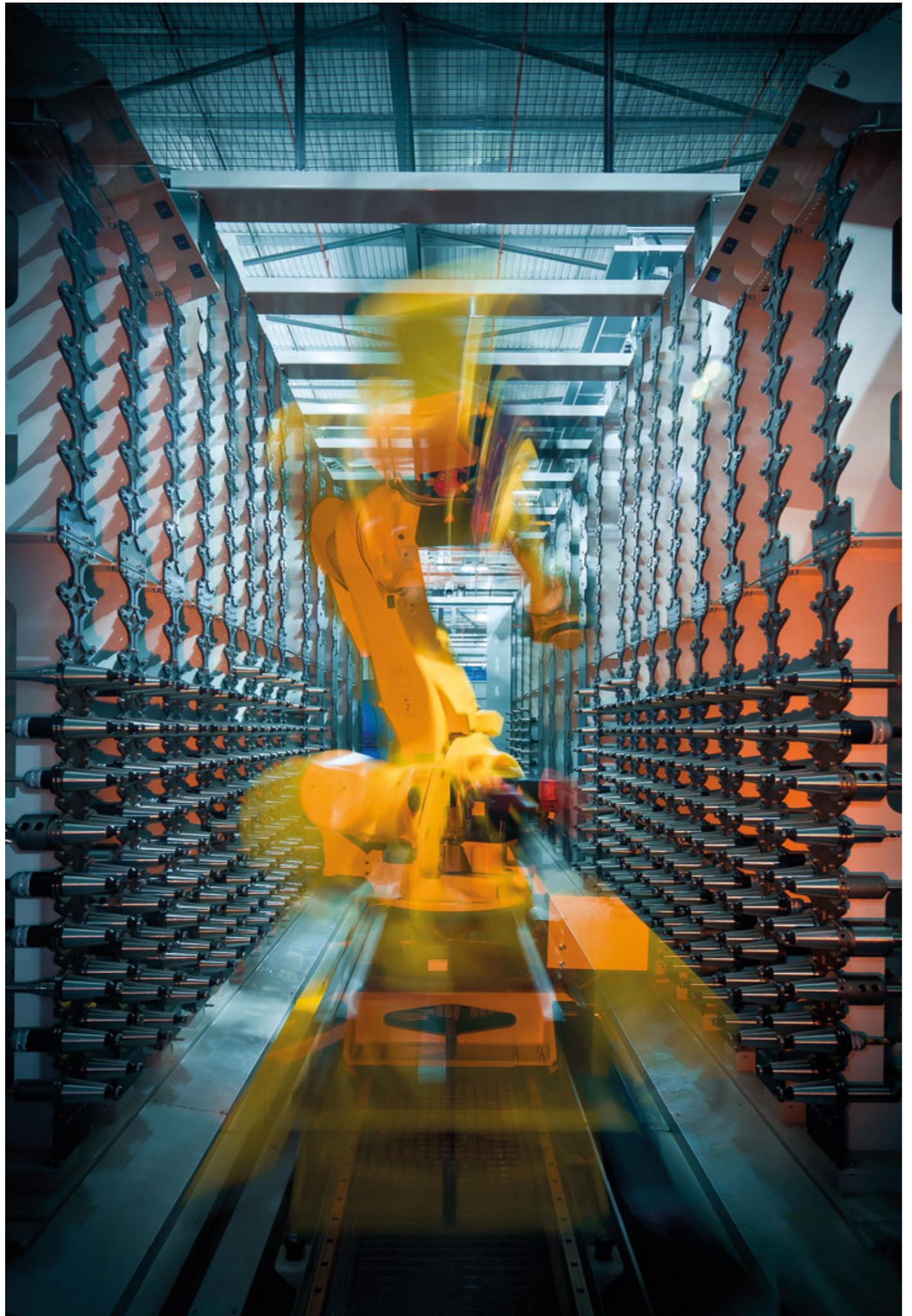
The current market value of nanomaterials is around £17 billion (EC, 2014a) and the spectrum of commercially viable applications is increasing rapidly (e.g. medicine, imaging, energy and hydrogen storage, catalysis, lightweight construction, and UV protection). Applications such as carbon black and amorphous silica have already reached high volumes. Other nanomaterials target low-volume but very high value markets such as medicine, which currently accounts for the highest share of applied Nano products (Vance et al., 2015).

Notable examples with a primary focus on Advanced Manufacturing, Chemicals and Materials include (i) Materials Innovation Factory (MIF) (ii) Virtual Engineering Centre and LC4.0 and (iii) the North West Advanced Manufacturing Research Centre.

In Merseyside, the **Materials Innovation Factory (MIF)** is a £65 million partnership between the University of Liverpool, Unilever and HEFCE to develop a unique materials chemistry research hub. Officially opening in late 2018, it will provide an unparalleled suite of open access, state-of-the-art equipment and internationally-leading academic expertise to develop fundamental innovations in manufacturing at the molecular level and create new materials with step-change functional enhancement in a range of important applications. Liverpool John Moores University provides complementary support in specific areas, for example in materials technology design and performance.

The **Virtual Engineering Centre (VEC)** is a UK centre leading in the integration and exploitation of Virtual Engineering technologies such as advanced modelling and simulation and immersive visualisation for industrial and commercial applications. VEC comprises a multi-disciplinary team including specialists in engineering, computer science, visualisation and manufacturing technology, and is underpinned by the University of Liverpool and specialist Centres of Excellence. Located at both Sci-Tech Daresbury and The University of Liverpool. It acts as a hub in communicating research back to potential end users, while providing competitive advantage to industry. VEC is part of **LCR 4.0**, a collaborative community that connects SMEs to expertise and support from key knowledge assets in the region.

Many of our research and innovation assets are active across multiple aspects of Clean and Sustainable Growth, some across all three themes of this SIA.



SMEs are able to explore the potential of Industry 4.0 technologies by accessing support ranging from research and development, knowledge transfer and the acceleration of ideas from concept through to commercialisation. Other partners include Liverpool John Moores University, the University of Liverpool, Sensor City, Liverpool City region LEP and the Hartree Centre.

The audit has also highlighted that two major new research and innovation assets focused on advanced manufacturing are being developed in different parts of the NWCA and are led by the Advanced Manufacturing Research Centre (AMRC) part of the High Value Manufacturing Catapult Network. These are the **North West AMRC** based on the Samlesbury Enterprise Zone (EZ) in Lancashire, focused on supporting advanced manufacturing supply chains and driving productivity improvements in regional SMEs and the **Advanced Manufacturing and Research Institute** in Broughton on North Wales focusing on aerospace, automotive, nuclear and food. Both integrate across multiple sectors and all three capabilities of this Science and Innovation Audit and so are described in detail in Chapter 6.

## 5.2.2 Industrial assets

### 5.2.2.1 Aerospace Sector

As highlighted by the Wave 1 audit (high value manufacturing) led by the Lancashire and Sheffield City Regions<sup>17</sup>, Lancashire holds the greatest concentration of aerospace production in the UK and 4th largest globally. Lancashire's key capabilities include the design, testing, manufacture and assembly of aerospace components and a tightly integrated supply chain feeding into those larger companies. Around 20,000 people in the county are employed in 120 companies, including major players such as BAE Systems, Rolls-Royce and Safran-Aircelle, and supply chain companies such as Kaman, Assytem and Spirit Aero Systems.

Lancashire sites are contributing roughly £6 billion of output to the F35 fighter jet programme, which is the UK's single largest trade contract.

The North West Aerospace Alliance (NWAA) is a key industry organisation in the region, representing and uniting companies and organisations involved in the aerospace supply chain. Formed in 1994 NWAA represents approximately 25% of the UK aerospace industry with over 220 member companies and a combined turnover in excess of £7 billion.

North Wales also has particular strengths in this area, playing host to companies including Airbus Broughton (which manufactures wings for all Airbus commercial aircraft), BAE Systems, Gardner Aerospace and CAV Aerospace which develops new 'green' technologies for aeronautical applications.

### 5.2.2.2 Automotive Sector

The strength of the automotive sector in the NWCA region lies in its diversity, ranging from volume car manufacturers and prestige brands to niche vehicles and truck manufacturers. Companies include: PACCAR (Leyland Trucks), Sankt Gosei, and Erlson in Lancashire; Bentley Motors in Staffordshire; Vauxhall in Cheshire; Toyota's engine plant in Deeside, North Wales and Jaguar Land Rover and Getrag Ford in Merseyside. These key employers are supported by an extensive supply chain operating across the design and manufacture of vehicles and components, including high value parts for Aston Martin and Bentley. A recent addition to the automotive supply chain in the area is Plastic Omnium which has opened a 240,000 sq ft state-of-the-art manufacturing facility in Warrington. The company provides bumpers and plastic body parts for Jaguar Land Rover's Halewood plant.

The North West automotive cluster generates some £9 billion of the total UK automotive manufacturing economy which equates to approximately 12% of the UK total, placing it as the second most significant region for automotive manufacture in the UK. It employs an estimated 16,200 people. The Northern Automotive Alliance is an independent, not for profit, company which provides membership service combined with a project management delivery function to the automotive community.

### 5.2.2.3 Multi-sector Assets related to Advanced Manufacturing, Chemistry and Materials

Stoke-on-Trent and Staffordshire host Alstom, Coors, JCB, Moog, and Ztek alongside Bostik, Fuchs (polymers), Michelin (lubricants), Perkins, MG Sanders, Goodwin (engineering), Steelite International, Wedgwood Waterford and Royal Doulton (ceramics). All use novel and new applied materials (metallic and non-metallic) in their products and demand low carbon innovation to remain globally competitive.

The Cheshire and Warrington economy was founded upon chemicals, petrochemicals and minerals with much of the sector remaining an important employer today (over 5,000 people work in the chemicals industry in Cheshire and Warrington which represents almost 1.2% of total employment in the region)<sup>22</sup>. Companies include Astra Zeneca (chemicals/pharmaceuticals), Bodycote PLC (surface engineering technologies), Siemens (variable speed drive manufacture) and Tata Chemicals (producing feedstock materials for the glass industry).

As well as these focused strengths in aerospace and automotive, the region is home to numerous international businesses across advanced manufacturing, chemicals and materials.

Figure 5.1  
Research quality for the NWCA in the six sub-disciplines included under our Advanced Manufacturing, Chemicals and Materials capability (AMCM), compared with other major university groups or regions.

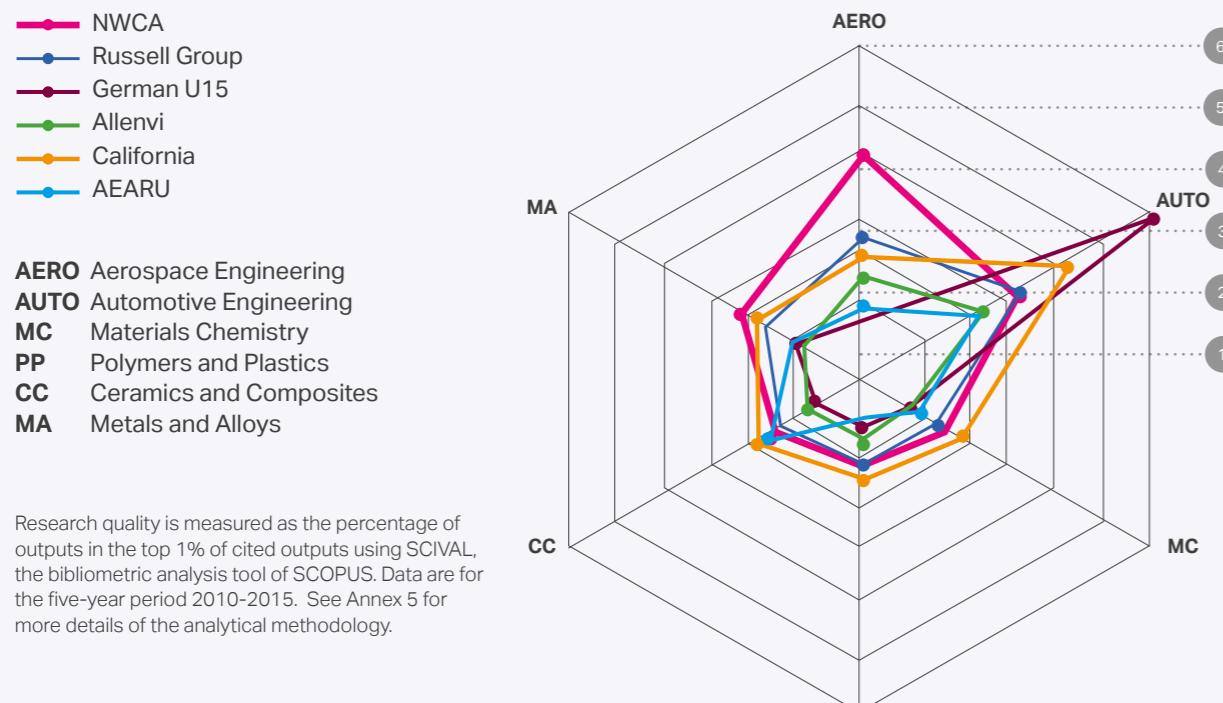
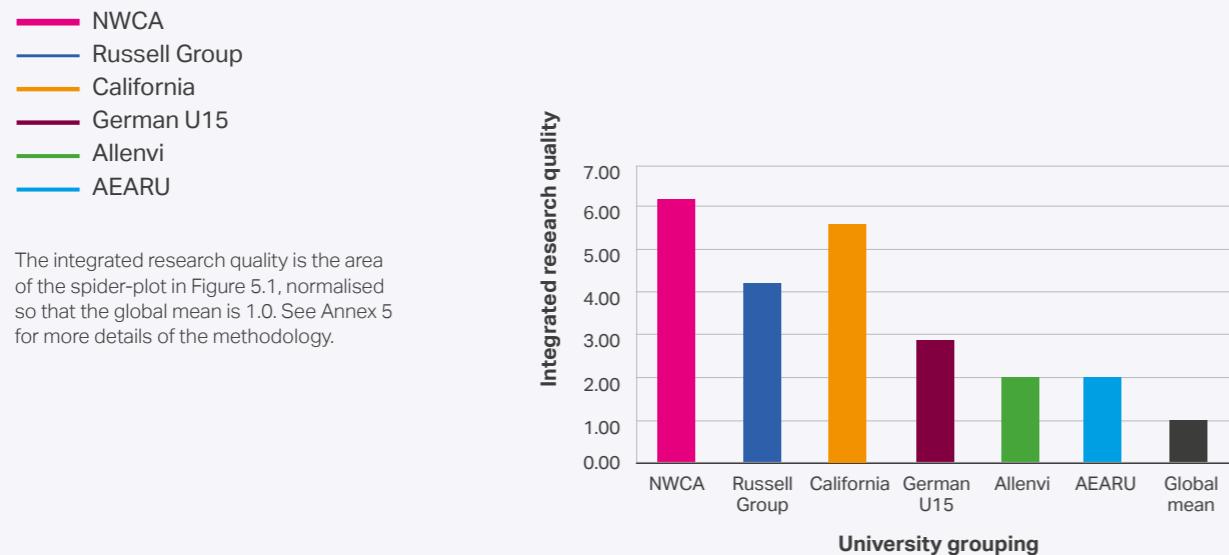


Figure 5.2  
Integrated research quality across Advanced Manufacturing, Chemicals and Materials for the NWCA compared with other major university groups or regions.



Other niche and specialist companies include Surface Transforms, who design and make high-performance brakes from carbon fibre reinforced ceramic composite materials, and Waters Corporation's 'International Centre of Excellence' for Mass Spectrometry. The 37-acre site employs some 500 staff and in addition to its expanded manufacturing capacity the facility contains enhanced research and development capabilities. Other global companies include Henkel Consumer Adhesives, Britton Taco (polyethylene production) and Flexfilm (UK prime specialist polyethylene extruder), Thor Specialities and Harman Technology (specialist products for the professional imaging industry).

Lancashire boasts one of the largest economies in the Northern Powerhouse with 52,350 businesses generating over £29bn per year<sup>23</sup>. Around 85,000 workers are employed in the manufacturing and engineering sectors with major employers (outside of aerospace and automotive) including Alstom Transport, Victrex, Eka Chemicals, Ashi Glass Fluoropolymers, Hanson Heidelberg Cement Group, Crown Paints and Promethean.

In Merseyside, Unilever R&D at Port Sunlight employs c.1,000 scientists and a further 1,500 senior staff in their manufacturing hub, in addition to the powders manufacturing site at Warrington Bank Quay. Unilever has recently announced the closure of 4 major European sites (including the Rotterdam R&D hub) with the associated 2,000 jobs potentially destined for relocation to the UK subject to planned infrastructure investment in the North. Liverpool John Moores University has partnered with the Manufacturing Technology Centre (MTC), part of the High Value Catapult Network, to create MTC@LJMU. The Centre encourages collaborative partnerships between the University and businesses to develop products for the maritime industry, as well as highlighting the potential of emerging technologies and access to new funding streams. MTC@LJMU contributes to delivering world class services to industry through LCR4.0.

### Insulate Ltd. Innovative Insulation Fixing and Hanging Devices

Insulate Ltd is a Cumbrian based SME specialising in the development, manufacture and sale of insulation products for the construction industry. They are working with the Lancaster Product Development Unit at Lancaster University to develop an innovative method of positioning and installing cavity wall insulation systems for installation during the construction process. Lancaster has provided Computer Aided Design (CAD) models and used them in Selective Laser Sintering (SLS) to allow the company to produce accurate prototypes, mitigating the need for costly tooling or time-consuming subtractive manufacturing methods. As a result, Insulate moved quickly to produce a final mould tool for use in the first production run.

Cumbria has a long industrial heritage and manufacturing companies continue to be significant employers. Two of the UK's largest industrial sites are located in the county, Sellafield (treated in detail in the NW Nuclear Arc SIA) and the submarine shipyard operated by BAE Systems at Barrow-in-Furness. Other multinational companies manufacturing in the county include Pirelli Tyres, Nestlé, United Biscuits, Iggesund Paperboard, Kimberley-Clark, Heinz, Sealy Beds, GSK bio-pharmaceuticals, Innovia Films and Siemens sub-sea technologies.

## 5.3 Local science and innovation talent

### 5.3.1 The current workforce and the likely future skills needs and sources

Our audit of the current NWCA workforce relevant to Clean and Sustainable Growth showed the challenge of separating sectors that are strongly inter-linked. For that reason, we cover this across capabilities in Annex 6. There are also substantial overlaps between capabilities in training provision and need at all levels, so these common elements are also covered in Annex 6. We focus here on specific skills need and provision for Advanced Manufacturing, Chemicals and Materials.

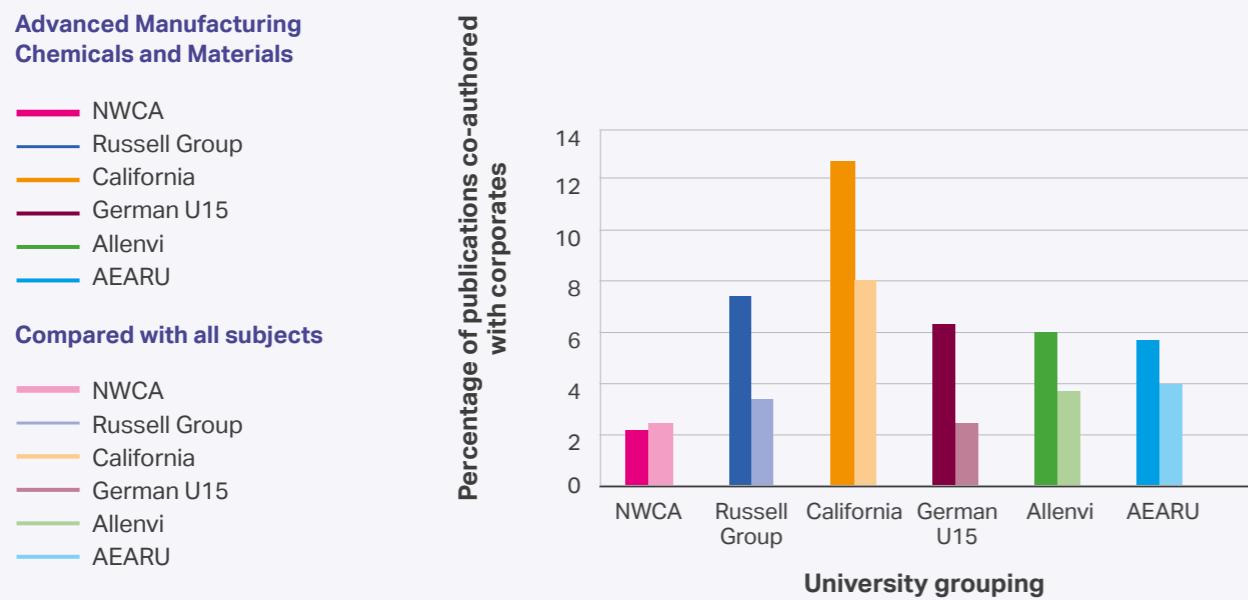
Whilst the output of the region's higher education institutions includes substantial numbers of STEM and management graduates and some can demonstrate good 6-month retention rates, the loss of highly trained graduates to the south of England remains a consideration. To combat this in part, university and private sector partners have responded by developing award winning or best practice schemes working with the SME community to unlock barriers to graduate employment and to break down graduate perceptions of SME careers.

### Cambridge Biopolymers Ltd. Commercial applications for vegetable oil derived thermosetting 'bioresins'

Cambridge Biopolymers Ltd are working with the BioComposites Centre at Bangor University to commercialise novel proprietary patented technology around the manufacture of thermosetting 'bioresins' from vegetable oils. These products will find use in applications currently dominated by formaldehyde-based resins, such as wood-based panels and fibre reinforced composite applications.

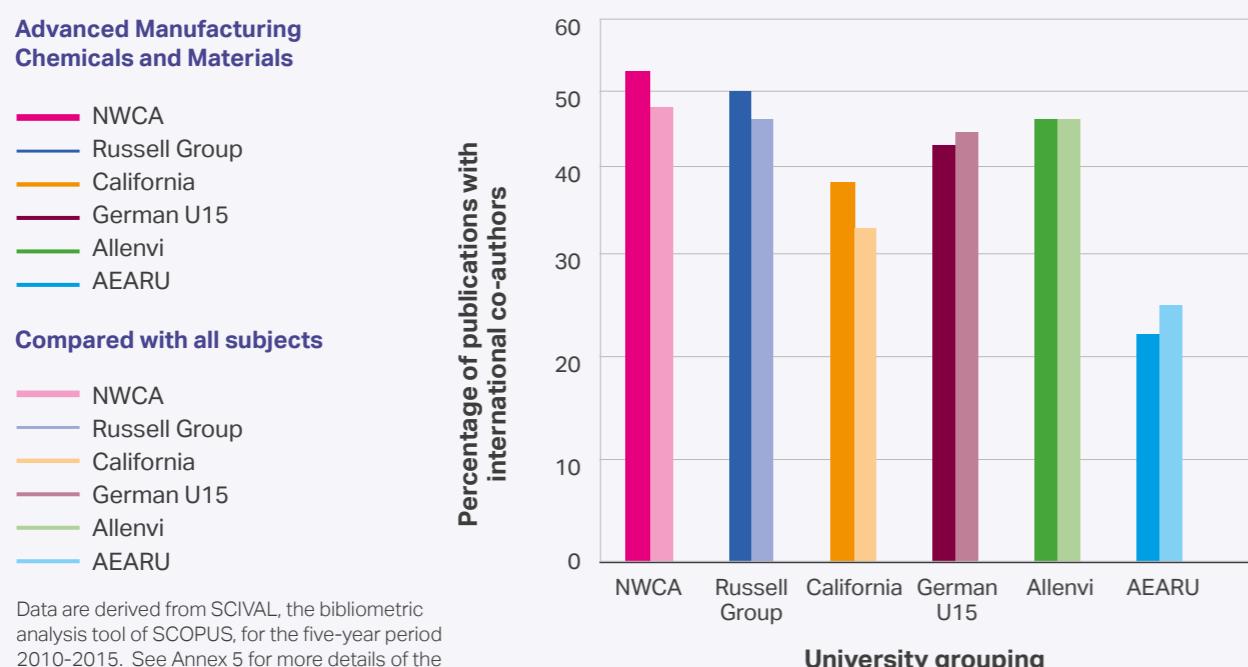
North Wales is also home to a number of globally significant manufacturers and engineers including Warwick Chemicals, Headland Agrochemicals, BASF Coatings, Kingspan, Tata Steel Europe, Sharp Manufacturing and Honeywell<sup>24</sup>.

Figure 5.3  
**Percentage of Advanced Manufacturing, Chemicals and Materials (AMCM) research outputs co-authored with colleagues from a non-academic (corporate) organisation. Data for the NWCA are compared with other major university groups or regions.**



Data are derived from SCIVAL, the bibliometric analysis tool of SCOPUS, for the five-year period 2010-2015. See Annex 5 for more details of the methodology.

Figure 5.4  
**Percentage of Advanced Manufacturing, Chemicals and Materials (AMCM) research outputs co-authored with colleagues from outside the UK. Data for the NWCA are compared with other major university group or regions.**



Data are derived from SCIVAL, the bibliometric analysis tool of SCOPUS, for the five-year period 2010-2015. See Annex 5 for more details of the methodology.

The University of Central Lancashire's **Engineering Innovation Centre (EiC)** is a £40m project developing the University's research, knowledge transfer and training capabilities in Engineering. The EiC is a signature knowledge transfer project within the Lancashire Strategic Economic Plan, working with local SMEs to prime the advanced engineering and manufacturing sector.

**The Knowledge Economy Skills Scholarships (KESS 2)** scheme is a major pan-Wales operation led by Bangor University supported by European Social Funds (ESF) through the Welsh Government. KESS 2 links companies and organisations with academic expertise in the Higher Education sector in Wales to undertake collaborative research projects, working towards a PhD or Research Masters qualification. Research elements are integrated with a higher-level skills training programme, leading to a Postgraduate Skills Development Award. Lancaster University is a partner in the Institute of Coding, a national consortium of more than 60 universities, businesses and industry experts that will tackle the UK's digital skills gap. The government's £20m investment will be matched by a further £20m from industry, including in-kind contributions such as training and equipment. A pipeline of world class digital skills is essential to exploit the productivity improvements enabled through increased industrial digitisation as outlined in the Made Smarter Review<sup>15</sup> and the collaboration of universities, employers and industry leaders can help graduates build the right skills, in fields ranging from cybersecurity, artificial intelligence through to industrial design.

Lancaster is leading the **Employer Engagement for Skills in Manufacturing and Engineering (EnginE)** project. This £2.3m project will build capacity within Advanced Engineering and Manufacturing SMEs for higher level skills provision and degree apprenticeships. EnginE has been co-designed by Higher Education (Lancaster), Further Education (Blackpool and the Fylde College, Blackburn College) and industry partners (North West Aerospace Alliance, Northern Automotive Alliance and BAE Systems) and will engage with 200 SMEs within the project lifetime.

#### Blackpool and The Fylde College Degree Apprenticeship Provision

In providing the requisite skills for Clean and Sustainable Growth, Blackpool and the Fylde College are acutely aware of the importance of developing a multi-disciplinary portfolio of core knowledge competencies in line with requirements of the relevant sectors. The approach adopted is one of co-creation where the graduating skill sets required by specific technicians and entry level staff are identified in close collaboration with employers. The aim is to effectively fulfil forward demand for apprenticeships at all levels by bringing together experiential learning and an enquiry-led approach where theory can be contextualised into practice. The Apprenticeship in Civil and Defence settings is now in its third year, with a Materials Science Degree Apprenticeship (spanning the physics and chemistry of matter, engineering applications and industrial manufacturing processes) in the early stages of development.

As well as these focused strengths in aerospace and automotive, the region is home to numerous international businesses across advanced manufacturing, chemicals and materials.

#### 5.3.2 Evidence-based assessment of the region's existing science and innovation talent

As with other capabilities our very rigorous approach to comparing research quality (i.e. defining quality as the percentage of outputs in the top 1% of citations in the field, and comparing the NWCA with leading national and international university groupings plus California: Figure 5.1a) highlights not just research excellence but also clear specialisations in some groups. The NWCA's outstanding research excellence in Aerospace Engineering is clear against all comparators, as is the specialisation of the German U15 in Automotive Engineering (Figure 5.1.). However, unlike the U15, the NWCA's excellence in Aerospace Engineering is supported by real strength in depth across Materials and Chemistry disciplines. The percentage the NWCA's outputs in the top 1% of cited outputs is equal to or greater than that of the Russell group across all six AMCM disciplines, substantially so for Metals & Alloys and Polymers & Plastics (Figure 5.1). The region outperforms these comparators, including the Russell group and other international comparators, only California shows similar breadth in research excellence (Figure 5.1). The NWCA's integrated research quality in AMCM, the area of the research space, slightly exceeds that of California, and is well ahead of all other comparators (Figure 5.2). Looking ahead, this SIA and other activities are beginning to highlight how excellence in AMCM can cross-fertilise our other capabilities, notably Future Energy Systems (Chapter 4). Equally, the region's excellence in Waste Technology and Management (included under Environmental Industries, Technology & Services, Chapter 3) offers synergies with AMCM in relation to an integrated perspective on the circular economy of a wide range of materials.



This further illustrates the power of the NWCA's holistic vision of eco-innovation, based on current experience and as developed further in Chapters 6 and 7.

#### 5.4 National and international engagement

Engagement between the NWCA's research based and national and international research users in AMCM is evident from the many assets listed in Section 5.2. Other measures of engagement emerge from the SCIVAL analysis of research metrics for publications with corporate co-authors and publications with international co-authors.

Across all the comparator groups audited, a much greater percentage of research outputs are jointly published with corporate co-authors in AMCM than expected from the mean across all subjects (Figure 5.3). Surprisingly, despite the region's many research and innovation assets and high-quality research across the AMCM subject area, this difference is less evident in the NWCA than in our comparators (Figure 5.3). We are publishing fewer AMCM research outputs with corporate co-authors (2.3%) than all our chosen comparators.

The other two comparators are much lower (38% in California and 23% in the East Asia AEARU group). With the exception of AEARU, the percentage of research outputs published jointly with international co-authors in AMCM subjects is similar to or slightly higher than expected from the mean across all subjects (Figure 5.4), with the NWCA having the largest difference (55% in AMCM compared with a mean of 48% across all subjects). As with the other themes, the NWCA stand up well in terms of publications with international partners, even against these strong comparators.

#### 5.5 Developments in the wider funding landscape

The UK Government Industrial Strategy aims to make the UK the world's most innovative nation by 2030. To support this aspiration government has committed to investing a further £725 million over the next three years into the Industrial Strategy Challenge Fund. Of the four Grand Challenges (Artificial Intelligence, Clean Growth, Ageing Society, Future of Mobility) identified in the industrial strategy, Advanced Manufacturing, Chemistry and Materials is likely to play an especially significant role in improving productivity and sustainability under the Clean Growth and Future of Mobility Grand Challenges. In particular, Innovate UK has recently announced opportunities for up to £30 million of collaborative match funding for UK-developed late stage R&D to support advanced low carbon propulsion technologies in automotive. Through the scheme UK based R&D projects are sought that will significantly reduce carbon dioxide emissions and improve air quality. A further £20 million is also available to support the commercialisation of prototype quantum devices.

The Research councils also have a role to play in supporting the acceleration of innovation through designated funding calls. Of particular relevance to the Advanced Manufacturing, Chemistry and Materials theme are the EPSRC funding streams which will make almost £800 million available from EPSRC resource funding and the £15 million Global Challenges Research Fund, plus a further £54 million of capital funds designed to pump prime the development of EPSRC World Class Labs.

The NWCA publishes a higher percentage of its AMCM research outputs with international partners (55%) than all our university group comparators.