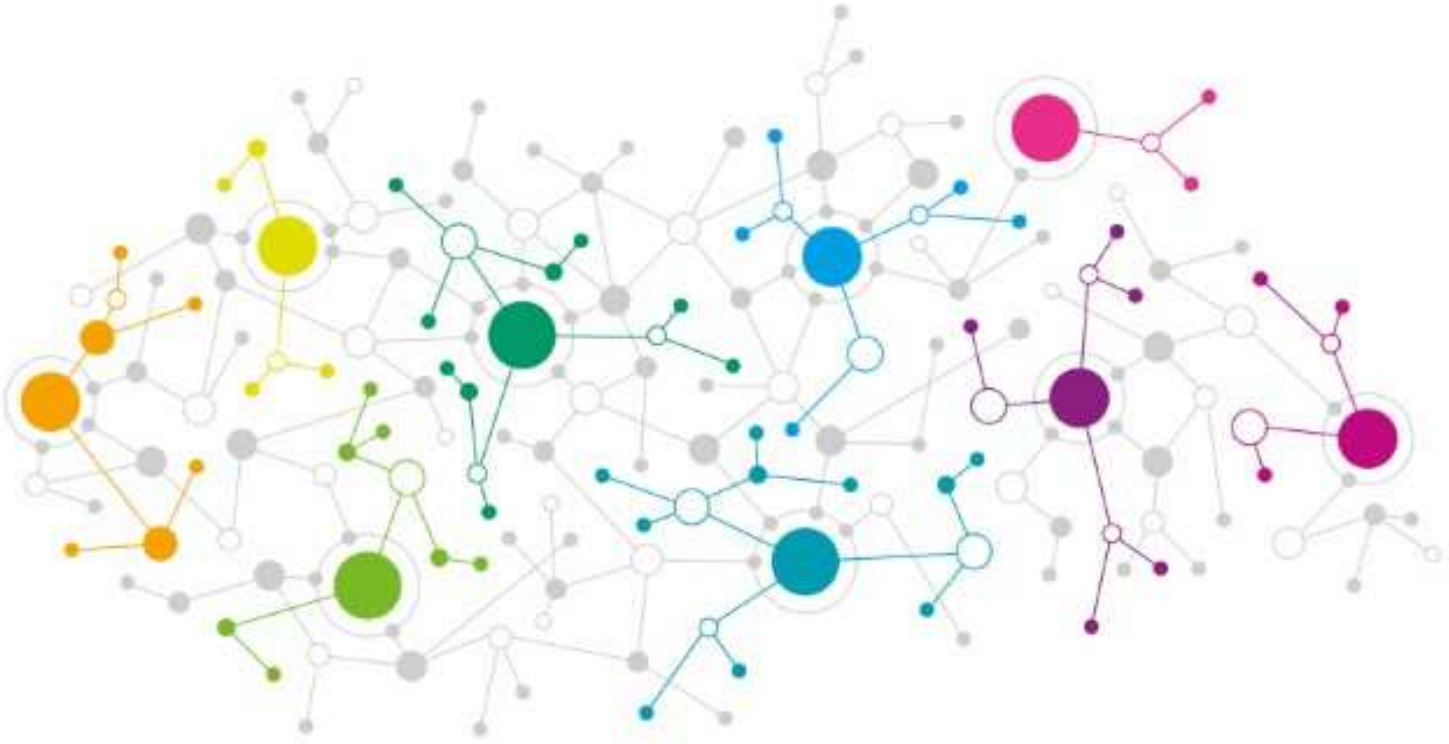
A Science and Innovation Audit Report for the Midlands Engine, sponsored by the Department for Business, Energy & Industrial Strategy

Volume 1: Main Report

01 November 2016



Contents

Midlands Engine SIA – the headlines

1. In Autumn 2015 the UK Government announced regional Science and Innovation Audits (SIAs) to catalyse a new approach to regional economic development. SIAs enable local consortia to focus on analysing regional strengths and identify mechanisms to realise their potential.

2. In the Midlands Engine, a consortium was formed to focus on our strengths in Next Generation Transport, Medical Technologies and Pharmaceuticals, Future Food Processing, and Energy and Low Carbon. This report presents the results which includes broad-ranging analysis of the Midlands Engine's capabilities, the challenges, and the substantial opportunities for future economic growth.

Context

3. The Midlands Engine is the heartbeat of the UK's economy. Built on an internationally-competitive and highly connected manufacturing base, and enhanced by a range of complementary sectoral strengths, the Midlands Engine is positioned perfectly to drive improved productivity performance for the UK in the rapidly evolving and increasingly digitised 21st century global economy.

4. The Midlands Engine is home to almost 12 million people, 18% of the UK's total. The diversity of our population is also one of our key strengths. We are a £230 billion economy, generating approximately 15% of the UK's GVA.

5. The region's sectorally diversified economy includes a strong manufacturing base, with the Midlands Engine accounting for around 21% of the UK's total manufacturing GVA in 2014. The region supports over five million employees, nearly one in five across Great Britain (GB) as a whole. Approximately one-fifth of all business R&D in the UK is delivered within the Midlands Engine footprint.[1]

6. However, despite the scale and diversity of our regional economy, our productivity performance lags behind national levels. The latest data (for 2014) indicate GVA per employee in the Midlands Engine at £44.6k, compared to £49.85k across the UK as a whole. Productivity deficits are evident across our economy, in both manufacturing and service-based sectors.[2]

7. Driving-up productivity has framed this Science and Innovation Audit and is the key long-term priority for the Midlands Engine. This will mean capitalising on the existing strengths in our business base, and leveraging fully the critical mass of world-class science and innovation assets across the region.

Our SIA Framework for long-term productivity growth

Three Enabling Competencies

- **Advanced Manufacturing and Engineering**: covering the region's pervasive leading-edge technical knowledge, and practical know-how, in designing, validating, producing, and servicing new products and industrial processes, across a diverse and increasingly integrated range of sectors and markets.
- **Digital Technologies and Data**: covering the strengths in the region's academic, research and industrial base in exploiting and understanding data and information, including satellite-enabled data, and the use of digital technologies in product, process and service development and research commercialisation.
- **Systems Integration**: covering the strengths in the region's academic, research and industrial base on how increasingly complex systems – from energy and transport systems, through to manufacturing and service delivery – can be better designed, managed and operated.

Four Market Driven Priorities

- **Next Generation Transport**: covering aerospace/space, automotive, motorsport and rail sectors, with a focus on high performance system simulation/modelling; advanced digital design/physical validation; advanced materials/processes; and digital manufacturing, supply chain and service management
- **Medical Technologies and Pharmaceuticals**: covering medical devices, diagnostics (including in vitro diagnostics and diagnostic imaging), software as a medical device, and pharmaceuticals
- **Future Food Processing**: covering the areas of 'food processing efficiency', 'delivering a zero waste food chain'; and 'food product innovation' in the food and drink sector
- **Energy and Low Carbon**: covering geo-energy, thermal energy systems, nuclear, energy storage and smart integrated energy systems.

Moving Forwards

8. This audit has created the opportunity for the key players around the Midlands Engine area to come together and identify clear and current opportunities for growth. Unsurprisingly, in a region of the reach and vibrancy of the Midlands, significant efforts are already underway that provide a close match to some elements of the market opportunities we have identified. In particular:

- Midlands Innovation's thinking on '*Transport Innovation for a Low Carbon Economy*' that takes forward aspects of the Next Generation Transport theme
- The proposed National Space Park, which would bring a step change to space research and space-enabled data service provision
- Proposals for Life Science Opportunity Zone status for the former AstraZeneca site at Charnwood
- Emerging proposals for building on the significant investments made in the region through the Energy Research Accelerator (ERA).

9. These projects are welcome early steps in taking forward key elements of this ambitious audit. However, in order unleash our full productivity potential and deliver the economic transformation that this SIA has shown is possible, more will need to be done.

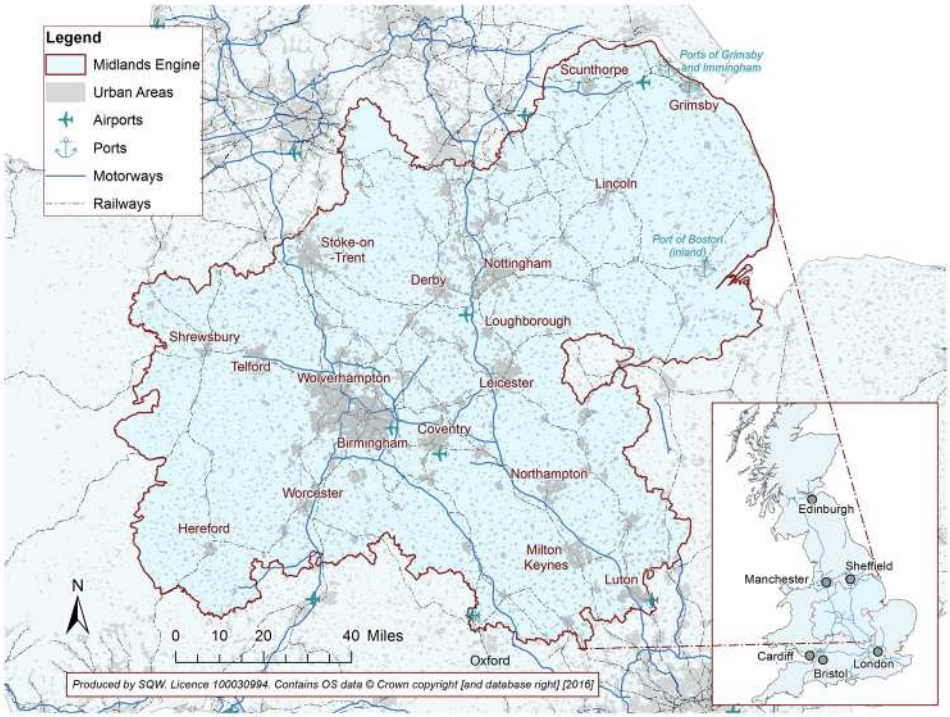
1. Introduction to the Midlands Engine SIA

1.1 Our strategic spatial location, and the quality, scale, and export-oriented nature of our economy, make the Midlands Engine the heartbeat of the UK's economy. Built on an internationally-competitive and highly connected manufacturing base, and enhanced by a range of complementary sectoral strengths, the Midlands Engine is positioned perfectly to drive improved productivity performance for the UK in the rapidly evolving and increasingly digitised 21st century global economy. We are also well equipped to make a substantial and lasting contribution to the Government's developing industrial strategy. Leveraging fully our science and innovation excellence is a prerequisite for success in delivering on these key intents.

The place

1.2 A diverse and substantial economy, the Midlands Engine covers 11 Local Enterprise Partnership (LEP) areas. The region contains important urban centres, including internationally significant core cities like Birmingham and Nottingham, and growing regional hubs like Stoke-on-Trent, Derby, Milton Keynes, Lincoln, Coventry, Leicester and Wolverhampton. The region also has a high quality natural environment, including the Peak District National Park, and market and county towns like Shrewsbury, Stafford, and Northampton, serving as economic, leisure and service centres.

Figure 1-1: The Midlands Engine



1.3 Our strategic road and rail networks such as the M6, the M1, the West Coast Mainline, the East Coast Mainline and the Midlands Mainline are of national importance. They are used to transport people and goods across the Midlands as well as across the country; HS2, with Phase One providing a high-speed link between Birmingham and central London, and proposals for an additional station between Derby and Nottingham, will strengthen further our offer at the centre of the UK's strategic transport network.

1.4 The Midlands Engine also links the UK to the rest of the world: Birmingham Airport handles more than 10 million passengers annually; East Midlands Airport is the second largest freight airport in the country; Luton airport is the fastest growing in the UK; and the airport at Cranfield University is favoured by senior business executives and investors owing to its proximity to London and the M1. The Midlands is also served by ports including Grimsby and Immingham, and Boston.

The economy

1.5 The Midlands Engine is a £230 billion economy, generating approximately 15% of the UK's Gross Value Added (GVA). The region's sectorally diversified economy includes a strong manufacturing base, with the Midlands Engine accounting for 21% of the UK's total manufacturing GVA in 2014.

Table 1-1: Midlands Engine GVA by industrial group (2014)

	Midlands Engine GVA (£m)	Proportion of UK GVA
Agriculture, forestry and fishing	2,169	20%
Production industries	44,675	20%
… of which Manufacturing	*36,681*	*21% (of UK manufacturing)*
Construction	14,977	15%
Distribution; transport; accomm, food	49,088	17%
Information and communication	9,369	9%
Financial and insurance activities	9,465	7%
Real estate activities	25,397	14%
Business service activities	24,488	13%
Public administration; education; health	44,228	15%
Other services and household activities	10,010	14%

Source: SQW analysis of ONS Sub-Regional GVA data. Note: numbers may not add to 230bn owing to rounding

1.6 The region supported over **five million employees in 2014**, nearly one in five across Great Britain (GB) as a whole. The region's diversified employment base is set out in Table 1-2, which shows over 650,000 employees in health industries, and more than 600,000 in manufacturing (representing 26% of the GB total), with a Location Quotient of 1.5, well above the national average (GB = 1.0).

Table 1-2: Midlands Engine workplace based employees by Broad Industrial Group (2014)

Broad Industrial Group	Employees in ME	Location Quotient	% GB total
Mining, quarrying & utilities	67.9	1.1	19%
Manufacturing	616.6	1.5	26%
Construction	217.3	1.0	17%
Motor trades	126.9	1.4	25%
Wholesale	251.5	1.2	22%
Retail	507.8	1.0	18%
Transport & storage (inc. postal)	260.5	1.2	21%
Accommodation & food services	290.4	0.8	15%
Information & communication	134.5	0.7	12%
Financial & insurance	106.8	0.6	10%
Property	72.3	0.9	16%
Professional, scientific & technical	328.9	0.8	15%

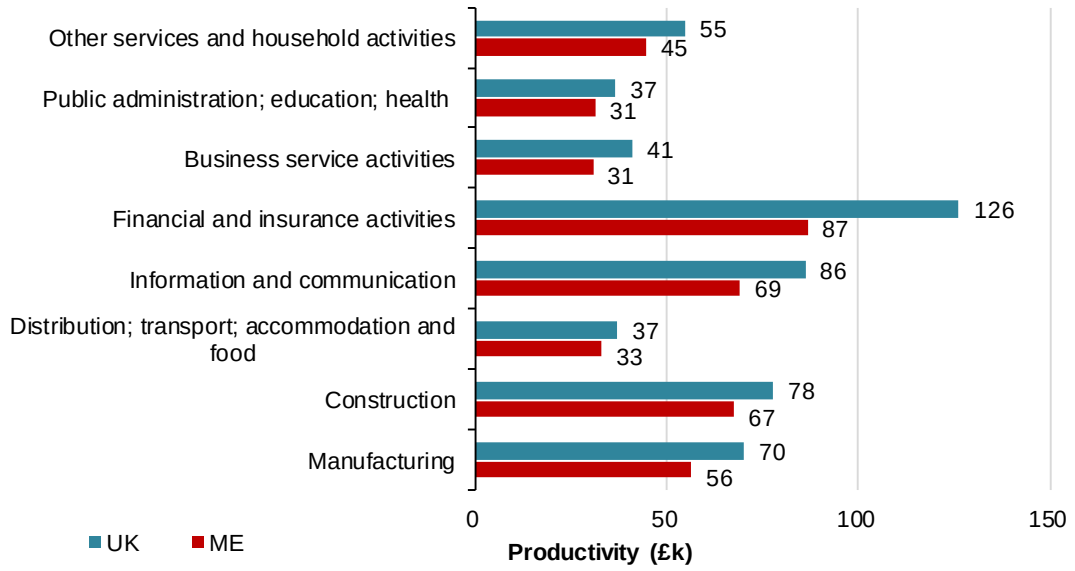
Broad Industrial Group	Employees in ME	Location Quotient	% GB total
Business administration & support services	456.8	1.0	19%
Public administration & defence	207.5	0.9	16%
Education	488.0	1.0	19%
Health	654.7	1.0	18%
Arts, entertainment, recreation/other services	214.5	1.0	17%

Source: SQW analysis of BRES data. Note: Table excludes agriculture

1.7 The region is also the bedrock of the UK's manufacturing exports. Firms in the Midlands Engine generated export sales in 'Machinery and Transport' goods in 2015 of £34 billion, approaching a third (31%) of the UK's total in this category. Looking more broadly across all export types, over 12,500 businesses in the Midlands Engine exported in 2015, 17% of all UK businesses exporting.[3]

1.8 However, **despite the scale and diversity of our regional economy, our productivity performance lags behind national levels**. The latest data (for 2014) indicate GVA per filled job in the Midlands Engine at £44.6k, compared to £49.85k across the UK.[4] Productivity deficits are evident across the economy, in both manufacturing and service-based sectors, as illustrated in Figure 1-2 below.

Figure 1-2: Productivity (GVA per employee) in the Midlands Engine and GB (2014)



Source: SQW analysis of ONS data[5]

1.9 Driving-up productivity has framed this Science and Innovation Audit (SIA) process and is the key long-term priority for the Midlands Engine. This will mean capitalising on the existing strengths in our business base, and exploiting the critical mass of world-class science and innovation assets in the region.

1.10 Across our 11 LEPs, strategies and plans emphasise the need to drive-up productivity performance. Consistent with the scale and complexity of the region, different LEPs focus on different sectors to deliver against this imperative. However, there are common themes including automotive, aerospace, and agri-food, alongside established strengths such as healthcare incorporating both the pharmaceutical and medical technology sectors. The creative industries, and our tourism and cultural offers are also important strengths, and these are reflected in our local strategic commitments.

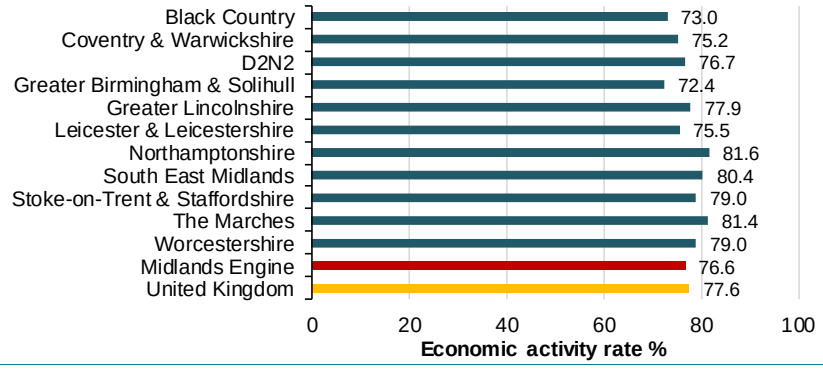
1.11 The Midlands is recognised as *the* place in the UK where high quality products across a wide range of industries are creatively designed, developed, manufactured and distributed. Local priorities focus consistently on taking advantage of our widely recognised strengths in these areas in order to boost productivity and economic growth.

The people

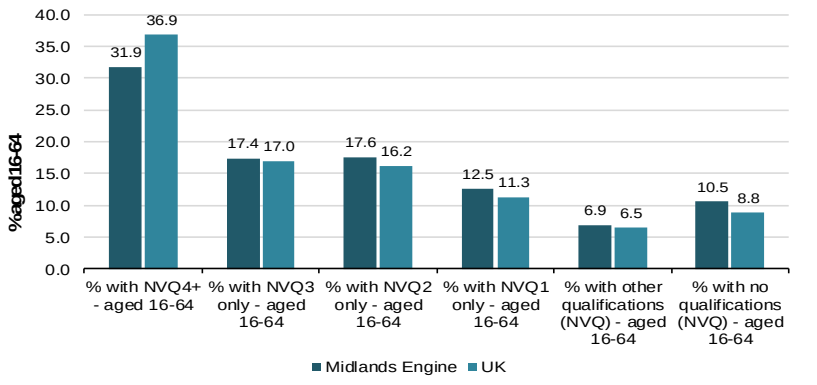
1.12 The Midlands Engine is home to almost 12 million people, 18% of the UK's total. Around 63% of our population are of working age (in line with the national level), offering a substantial and sustainable workforce and skills base. The diversity of our population is also one of our key strengths; for example, Leicester, Birmingham and Luton are some of the most culturally diverse cities in the UK. However, we face significant challenges as a region, particularly in terms of skills and the occupational mix, as summarised in Figure 1-3 below.

Figure 1-3: Economic activity, qualifications and occupations across the Midlands Engine (2015)

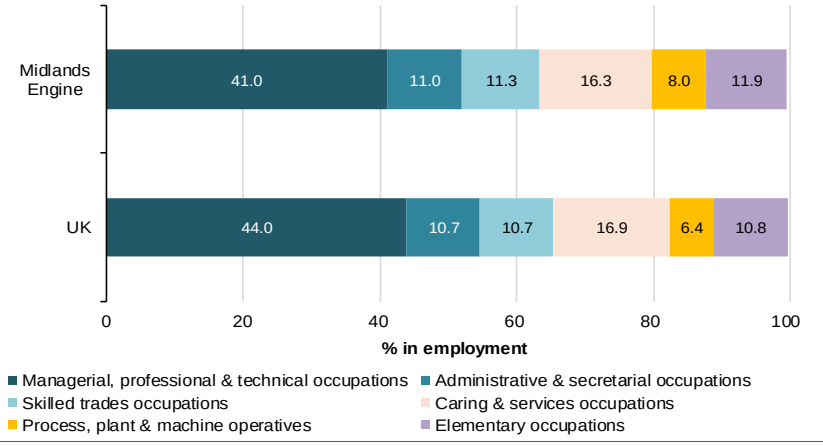
Our economic activity rate is close to the national average, but this varies across our LEP areas



We have too few people with high-level qualifications relative to the national level, and too many with no qualifications ...



... reflected in our occupation mix where we have fewer people working in managerial and professional occupations than is the case nationally



Source: SQW analysis of Annual Population Survey data. Note: all data are residence based

1.13 Whilst the focus of the SIA is on our innovation strengths and science base, these wider labour market issues matter fundamentally for addressing the productivity deficits in the Midlands Engine, and provide the underpinning context within which focused action on science and innovation needs to be taken. Further, whilst the qualifications and occupations data will vary by local area, the key message is that at a regional level, driving up skills and attracting employers offering high level occupations to the region (and retaining them) will be key to supporting our transformational productivity agenda.

The ME SIA process

1.14 Given the scale of the Midlands Engine, and the emerging nature of the underpinning partnership structures and pan-regional networks, this SIA has intentionally been developed based on extensive engagement and primary research with partners and stakeholders across the region. The process of developing the SIA has been an open and inclusive one.

1.15 We have used the process of developing the SIA to build momentum with, and trust between, partners and stakeholders. By fostering new relationships and identifying synergies, the SIA process itself has helped to strengthen the innovation ecosystem(s) across the region. This innovation intent is a key element of the Government's commitment to the Midlands Engine, encompassing action to improve the skills, transport, and finance for business landscape across the region, and enhancing awareness and commitment to the Midlands as a place to visit, live, and invest.

1.16 Led and overseen by a high-level and inclusive Delivery Group with representation from BEIS, businesses, LEPs, universities, translational research bodies and science parks across the region, the SIA process has drawn on three core strands of evidence collection:

- **Strand 1: Thematic workshops** to secure feedback on the key strengths and opportunities in science and innovation across the region. Six workshops were held during the summer focused on the Themes identified in the original SIA Expression of Interest (EoI; see Section 2), attended by c.150 attendees.
- **Strand 2: E-consultation**, to provide an opportunity for partners and stakeholders not able to attend the workshops to provide their perspectives on the key strengths and opportunities in science and innovation across the region, and to collect evidence on networks and relationships to inform the SIA. In total, over 100 individual responses were collected. The organisations that responded are set out in Annex A.
- **Strand 3: Data collation and analysis**, drawing on data provided by the national contractor working for BEIS[6], and additional information from regional partners, including the work of a dedicated SIA Local Data Group. We have also drawn on data on research expertise (including citations analysis), analysis of the Business Register and Employment Survey (using the latest available data), and data on collaborative R&D provided by Innovate UK.

1.17 The qualitative and quantitative evidence has been used by the SIA Delivery Group to frame the analysis, and led to the development of a bespoke SIA Framework, which has been approved by the Delivery Group and the strategic Midlands Engine Innovation Group. The Framework sets out the key enabling competencies and market-driven opportunity areas. These are the priorities at a pan Midlands Engine level that will drive productivity growth from the science and innovation base, alongside wider investments and efforts that will be required to optimise skills, behaviours, and networks, to strengthen the innovation system.

1.18 Taken together, **our approach to the SIA has been explicitly both inclusive in engagement and focused in analysis**. The scale of the region provides significant opportunities, enabling collaboration across a diverse range of fields and providing a critical mass of science and innovation competence with which industry can collaborate. However, it also provides a challenging backdrop for an SIA, seeking to cover the breadth of the science and innovation offer in a place of 12 million people, with approaching half a million local business units, and generating around 15% of the UK's total GVA.[7] The challenge is particularly pronounced in seeking to identify the specific target areas of opportunity and excellence within this complex and crowded landscape. Ultimately, this involves making tough choices on what to focus effort and resources on – the evidence underpinning and informing these difficult strategic choices are the focus of this SIA report.

1.19 Despite the challenges, the SIA opportunity has been seized fully by regional partners. However, there is recognition that this SIA forms the first step in a longer journey to develop a competitive and integrated innovation ecosystem for the Midlands Engine, and its constituent areas. More detailed and comprehensive innovation strategy development and action planning work will continue over the next 12 months and beyond, building on the platform set by the SIA. We have also sought to ensure that the SIA process and resulting outputs can be used to define investment priorities by our LEPs and Combined Authorities.

1.20 This main SIA report sets out the key findings from the research. It is accompanied by a separate annex volume providing the detailed evidence underpinning the SIA. This separate volume includes case examples of innovation activity across the region, including how our business base (including SMEs) is collaborating and engaging with the research and scientific base, additional data on science and innovation performance, a 'long-list' of innovation assets, and further examples of innovation networks and behaviours. The annex also includes details of the organisations that responded to the SIA e-consultation.

2. SIA 'hypotheses' and 'framework'

Setting the Scene

From Themes…

2.1 Six themes were identified in our original Expression of Interest. The Themes were based on the innovation priorities in the Midlands Engine Prospectus, launched in December 2015. They were deliberately broad-ranging, reflecting both the scale and diversity of the innovation landscape across the region, and the fact that our partnership arrangements across the Midlands Engine geography were still very much in their infancy. The purpose of the six themes was to provide an accessible analytical framework for partners and stakeholders to focus on, and to frame the data analysis and engagement process. The SIA itself was tasked with testing the validity of the themes, and, where appropriate, drilling down to focus on particular specialisms where the region had genuine excellence, leadership, credibility and opportunity.

2.2 A headline profile of the six themes is set out in Table 2-1, with further details in Annex C. Note that a Location Quotient of more than 1.0 indicates that the region has an over-representation of employment compared to the national average.

Table 2-1: SIA Themes

Thematic area	Theme-level profile			Key employment sub-sectors
	Employees (2014)	Location Quotient (2014)	Local business units (2015)	
Transport Technologies	98k	1.8	1.5k	• Automotive & aerospace manufacturing & R&D
Agri-food & drink manufacturing and production	132k	1.4	33k	• Food & drink manufacturing • Manufacture of instruments/appliances for measuring testing etc.
Advanced Manufacturing & Engineering	359k	1.2	32k	• Engineering & related technical consultancy • Materials engineering & application
Healthcare, life sciences & translational medicine	312k	1.0	7.2k	• Hospital & human health activities • Medical devices & instruments
Energy & Low Carbon Technologies	180k	0.9	27k	• Electricity & gas supply • Technical testing & analysis
Creative, Digital & Design Sector	131k	0.7	27k	• Computer programming & consultancy

Source: BRES and Business Counts

… to Competencies and Market-driven Priorities…

2.3 The six themes informed the primary research and initial data analyses, with a very significant body of evidence on the science and innovation landscape across the region developed at a thematic level, including secondary data, workshop feedback, and the responses to the e-consultation. Consistent with the EoI approach, for each theme, three potential focus areas were identified, covering those activities where the feedback from partners and stakeholders suggests that the Midlands Engine has distinctive science and innovation strengths, and significant future

productivity growth opportunities. The eighteen fields identified across the six themes are summarised in Table 2-2 (further details regarding the fields, and the feedback collected through the workshops are provided at Annex D).

Table 2-2: Thematic priority fields

Transport Technologies	Advanced Manufacturing etc.	Energy etc.	Healthcare etc.	Creative, Digital etc.	Agri-food etc.
Next generation vehicles (e.g. autonomous)	Advanced materials engineering & application	Energy for 'smart' transport'	Medical technologies and pharmaceuticals	Cyber security	Food & drink packaging innovation
High performance transport engineering (aero, auto, rail)	Digital manufacturing	Energy systems integration and networks	Defence & trauma medicine	Digital and smart design for advanced manufacturing	Food & drink quality improvement
Smart transport & systems integration	Manufacturing systems integration	Thermal energy	Bioinformatics & diagnostics	Gamification – games / app development	Advanced engineering for agriculture

Source: Midlands Engine SIA

2.4 Three key (interrelated) issues emerged from the initial theme-level analysis that have informed the SIA, and the prioritisation from this 'long list' to a more focused framework for action. Each of these is considered in turn below.

- First, across the range of distinctive fields identified at an individual theme-level, there were a number of key commonalities, that reflected the nature of innovation activity across the Midlands Engine, specifically:
  - an emphasis on '*systems thinking and integration*' as a key differentiator for the region, drawing particularly on its broad industrial base, identified in the Transport Technologies, Advanced Manufacturing, and Energy Themes. Although not identified as one of the three specific fields, many attendees at the Agri-food workshop also referred to the 'integrated food system' as a strength of the region, given the breadth of activity from primary agriculture, through to manufacturing, processing, packaging, and distribution.
  - the increasing pervasiveness of *digital technologies, applications and Big Data underpinning innovation activity* in the region, particularly with the growing prominence of Industry 4.0 thinking. Digital and/or smart technologies underpinned fields across all six Themes, for example Advanced Manufacturing focused on digital manufacturing, Agri-food focused on advanced engineering for agriculture (including robotics, satellites and sensors), and Transport Technologies with autonomous vehicles, underpinned by data and digital systems.
  - how innovation and new business opportunities in the region draw heavily on *our longstanding reputation, workforce skills, and research excellence, in advanced manufacturing*, whether this is in Transport Technologies (e.g. high performance motorsport), Energy (e.g. thermal energy and innovation in industrial process engineering and control), Healthcare (e.g. medical technologies), or Agri-food (all three identified priority fields).
- Second, and related to the above, the evidence indicates that the region has an important digital and creative sector supporting over 130,000 employees. There are concentrations of highly innovative and successful digital firms in the region (including cyber security

clusters in Malvern and Nottingham, and games development clusters in Leamington Spa and Coventry) and in design and creative industries (textiles in Leicestershire, and creative and digital in Digbeth, Birmingham for instance). However, the digital and creative industries as a distinct sector is not an area where according to the headline data, the Midlands Engine as a whole can claim a genuine comparative advantage relative to other places in the UK. This is reflected in the overall regional Location Quotient (LQ) of 0.7 reported in Table 2-1, and all 11 LEP areas across the region had an LQ of below 1.0, meaning an under-representation of employment relative to the national level (Coventry and Warwickshire and the SEMLEP areas had the highest LQs at 0.95 and 0.94 respectively). These data are consistent with wider evidence. For example, recent research conducted by Nesta identified four 'creative clusters' in the Midlands Engine (Northampton, Leamington Spa, Milton Keynes, and Luton) out of 47 across the UK. However, none of our largest cities such as Birmingham, Nottingham, Leicester, Derby or Wolverhampton were found to contain creative clusters[8] although there are exciting concentrations of businesses and technology development acknowledged by the local LEPs in each case. The SIA research indicates that the core offer of the region in a digital context is in the application of digital technologies and data to support economic activity in other sectors and fields, including through our creative industrial design excellence, and some of the supporting digital capabilities associated with this such as analytics, visualisation and computer-based modelling and simulation.

- Third, advanced manufacturing and engineering skills and capabilities were increasingly regarded as 'cross-cutting' as opposed to a stand-alone area, given the interrelationships and linkages with all the other fields identified. The key differentiator of the Midlands Engine is the broad excellence in advanced manufacturing and engineering, and how this supports the development of innovative products and services across a wide range of industries.

…informed by global trends

2.5 As part of the process of identifying the Midlands Engine's distinctive science and innovation strengths and their potential for helping the region to tackle its overarching productivity challenge, partners have sought to ensure that any emerging priority focus areas are aligned fully with what the latest foresight research is calling for. The work has also been informed by the vision of the Midlands Innovation Group, which is outlined in Annex B.

2.6 In Section 5 of this report we set out a fine-grained analysis of the most relevant market and technology drivers of change. However, prior to introducing our ME SIA Framework, we summarise those global megatrends and grand challenges that we have sought to respond to.

2.7 The European Commission's Joint Research Centre developed a vision of the industrial landscape in 2025 as part of a broader foresight study[9]. The work identifies five high-level agents of change and six enablers or constraints.

Table 2-3: Agents of change and enablers or constraints

Agents of Change	Enablers/Constraints
Society • Increased importance of consumer requirements and behaviours • Changing societal risks • Increased global population • An ageing population • Increased urbanisation	**Infrastructure** • Smart and interoperable physical infrastructure • ICT infrastructure • Knowledge infrastructure • financial infrastructure **Services** • Services for customers • Services for production

Agents of Change	Enablers/Constraints
• Changing social norms, values and ethical issues • Evolving modes of education and learning • Increased social innovation • Evolving workforce and culture • Digitisation of society **Technology** • Converging technologies • New and emerging technologies • Technology dissemination **Environment** • Multiple, new energy sources • Increasing scarcity of natural resources • Need to mitigate and adapt to climate change • Increased threats to ecosystems **Economy** • Market forces • Globalisation of markets and manufacturing • Changing economic norms and values **Policy** • Evolution of international trade relations • Public policy (greater alignment, more sophisticated industrial policy and macroeconomic policy co-ordination) • Governance 2.0 (regionalism, maximise the impact of public procurement on innovation and competitiveness, and the emergence of new governance settings).	• Services for business **Materials** • Materials and reusable parts for sustainability • Advanced Materials for Performance **Technologies** • Resource-efficient and clean production processes • Flexible, smart and customer-oriented technologies • Human-Centred Factories • Digital factories • Logistics and supply chain • Holistic design **Business environment** • Global integration • Value chain optimisation • Dynamic and sustainable business models • New innovation models • New business partners (specialisation and collaboration) • Skills and talent (increased competition, more inclusive workforces, new management models and technology-based solutions) • Customer involvement **Knowledge management** • Data capture • Knowledge generation • IP management

Source: Adapted by SQW from the European Commission, Joint Research Centre, Industrial Landscape Vision 2025

The resulting SIA Framework and Hypotheses

2.8 Drawing on the theme-level analysis, and detailed work by the Delivery Group and sub-groups tasked with reviewing in greater detail the evidence, the SIA Framework is underpinned by three hypotheses.

Hypothesis 1 - Enabling Competencies

Across the Midlands Engine, its functional economies and strengthening innovation ecosystems, we have three stand-out core 'Enabling Competencies' which drive our global business competitiveness. Over the coming years, these competencies can be better developed, championed and leveraged to support faster innovation and productivity growth for the region and for the UK as a whole.

Hypothesis 2 - Market Driven Priorities

The Midlands Engine has world-class innovation strengths in four Market Driven Priority areas, underpinned by our Enabling Competencies. The potential of these four priority areas can be further unlocked by the exploitation of disruptive technologies and innovations in order to build long-term competitive advantage.

2.9 A third component is critical to the SIA Framework. This is the wider innovation ecosystem that underpins the competencies and market priorities. This includes physical assets and infrastructure (including science parks, commercial premises, transport infrastructure), funding and business support, people and skills (including innovation behaviours and mind-sets), policy and regulation, as well as networks and knowledge exchange (for example, facilitated by the region's Catapult centres and other translational assets). Getting these hard and soft infrastructure factors 'right' is essential in creating a successful knowledge-based economy, and exploiting fully the science and innovation potential in our region.

2.10 Whilst crucial, we recognise that physical assets and infrastructure including transport, funding and business support, and people and skills sit largely outside the formal remit of this SIA, and are the focus of other themes of the Midlands Engine, including the development of a transport strategy for the region via Midlands Connect. Further, while we can, and do, seek to inform national policy and regulation, these are principally the responsibility of Government and its agencies. Our third hypothesis therefore, focuses on the networks and knowledge exchange element of the innovation ecosystem, although as a region we know that in order to achieve our long-term goals, we need *all* aspects of our innovation system to be genuinely world-class.

Hypothesis 3 – Networks and Networking
Effective innovation alliances and networks exist in specific areas of the Midlands Engine. However, there is an opportunity to strengthen, better integrate, and extend the reach of these so as to support and embed a more pervasive culture of collaboration and innovation excellence, spatially, sectorally and across different technology areas. Building on the highly successful Midlands Engine SIA process, there is an opportunity to develop a more open, inclusive and market-facing science and innovation system.

2.11 The SIA Framework for the Midlands Engine is set out in full in Figure 2-1 below, along with an explanation of the three Enabling Competences and four Market-Driven Priorities. The Enabling Competencies frame the analysis of research assets and strengths in Section 3, and the Market-Driven Priorities are explored in further detail in Section 4.

Figure 2-1: SIA Framework

Three Enabling Competencies

Advanced Manufacturing and Engineering: covering the region's pervasive leading-edge technical knowledge, and practical know-how, in designing, validating, producing, and servicing new products and industrial processes, across a diverse and increasingly integrated range of sectors and markets.

Digital Technologies and Data: covering the strengths in the region's academic, research and industrial base in exploiting and understanding data and information, including satellite-enabled data, and the use of digital technologies in product, process and service development and research commercialisation.

Systems Integration: covering the strengths in the region's academic, research and industrial base on how increasingly complex systems – from energy and transport systems, through to manufacturing and service delivery – can be better designed, managed and operated.

Four Market Driven Priorities

Next Generation Transport: covering aerospace/space, automotive, motorsport and rail sectors, with a focus on high performance system simulation/modelling; advanced digital design/physical validation; advanced materials/processes; and digital manufacturing, supply chain and service management.

Medical Technologies and Pharmaceuticals: covering medical devices, diagnostics (including in vitro diagnostics and diagnostic imaging), software as a medical device, and pharmaceuticals.

Future Food Processing: covering the areas of 'food processing efficiency', 'delivering a zero waste food chain'; and 'food product innovation' in the food and drink sector.

Energy and Low Carbon: covering geo-energy, thermal energy systems, nuclear, energy storage and smart integrated energy systems.

Source: Midlands Engine

Defining our three Enabling Competencies

2.12 The Enabling Competencies underpin and support much of the innovative business activity across our region. The coverage of these competencies is not unique to the Midlands Engine, and strength in these areas is increasingly important for all advanced knowledge-based economies. However, the Midlands Engine has a critical mass of assets and expertise in these areas, which share three important characteristics:

- they are based on a strong **alignment between strengths in the science and research base and the considerable industrial assets across the region**, reflecting the private-sector led nature of much of our innovation activity. The balance between science and innovation varies across the three. However, in all cases it is this shared capacity that enables innovation activity to be delivered across a wide range of industrial sectors
- they are **evident across the region spatially and sectorally** and they are competencies where despite the size and breadth of the Midlands Engine geography, there is a genuine 'pan Midlands Engine offer', that collectively provides a base that is significantly greater than the sum of its individual parts
- they are **inherently cross-sectoral, mutually reinforcing, and forward facing**, with application, insight and knowledge in advanced manufacturing, digital technologies and data, and systems integration, playing into a wide range of sectors, and aligned fully to the agents of change and enablers/constraints outlined above.

2.13 Whilst tightly defining rapidly evolving competence areas is not always helpful, and there are important synergies between them, for the purpose of clarity and framing the SIA, the paragraphs below set out in more detail 'what' ground (in broad terms) each of the three Enabling Competencies covers.

Advanced Manufacturing and Engineering

2.14 Manufacturing is changing. The traditional focus on production is becoming outdated as the manufacturing value chain expands. In the context of the Midlands Engine SIA, advanced manufacturing and engineering therefore incorporates a much broader value chain, stretching

from R&D and product design and development, to supplier management, production, after sales services and consumption, followed by recycling, remanufacturing and reuse ('the circular economy'). This creates new opportunities for value generation, including the 'servitisation' of manufacturing.

2.15 The 'production' section of the value chain is also undergoing rapid change with the emergence of new technologies and techniques such as additive manufacturing and mobile internet. When combined, these changes have allowed the emergence of 'Industry 4.0' – incorporating automation and data exchange in smart factories (see Section 5).

2.16 As a region we have significant industrial and research capacity in this evolving context, and indeed, key players in the Midlands Engine are at the forefront of the 'Industry 4.0' agenda nationally and internationally. For example, the High Value Manufacturing Catapult is based in the region, as are two of its Centres at Warwick Manufacturing Group, and the Manufacturing Technology Centre (founded by University of Birmingham, Loughborough University; University of Nottingham and TWI); these centres contain some of the most advanced manufacturing equipment in the world and leading scientist and technicians. We have universities with globally significant manufacturing and engineering competence, for example: Cranfield's excellence in aerospace and Leicester's in space, Nottingham's Precision Manufacturing Centre, and the Midlands Simulation Group at the University of Wolverhampton focused on R&D in the area of computer simulation for engineering and related industries.

> ***E-consultation feedback***
>
> *"There is a world class research and development sector within the West Midlands with a particular focus on the regions strength in automotive manufacture and mobility. This is supported with advanced manufacturing research relating to materials production, digital technologies and design that have put the region at the forefront in the UK."*

2.17 We are also home to some of the world's leading R&D intensive firms engaged in manufacturing and engineering activity; and Advanced Manufacturing and Engineering skills are pervasive across the region. Data suggest there are over 350,000 employees in 'traditional' manufacturing and engineering industries across the region, with over-representation in employment relative to the national level of employment in ten of our 11 LEP areas.[10] The Midlands is traditionally viewed as the UK's leading region to 'make things', this perception holds true, but what we make, and how we design and make them, is changing rapidly, and we are at the leading-edge of this paradigm shift in the technologies employed, and the skills required, to meet modern manufacturing requirements.

Digital Technologies and Data

2.18 For the purposes of the Midlands Engine SIA, this Enabling Competency encompasses a broad mix of supporting scientific research and innovation strengths, physical assets and complementary technical capabilities (including highly specialised skills and expertise) that exist currently across our region. These capabilties enable organisations operating across all sectors and technology areas to derive real value and insight from the exploitation of big data and digital technologies.

2.19 We have seen through the advent of Industry 4.0 thinking how many of our globally leading transport manufacturing firms are using digital capabilities (especially advanced simulation, modelling and visualisation capabilities) and data analytics routinely to accelerate their R&D activities, improve quality, and reduce costs. Elsewhere, our software developers have produced e-health applications solutions, which support assisted-living agendas, helping to improve patient outcomes. Additionally, our researchers are undertaking globally significant research in the application of 'serious games' to business and study. In agri-food, our farmers are using sophisticated remote sensing and satellite technologies to maximise crop yields, improve farm planning, and boost productivity. Within the energy sector, the use of smart meters and connected

networks are delivering major operational benefits to suppliers, as well as real-time intelligence to consumers, which is helping to reduce and manage demand more effectively.

2.20 The core components of our digital and data Enabling Competency include:

- satellites and earth observation, for example drawing on the capabilities, specialist facilities and expertise of the East Midlands Satellite Applications Centre of Excellence;
- sensor technologies and instrumentation, with internationally significant scientific research strengths through for example, the Aston Institute of Photonic Technologies;
- digital applications development, gamification and cyber security including relatively small, but rapidly expanding digital clusters such as gaming in Leamington Spa and Cyber Security at Malvern, and research assets including the University of Birmingham's Academic Centre of Excellence in Cyber Security Research, the Cyber Security Centre at Warwick University, the Cyber Security Centre at De Montfort University, the Centre for Cyber Security and Information Systems at Cranfield University, and the Serious Games Institute at Coventry University;
- High Performance Computing (HPC) and associated strengths in software development and smart algorithms, data analytics, with the University of Warwick a founding partner in the Alan Turing Institute for data science, and visualisation, simulation and modelling to support advanced digital design, and one of five integrated supercomputing facilities, the Distributed Research using Advanced Computing (DiRAC) is based at the University of Leicester, for theoretical modelling, and research in particle physics, astronomy and cosmology.

> ***E-consultation feedback***
>
> *"Utilising virtual simulation to lower the cost of prototyping, analyse human computer interaction and provide as real an environment as possible, the Midlands Engine is leveraging the digital incubator environment and creative skills that use data and design."* Public sector respondent

2.21 As a region, we recogise fully that the big data revolution, the emergence of energy efficient and high performance computing, as well as the pervasiveness of new digital technologies and developments such as the Internet of Things are transforming the global economy. Encouragingly, we are well-positioned to exploit these opportunities, but we must continue to invest in and develop our offer if we are to 'stay ahead' of our global competitors. We must also develop and enhance linkages with other places to drive innovation activity; at present, none of the 500 most powerful supercomputers in the world are located in the region[11], so we must be outward facing, ambitious and pro-active.

Systems Integration

2.22 Systems integration, in the context of this SIA, involves research into the development of products and services that enable, and in-business implementation of, 'whole systems' approaches to a wide range of economic and social activities. It also covers how these products and services can be better designed, managed and operated, including the intelligent use of data and information to inform decision making.

2.23 Whole systems thinking and integration is particularly prominent, and evident in the region, in the areas of transport and energy. For example, in transport, for autonomous vehicles to move from the laboratory and test track to the city, requires a complex system of information technology systems, multimodal sensing (ground-based, satellite and aerial), and underpinning modelling and data analytics, to both ensure safety and make the market a viable commercial opportunity; if any one part of this system is not operating effectively, the whole is compromised significantly. More broadly, as the population continues to rise and urbanisation continues, sprawl, traffic congestion,

overloaded infrastructure, noise and air pollution will need to be managed in a much more integrated fashion; problems which the region has the expertise to address. In energy, the headline challenges of decarbonisation, an ageing infrastructure and shifts in societal expectations require a 'whole systems' rethink in how energy is generated, stored, supplied, managed and consumed.

2.24 Systems thinking and integration also has wider applications across industries and contexts, including integrated manufacturing systems ensuring efficient and high quality product design, development and production, and the management of the full-cycle food-chain from 'farm to fork', maximising the yield of primary produce, minimising waste, and making use of by-products.

2.25 The region has a critical mass of research and innovation assets with an explicit focus on systems integration. Notably, both the Energy Systems Catapult (in Birmingham) and the Transport Systems Catapult (in Milton Keynes) are based in the Midlands Engine.

2.26 We also have a range of dedicated research centres and projects focused on systems integration across sectors e.g. the Manufacturing Systems Integration Laboratory at Nottingham University focused on manufacturing processes, automation control and the use of robotics, the RAPID project at Birmingham Children's Hospital using real-time diagnostic information inspired by F1 technology to measure vital signs in children, and systems integration services to the automotive, aerospace, rail, industrial, and defence engineering sectors at Horiba MIRA in Nuneaton. Partners in the west of the region are also progressing (under the West Midlands Combined Authority) the Consortium for Distributed Intelligent Systems (CDIS), a network that draws on and builds up existing centres of research and innovation excellence in the development and demonstration of intelligent systems, with an initial focus on Intelligent Systems to the Mobility, Health and Energy sectors.

E-consultation feedback

"Innovation here is all about systems integration and effective commercialisation of technologies across a diversity of building types and multiple academic and industrial specialisms. The Midlands Engine geography has a unique combination of innovation assets and demand, plus innovative and world leading specialist whole systems thinkers such as the Energy Systems Catapult."

2.27 Crucially, across our private sector we have firms with internationally significant systems integration offers, including Rolls-Royce, Jaguar Land Rover, QinetiQ, Lockheed Martin and SNC-Lavalin, underpinned by a significant consultancy and technical testing and analysis business base.

3. Regional science and innovation assets and excellence

Overview

3.1 The Midlands Engine is home to a critical mass of science and innovation assets, covering the full 'Technology Readiness Level' (TRL) spectrum from basic and experimental research, through applied and collaborative R&D, and on to commercial implementation.

3.3 Our asset base includes 27 universities, and over 50 research technology organisations and science parks and innovation centres, including the HQs of three of the UK's Catapult Centres. Our region also includes a nationally and internationally competitive collection of industrial R&D centres across a range of sectors, including aerospace, automotive and rail, food and drink, medical technologies, and energy; indeed, the scale of our industrial and applied R&D offer is one of our key differentiators.

> ***E-consultation feedback***
>
> *"The region's strength is that it has an R&D critical mass, enabling all parts of the Technology Readiness Levels (TRLs) to be adequately covered … By bringing this community together in the first instance the innovation ecosystem will be elevated with the true gaps being identified. This will allow the region to really deliver its true potential."*

University assets and scientific excellence

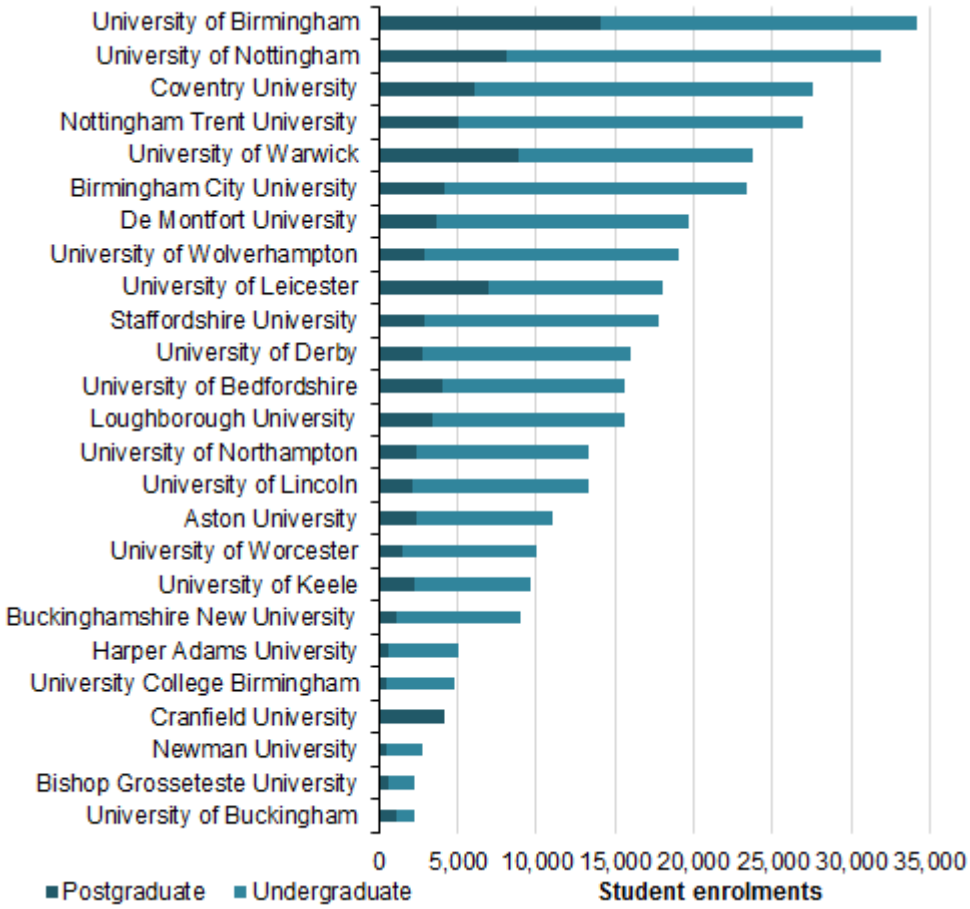
3.4 Our university assets provide the Midlands Engine with both research scale and excellence across the full range of scientific and research disciplines. The region also offers students, academics, and businesses a complementary mix of research-oriented and teaching-focused institutions, and early stage 'pure' and later stage 'applied' industrial collaboration models.

3.5 Whilst competing for the brightest and best talent at national and international levels, our universities also work closely together to generate synergies from shared excellence. For example, 'Midlands Innovation', a partnership of the universities of Aston, Birmingham, Leicester, Loughborough, Nottingham and Warwick, are currently collaborating on the £180m Energy Research Accelerator (ERA), to tackle some of the biggest energy challenges facing the UK. 'Midlands Enterprise Universities' a collaboration of Birmingham City University, Coventry University, Nottingham Trent University, University of Derby, University of Lincoln, University of Wolverhampton, and De Montfort University, is a partnership of seven universities working collaboratively to promote economic growth and productivity gains across the Midlands.

3.6 Over 375,000 students enrolled at our residential universities in 2014/15 (see Figure 3-1), meaning **one in five of all students signed-up with residential English universities was studying at one of our universities**. A further 107,000 students enrolled at the Open University, which has its base in the region in Milton Keynes.[12]

3.7 Excluding the Open University, four of the UK's 20 largest universities by total student numbers are located in the Midlands Engine: Birmingham; Nottingham; Coventry; and Nottingham Trent universities. These (and other) large multi-disciplinary universities are complemented by specialised institutions, for example, Cranfield University focuses on post-graduate education in technology and management, and Harper Adams specialises in farming and agricultural studies.

Figure 3-1: Universities in the Midlands Engine and student enrolment numbers in 2014/15



Source: HESA, HE student enrolments by HE provider, level of study, mode of study and domicile 2014/15 Note: excludes Open University; HESA data does not include specific data for University Campus Milton Keynes, which is part of the University of Bedfordshire

3.8 The Midlands Engine is a major driver of scientific research. **Our institutions secured 30% of all UK Research Council funding over the 2010-2015 period, in total around £1.4bn.**[13] Figure 3-2 shows the proportion of Research Council funding secured by Midlands Engine universities, and the scale of the funding by detailed subject area. Note that data on EU Horizon 2020 funding is discussed in Section 6.

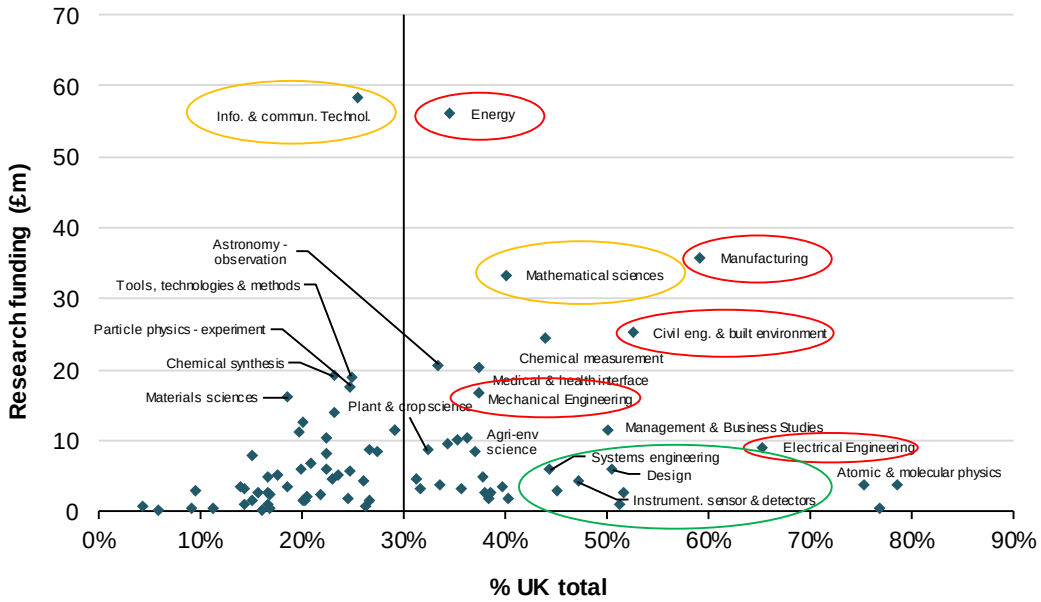
3.9 The funding data reflect strongly our identified 'Enabling Competencies':

- *Advanced Manufacturing and Engineering*: our institutions secured significant funding, absolutely and relative to the UK in 'Manufacturing', 'Energy', 'Civil Engineering/Built Environment', and a high relative share in 'Electrical Engineering' and 'Mechanical Engineering' (*highlighted in red in* Figure 3-2)
- *Systems Integration*: our institutions secured a high relative share in 'Systems Engineering', 'Instrumentation, Sensor and Detectors' and 'Design' (*highlighted in green in* Figure 3-2)
- *Digital Technologies and Data*: Information and Communications Technology was the single research area where our institutions secured the highest level of funding absolutely, approaching £60m, over a quarter of the UK total, and Mathematics (also of relevance to the other capabilities) (*highlighted in orange in* Figure 3-2).

3.10 The data also indicate significant research income in subjects underpinning our identified Market-Driven Priorities (for example, agri-environmental science for Future Food Processing, medical

and health interface for Medical Technologies); these are explored in detail in Section 4 of this report.

Figure 3-2: Research council funding secured by the Midlands Engine (2010-15)



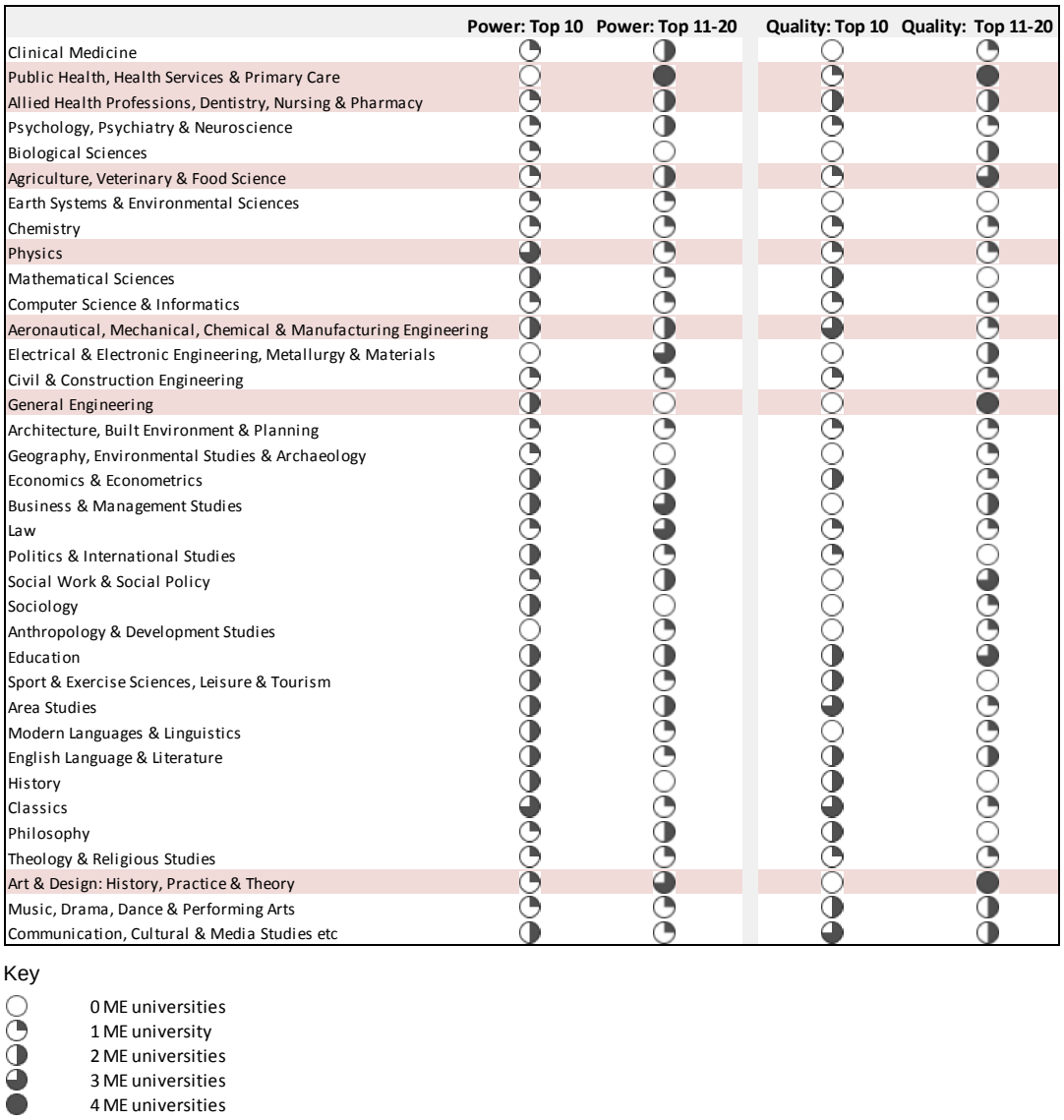
Source: SQW analysis of Gateway for Research data - note figures are based on fractional counting (as the same project could have been assigned to one or more research subjects)

3.11 The region's universities lead or participate in 18 EPSRC Centres for Doctoral Training; the University of Nottingham and the University of Warwick lead BBSRC Doctoral Training Partnerships, the latter including research partnerships with the universities of Birmingham and Leicester; and the University of Warwick and the University of Birmingham lead MRC Doctoral Training Partnerships, the latter including research partnerships with the universities of Leicester and Nottingham. There are also ESRC Doctoral Training Centres at the University of Birmingham, Nottingham, and Warwick, and an ESRC Doctoral Training Partnership involving the Midlands Innovation universities.

3.12 The REF 2014 also indicates both the scale and excellence of our research offer. Our institutions accounted for 14% of FTE Category A submissions[14], with submissions reflecting our identified Enabling Competencies. For example, relative to the 14% average, we were over-represented in Aeronautical, Mechanical, Chemical and Manufacturing Engineering, and General Engineering (Advanced Manufacturing and Engineering competence), and Computer Science and Informatics (Digital Technologies and Data).

3.13 Demonstrating the range of our science and research asset base, across *all* 36 Units of Assessment (UoA) of the 2014 REF, at least one Midlands Engine university was in the top 20 nationally in research Power or Quality (Figure 3-3). Put another way, across all areas of research, the Midlands Engine is evidentially home to some of the UK's leading science. Those areas where the Midlands performs particularly strongly with direct relevance to our SIA are highlighted.

Figure 3-3: REF 2014 Power and Quality – ME universities in the Top 10 and Top 11-20 nationally[15]



Source: SQW analysis of REF 2014 Note: no more than four ME Universities were in the Top 10/20

3.14 Looking across this broad base of research strength, key areas of excellence (as evidenced by being in the Top 10 of UK institutions in the REF 2014 by Power or Quality) with particular relevance to the SIA (for example, excluding humanities subjects) are set out in Table 3-1.

Table 3-1: Key university level REF rankings (Top 10 nationally)

Key 'Power' rankings
• Aeronautical, Mechanical, Chemical and Manufacturing Engineering - Cranfield (#2), Loughborough (#3)
• Agriculture, Veterinary and Food Science – Nottingham (#2)
• Allied Health Professions, Dentistry, Nursing and Pharmacy – Aston (#10)
• Architecture, Built Environment and Urban Planning – Loughborough (#9)
• Art and Design: History, Practice and Theory – Loughborough (#4)
• Biological Sciences – Nottingham (#8)
• Business and Management Studies – Warwick (#3), Nottingham (#6)
• Chemistry – Nottingham (#10)
• Civil and Construction Engineering – Loughborough (#7)
• Clinical Medicine – Birmingham (#7)
• Computer Science and Informatics – Nottingham (#9)

- Earth Systems and Environmental Sciences - Open University (#6)
- Economics and Econometrics - Warwick (#3), Nottingham (#6)
- General Engineering - Nottingham (#3), Warwick (#7)
- Geography, Environmental Studies and Archaeology – Nottingham (#8)
- Mathematical Sciences - Warwick (#3), Nottingham (#9)
- Physics - Nottingham (#8), Warwick (#9), Leicester (#10)
- Psychology, Psychiatry and Neuroscience – Nottingham (#10)
- Sport and Exercise Sciences, Leisure and Tourism – Loughborough (#1), Birmingham (#4)

Key 'Quality' rankings

- Aeronautical, Mechanical, Chemical and Manufacturing Engineering – Birmingham (#4), Cranfield (#8), Loughborough (#9)
- Agriculture, Veterinary and Food Science – Warwick (#2)
- Allied Health Professions, Dentistry, Nursing and Pharmacy – Nottingham (#4), Aston (#8)
- Architecture, Built Environment and Urban Planning – Loughborough (#5)
- Chemistry – Warwick (#6)
- Civil and Construction Engineering – Birmingham (#10)
- Computer Science and Informatics – Warwick (#2)
- Economics and Econometrics - Warwick (#5), Nottingham (#10)
- Mathematical Sciences - Warwick (#3), Nottingham (#10)
- Physics - Nottingham (#3)
- Psychology, Psychiatry and Neuroscience – Birmingham (#7)
- Public Health, Health Services and Primary Care – Keele (#6)
- Sport and Exercise Sciences, Leisure and Tourism –Birmingham (#4), Loughborough (#9)

Source: SQW analysis of REF 2014

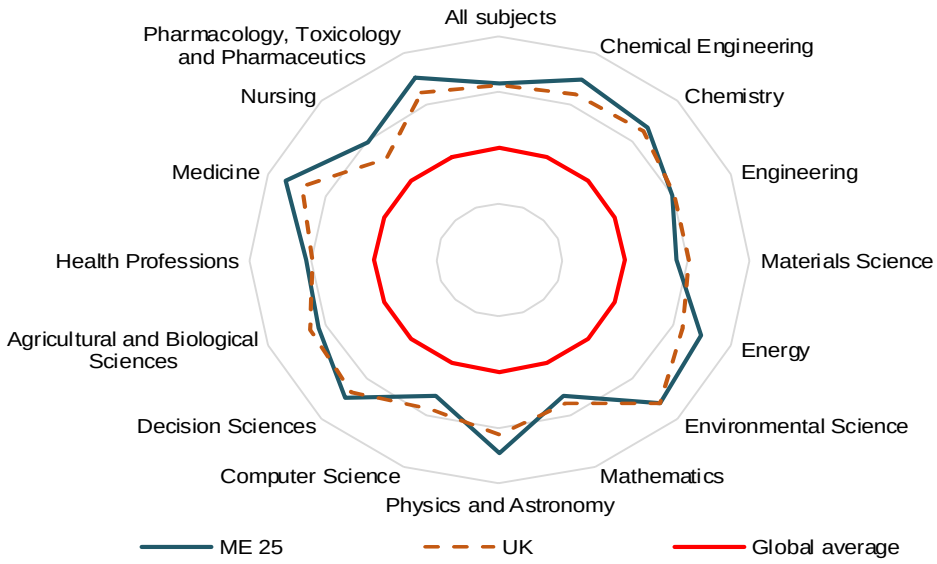
3.15 Our universities are also internationally competitive with Warwick, Nottingham and Birmingham ranked in the world top 100 by QS (48th, 70th and 76th respectively). [16] At subject and department level, key strengths include:

- **Healthcare and Life Sciences**: QS world rankings data place Nottingham's pharmacy and pharmacology offer 6th in the world (Birmingham is in the top 100) and Birmingham's dentistry 17th. The Shanghai Jiaotong rankings position Nottingham's clinical medicine and pharmacy provision as 42nd in the world (Birmingham is in the top 100); Nottingham and Birmingham are also in the top 100 for life and agricultural sciences.[17]
- **Advanced engineering and manufacturing**: QS ranks Cranfield's mechanical, aeronautical and manufacturing engineering 27th in the world (with Loughborough in the top 100). QS also ranks materials science at Birmingham and Nottingham and chemical engineering at Warwick in the top 100 globally.
- Other notable strengths include Loughborough's Art and Design ranked 38th by QS, and physical sciences at Warwick, ranked 64th by the Times Higher rankings.[18]

3.16 To provide a further perspective on national and international research excellence, we have used Elsevier's SciVal database. A bespoke sub-group has been set-up including the 25 Midlands Engine universities included in Sci Val ('ME 25')[19], with data collected on: the Field Weighted Citation Index (FWCI)[20]; percentage of outputs in Top 10 citation percentile internationally; and number of research outputs, and university-level Distinctive and Enabling Capabilities. Detailed data are presented in Annex E, and data relevant to the Market-driven Priorities are included in Section 4.

3.17 A summary of the FWCI for subject areas of relevance to the SIA is presented in Figure 3-4. Overall, the ME 25 grouping has a FWCI of 1.58, in line with the UK at 1.57. This reflects the scale and breadth of the research capability in the region. However, the 'ME 25' performs well above the UK level in a range of subject areas including Chemical Engineering, Chemistry, Energy, Physics and Astronomy, Medicine, and Pharmacology, Toxicology and Pharmaceutics.

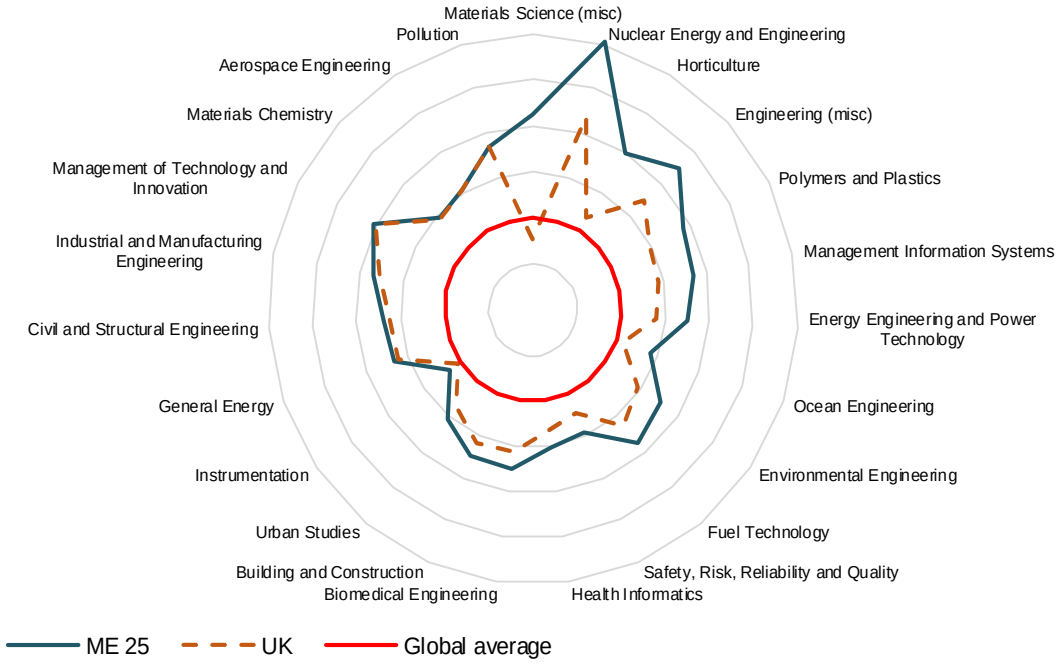
Figure 3-4: Field Weighted Citation Index for the ME 25 relevant subject areas



Source: SQW analysis of 2016 Elsevier B.V data

3.18 The data have also been used to provide further insight into the more specific research strengths across the region, including research underpinning the three Enabling Competencies (Figure 3-5). Areas where the 'ME 25' performs at or above the national level, include Nuclear Energy and Engineering, Energy Engineering and Power Technology and Fuel Technology, and disciplines underpinning manufacturing and engineering activity, including Polymers and Plastics, Instrumentation, Physics and Astronomy and Industrial and Manufacturing Engineering. The data also indicated the region's strength (in line with the UK level) in research on Pollution, relevant particularly to the Systems Integration and Advanced Manufacturing/Engineering Competence, and responding to the Environment 'agent of change' discussed above.

Figure 3-5: Field Weighted Citation Index for the ME 25 for relevant detailed disciplines

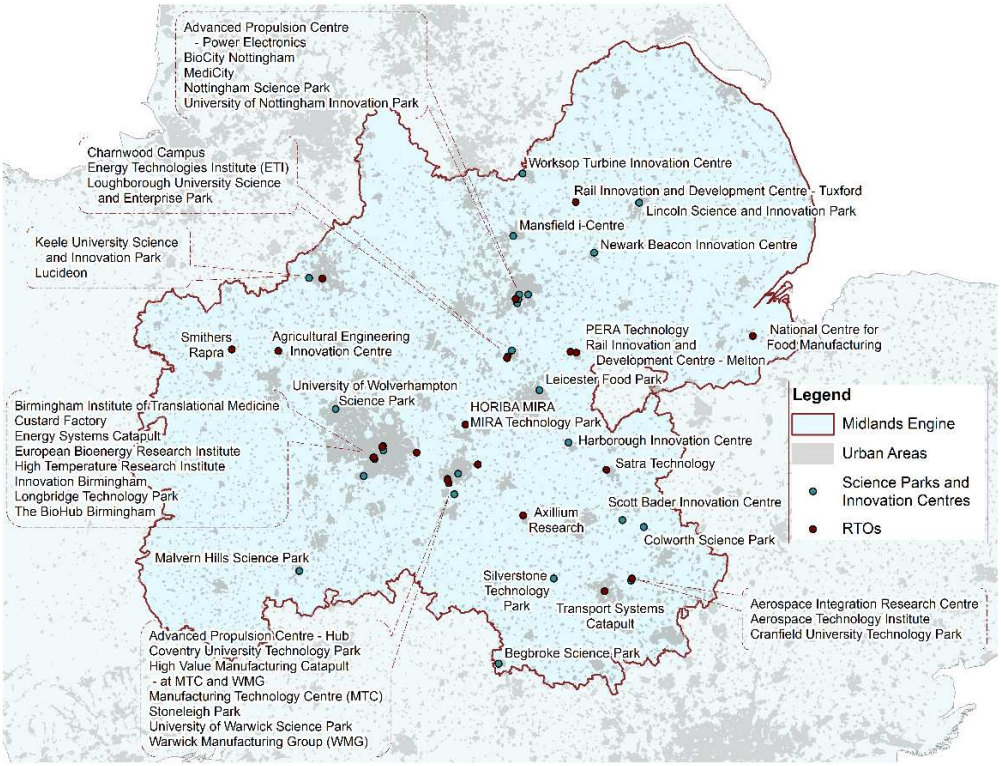


Source: SQW analysis of 2016 Elsevier B.V data

Research and technology organisations and science parks

3.19 Alongside our universities, the Midlands Engine is home to a large concentration of research and technology organisations (RTOs), science parks[21] and related hard and soft infrastructures designed to support the creation and growth of knowledge-intensive businesses. Our RTOs and science park assets span a wide range of sectors and technology areas, and are evident across all 11 of our LEP geographies, as shown in the map below.

Figure 3-6: RTOs and science parks in the Midlands Engine



Source: Produced by SQW 2016. Licence 100030994. Contains OS and National Statistics data © Crown copyright [and database right] [2016]

3.20 Brief descriptions of a selection of **nationally significant RTOs**, **which are particularly important in developing and sustaining our underpinning Enabling Competencies** are provided in the table below. Note that this list does not include university research centres or groups; the focus is on providing insight into the RTO innovation asset base across the Midlands Engine, with explicit contribution to each of our three Enabling Competencies.

Table 3-2: RTOs in the Midlands Engine (EC1 = Advanced Manufacturing/Engineering, EC2 = Digital Technologies/Data, EC3 = Systems Integration)

		EC1	EC2	EC3
Catapult Centres				
Energy Systems Catapult (ESC)	• Based in Birmingham, the ESC aims to help the UK navigate the transformation of the energy system and capture commercial opportunities this creates • Focused on electricity, heat and combustible gases. Key activities include the Smart Systems and Heat programme, and the Future Power Systems Architecture project			✓
EMBRACE – East Midlands Satellite Applications Centre of Excellence	• A consortium of the University of Leicester, University of Nottingham, and British Geological Survey • Aims to promote and enable the regional exploitation of earth observation, global navigation satellite systems		✓	✓

		EC1	EC2	EC3
	(GNSS) and geospatial data and services throughout the business and public sectors			
Manufacturing Technology Centre (HVM Catapult)	• Based in Coventry (and founded by Birmingham, Loughborough and Nottingham Universities with TWI[22]), the MTC provides manufacturing system solutions in partnership with industry, academia and RTOs • Focused on three core technology areas: Assembly Systems; Component Manufacturing Systems; and Data Systems for Manufacturing	✓	✓	✓
Transport Systems Catapult	• Based in Milton Keynes, the TSC is the UK's innovation centre for Intelligent Mobility • Working across all major forms of transport, the main focus areas are Automated Transport, Modelling and Visualisation, Customer Experience and Smart Infrastructure		✓	✓
Warwick Manufacturing Group (HVM Catapult)	• Part of the wider Warwick Manufacturing Group at the University of Warwick, the HVM Catapult at WMG works with business to transfer research to industry • Focused on the global challenge of Low Carbon Mobility and in particular two priorities areas: Lightweight Technologies; and Energy Storage and Management. Also has expertise in digital/data through visualisation team and cyber security centre	✓	✓	✓
Other National RTOs based in the region				
Advanced Propulsion Centre (APC)	• With its Hub at the University of Warwick[23], the APC aims to position the UK as a global centre of excellence for low carbon propulsion development and production • Its mission is to turn new low carbon propulsion technologies into products for the automotive industry by supporting collaborations and providing funding	✓		
Aerospace Technology Institute (ATI)	• The ATI is responsible for developing and maintaining the UK's prominence in the aerospace sector • Headquartered in Cranfield, the ATI works with industry, government and academia to stimulate breakthroughs in technologies and manufacturing capabilities	✓		✓
Independent centres				
Energy Technologies Institute (ETI)	• A partnership combining academia, industry and government to accelerate the development of low carbon technologies • Focused on nine technology programmes: offshore wind; marine; distributed energy; buildings; energy storage and distribution; smart systems and heat; carbon capture and storage; transport; and bioenergy. It also hosts the Energy System Modelling Environment			✓
HORIBA MIRA	• Part of the wider HORIBA Group, HORIBA MIRA is an independent vehicle engineering and development consultancy • Specific engineering capabilities include unmanned vehicles, low carbon vehicles and intelligent mobility	✓		✓
Rail Innovation and Development Centre (RIDC)	• Network Rail's RIDC Melton has two separate, purpose built test tracks for rolling stock and infrastructure • RIDC Tuxford is another test track facility for developing rail vehicles, technology and equipment.	✓		

Source: SQW analysis

3.21 Other assets linked directly to our three Enabling Competencies identified via the Midlands Engine SIA research including the e-consultation survey and workshops are set out in Table 3-3.

Table 3-3: Assets underpinning our Enabling Competencies

Advanced Manufacturing and Engineering

- UK Quantum Technology Hub for Sensors and Metrology at the University of Birmingham
- British Hydromechanics Research Group, based at Cranfield University
- The European Powder Metallurgy Association, based in Shrewsbury
- Welding Engineering and Laser Processing Centre
- Advanced Structural Dynamics Evaluation Centre, at University of Leicester, Nuneaton
- Institute for Advanced Manufacturing and Engineering

Digital Technologies and Data

- University of Leicester Space Research Centre
- University of Nottingham Geospatial Institute
- National Centre for Earth Observation (NCEO)
- High Performance Computing Midlands (a joint venture between the Universities of Loughborough and Leicester)
- MidPlus, a regional HPC facility established in 2012 with support from partner universities of Warwick, Birmingham, and Nottingham
- Institute of Creative Technologies at De Montfort University
- Horizon Research Institute at Nottingham University
- Aston Institute for Photonics

Systems Integration

- Energy Systems Integration Laboratory, part of the Birmingham Centre for Rail Research and Education
- Manufacturing Systems Integration Laboratory, University of Nottingham
- Vehicle Electrical Systems Integration project
- Centre for Systems Engineering at Cranfield University

Source: E-consultation survey

3.22 A number of other important centres and locations are in the pipeline; when developed fully, these will add substantially to the innovation asset base across the region. Examples include:

- the **High Temperature Research Centre** (HTRC), a collaboration between the University of Birmingham and Rolls-Royce; the initial focus will be on the key design and manufacturing aspects of investment casting, allowing the development of advanced manufacturing technologies for high temperature materials
- the **National Automotive Innovation Centre** (NAIC) at the University of Warwick, which is under construction and will open in 2017. It will bring academic and industrial R&D teams together using state-of-the-art equipment and facilities to develop breakthrough designs, technologies and processes in automotive engineering
- the long-term plan for the development of a **Life Sciences Campus** in capitalising on the existing clinical and innovation strengths in Birmingham and the work of Birmingham Health Partners, a strategic alliance between the University of Birmingham, Birmingham Children's Hospital, Birmingham Women's Hospital and University Hospitals Birmingham NHS Foundation Trust (UHB).
- the planned **National Space Park** in Leicester, which aims to become a global hub of a collaborative space and space-enabled community engaged in the development of new technologies and as such is fully in line with the National Space Policy.[24] A key focus will be the exploitation of satellite data and images, leveraging the location of the University of Leicester, National Space Centre, and industry partners at the UK's centre providing skills, training, education and research to meet the requirements of the space industry and space enabled businesses
- **Infinity Park** in Derby, a commercial and technology park including the 'Centre for Supply Chain Innovation in Transport Engineering', which will host 'Enscite', a collaboration

between the universities of Derby and Aston, and Derby City Council. It will provide access to cutting edge research and technology transfer expertise to supply chain companies in the aerospace, automotive and rail sectors

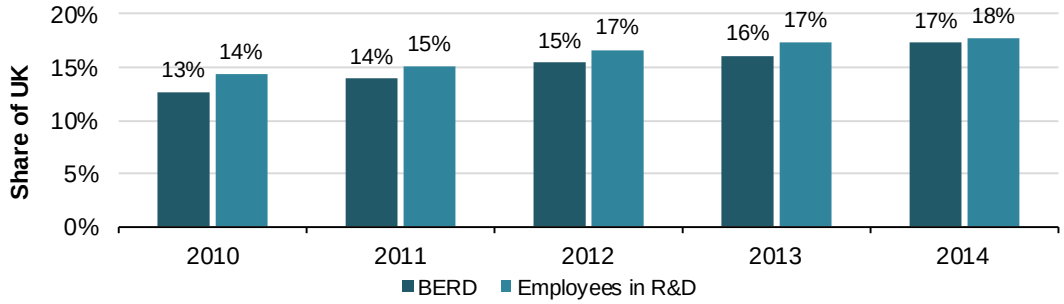
- the £4m UK Space Agency funded **National Propulsion Test Facility** at Westcott in the South East Midlands LEP area; the planned facility will be open to industrial and academic users, and will add new capabilities for the UK space sector[25]
- the planned **Life Science Opportunity Zone at Charnwood Campus** in Loughborough, where the innovation focus is on pharmaceuticals and life sciences
- the **National Transport Design Centre** in Coventry, focusing on education in transport design, research projects in collaboration with industry, and support for the high-value manufacturing sector and its supply chain to improve design capability.

3.23 There are also important pan-regional and non-spatially sited projects of note, including the Energy Research Accelerator, across the Midlands Innovation group of universities, and the UK Autodrive project, which is trialling self-driving vehicle and connected car technologies, culminating in a series of urban demonstrations in Milton Keynes and Coventry.

Industrial R&D

3.24 Industrial R&D is core to the Midlands Engine. Our businesses invested over £3.4bn in R&D in 2014 (the latest available data) with over 34,000 employees engaged in R&D activity.[26] The Midlands Engine is an increasingly important part of the UK's R&D base (Figure 3-7), accounting for a growing proportion of UK investment and employees in R&D over the past five years. In absolute terms, R&D investment increased from £2.0bn in 2010 to £3.4bn in 2014, and the number of employees engaged in R&D activity increased from 22,000 to 24,000.

Figure 3-7: Midlands Engine share of the UK investment in business R&D (BERD) and business employment in R&D (2010-2014)



Source: Research and Development in UK Businesses, 2014 – Datasets

3.25 The data presented in Figure 3-7 underestimates the contribution of the Midlands Engine, as it is based on the administrative areas of the West and East Midlands only. Taking into account R&D in Milton Keynes, Luton, Bedford, Central Bedfordshire, Cherwell, and Aylesbury Vale[27], we estimate that approximately one-fifth of all business R&D in the UK is delivered within the Midlands Engine footprint.

3.26 Much of this R&D investment is made in our globally-recognised R&D intensive firms. Ten examples of key private sector R&D assets in the region, identified through the SIA research including the mapping by the national contractor and additional evidence collected via the e-consultation and workshops, are given in Table 3-4. These examples provide a combination of Midlands-grown firms and major international investors that have a well-established presence in the region. The 'long list' of R&D assets is provided in Annex F.

Table 3-4: Selected R&D intensive firms in the Midlands Engine

Company	Overview of ten key industrial R&D hubs in the Midlands Engine (non-exhaustive list)
3M	• 3M is a science based technology company that sells products directly to consumers and businesses in a variety of sectors. An innovative company, one third of their revenue comes from products brought to market within the last five years. • Part of the wider 3M group, 3M Healthcare's division is located in Loughborough. This includes 3M's Technical Centre of Excellence for R&D into inhalation drug delivery systems, and 3M's largest manufacturing site in the UK (producing conventional and inhalation drug delivery systems).
GKN	• Headquartered in Redditch, GKN is a global engineering business which designs, manufactures and services systems and components for original equipment manufacturers worldwide. Operations in the Midlands Engine are particularly relevant to the aerospace and automotive industries. • Innovation is important to GKN as, across all parts of its business, differentiation through technology is one of five key strategic objectives.
IBM	• IBM is the world's largest IT and consulting services company, and a global business and technology leader. It conducts research and development in areas such as data analytics, cloud computing and IT infrastructure. • The first of its kind in the UK, the IBM Client Innovation Centre in Leicester provides high value application development and maintenance, and systems management services.
Jaguar Land Rover (JLR)	• JLR is a multinational automotive manufacturer headquartered in Coventry and both of JLR's advanced design and engineering centres in the UK are in the Midlands Engine area (Gaydon and Whitley). • Committed to R&D, JLR has invested £12bn over the past five years in areas such as low carbon emissions and autonomous vehicle technologies.
Mondelēz International	• A multinational confectionery, food and beverage company, Mondelēz's largest R&D footprint outside North America is in the UK. • Both of Mondelēz's Global Centres of Excellence which are based in the UK are in the Midlands Engine: Chocolate R&D at Bournville; and Coffee R&D at Banbury. This means that any new chocolate or coffee product launched worldwide by Mondelēz starts life in the Midlands Engine.
PepsiCo	• PepsiCo is one of the world's leading food and beverage companies with brands including Walkers Crisps (manufactured in Leicester), Pepsi and Quaker Oats. • PepsiCo's R&D Centre in Leicester houses the company's core technical staff across R&D, engineering and technical services. It aims to drive the development of healthier foods for the European market.
QinetiQ	• QinetiQ is a British multinational defence, aerospace, technology and security company. Key markets include air, transport and telecoms (both cyber and data security). • QinetiQ's scientists and engineers both develop new products/technologies and also test and evaluate next generation equipment. QinetiQ has had 1,000 patents granted with a further 1,500 pending.
Rolls-Royce	• Rolls-Royce provides highly-efficient integrated power and propulsion solutions, mainly for aerospace, marine, energy and transport applications. Key locations within the Midlands Engine are Birmingham (controls and data services), Derby (civil aerospace, marine and nuclear) and Hucknall (aerospace and marine). • Innovation is central to Rolls-Royce's strategy; they invest £1.2bn in R&D each year and filed 600 patents in the UK in 2015
JCB	• JCB are a globally competitive agri-engineering and construction equipment firm, exporting to over 150 countries. • World HQ in Rocester, Staffordshire and a series of manufacturing, R&D and service locations across the Midlands Engine.
Unilever	• Colworth Park in Bedfordshire is one of Unilever's two main UK R&D centres. With over 700 scientists, technologists, legal professionals and support staff work at Colworth on a diverse range of activities. • Specialist R&D capabilities cover digital, open innovation, consumer insights, sensory assessment, scientific measurement, microbiology, design and engineering. Unilever has a substantial IPR portfolio – 20,000 granted patents – and Colworth drives a strong pipeline delivering new patent filings and publications annually.

Source: SQW analysis

4. Innovation strengths and our growth priorities

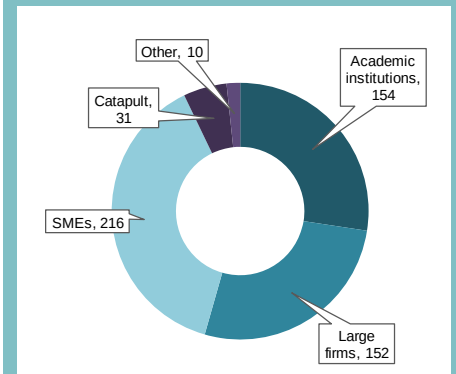
Regional-level metrics

4.1 Innovation is increasingly pervasive across our business base, including our SMEs. A number of key metrics highlight the scale and quality of our innovation offer across different sectors and disciplines.

4.2 First, in the latest UK Innovation Survey from 2015, **56% and 55% of firms surveyed in the East Midlands and West Midlands were 'innovation active'**, up from 50% and 44% in 2013 respectively. The East Midlands and West Midlands regions were ranked as the UK's fourth and fifth most innovation active regions, out of 12. Further, the data indicate that the West Midlands had the highest proportion of firms that are both product *and* process innovators of all UK regions; and the East Midlands is the second most innovative region in terms of the proportion of firms who are classified as being product *or* process innovators. Within this, almost a quarter of firms in the East Midlands reported that they had engaged in internal R&D over the period 2012-14, a higher proportion than in any other region, and the West Midlands had the second highest proportion of firms who acquired advanced machinery linked to their innovation activities.[28] More localised data from the previous wave of the Innovation Survey (covering the 2010-12 period) found that the South East Midlands was the third most innovative LEP area across England, out of 39, with Northamptonshire, Coventry and Warwickshire, the Black Country and Leicester and Leicestershire also amongst the best performing LEP economies, in the top 20.[29]

4.3 Second, over 2010-16, **institutions based in the Midlands Engine secured grant offers from Innovate UK worth over £560m**, representing 18% of the total across the UK, involving over 3,000 individual projects. Our academic institutions were particularly successful in securing Innovate UK funding, with the £154m accounting for 24% of the total Innovate UK funding to academic institutions across the UK. The approximately £210m in funding to SMEs included over £35m in Smart awards to support business R&D, £22m in Knowledge Transfer Partnerships to facilitate collaboration between firms and universities, and over £2m in Innovation Vouchers, supporting early stage innovation activity.[30]

Innovate UK grant offer to the ME, by participant type (2010-16, £m)

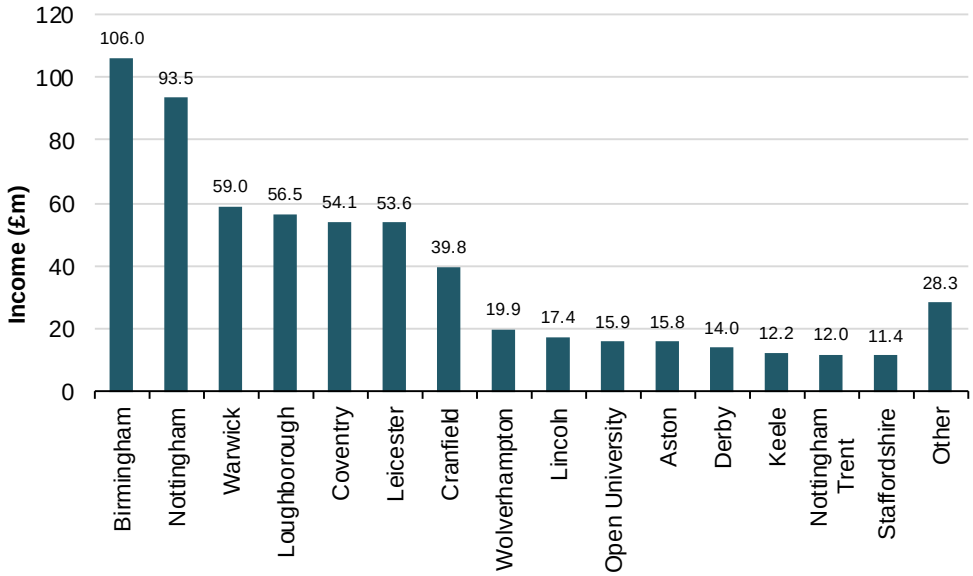


4.4 Third, **innovators based in the Midlands Engine were responsible for 18% of all patents submitted in the UK** over the 2004-13 period. In total, over 8,000 patents were submitted across our region over this period, averaging 900 a year.[31] Note that this figure should be treated with caution as patents are often filed from HQ locations rather than R&D centres.

4.5 Fourth, there were **approaching 170 'Spin-offs still active after three years from institutions across the Midlands Engine** according to the latest (2014/15) Higher Education-Business Community Interaction (HE-BCI) data (around one-fifth of the total across the UK), with spin-outs from our universities across the range of scientific and technical disciplines, many of whom are now based, and growing, in our network of science parks and innovation centres.

4.6 Fifth, **our institutions generated innovation income of over £630m in 2014/15, as identified by the HE-BCI data**. This included over £150m in contract research funding from industry (of which c.£8m was from SMEs, over 18% of SME contract research income across all UK institutions), and £180m in collaborative research**.** A breakdown by institution is set out in Figure 4-1 covering contract research, consultancy, collaborative research, facilities and equipment services, courses for business and community, and income from regeneration and development (IP and sales of spin-offs/shares are excluded as single-year figures can be distorted by individual sales/events).

Figure 4-1: HE-BCI income in 2014/15 by institution



Source: SQW analysis of HEBCIS 2014-15 Note: individual institutions with income >£10m identified individually

4.7 In addition to being key contributors to the strengths identified above, **our SME base is actively engaged in our innovation ecosystem** in many other ways. Evidence includes:

- Catapult Centres based in the region are developing programmes of engagement with SMEs: the Transport Systems Catapult has collaborated on projects or is developing joint bids with a total of 37 SMEs, and together the High Value Manufacturing Catapult MTC and WMG centres are currently working with over 200 SMEs on innovation projects.[32]
- Data from HM Revenue and Customs indicate that SMEs across the Midlands Engine claimed 2,350 R&D tax credits in 2013-14, amounting to a total claim of £90m and accounting for 15% and 12% of the respective UK totals, and 23% and 22% of the respective UK totals excluding London and the South East.[33] Note this data covers the 'West Midlands' and 'East Midlands' areas only (i.e. excluding Milton Keynes, Luton, Bedford, Central Bedfordshire, Cherwell, and Aylesbury Vale as data is not available at a finer spatial scale); as such, the data will underestimate the total volume and value of R&D tax credits claimed by SMEs across the Midlands Engine as a whole
- 40% of our science parks provide specific business incubation facilities, making them an attractive location for new start-ups and early stage firms. In total, Midlands Science Parks provide space and support for more than 1,400 SMEs on their sites, who in turn employ more than 15,000 people.[34]
- Our SMEs have engaged in R&D innovation activities through the European Regional Development Fund (ERDF) programmes operating across the East Midlands and West Midlands. Almost 12,000 SME businesses received assistance to improve their

performance during the last completed round (2007-2013), with over 6,000 SMEs engaged in new collaborations with the UK knowledge base. The majority of these projects were led by universities from across the two regions, indicating a high level of engagement in support of SMEs.

Table 4-1: Outputs under Axis Priority 1 of the 2007-13 ERDF

	East Midlands	West Midlands	Total
Number of SME businesses assisted to improve performance	17,034	5,451	22,485
Number of SME businesses engaged in new collaborations with the UK knowledge base	3,256	3,056	6,312

Source: Data provided by the Department for Communities and Local Government

Four Market Driven Priorities

4.8 Across this broad innovation landscape, the SIA has identified four Market-Driven Priorities (see Figure 2-1) which are the focus of this Section. The following is provided for each priority: an overview of the scope and competitive advantage of the Midlands Engine offer; a summary of the scale and concentration of activity, including spatial clusters of businesses; and a synthesis of the supporting assets and science/research base. The evidence is packaged using a consistent template, with broadly consistent data (including research quality, funding, and relevant patent applications), although there is some flexibility to reflect the different scope of each priority area.

4.9 Annex G provides case examples of innovation in each priority area, demonstrating the strength and breadth of our innovation system and providing 'real world' examples of cutting-edge innovative activity. More detailed profiles of the Market-Driven Priorities are provided at Annex H, completed on behalf of the SIA Delivery Group by dedicated priority sub-groups.

Market-Driven Priority Area 1: Next Generation Transport

Scope and competitive advantage

4.10 The Midlands Engine contains a critical mass of globally competitive businesses operating within and across a range of transport-related industries. Our business base covers the full spectrum from R&D and design through to production and after sales service, and places us at the leading-edge of Next Generation Transport systems, vehicles and technologies globally.

4.11 The Next Generation Transport priority is focused on opportunities within four distinct, but inter-related, sectors: Aerospace/Space; Automotive; Motorsport; and Rail. Whilst each sector has its own specific circumstances as well as market and technology imperatives (see Section 5 for details), what draws them together is a set of shared high-level drivers of change and resulting challenges (as well as growth opportunities), which are summarised below.

Table 4-2: Drivers of change and challenges for Next Generation Transport

Drivers of change …		
The Greening of Transport With an ever greater appetite for travel and need for the effective mobility of goods and people to support economic growth, measures are increasingly being taken to curb the potential harmful effects from CO_2 emission reduction targets through to measures for NOx and noise.	**Global Competition** Transport sectors are fiercely competitive global industries, in which the pace of innovation and focus on meeting changing customer needs is incredibly high. New product introduction and upgrade cycles are accelerating, and while the physical performance attributes of products (e.g. capacity,	**Customer Demands** A requirement in any transport environment is 'no surprises'. Users expect absolute reliability, safety and predictability, alongside convenience, better performance, lower cost, new functionality and good connectivity. Increasingly, the desire for 'on-demand' transport or propulsion is shifting the onus of operational risk

These step changes require advanced, integrated technologies and novel approaches to be deployed by infrastructure providers, manufacturers, institutions and end users.	power, weight, strength and temperature tolerance) remain crucial, deploying digital capabilities across the product lifecycle is becoming the new competitive differentiator for the products, systems and services future transport demands.	and asset management onto the product/service provider. Delivering this while pushing the boundaries of technology demands closely coupled processes capable of translating new innovation and technologies into trustworthy products and services with minimum lag and waste.
⬇	⬇	⬇

… and the resulting challenges

Transport System Integration

Effectively designed, managed and operated transport systems are fundamental to secure sustainable mobility, commerce, welfare and economic growth. Central to meeting the challenge is the development of intelligent, integrated transport systems, which enable the movement of people and goods in ways which increase efficiency, safety, mobility and customer satisfaction - whilst decreasing environmental impact, through the integration of logistics and traffic systems using ICT, multimodal sensing (ground-based, satellite and aerial), system modelling, data integration and analysis

Advanced Propulsion, energy & power

The transport sector is fundamentally reliant on propulsion technologies and, by extension, on the energy and power required to drive them. Rapid technological change in these areas is addressing legislative and societal challenges from the need to reduce carbon and pollutant emissions, and to increase efficiency. Propulsion technologies include internal combustion engines, gas turbines, transmissions, kinetic energy recovery systems, traction electric machines and power electronics. The move towards electric propulsion systems is increasing focus on energy storage technologies and scale-up (battery, fuel cell) and energy management systems. Advances in autonomous vehicles are also critically dependent on electrification. These technologies are common across the entire transport sector, from mainstream automotive and motorsport to rail and more electric aircraft

Light-weighting

Driven by the 'greening' of transport agenda, the use of lightweight materials – high-strength steel, aluminium, and carbon fibre - in all transport industries will increase significantly. The changes in the material mix present significant challenges that will require changes in design, processing of materials and manufacturing of components and assembly of vehicles. The ability to fully exploit the properties of new advanced materials and manufacturing processes in the design of superior new products is a key differentiating capability in transport market products.

Optimised production and operation

In responding to the demands of faster product introduction, mass customisation and 'no surprises', transport companies are increasingly looking to digital technologies to link all the stages of a product or system's lifecycle. From initial requirements captured through concept design, design for manufacture, supply chain coordination and factory control, the data builds up to become the full digital definition of a product and how it is made. The concept of 'digital twin' factories and products testing, plus perfecting every aspect of the design, production and operation of advanced, complex products and systems is becoming possible with modern digital technologies. There are commercial 'product lifecycle management' tools on the market, but innovation in how to deploy and integrate these into smart systems including automated design and optimisation, integration with factory and supplier systems, and feedback from real production data is needed to get to market with better products, faster. Once the product is in use, its digital twin continues to grow and evolve with increasing innovation in telematics and two-way communication between the product, the system it operates in, and its manufacturer. This ongoing data stream gives the opportunity to learn more about the product in service, improve current and future performance, and offer new services based on availability. It also forms the foundation from which increasing autonomy can be safely developed and deployed.

Source: Midlands Engine

4.12 Set against these high-level drivers and challenges, and across the sectors of aerospace/space, automotive, high value motorsport, and rail, the SIA has identified a number of technology areas where the region has particular strengths in its industrial and research base, where there will therefore be significant opportunities to drive productivity growth going forward:

- **simulation and modelling using high performance computing capabilities** that will reduce the time to market and associated R&D costs
- **advanced digital design and physical validation** to support 'right-first-time' design, reducing the need for testing and prototyping, and accelerating the development and deployment of novel technologies in future vehicles
- **advanced materials and manufacturing processes**, with a focus in the Midlands on the application of advanced materials and processes such as composites and additive manufacturing to exploit fully the materials and processes most effectively

- **digital manufacturing, supply chain and service management** including big data, supply chain management, intelligent automation and assembly, machining and condition monitoring, manufacturing metrology, metal precision manufacturing, responsive manufacturing, and advanced robotics.

4.13 The management and reduction of environmental impact, including vehicle emissions and the impact on air quality, the impact of car greening, intelligent transport systems, and dynamic routing and data to support the green economy is also a significant growth opportunity for the region. An example of work by regional universities in this area, also demonstrating our Enabling Competency in Systems Integration, is provided in Annex J.

Scale and concentration of activity. . .

4.14 By any measure, the Midlands Engine is the UK's leading region for manufacturing in transport technologies, with breadth across aerospace and space, automotive and rail sectors, and across the value chain from R&D and design through to production and post-sales servicing. Over 85,000 employees are supported in the region in 'core' transport manufacturing sectors, where the technologies and disciplines outlined above are integrated increasingly into company activity. Notably, as shown in Table 4-3 across all relevant 'core' transport sectors, the Midlands Engine has an LQ of over 1.0, reflecting our status as the driver of the UK's transport sector.[35] Further, it is worth noting that BRES employment data identified via SIC codes are imperfect; feedback from regional partners suggested that employment in rail across the Midlands Engine is likely to be significantly higher than the data presented later in this section suggest; for example, the cluster of rail companies centered around Derby and Bombardier Transportation includes countless supply chain companies including the provision of design services, rolling stock consultancy, product design and manufacturing, IT systems and rolling stock assurance. Rail infrastructure companies are also prevalent from global consultancies to specialist inspection services. Similar issues will apply to our aerospace and space, and automotive sectors; this issue is particularly relevant given the increasing role of digital- and service-based application in the manufacturing process.

4.15 To reflect this, Table 4-3 presents 'supporting' sectors, with employment of over 75,000, including technical testing and analysis (with an LQ of 1.4) and engineering design.[36] These sectors form a key component in transport supply chains, and offer services and expertise to enable the region to exploit fully the opportunities from high performance system simulation and modelling, advanced digital design and physical validation, advanced materials and manufacturing processes, and digital manufacturing, supply chain and service management.

Table 4-3: Employment in core and supporting sectors for Next Generation Transport (2014)

	Employees	LQ
Aerospace/space		
Manufacture of air and spacecraft and related machinery	25,000	1.7
Automotive		
Manufacture of motor vehicles	29,900	2.4
Manufacture of bodies (coachwork) for motor vehicles (except caravans)	1,800	1.3
Manufacture of electrical and electronic equipment for motor vehicles	1,000	2.3
Manufacture of other parts and accessories for motor vehicles	25,900	2.8
Rail		
Manufacture of railway locomotives and rolling stock	2,400	3.7
Supporting		
Engineering design activities for industrial process and production	10,000	1.0

	Employees	LQ
Engineering related scientific and technical consulting activities	9,200	0.7
Other engineering activities	38,400	0.9
Technical testing and analysis	12,500	1.4
Specialised design activities	7,500	0.9

Source: SQW analysis of BRES data

4.16 Our fourth focus area for Next Generation Transport, is different in nature to the three transport sectors outlined above, and is a spatially concentrated cluster of globally leading motorsport firms located around Silverstone in Northamptonshire, and centred around Northampton and Milton Keynes. The Midlands Engine is the spatial focus of a high performance technology and motorsport cluster which also covers parts of Southern England, characterised in a recent study[37], highlighting its global leadership and international reach.

The High Performance Technology and Motorsport (HPTM) Cluster

The cluster stretches across several functional economic areas and has a dual focus: it is 'mature' in relation to motorsport and continues to demonstrate global competitive advantage in this area, and it is 'developing' in relation to mainstream high performance technology applications; it is an area with real growth potential. Four main aspects of the cluster's make-up and dynamics, and the interactions across it have been identified:

Knowledge "in the air" - As individuals have moved from one firm in the cluster to another, knowledge has been disseminated and built. This movement has also led to new businesses being formed; a process central to the growth of the cluster

Innovation and adaptation - Innovation, whether technological or organisational, has been crucial to the growth of the cluster. This innovation is increasingly influenced by regulation on carbon emissions, for example, and is conducted in a variety of ways: internal to a firm; in collaboration with other companies and/or research institutions within the cluster (e.g. Cranfield University); or with similar organisations outside the cluster

Financing, networks and growth - Whilst some parts of the cluster, e.g. F1 teams, are well resourced, smaller firms have typically financed their own growth. This lack of bank/equity finance may be changing though with the emergence of financial sources external to the cluster

Links between local and global - Firms within the cluster may be small but many have a global footprint and there are outstanding exporters. In addition, the cluster acts as a global magnet for highly skilled, ambitious people.

Source: The Evolution of the High Performance Technology and Motorsport Cluster, SQW, 2016

4.17 This cluster contains Formula One teams (including Red Bull Racing, Mercedes AMG Petronas, and Sahara Force India), high profile motorsport oriented manufacturing and engineering firms such as Cosworth (in Northampton), Prodrive (in Milton Keynes, and Banbury) and Mercedes AMG-High Performance Powertrains (in Brixworth), and small firms in motorsport supply chains ranging from supporting F1, IndyCar and NASCAR, to semi-professional and amateur events. Both Aston Martin's HQ and global engineering consultancy Ricardo's Midlands Technical Centre are based in Warwickshire, in proximity to the spatial focus of the cluster (Ricardo also has Technical Centres in Derby and Leicestershire). The cluster is characterised by the development of products and services across the 'high performance area', with cluster firms playing a key role as first-adopters of new product and process innovations, which can then be adopted by wider transport industries including aerospace and space, automotive, rail, and through other non-transport applications.

4.18 Indeed, the SQW cluster report identified the links between the spatial focus in and around Silverstone and the wider Midlands Engine, particularly in relation to the automotive sector. For example, the activities of JLR (e.g. the AMPLiFII project with the Vayon Group and Delta Motorsport [both based in the South East Midlands] and the Universities of Warwick and Oxford), Warwick Manufacturing Group and the Advanced Propulsion Centre at Warwick, and HORIBA MIRA near Nuneaton. Supply chain links are also important – the supply chain of the Force India F1 team includes firms based in Coventry, Birmingham and Derby.

4.19 The HPTM cluster as a whole has a broader sectoral and spatial focus than the Midlands Engine and motorsport. Whilst the porous boundaries of the cluster are an important part of its strength, for the purpose of the SIA we have focused specifically on activities directly part of, or supporting,

the motorsport industry, and a spatial focus on the South East Midlands and Northamptonshire LEP areas.[38] These data indicate employment of around 23,400 in motorsport and its supply chain in the South East Midlands, with around 8,500 in Northamptonshire, giving an overall LQ of 1.16.[39]

4.20 Data provided by UKTI indicate that in 2015/16, the Midlands Engine (defined as the regions of the West Midlands and East Midlands) secured 62 inward investment projects in the broad sector of 'Transport', supporting some 8,450 jobs. Reflecting the importance of the Market Priority to the regional economy, 'Transport' accounted for one in five of all inward investment projects recorded by UKTI in the region in 2015/16, and 30% of all jobs.[40]

… and the supporting asset and research base

Innovation assets

4.21 The Midlands Engine has a nationally unrivalled concentration of research and innovation assets in Next Generation Transport. In the industrial base, we have national/international R&D Centres for global companies including JLR, Rolls-Royce, Bombardier and SNC-Lavalin.

4.22 Our universities participate in over half the EPSRC's flagship Centres in Innovative Manufacturing, and we host five centres with direct relevance to Next Generation Transport: Intelligent Automation (at Loughborough University); Through-Life Engineering Services (Cranfield University); Ultra Precision (Cranfield University); Additive Manufacturing (Nottingham University); and Composites (Nottingham University). Our universities also lead six related EPSRC Centres for Doctoral Training in manufacturing, focused on Intelligent Automation, Metal Processing, Additive Manufacturing, Composites, Sustainable Materials, and Low Environmental Impact Manufacturing, all of which are relevant to Next Generation Transport and which reinforce our Advanced Manufacturing and Engineering Enabling Competency.

4.23 Other research centres include: the Institute for Aerospace Technology at The University of Nottingham; the Birmingham Centre for Railway Research and Education (one of only three universities in the UK offering rail specific education programmes); Warwick Manufacturing Group (WMG); Coventry University's Institute of Advanced Manufacturing and Engineering; Cranfield University's Institute for Vehicle Health Management; and a network of Rolls-Royce University Technology Centres in Materials (Birmingham), Performance (Cranfield), Combustion Aerodynamics and Aerothermal Technology (Loughborough), and Manufacturing Technology, and Gas Turbine Transmission Systems (Nottingham).

4.24 Many other universities in the region contribute specialist expertise to companies in these sectors, for example, Aston University on photonics and sensors, and De Montfort University's Institute for Energy and Sustainable Development, which is undertaking research into sustainable transport. Space research and access to satellite-enabled data also provides the region with specialist capabilities and research assets, whilst the development of the National Space Park will build on the emerging trends identified in the Midlands Engine SIA. Birmingham will also be the base for HS2, and the location for one of the campuses of the National College for High Speed Rail due to open in autumn 2017, and Northampton is home to the National Training Academy for Rail, a public private sector partnership between government and Siemens focusing on rolling stock technician development.

4.25 We also have a network of RTOs and research-oriented innovation assets, identified in Table 4-4 below, with their contribution to the four transport sub-sectors identified.

Table 4-4: Key research-oriented assets (dark = core offer, light = supplementary offer)

	Aerospace / space	Automotive	Rail	Motorsport
Manufacturing Technology Centre				
Warwick Manufacturing Group Catapult HVM Centre				
Transport Systems Catapult				
MIRA Technology Park				
Advanced Propulsion Centre Hub (Warwick)				
Network Rail's Rail Innovation and Development Centre (RIDC)				
Millbrook Proving Ground				
Cranfield University – Aerospace Integration Research Centre				
Aerospace Technology Institute				
East Midlands Satellite Applications Centre of Excellence				

Source: SQW and Midlands Engine analysis

4.26 These asset possess significant expertise in the technologies and disciplines identified above e.g:

- **High performance system simulation and modelling**: the Transport Systems Catapult's Visualisation Laboratory demonstrates the power of a first person perspective in an accurately simulated environment. For example, users can walk around a virtual Milton Keynes populated with pedestrians and next generation autonomous vehicles
- **Advanced digital design and physical validation**: WMG's 3D visualisation suite provides real time interactive immersive visualisation and virtual reality capabilities, allowing virtual inspections and physical user interaction to allow effective design decision making
- **Advanced materials and manufacturing processes**: the MTC, working with Birmingham University and MG Motor UK (and others outside the region) are part of the Innovate UK Automated Manufacturing Process Integrated with Intelligent Tooling Systems (AUTOMAN) project, that aims to develop a flexible panel manufacturing process based on digitally re-configurable tooling to produce high quality, 3D-functional, lightweight panels. The MTC also worked with Rolls-Royce to develop a fully automated system for the manufacture of wax patterns for the turbine blade casting process.
- **Digital manufacturing, supply chain and service management**: WMG's Digital Lifecycle Management group conducts manufacturing systems research aimed at integrating products, processes and services with system design to create novel closed-loop production systems for the factories of the future.

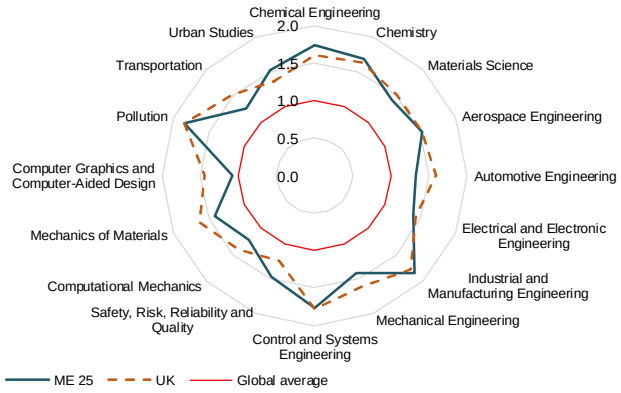
4.27 The research assets and strengths also demonstrate strong alignment between Next Generation Transport and other Market Driven Priorities, notably Energy and Low Carbon (see below), with reducing the environmental impact of transport – for example, via lightweight vehicles, more efficient power systems, and more intelligent use of automation to both produce transport products and improve transport systems – a core component of both priority areas.

Research and innovation base – further evidence

Sci Val data

The ME 25 performs on a par with the UK in engineering disciplines of Aerospace, Electrical and Electronic, Control and Systems and Industrial and Manufacturing, and above the UK in Safety, Risk, Reliability and Quality. The ME 25 also outperforms the UK in Urban Studies, important for transport systems.

The ME 25 performs well in the supporting subject areas of Chemical Engineering and Chemistry, and in line with the UK on Pollution.



Witty Review

Institutions in the Midlands Engine ranked in the top 20 in the UK for their field weighted citation impact:

- **Aerospace**: Nottingham (2), Leicester (11), Loughborough (13) and Cranfield (14)
- **Automotive**: Loughborough (9), Warwick (13), Nottingham (15) and Cranfield (20)
- **Satellites**: Birmingham (5) and Leicester (17)

Research Council Funding

Research area	% UK funding 2010-15	Value of funding (£m)
• Manufacturing	• 59%	• 35.8
• Mathematical Sciences	• 40%	• 33.4
• Mechanical Engineering	• 37%	• 16.6
• Electrical Engineering	• 65%	• 9.1

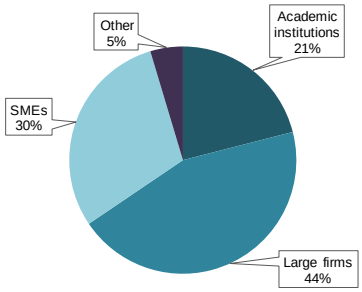
Innovate UK Funding

- £110m of grants offered over the 2010-16 period in Transport budget area …
  - ➢ 41% of UK total in the budget area (plus further £11m for Aerospace in BISF budget area)

… by project activity type

Project activity area	Value (£m)
Low carbon and electric vehicles	52.6
Advanced Propulsion Centre projects	13.8
Aerospace (including ATI projects)	13.5
Autonomous vehicles	9.6
Rail innovation	3.6
Motorsport Valley	0.4
Other	16.2

… by recipient type



Patents (2004-13)

- *Engines, pumps and turbines*: 38% of UK patent applications, 629 patent applications
- *Transport*: 28% of UK patent applications, 411 patent applications
- *Surface technology, coating*: 22% of UK patent applications, 143 patent applications

Source: SQW analysis of 2016 Elsevier B.V, Gateway for Research, Innovate UK, EPO PATSTAT data and Witty Review (2013)

Market-Driven Priority Area 2: Future Food Processing

Scope and competitive advantage

4.28 The Midlands Engine contains much of the most productive agriculture in Europe, and the UK's largest concentration of food processors and supply chain companies. In food processing, the region is truly distinctive, with a depth and breadth of industrial scale, innovation assets, and innovative and progressive companies unmatched elsewhere in the UK. In an increasingly competitive food and drink market, the principal innovation opportunity for the Midlands Engine, and where continued investment is crucial to sustain growth, is 'Future Food Processing'. This priority contains three sub-elements:

- **Efficient food processing**: reflecting that the food and drink market is characterised typically by high volume, low margin products. With intense competition, production efficiency is a key determinant of profitability, and thus food and drink companies across the region are investing in innovative production processes to facilitate competitiveness, including: automation and labour efficiency; low energy food processing (including reduced energy use in cooking, chilling, logistics and storage); and water efficiency. Competitive food processing also creates demand for data analytics; as the quantity of data captured through sensors or automated processes increases, food chain efficiency requires the adoption of innovative analysis and interpretation models
- **'Zero waste' food chains:** Food chain waste comprises around a third of all food produced, and reductions in waste improves economic efficiency and resource utilisation. Innovative food companies across the region are striving to become zero waste food companies by: optimising the yield of primary products from raw materials through technology to reduce damage; increasing the exploitation of secondary products; and developing 'waste' product utilisation strategies for residual biomass, this includes packaging waste recyclability and reuse
- **Food product innovation**: The UK launches more new food products annually (around 10,000) than any other country except for the USA. Innovation in food is targeted at a number of key areas including: reformulation to reduce levels of salt, fat and/or sugar, to address healthy eating concerns; convenience and ease of use for the consumer as busy lives lead to a reduced propensity to cook or prepare food from scratch; increased demand for snacking/grazing; and smart packaging which enhances the product's attractiveness, whilst reducing waste, and is closely linked to shelf life extension which increases consumer convenience and reduces waste. Innovation around smart packaging is also helping firms to tackle issues such as food security, authenticity and traceability.

4.29 The strength of the agri-food sector in the Midlands Engine, from 'soil to health', and in every major food category, is unique in the UK. In the intensely competitive marketplace, where product and process innovation is key to maintaining competitiveness – through more efficient and lower waste processes, and more innovation and long-lasting products, other regions in the UK have significant primary production and/or or food sciences offers (notably Scotland and the East of England). However, they do not possess the scale, concentration, and quality of food and drink manufacturing and innovation that is found in the Midlands Engine.

> ***E-consultation feedback***
> *"The diversity of product range and expertise is certainly a source of competitive advantage for the Midlands Engine"* Public sector respondent

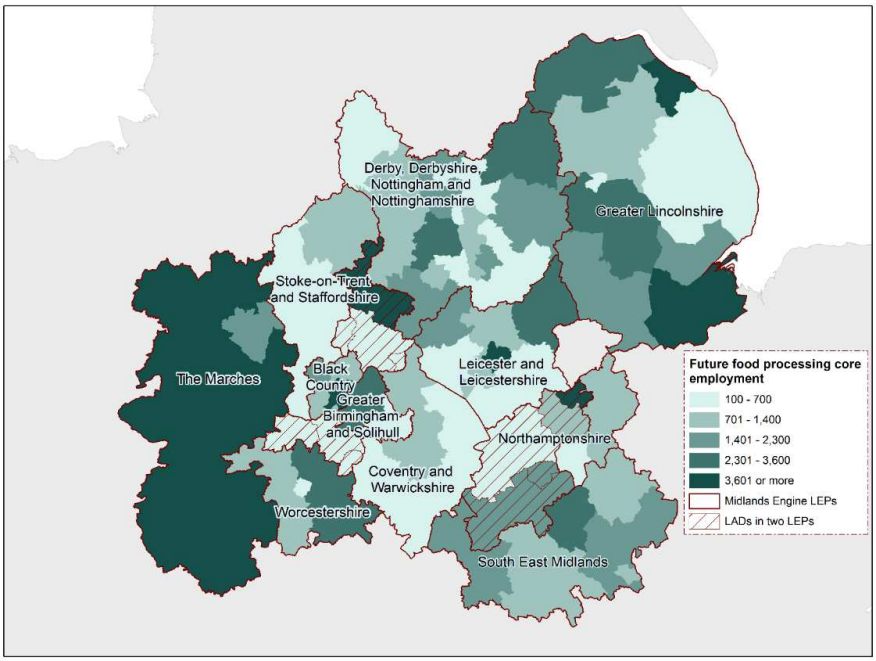
4.30 This strength in the commercial food chain is complemented by a depth and breadth of innovation, science and technology support assets allied to the food chain across the region, including university departments, innovation centres and global companies, which drive innovation.

Scale and concentration of activity …

4.31 Businesses operating in Future Food Processing supported around 118,000 employees in 2014, with an LQ of 1.53, demonstrating the high level of specialisation in food and drink manufacturing. Employment increased by 9% over the 2009-14 period, further enhancing our leadership position.[41]

4.32 Significant employment is supported across the region (Figure 4-2), with concentrations in Lincolnshire, the Marches and Leicester/ Leicestershire. A further 22,000 employees were in 'supporting' sectors including 12,500 in 'Technical Testing and Analysis' and 9,000 in R&D in natural sciences and engineering. As the food and drink industry responds to the challenges of automation, waste reduction, and product re-formulation, these wider industries will play an increasingly important role.

Figure 4-2: Future Food Processing employment (2014)



Source: Produced by SQW 2016. Licence 100030994. Contains OS data © Crown copyright [and database right] [2016]. Contains BRES data

4.33 The market priority includes an estimated 2,400 enterprise units in the region, including over 1,500 food manufacturing firms; over 300 beverages manufacturers, and over 450 firms engaged in packaging manufacturing or packaging activities.[42] This business base includes an unrivalled concentration of global, blue chip and sector-leading food chain companies including Mondelēz International (owners of Cadbury), 2 Sisters Food Group, Unilever, Walkers (PepsiCo), and Moy Park, and a thriving SME sector, including fast growing companies such as JDM Foods, Belvoir Fruit Farms and Food Fresh Technologies. There are also many regional food groups/brands e.g. Select Lincolnshire and Melton Mowbray: the Rural Capital of Food.

4.34 The location of the Midlands Engine also makes it strategically important for distribution. The region includes Regional Distribution Centres for Tesco, Sainsbury, Asda, Morrisons, John Lewis, Coca Cola and AG Barr. In addition, we host major supply chain companies serving the food service sector including Bidvest in Nottingham and Birmingham, Booker Group with a distribution and wholesale network for food service with over 25 locations across the Midlands, and NFT in Northamptonshire.

4.35 UKTI data indicate that in 2015/16, the Midlands Engine secured 28 inward investment projects in the broad sector of 'Food and Drink', supporting some 1,600 jobs.[43]

… and the supporting asset and research base

Innovation assets

4.36 Capturing the scientific and innovation base underpinning Future Food Processing is challenging; the region's food industry is increasingly engaged in research on topics which do not fit only within the 'traditional' areas such as agriculture and food science. Increasingly, engineering, ICT, logistics, cool chain and similar technologies are just as important. However, the data do not allow the identification of the specific food processing elements in these wider activities. This caveat noted, key educational/university assets, working with industry in efficient food processing, zero waste food chains, and food product innovation, include:

- **The National Centre for Food Manufacturing in Holbeach**, with a particular focus on the disciplines of: agri-tech and food manufacturing automation; food refrigeration and the cold chain; heat processing; food safety; product quality and shelf life enhancement; and product innovation
- **The EPSRC Centre for Innovative Manufacturing in Food**, an integrated centre hosted by the Universities of Nottingham, Birmingham and Loughborough and conducting industry backed research in novel food manufacturing techniques
- **The Lincolnshire Institute for Agri-Food Technology**, a major provider of Innovate UK funded applied research projects in the food chain
- **The Food Refrigeration and Process Engineering Research Centre** at The Grimsby Institute, which specialises in applied research with industry on how to refrigerate and process food products
- **The Agricultural Engineering Innovation Centre** (AEIC) at Harper Adams University, including the National Centre for Precision Farming; the AEIC provides a base around which university/industry collaboration can be stimulated.

4.37 In the broader agri-food field, key assets include: the Warwick Crop Centre, an internationally recognised centre for research in sustainable agriculture, horticulture and food security; the University of Northampton specialising in food waste streams and how they can be exploited to produce new products; Cranfield University, with strengths in food science and nutrition, water and soils engineering; and the Centre for Agroecology, Water and Resilience at Coventry University undertaking transdisciplinary research on the understanding and development of resilient food and water systems internationally. Other key assets are summarised below.

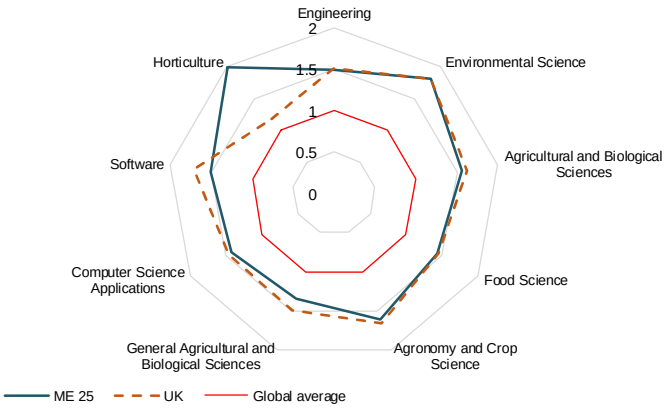
- Six of England's 17 Food Enterprise Zone designations: Europarc, Central Lincolnshire and Holbeach in Lincolnshire; Melton Mowbray in Leicester and Leicestershire; the Vale of Evesham in Worcestershire; and Ivel Valley Stratton Business Park in South East Midlands
- Southglade Food Park in Nottingham that hosts start up and growing food companies, with space to accommodate up to 190 employees in multiple small food companies
- Leicester Food Park that provides food manufacturing space with purpose-built units, providing start-up and grow on space for new and established food businesses
- Humber Seafood Institute and Innovation Centre, and the Grimsby Seafood Village, which provides start up units for 20 food chain companies
- Unilever at Colworth Park in Bedfordshire hosts its global R&D centre for ice cream and beverages. This facility also hosts an office of the Institute for Manufacturing from Cambridge University
- Mondelēz International's Global Centre of Excellence for Chocolate R&D at Bournville
- Sutton Bridge Crop Storage Research (AHDB Potatoes) is a top 5 global root vegetable storage research centre based in South Lincolnshire.

Research and innovation base – further evidence

Sci Val data

The ME 25 as a group performs on a par with the UK in most relevant detailed disciplines including Food Science, Agronomy and Crop Science, and in the broader subject areas of Engineering, and Environmental Science.

The ME 25 performs better (by a very large margin) than the UK in the detailed research area of Horticulture, with direct relevance, for example, to supporting firms in optimising the yield of primary products from raw materials through technology to reduce damage.



Citation data

The Witty review did not identify any Midlands Engine institutions in the Top 20 in the UK for the areas of Agri-Tech or Agri-science. However, Sci Val data identifies universities across the region with 'distinctive competencies' or 'enabling competencies' that fall into relevant subject areas summarised below.

Subject areas	ME HEIs with 'Distinctive Competencies' in the subject area	ME HEIs with 'Emerging Competencies' in the subject area
Food Science	Coventry, Cranfield, Nottingham Trent	Birmingham, Coventry, Harper Adams, Loughborough, Nottingham, Warwick, Wolverhampton
Agronomy and Crop Science	Cranfield, Nottingham	Cranfield, Harper Adams, Nottingham, Warwick, Wolverhampton

Research Council Funding

Research area	% UK funding 2010-15	Value of funding (£m)
Food Science and Nutrition	33%	2.0
Plant and Crop Science	32%	8.7
Agri-environmental Science	36%	10.3

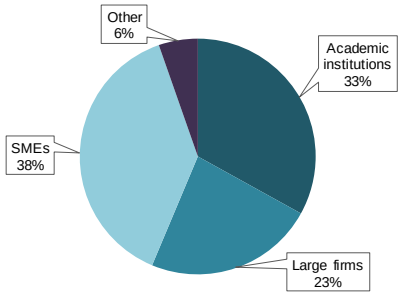
Innovate UK Funding

- £21m of grants offered over 2010-16 in Sustainable Agri-Food (SAF) Protection budget area …
  - 21% of UK total in the budget area

… by project activity type

Project activity area	Value (£m)
Improving food supply chain efficiency	3.4
Food processing and manufacturing efficiency	3.2
Engineering solutions to enhance agri-food production	2.9
Agri-Tech Catalyst	2.9
Measurement technologies for agri-food systems	1.9
Other	6.3

… by recipient type



Patents (2004-13)

- Food Chemistry: 39% of UK patent applications, 186 patent applications

Source: SQW analysis of 2016 Elsevier B.V, Gateway for Research, Innovate UK, EPO PATSTAT data

Priority Area 3: Medical Technologies and Pharmaceuticals

Scope and competitive advantage

4.38 Our priority area of medical technologies primarily focuses on Medical Devices, Diagnostics and Software as a Medical Device i.e. those technologies following a Medical Device regulatory pathway, and conventional pharmaceuticals – but embracing other aligned emerging/next generation medical technologies including those focussed on regeneration that are largely currently within the academic science base.

4.39 More specifically, we focus in particular on *growing* activity in diagnostics, including in vitro diagnostics (IVD) and Diagnostic Imaging. This is because of its importance in medicine, significant linkages to our broader life sciences capabilities and pharmaceutical heritage, engineering and bio-engineering strengths, as well as national and regional recognition of diagnostics as a next step for devices businesses. Importantly, there is also strong evidence of success in translation in this field from academic science to commercial success (including trade sales) and patient and healthcare system impact.

> ***E-consultation feedback***
>
> *"The Midlands has a strong academic base engaged in translational medicine evidenced by high impact journal publications, intellectual property filings and synthesis of spin outs".* HEI respondent

4.40 We will also work to *sustain* our activities in pharmaceuticals. The Midlands Engine is already home to pharmaceutical research, contract pharmaceutical manufacturers and clinical research organisations who are supported through specialist incubators such as BioCity; with expansion potential at the Charnwood Campus demonstrated by Almac's recent investment.

4.41 The whole life sciences sector is underpinned by our broad and deep clinical and university base. Our region has five large NHS Trusts with integrated hospitals and two Academic Health Science Networks (AHSNs) which help to accelerate the adoption of innovations. The Midlands Engine also has seven medical schools who produce large numbers of highly qualified healthcare professionals and researchers. Additionally, we have five major trauma centres, four adult and two paediatric (Nottingham is a combined adult/paediatric). Our large and stable multi-ethnic population is another key asset and helps to differentiate our offer to global pharma firms.

4.42 Our region has an exceptional opportunity to support the entire supply chain for research and development of new therapeutics and medical devices. The broad diversity of our companies acts as a magnet to attract and retain well paid, highly qualified staff through broader career opportunities, with concomitant benefit to the regional economy. This diversity also provides sustainability and resilience, as the sector is not dependent on one major pharma company.

Scale and concentration of activity…

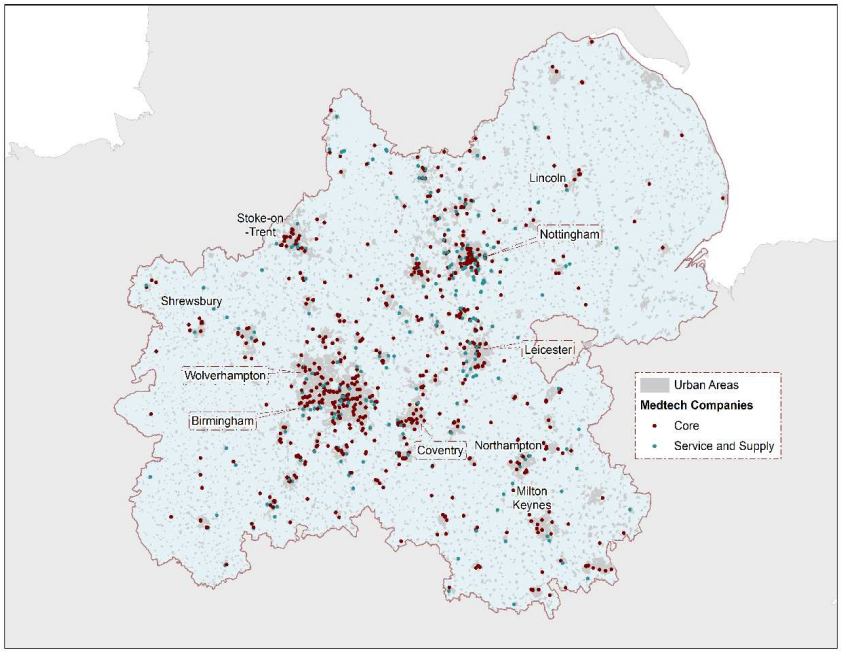
4.43 Defining the medical technologies market priority area with SIC codes suggests that our businesses in the sector had a combined employment of 8,000 in 2014, a 20% increase on the 2009 figure.[44] More broadly, 95,000 were employed in related supporting sectors including research and experimental development on biotechnology, and other human health activities.

4.44 However, using SIC codes to define the medical technologies sector(s) is particularly problematic as it cuts across parts of a number of different SIC codes. A more accurate picture may be given by the Office of Life Sciences' (OLS) 'Strength and Opportunity' 2015 dataset. This suggests that we have 760 core medical technologies businesses, and a further 305 associated service and supply businesses. Combined, these account for 29% of the UK total. The three most important sub-sectors are assistive technology (121 businesses, 35% of the UK total), digital health (77, 27%), and dental and maxillofacial technology (63, 46%).

4.45 As shown in Figure 4-3, our medical technologies businesses, as identified by the OLS, are spread across the regional geography, with particular concentrations in Nottingham and Birmingham, reflecting the presence of incubator facilities (and incubation services) at BioCity Nottingham and the Birmingham Biohub. Emerging initiatives which may become significant for the priority area over the coming years include: Medicity in Nottingham; the Life Sciences Campus (Institute of Translational Medicine and Battery Park) and the Digital Health Quarter in Birmingham; Woodlands Enterprise Zone in Aylesbury Vale; and the planned Life Sciences Opportunity Zone on the former AstraZeneca Charnwood Campus.

4.46 Our commercial manufacturing and supply capability and capacity in medical technologies is emphasised by the presence of 3M and Fisher Scientific (both in Loughborough). Other medical technologies businesses based in the region include Binding Site (Birmingham, a developer and manufacturer of immunodiagnostic assays and instrumentation), Pennine Healthcare (Derby, a manufacturer of single use, sterile medical devices) and NRS Healthcare (Coalville, a provider of products and services designed to support independent living).

Figure 4-3: Locations of med tech companies in the Midlands Engine (2015)



Source: Produced by SQW 2016. Licence 100030994. Contains OS and National Statistics data © Crown copyright [and database right] [2016]. Contains Office for Life Sciences data

4.47 The East Midlands has historic strengths in pharmaceuticals supply and R&D, building on the heritage of Boots, Fisons and Ciba-Geigy. However, the reduction in, and concentration of, pharmaceutical employment over the last 10 years has seen job losses, e.g. AstraZeneca at Charnwood. Despite this, the Midlands Engine retains a modest, but strategically important core of biopharmaceuticals businesses. The OLS identifies 61 core biopharmaceutical businesses in our region, with five of these employing over 250 people. These include 3M in Loughborough, AstraZeneca in Luton, and Novartis in Grimsby. These firms are supported by a growing biopharmaceutical service and supply sector, totalling 166 firms across the Midlands Engine. The largest employers identified by OLS include AAH Pharmaceuticals in Coventry, Movianto in Bedford, and Alloga in Alfreton.

4.48 Data from UKTI identified seven inward investment projects into the region in the Market Driven Priority in 2015/16, supporting around 100 jobs.[45]

… and the supporting asset and research base

Innovation assets

4.49 Alongside our broad and deep industrial base, the medical technologies and pharmaceuticals sector also leverages key regional assets including our large and stable diverse population, five major teaching NHS trusts and their large integrated hospitals (with 34 NHS Trusts in all), our life sciences, pharmaceutical and manufacturing heritage, and pan-regional investments in medical technologies incubation and rehabilitation. This supporting base is crucial for medical technologies and pharmaceuticals research, as innovation in this field requires 'ABC' - academic, business and clinical actors. More specifically, key academic assets include seven medical schools (Aston, Birmingham, Buckingham, Keele, Leicester, Nottingham and Warwick) which, with relevant departments at other universities, support key research centres, summarised below.

Table 4-5: Key research centres across the region

- Six Biomedical Research Units funded by the National Institute for Health Research (Hearing, Digestive Diseases, Cardiovascular, Respiratory, Diet Lifestyle and Physical Activity, Liver Disease); and six Arthritis Research UK Centres (Tissue Engineering; Musculoskeletal Ageing; Pathogenesis of Rheumatoid Arthritis; Experimental Arthritis Treatment; Pain; Sport, Exercise & Osteoarthritis)
- UK Research Council Centres for Doctoral Training in Regenerative Medicine; From Targeted Therapeutics to Next Generation Medicine; Systems Biology
- Cancer Research UK activities at their UK Clinical Trials Unit (Birmingham) and the Leicester Cancer Centre
- The Birmingham Institute for Translational Medicine which aims to use cutting edge scientific discoveries to accelerate the provision of personalised healthcare.
- The Clore Life Sciences laboratory at the University of Buckingham houses the Buckingham Institute for Translational Medicine which partners with industry in developing new therapies for diabetes and obesity
- The National Centre for Sports and Exercise Medicine (Loughborough), aiming to translate high quality research in sport, exercise and physical activity into health outcomes that will improve health and wellbeing
- The UK's largest NIHR/Wellcome Trust Clinical Research Facility in Birmingham includes adult and paediatric facilities and provides high-quality for experimental and complex clinical research studies
- The National Institute for Health Research Surgical Reconstruction and Microbiology Research Centre in Birmingham is a national centre for trauma research
- The Aston Brain Centre at Aston University aims to develop translational applications of fundamental neurophysiological research to clinical service provision.

Source: Midlands Engine

4.50 Investment is ongoing with the announcement in June 2016 of the establishment of the Leicester Precision Medicine Institute, which will develop diagnostics and treatments to serve Leicester's diverse population, and the £ new Science and Health Building at Coventry University.[46]

4.51 Our strength in subjects allied to medicine is also an important innovation asset because the skills and expertise of people trained by our universities can be the catalyst for new devices and treatments. In addition to facilities such as Coventry's Centre for Technology Enabled Health Research, our strengths are demonstrated through the REF scores of Aston and Nottingham on Allied Health Professions, Dentistry, Nursing and Pharmacy; see Table 3-1.

4.52 The research conducted at our leading institutions can be applied in the Midlands Engine area because our large, ethnically diverse and stable population provides a 'living laboratory' which, combined with the clinical trials infrastructure and expertise present in the region (for example in Birmingham, Derby, Leicester and Warwick), allows the Midlands Engine to act as a test-bed for new technologies with our large NHS trusts acting as a key route to market.

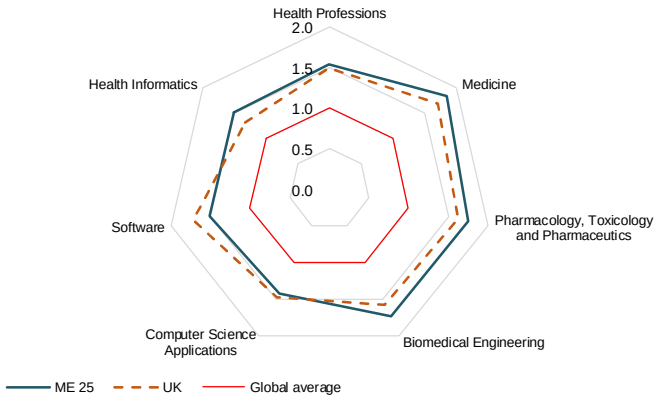
4.53 The Midlands Engine has the potential to support the early and rapid adoption of new devices and therapeutics at scale, giving the area an important competitive advantage. This is based on the Royal Centre for Defence Medicine and the NIHR SRMRC (in Birmingham) and will be enhanced by the Defence and National Rehabilitation Centre under construction in Nottinghamshire: combined with trauma medicine capabilities at Stoke Mandeville, the Nottingham Trauma Centre, and Stoke-on-Trent and Oswestry Hospitals, this confirms our position as a national leader in defence and trauma medicine.

Research and innovation base – further evidence

Sci Val data

The ME 25 performs above the UK average in the key medical technologies discipline of Biomedical Engineering, with a FWCI of 1.7, compared to 1.6 for the UK.

Highlighting regional strength in Health Care the ME25 outperforms the national level not only in established disciplines such as Medicine, Biomedical Engineering, Pharmacology Toxicology & Pharmaceutics but also in the emerging discipline of Health Informatics.



Witty Review

Institutions in the Midlands Engine ranked in the top 20 in the UK for their field weighted citation impact:

- **Life sciences**: Nottingham (19), Birmingham (20)
- **Life sciences - genetics and synthetic biology**: Nottingham (11), Birmingham (17)
- **Regenerative medicine**: Birmingham (17), Nottingham (19)

Research Council Funding

Research area	% UK funding 2010-15	Value of funding (£m)
• Bioengineering	• 29%	• 11.4
• Medical and health interface	• 37%	• 20.4

Institutions in the Midlands Engine also secured £93.5m in research funding in 2014 from medical charities and other sources of health research funding (excluding MRC and Innovate UK), including over £14m in the areas of pharmaceuticals and medical devices.

Innovate UK Funding

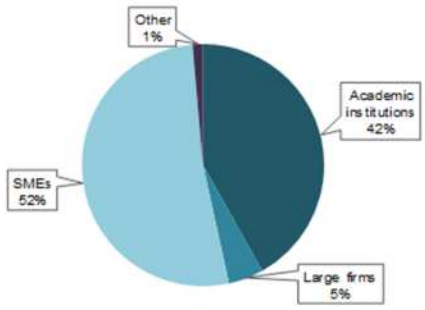
- £13.4m of grants offered over 2010-16 in the Healthcare budget area …
  - ➢ 5% of UK total in the budget area

… by project activity type

Funding provided across a wide range of healthcare research areas, with over £4m of grant offered by Innovate UK to participants in the Midlands Engine through the BioMedical Catalyst. Selected projects funded in the region in the specific area of med-tech include

- £1.4m for developing a medical device to resuscitate new-born babies
- £300k for developing a medical device for multiplex genotyping and tumour staging and profiling
- £140k to develop an innovative inhaler to aid patient compliance with their prescribed drug regime

… by recipient type



Patents (2004-13)

- Medical Technologies: 18% of UK patent applications, 446 patent applications

Source: SQW analysis of 2016 Elsevier B.V, Gateway for Research, Innovate UK, EPO PATSTAT data and Witty Review (2013)

Priority Area 4: Energy and Low Carbon

Scope and competitive advantage

4.54 The Midlands is at the heart of the UK's energy system, with expertise and capability across a diverse range of areas from conventional energy supply and distribution, through to renewables and low carbon technologies. Within this significant and broad sector, informed by emerging green energy and energy efficiency drivers of change, the SIA has identified five interrelated sub-elements that form the Energy and Low Carbon Technologies Market Priority Area:

- **Geo Energy:** The UK's natural resources are declining and will only be partially replaced by indigenous renewables. UK leadership in Geo Energy is provided by The British Geological Survey (BGS), which has its HQ near Nottingham, with expertise in the development of renewable energy such as geothermal power, carbon capture and storage, and unconventional hydrocarbon and coal resource development
- **Thermal Energy Systems:** heat and cold are important parts of thermal energy. There is a market demand for the decarbonisation of both systems and their integration with the remainder of the energy system. In order to deliver on these opportunities research institutions across the region are working nationally and internationally with industry on topics as diverse as metallurgy, materials, industrial process engineering and control, bio-fuels, bio-energy systems, and cryogenics
- **Nuclear:** the civil nuclear industry will play a key role in the UK's energy mix going forward, with no viable alternative for clean electricity on demand as base load. Opportunities are evident in the management of nuclear waste and decommissioning, and the development of small modular reactors that can provide additional capacity adding to and complementing the current plans for large nuclear plants. The Midlands has many companies involved in nuclear systems design and construction, including Rolls-Royce, who have delivered many reactor systems for the UK submarine fleet
- **Energy Storage:** will support smart integrated energy systems and enable previously isolated components of the energy system to work together (electricity, gas and heat). The Midlands is working on a very wide range of potential energy storage systems in conjunction with industry including battery technologies (materials and chemistry); Hydrogen; Compressed Air; Molten Salt; Geo systems and Cryogenic systems (Nitrogen, Air and Hydrogen). These Energy storage systems have relevance to the decarbonisation of transport systems, integration with solar systems and grid level storage to complement intermittent renewable energy sources. In the domestic sector, where heat currently accounts for over 40% of the UK's energy demand, significant innovation opportunities exist in designing and delivering low-carbon energy services to consumers that use Energy Storage as part of the answer
- **Smart Integrated Energy Systems:** deploy and use intelligence to integrate the actions of all the components in the energy system to achieve desired outcomes. Such systems present substantial innovation opportunities in the UK and internationally. They support optimisation of investments in renewing energy infrastructure and re-configuration of value-chains to allow the delivery of new energy services to consumers. Innovation opportunities to exploit smart systems exist largely at the 'system edge' (in the 'last mile' of supply), adjacent to the point of use and 'behind the meter' in the consumer's home or premises. Vital research and industrial capabilities which sustain innovation will be in sensors, controls, communications, data (including the architectures which will enable

them to be deployed effectively), power systems, and modelling and simulation capabilities to analyse system behaviour under change, and the Midlands is leading demonstration level research on energy efficiency issues including human interactions inside and outside the home with significant commercial potential.

4.55 There are strong synergies between this Market Driven Priority and other parts of the SIA Framework. For example, Energy and Low Carbon Technologies aligns closely with Next Generation Transport, in the areas of low-carbon vehicles, and in research and industrial capabilities on the design, integration and control of electrical power systems. In common with innovation opportunities in the modernisation of other infrastructure systems, the future value will be in 'knowledge' based capabilities and the delivery of value-adding services as much as technology or equipment supply, aligning strongly with our Enabling Competencies.

Scale and concentration of activity…

4.56 The Energy sector and relevant supporting technical disciplines supports around 180,000 work-based employees across the region; the breakdown by sub-sector is set out below, including over 28,000 employees in Electricity, gas, steam and air conditioning supply (with an LQ of 1.43). The business base in the region includes major sites of global energy businesses such as Alstom, Cummins, E.ON and their new formed technology arm at Uniper, GE, Jaguar Land Rover, National Grid, Rolls-Royce and Siemens as well as a large number of Innovate SME's including Bladon Jets, Ekkosense, Lindhurst Engineering, and Intelligent Energy.

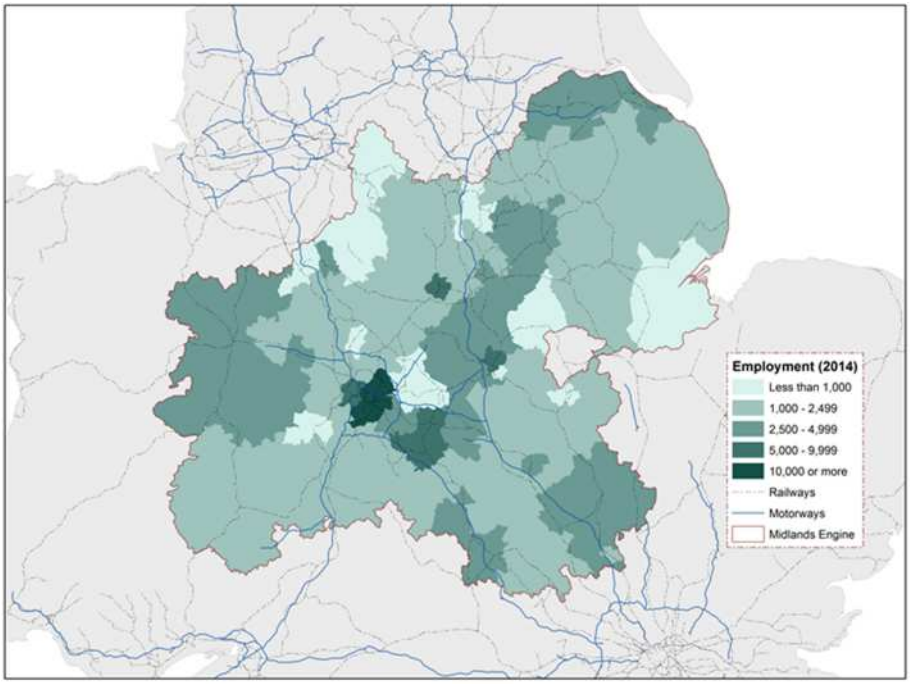
Table 4-6: Employment and LQ in Energy and Low Carbon (2014)

Sub-sector	Employees	LQ
Core Energy		
Electricity, gas, steam and air conditioning supply	28,000	1.4
Waste collection, treatment and disposal activities; materials recovery	21,900	1.0
Water collection, treatment and supply	6,900	1.2
Sewerage	3,500	0.9
Manufacture of electric lighting equipment	3,500	1.4
Remediation activities and other waste management services	3,200	3.7
Manufacture of coke and refined petroleum products	3,000	2.0
Manufacture of other organic basic chemicals	1,600	0.9
Mining of coal and lignite	500	0.9
Mining support service activities	300	0.1
Extraction of crude petroleum and natural gas	100	0.0
Manufacture of batteries and accumulators	100	0.4
Test drilling and boring	100	0.2
Supporting disciplines		
Engineering activities and related technical consultancy	58,500	0.9
Other professional, scientific and technical activities n.e.c.	18,600	0.9
Technical testing and analysis	12,500	1.4
Research and experimental development on natural sciences and engineering	9,800	0.5
Specialised design activities	7,900	0.9

Source: SQW analysis of BRES

4.57 As shown in the map at Figure 4-4, there are particular concentrations of activity in Birmingham and Nottingham, but significant employment in energy and support disciplines is evident across the region and its local areas.

Figure 4-4: Employment in the 'core' and 'supporting' elements of the market priority area (2014)



Source: Produced by SQW 2016. Licence 100030994. Contains OS data © Crown copyright [and database right] [2016]. Contains BRES data

4.58 Data from UKTI identified eight inward investment projects into the region in Energy in 2015/16, supporting over 450 jobs.[47]

… and the supporting asset and research base

4.59 Our large-scale industrial base in energy is complemented by a critical mass of research and innovation assets focused on driving forward and delivering UK leadership in key areas of energy research and rapid translation into industrial pilot and demonstration-scale activities. There is a large number of research posts, scientists and academics across Midlands institutions with approximately 2,000 skilled people working in this arena. Key assets in the region include:

> ***E-consultation feedback***
>
> *The region has "strong track record and expertise in addressing this government's priority [energy networks] and how energy storage systems can contribute to the reduction of CO_2 emissions and increase security of supply."* HEI respondent

- The **British Geological Survey** (BGS), is a world leading geological survey and the UK's premier provider of objective and authoritative geoscientific data, information and knowledge for wealth creation, sustainable use of natural resources, reducing risk and living with the impacts of environmental change. It advances understanding of the structure, properties and processes of the solid Earth system through interdisciplinary surveys, monitoring and research for the benefit of society

- The **Centre of Excellence for Low Carbon and Fuel Cell Technologies** (CENEX), based in Loughborough, specialises in the delivery of projects, innovation and market development with a direct focus on low carbon vehicles and associated energy infrastructure. It works to increase the use of alternative fuels through the addition of infrastructure including electric vehicle charge points, gas and hydrogen stations

- The **Energy Research Accelerator**, a cross-disciplinary energy innovation hub which brings together capital assets, data and intellectual leadership to foster collaboration between academia and business to accelerate the development of solutions to the global energy challenge. ERA's initial priorities of Geo-Energy Systems, Integrated Energy Systems and Thermal Energy will help deliver the new technologies and behaviours that will open the avenues for its future development and demonstrate the transformative effect the collaboration can have across the energy spectrum
- The **Energy Systems Catapult**, based in Birmingham, holds relationships and methodologies to analyse future requirements for the energy sector, many of which will involve exploitation of smart systems. It is currently executing innovation projects focused on delivery of smart heat services to domestic consumers and provides networked links to other Catapults holding enabling capabilities for 'smart infrastructure' (Transport, Digital, Future Cities and Satellite Applications)
- The **Energy Technologies Institute** (ETI) has capabilities in whole systems energy analysis and informing innovation priorities for smart systems. The ETI acts as a conduit between academia, industry and the Government to accelerate the development of low carbon technologies. It makes targeted commercial investments in nine technology programmes across heat, power, transport and the infrastructure that links them
- The **High Value Manufacturing Catapult** (HVMC), with centres at the MTC and WMG is supporting the advancement of manufacturing and supply chain readiness levels of technologies of partner organisations and companies as well as create a virtual manufacturing environment to inform production.

4.60 The region also hosts demonstrators with the potential to support the integration of future smart energy system technologies into infrastructure. Examples are set out below.

Table 4-7: Examples of regional energy demonstrators

- The **Birmingham Thermal Belt** will deliver a network of 25 bioprocessing plants, each consuming on average 20,000 tonnes/year of biogenic waste and residue, delivering as much as 600GWh of combined green power and heat for use in transport, and biochar to be used for fertilisation.
- The **Community Energy Demonstrator at the Trent Basin** is a large scale regeneration scheme to redevelop a long neglected area, and combining an integrated smart heat and power micro-grid for low energy demand buildings and a large community energy store
- BGS are currently establishing the **Energy Security and Innovation Observing System for the Subsurface** (ESIOS), a pioneering system to realise the huge potential of Britain's underground energy resources. At the core of ESIOS will be a group of science research facilities where new subsurface activities can be tested and monitored under controlled conditions.
- The **Geo-Energy Test Bed**, based at the University of Nottingham's Sutton Bonington campus, is a facility designated for the testing and 'ground-truthing' of borehole sensors and software.
- A **Smart Energy Network Demonstrator** is planned at Keele University which will encompass 10,000 energy consumers and cover over 200,000m^2 of mixed built environment, a range of on-site generating technologies and 94km of a private network. It will provide a physical demonstrator for smart energy research and development, enabling the 'real' evaluation of new and evolving energy technologies.
- The **Smarter Network Storage project** at Leighton Buzzard is home to one of Europe's largest battery storage projects: the 6MW/10MWh hosted by UK Power Networks will improve the understanding of the economics of electrical energy storage.

Source: Midlands Engine

4.61 The breadth of multi-disciplinary related industrial and research activity conducted across the Midlands is supported by academic institutions whose individual research centres collaborate on large programmes to address the sub-elements of the priority area. Notable centres which reflect the Midlands competence base are set out in Table 4-8; evidence from the ERA indicates that across these universities there are some 500 academics and scientists working in energy research.

Table 4-8: University specialisms and key research centres in Energy and Low Carbon

University and Specialisms	Key research centres
Aston University Distinctive capabilities on bio-energy and the development of renewable gases and heat, its existing facilities have potential to operate as a demonstrator for an integrated heat and power network	European Bioenergy Research Institute acts as a focus for pan-European activities on scientific and technological aspects of biomass conversion and utilisation of products for renewable power, heat, transport fuels, hydrogen and chemicals. The University is a partner of the SUPERGEN Bio-Energy Hub
University of Birmingham Nationally significant capabilities on thermal energy storage and cold energy, including the Centre for Cryogenic Energy Storage and Centre for Fuel Cell Research	The Birmingham Energy Institute tackles challenges linked to energy systems, business of energy, energy transport and breakthroughs in energy technology. Partnerships are based around centres of excellence in nuclear energy, fuel cells, railway and automotive systems, policy and economics, and energy storage. The University is a partner of the SUPERGEN Energy Storage Hub, and hosts the Centre for Nuclear Education and Research, the Highview Cryogenic Energy Storage Pilot Plant, and the EPSRC Centre for Doctoral Training in Fuel Cells and their Fuels
Cranfield University Covers a range of the potential energy solutions from oil and gas to developing reliance on renewable energy. Focus is on industrial scale research and pilot scale demonstration programmes	Key research centres include Bioenergy and Resource Management; Combustion, Carbon Capture and Storage; Offshore Renewable Energy; Oil and Gas Engineering; Power Engineering. Industrial scale experimental facilities supporting the research activities span across many different kinds of energy systems, including an ocean systems laboratory, gas turbines, an anaerobic digestion plant, and high temperature coating test facilities. The University is partner of the SUPERGEN Wind Power Hub
Keele University Undertakes cross faculty research into sustainability with particular interest in fuel cells, wind energy, eco coal, geothermal energy and photovoltaics. This is supported by the Smart Energy Network Demonstrator facilities.	The Siemens' Research Centre focuses on wind power research and development. The research centre specialises in developing power converter technology, converting and controlling the electrical power from wind turbine generators into a form compatible with the electricity grid.
University of Leicester Environment, Energy and Climate Change theme integrates existing strengths of Earth Observation climate data from space, climate adaptation and mitigation, and geographical information systems	As a leading hub for activities utilising satellite (remote sensing) data the Earth Observation Group conducts integrated R&D with increasing exploitation of sophisticated and powerful sensors that are included in satellites.
Loughborough University Expertise includes: renewable energy technologies; efficient/flexible generation of power; electrical and thermal energy storage; efficiency of conventional transport systems; and end-use energy demand in buildings and for travel	The Centre for Renewable Energy Systems Technology is a leading UK sustainable energy research centre with significant facilities and capabilities drawing together both industry and academia. at Loughborough University. The University leads the EPSRC Supergen SuperSolar Hub
University of Nottingham A leading international centre for energy research, with a reputation for excellence across a broad range of technologies encompassing bioenergy, fossil energy, energy storage, the built environment and electrical grids	The Energy Technologies Research Institute is a focal point for research and industrial collaborations. Facilities and capabilities support the test and demonstration of energy in the built environment, and future collaborations have potential to deliver commercial demonstrations of smart community energy systems. Other research centres include joint collaborations with BGS on the GeoEnergy Research Centre and Centre for Environmental Geochemistry. The University hosts the EPSRC Centre for Power Electronics, and the Centre for Doctoral Training in Carbon Capture and Storage and Clean Fossil Energy
University of Warwick Core strengths in several key areas of Energy research, including: Power Electronics; Solar Energy; Thermal Energy; Energy Management; Low Carbon Transport and Energy Storage	As part of the national Centre for Power Electronics (led by Nottingham), there is a focus on capabilities and facilities to support the efficient, flexible conversion and conditioning of electrical energy. WMG has significant facilities and industrial collaboration support in battery technology innovation, including prototyping, production scale-up, test, simulation, performance evaluation, forensic analysis and integration of vehicles to the energy system. The University is a partner of the SUPERGEN Energy Storage Hub.

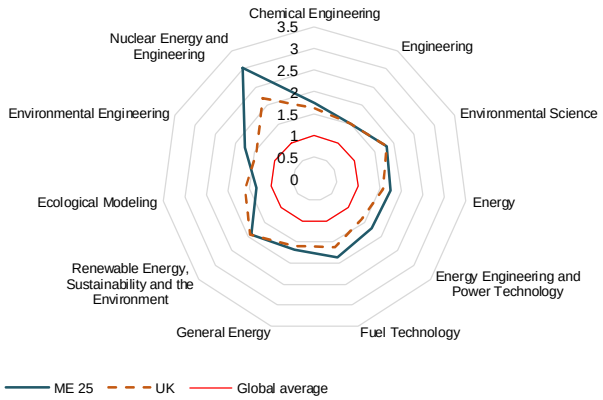
Source: Midlands Engine

Research and innovation base – further evidence

Sci Val data

The ME 25 performs above the national average in the broad subject area of 'Energy' with a FWCI of 1.75, compared to 1.59 in the UK. The ME 25 also outperforms the UK in the related area of Chemical Engineering.

Looking at detailed disciplines the ME25 performs above the national average in Fuel Technology, Energy Engineering and Power Technology, Environmental Engineering, General Energy, and Nuclear Energy and Engineering and on a par with the national level in Renewable Energy, Sustainability and the Environment.



Witty Review

Institutions in the Midlands Engine ranked in the top 20 in the UK for their field weighted citation impact:

- **Nuclear**: Nottingham (2), Warwick (7), Birmingham (14), Leicester (19)
- **Oil and gas**: Cranfield (18), Nottingham (19)
- **Offshore wind**: Loughborough (1), Birmingham (5), Nottingham (7)
- **Energy Storage**: Nottingham (4), Loughborough (8), Birmingham (12)

Research Council Funding

Research area	% UK funding 2010-15	Value of funding (£m)
• Energy	• 35%	• 162

Innovate UK Funding

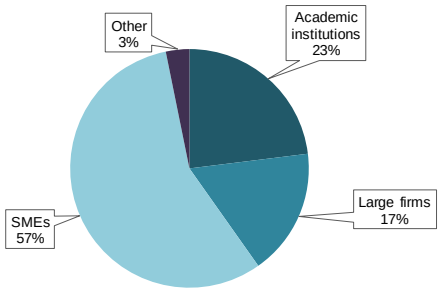
- £17.9m of grants offered over 2010-16 in the Energy budget area
  - ➢ 11% of UK total in the budget area

… by project activity type

Funding provided across a wide range of research areas. Selected projects funded in the region include:

- approx. £700k to the universities of Cranfield and Birmingham as part of the Carbon Abatement Using Surface Engineering Technologies project
- over £550k to partners in the region including E.ON Technologies and Alstom for the IMPACT project to improve the efficiency of future steel-based coal-fired power plant, and hence reduce carbon emissions
- over £400k for the Coventry and Birmingham Low Emission Demonstrators (CABLED) project

… by recipient type



Energy Research Accelerator (ERA) Funding

The £180m Energy Research Accelerator (ERA) includes: £60m Government capital investment; £100m of co-finance from private companies; and £20m from the Midlands Innovation universities.
The universities and EPSRC have committed another £2.4 million to recruit 33 doctoral students[48] and the ERA's research funding portfolio is £71.7m (EPSRC)[49]

Patents (2004-13)

Electrical machinery, apparatus, energy: 21% of UK patent applications, 378 patent applications

Thermal processes and apparatus: 28% of UK patent applications, 133 patent applications

Source: SQW analysis of 2016 Elsevier B.V, Gateway for Research, Innovate UK, EPO PATSTAT data and Witty Review (2013)

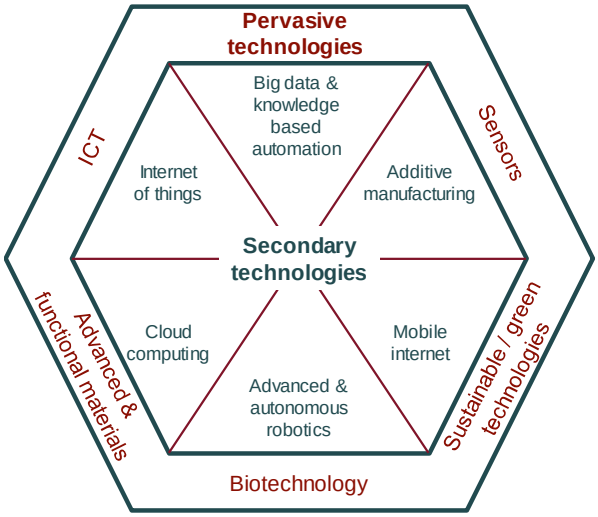
5. Market and technology drivers of change

Technology megatrends

5.1 A wide range of frameworks and models have been developed to characterise how new and emerging technologies will change how we design, make, sell and service products over the next decade and beyond, and the nature of changes that are already happening to a greater or lesser extent across our industries. To provide an accessible overview of these issues, Figure 5-1, adapted from the UK Government, summarises the key technologies that will shape the future.

5.2 To stay competitive, our businesses (large, medium-sized and small) must be ready to operate and thrive in this new environment, which will be characterised particularly by increased 'digitisation' and 'servitisation' of the manufacturing sector, known commonly as 'Industry 4.0'.

Figure 5-1: Pervasive and secondary future facing technologies



Source: SQW analysis, based on The Future of Manufacturing, The Government Office for Science, 2013

5.3 In this context, for the four Market-Driven Priority areas outlined in Section 4, we set out a **headline review** of the market/technology drivers of change. These profiles are not comprehensive, nor do they draw on primary research (consistent with the expectations of the SIA). However, they provide a powerful insight into the challenges and opportunities that will present in the region as we move forward. Encouragingly many of these changes have been anticipated in Section 4.

5.4 Whilst many of the same changes will influence the future of each of our four areas (e.g. increased elderly populations, climate change, etc.), the exact way in which they interact with each of the four varies – they have therefore been included multiple times in the tables below.

Next Generation Transport

Global drivers of change and megatrends

- **Climate change**: Due to the increasing numbers of extreme weather events, transport infrastructure will need to be built with resilience in mind, especially transport systems in coastal areas.[50] To combat climate change, the European Commission's goal is to allow a 75% reduction in CO_2 emissions per passenger kilometre and a 90% reduction in NOx emissions compared to year 2000 figures.[51]
- Coupled with emissions reduction targets, **resource scarcity (particularly of fossil fuels)** is also prompting a shift away from diesel and petrol vehicles towards electric and hybrid cars.[52]
- **Megacities and urbanisation**: By 2050, around 75% of the world's population will live in cities. This provides opportunities for transport that relies on high density to function efficiently e.g. rail, bus and metro systems.[53]
- An **increased elderly population** will have an impact on the design and choice of mobility solutions, which must become more accessible.[54]
- The **continued rise of emerging markets** provides a major growth area for export sales in all segments of the transport industry.[55]

Next generation transport trends

- Whilst fully **autonomous cars** are still some way-off market readiness, the rise of their pre-cursors will continue. This includes **connected cars** (fully digitised vehicles with Wi-Fi; advanced infotainment apps; vehicle-to-vehicle communications that let cars "talk" to each other; real-time location services; etc.) and **intelligent cars** (incorporating self-braking, self-parking, automatic cruise control, automatic accident-avoidance features, computer-operated power steering, etc.)[56]
- Use of **lightweight materials** is forecast to grow across all industries, particularly the automotive sector, due to stricter CO_2 emissions regulations, creating a €300bn market for high-strength steel, aluminium, and carbon fibre by 2030.[57]
- **Increasing adoption of high speed rail** across developed and developing markets is predicted; worldwide high speed track length is forecast to have a compound annual growth rate of 4.5% to 2020.[58]
- *"existing technology is insufficient [in rail],* ***we are moving into a technology-led decade of change and innovation****. That means both faster implementation of existing technology, and* ***a relentless drive to spur greater innovation and new technologies****" .*
- All sectors will face continued **customer demands** for increased customisation, reliability, safety and 'no surprises'.

Scale of market

- The global volume of air traffic is expected to increase to 16bn passengers annually in 2050 (compared to 3.4bn passengers in 2015[59]), with 25m commercial flights in Europe.[60] To meet this rising demand, 30,000 large civil airliners, 22,000 business jets, 5,800 regional aircraft and 40,000 helicopters will be needed by 2033.[61] Overall, the **large civil airliner market is forecast to be worth $3.2tn by 2030.**[62]
- **Global automotive sales are forecast to be 111m units by 2020**.[63] Within this, autonomous driving technology global sales are predicted to grow five-fold to €35.7bn by 2020, with sales of safety technologies to quadruple to €47.3bn between 2015 and 2020.[64]
- The **global rail market is forecast to be worth £128bn by 2019.**[65]

Competitor regions

- **Japanese firm Toyota** (including the Daihatsu and Hino brands) is the world's largest vehicle manufacturer by sales, selling 10.15m units in 2015. Toyota has a manufacturing plant in Burnaston, Derbyshire.[66]
- **California based firm Tesla** is at the forefront of innovation in electric and connected/semi-autonomous vehicles, whilst **driverless taxis are already being trialled in Singapore.**[67]
- For aerospace, **American firms including GE and Pratt and Whitney** benefit from US defence expenditure to develop technologies which can later be deployed into civil aerospace markets.
- By 2021, nearly 3 million cars will be built yearly in the Middle East and Africa (especially Algeria, Nigeria, Egypt, and Iran), an increase of 50%.[68]

Future food processing

Global drivers and trends

- **Precision agriculture** uses IT, satellites, remote sensing and proximal data gathering to optimise returns (both arable and pastoral) on inputs and potentially reduce environmental impacts by, for example, reducing the amount of pesticides used.[69]
- **Climate change** will be an important factor. Rising global temperatures and changing patterns of precipitation will affect both crops and livestock across the globe.[70]
- The **global increase in population** will demand ever greater levels of output and shifts within this output. For example, it is predicted that more than 30% of protein consumed in 2050 will be from non-animal sources, demonstrating the need for new sustainable sources of protein to feed the growing world population.[71]
- **Legislation will also drive change -** potentially through demanding reductions in waste.[72]
- **Changes in values and ethical stances of consumers** are already being reflected as the industry moves towards a health and nutrition focus. Examples include issues of national interest and food sovereignty, the acceptability of modern technology (e.g. genetic modification), the value placed on animal welfare, the importance of sustainability, and the provenance of food commodities.[73]
- The production and processing of food must **become more sustainable** to counter emerging threats such as water scarcity.[74]

Future food processing trends

- **Zero waste processing** – Ingredients are considered increasingly valuable if their 'co-products' can themselves be used to develop additional value streams and thus eliminate wastage".[75]
- **New Processing Technologies –** The evolution of extraction technologies, bio-transformation and improvements in freezing technology can be used to improve shelf-life.[76]
- **Bio-refining** - Developments in processing and biotransformation will allow the development of high quality ingredients and compounds from both raw materials and waste side streams.[77]
- There have been **mergers and partnerships** between leading players as they seek to expand their presence. For instance, Kraft foods partnered with Heinz, and Tyson Foods collaborated with Godrej Foods in India.[78]
- **Packaging** - the development of smart systems which contain nano-technologies that interact with products to extend shelf-life (*active packaging*), inform on the quality or safety aspects of the product (*intelligent packaging with the use of RFID chips etc.*), and/or are derived from sustainable resources.[79]
- In response to increasingly health-conscious consumers, **reformulation** to reduce salt, sugar and fat will become increasingly widespread.[80]

Scale of market

- **Revenue in the global packaged food market is expected to reach $3.03tn by 2020**. Within this, non-alcoholic drinks and baked foods constitute the largest product markets, accounting for 75% of the market value. Baby food and yoghurt are predicted to be the two fastest growers, at 6.4% and 6% respectively.[81]
- The global groceries market is forecast to reach **$11.8tn by 2020.** China is expected to be the largest market ($1,491bn), followed by the US (1,305bn) and India ($901bn).[82]
- Over the longer term, it is estimated that **demand for food will increase by 80- 100% by 2050**. This includes expected increases in meat consumption from 26 to 44 kg/person/year in low income countries by 2050, whilst consumption of dairy products in developing countries is predicted to rise by 70% by 2050.[83]

Competitor regions

- The key players operating in the packaged food market are Nestlé, General Mills, Kraft Food, Inc., ConAgra foods, Inc., Tyson Foods, Kellogg's, Frito-Lay, JBS Food, Smithfield Food, Inc. and Mars, Inc.[84]
- UK competitor regions include the East of England, Scotland and Northern Ireland, whilst The National Centre of Excellence for Food Engineering is based at Sheffield Hallam University.
- International competition comes from **Regio Food Valley Netherlands** and the wider Netherlands food industry, with supporting research conducted at Wageningen University.
- **New Zealand** has well-developed export orientated food sectors and abundant natural resources. There are also substantial investments being made in emerging economies in the agri-food sector, exemplified by **Brazil and China.**

Medical Technology

Global drivers of change and mega trends

- The global population aged 60 and above is expected to reach nearly two billion in 2050. This **increasing ageing population and its associated cost burden** will drive a shift away from remedial care/treatments to predictive/preventative care.[85] For example, the cardiovascular devices market is expected to feature more prominently, driven by the increasing incidence of cardiovascular diseases in the rapidly expanding elderly population.[86]
- Where previously physician preferences were the dominant factor in determining both the treatment to administer and equipment used, **evidenced-based care** is becoming increasingly important, along with cost considerations in making these decisions. This gives greater market power to payers and providers.[87]
- Emergence of major players within developing countries where there are significant growth opportunities – some of these firms now have major R&D budgets.

Medical Technologies trends

- Key players have consolidated their market position through **mergers and acquisitions**, for example Medtronic's acquisition of Covidien for $49.9bn. This is expected to continue as firms increasingly look to buy-in technologies to combat sluggish organic growth.[88]
- Worldwide medical technologies R&D expenditure is forecast to grow by 3.5% per annum to reach $29.5bn in 2020. However, this is a lower growth rate than that forecast for medical technologies sales (see below) meaning that the **R&D investment rate will fal**l from 6.4% in 2014 to 6.2% in 2020.[89]
- R&D expenditure will increasingly be focused on improving already approved devices rather than developing new products because of **heightened regulatory scrutiny**.[90] However, this trend may be reversing; the number of first-time device approvals awarded by the US FDA increased by 43% from 2013 to 2014 – and this rate continued into 2015.[91]
- Medical technologies growth in emerging markets will be dependent on adapted products as healthcare systems in these markets frequently lack the evidence base, qualified personnel and/or budgets to simply adopt products developed for established markets.[92]

Scale of market

- The European medical technologies market is worth an estimated €100bn, which accounts for almost a third of the global market.[93]
- **Average annual growth of 4.1% is forecast to drive the worldwide value of the medical technologies market up to $477.5bn by 2020.**
- Within medical technologies, **in vitro diagnostics will be the most important area** with predicted sales of $67.3bn, representing 14.1% of the medical device industry. Cardiology ($54.2bn) orthopaedics ($42bn) and diagnostic imaging ($40.9bn) will be the next largest areas.[94]

Competitor regions

- By 2020, the two largest medical technologies companies in the world, and a further five out of the top ten, are predicted to be **based in USA**. Medtronic, the largest 'pure-play' medical technologies company, is expected to capture 7.3% of the world market (sales of $34.9bn), and Johnson & Johnson 6.2% ($29.7bn).
- Towards the other end of the market, the top ten medical technologies venture financing deals by value (H1 2015) all involved US companies.[95]
- **Established competition also comes from Western Europe**, notably Siemens (predicted rank in terms of worldwide market share in 2020: 3, Germany), Roche (4, Switzerland) and Philips (10, Netherlands).[96]
- The trend towards increased medical technologies innovation in Asia is **particularly strong in Singapore,** where more than 30 companies carry out R&D for regional and global markets.[97]

Smart Energy Networks, Thermal Energy and Energy Storage

Global drivers of change and mega trends

- **Progressive electrification of the economy in developing countries** will lead to a convergence in energy use patterns and services between developed and developing countries[98]; non-OECD countries will account for 93% of the increased demand for energy to 2035.[99]
- In response to **climate change and environmental protection regulations**, efficiency improvements will be demanded in the generation and use of energy in all sectors of the economy. [100,] In response to the same issues, the share of renewables in total power generation is forecast to rise from 21% in 2012 to 33% in 2040.[101]

Energy trends

- **Smart information systems and smart grid technologies** will enable real time coordination and dynamic decision making.[102]
- Low-carbon futures will create a **greater role for systems thinking and integrated design**[103], especially as the energy mix diversifies into a range of technologies with vastly different profiles and an increasing reliance on distributed generation.[104]
- Growth in **microgeneration and small energy projects** targeting individual and rural energy needs with renewable technology applications (e.g. wind, solar PV, biomass-fuelled generation).[105]
- An increase in the development of **secondary alternative energy sources** (batteries, fuel cells) to provide effective energy storage and standalone energy-saving electrical equipment, vehicles and public utilities.
- The use of **nuclear power** will increase intensively in developing nations (e.g. China, India, Russia).[106]

Scale of market

- Global electricity demand is projected to increase by 85 percent between 2010 and 2040[107]
- World electricity generation is forecast to grow by 70% from 22,126 terawatt-hour (TWh) in 2011 to 37,000TWh in 2030[108]
- **Global investment in the power sector of $21tn up to 2040**, with over 40% in transmission and distribution networks[109]
- The worldwide **energy storage market is expected to quadruple to $6bn by 2020[110]**

Competitor regions

- Companies entering the energy storage market include General Electric and NEC Energy, Stem and Green Charge Networks.[111]
- Japanese giants Toshiba and Panasonic and South Korean conglomerates Samsung and LG are leaders in the fast-growing battery energy storage market for power generated from renewable sources.[112]
- Nissan, AESC, GS Yuasa and BYD are concentrating on the market for battery-powered electric vehicles.[113]
- **California**: Imperial Irrigation District aims to be operating lithium–ion energy storage equipment by the third quarter of 2016; the Public Utilities Commission has mandated that utilities purchase a predetermined amount of energy storage capacity to support energy storage developers; San Diego Gas and Electric proposes to introduce incentives for residential and small commercial customers to pay for their own 'behind the meter' energy storage.[114]
- The **Japanese government is supportive of energy storage projects** and has offered utility companies incentives to add energy storage, as well as providing grants for residential storage deployment.[115]

Implications for the Midlands Engine

5.5 The review of the global megatrends reveals the following key messages for the region:

- The global economy is changing rapidly, and *every* business in the Midlands Engine needs to understand and factor these changes into its day-to-day operations to remain viable and competitive. **Firms that recognise global economic changes fully and plan for them early and effectively are most likely to be the long-term winners.**
- The key market and technology drivers of change will also give rise to new business models/processes and different approaches to translational research and innovation. These developments will **call for a highly skilled and expert cadre of leaders and managers across our advanced manufacturing and wider sectors**.

- Each of the global megatrends and key technologies outlined above must not be seen in isolation. **Our firms and policy-makers must ensure that they understand the interrelationships and connectedness between these drivers**, as it is at the interface of technologies and markets where the most significant innovations and growth opportunities are likely to emerge.
- Given the scale and speed of change seen across the global economy in recent years, it is vital that all actors within the Midlands Engine innovation ecosystem have access to the most up to date and highest quality foresight material on an ongoing basis. As a region, we should **strengthen our horizon scanning capabilities so we can prioritise investments and adapt most effectively**.

6. Innovation networks and behaviours

Overview

6.1 Collaboration and networking is core to the Midlands Engine growth agenda; by combining the strengths of our 11 LEP areas and working together more closely and openly, we aim to achieve greater regional (and UK) economic growth and productivity improvement. Effective relationships and joint-working are also key to modern innovation models, with 'open innovation' increasingly pervasive, where knowledge, ideas and ingenuity are shared across sectors, institutions, firms and people.

6.2 Given the scale and breadth of the Midlands Engine, and the relative novelty of pan-regional working, it is perhaps not unexpected that many of the most effective and embedded networks in the region are operating at local and sub-regional, rather than pan-regional, levels. Indeed, given the importance in effective innovation ecosystems of personal relationships and shared spaces, such localised networks - often shaped around individual innovation districts, universities, science parks, hospitals or major industrial R&D hubs etc. – are likely to remain crucial. However, a broad range of effective alliances and networks do exist across the Midlands Engine, including:

- **Midlands Connect**, a collaboration with central government, 28 local authorities and 11 LEPs to develop a transport strategy that identifies the major infrastructure projects needed to improve the connectivity of our region's key locations
- **Midlands Innovation**, a collaboration of six research-oriented universities (Aston, Birmingham, Leicester, Loughborough, Nottingham and Warwick)
- **Midlands Enterprise Universities**, a partnership of seven universities aiming to drive productivity and economic growth (Birmingham City, Coventry, Nottingham Trent, Derby, Lincoln, Wolverhampton and De Montfort)
- **Midlands Aerospace Alliance** with some 300 members that represent the aerospace industry across the Midlands region.

6.3 Other formal networks operating at pan-regional or high-level geographies include:

- Medilinks in the East Midlands and West Midlands, Academic Health Science Networks in the West Midlands and East Midlands, and Birmingham Health Partners, an alliance between academics at the University of Birmingham and clinicians at University Hospitals, Children's Hospital and Women's Hospital NHS Trusts
- Universities West Midlands, an organisation which aims to foster strong partnerships to support economic, social and cultural well-being and public benefit.
- the Birmingham Science City Alliance of public, private and university stakeholders working to stimulate and promote science and technology driven innovation
- regional European Enterprise Network, led by partners at Coventry University, Birmingham Chamber of Commerce and Industry, and East Midlands Chamber.

6.4 Across our 11 LEPs there are also numerous alliances, associations and collaborator networks, crucial to supporting innovation activity within the region. Four examples, providing an insight into the nature of innovation collaboration on the ground across the region are provided in Annex K.

University networks and linkages

International students

6.5 Data from HESA indicate that in 2014/15 our universities attracted approximately 71,000 international students, of which over three-quarters (some 54,500 students) were from outside the European Union. Five institutions (Coventry University, University of Birmingham, University of Warwick, University of Nottingham, and University of Leicester), collectively accounted for over half of international students across the region, each with over 6,000 international students in 2014/15. Our universities accounted for 16% of international students across the UK in 2014/15, and 21% excluding London.

6.6 Demonstrating the international nature of our universities:

- Coventry University (at 9,100) had the fourth highest number of international students of all UK institutions
- over half (56%) of students at Cranfield University were from outside the UK, the fourth highest proportion of all UK institutions, and the highest outside London
- 39% of students at the University of Buckingham were from overseas, the third highest of any non-London institution.

Partnerships and international engagement

6.7 Our 27 universities are highly engaged in associations and groups across the spectrum of UK higher education. The alliances and coalitions that are institutions participate in are identified below.

Table 6-1: UK university alliances and coalitions

Body	University members in the Midlands Engine
Cathedrals Group	Bishop Grosseteste, Newman
Guild HE	Bishop Grosseteste, Buckinghamshire New, Harper Adams, Newman, University College Birmingham, Worcester
Million+	Staffordshire, Bedfordshire
Russel Group	Birmingham, Nottingham, Warwick.
University Alliance	Coventry, Lincoln, Nottingham Trent, Open University

Source: SQW analysis

6.8 In addition, our universities are involved in numerous international networks, research partnerships, and collaborations, reflecting the outward facing nature of our economy. Given the scale of our university base, with some 27 individual institutions, a comprehensive mapping of all these relationships was not possible within the remit of the SIA. However, in Annex K we provide four examples of the international collaborations and partnerships to illustrate the breadth of our collaboration.

Evidence on R&D and industrial collaboration

6.9 Using data to demonstrate effective linkages and engagement is challenging; however, a range of evidence is presented below to provide an indication of the nature and scale of R&D and industrial collaboration across the Midlands Engine.

European Research Programme

6.10 Data provided by the national contractor indicates that institutions in the Midlands Engine were involved in over 3,600 projects under the Framework Programme 7 and Horizon 2020 programmes, with an average total value of over £100m per annum. As set out in Table 6-2, higher education institutions accounted for over two-thirds of the funding. Within these headline data, the region secured a high relative share of funding in the themes of Energy, Transport and Environment, which align strongly to our identified Market Priority Areas.

Table 6-2: Value and number of projects involving ME institutions under FP7 / H2020 (2007-17)

Type	Value (£m)	Projects	% value	% projects
Higher or secondary education establishments	831.9	2,169	67%	59%
Private commercial	319.3	1,201	26%	33%
Public body (excluding research and education)	32.5	78	3%	2%
Research organisations	24.8	61	2%	2%
Other	41.9	153	3%	4%
Total	1,250.5	3,662		

Source: Technopolis

Knowledge Transfer Partnerships

6.11 Over 2010-2016, universities in the region supported over 250 Knowledge Transfer Partnerships (KTPs), one fifth (19%) of all delivered across the UK, and involving 22 of our 27 universities. Nottingham, Wolverhampton, and Aston were the universities responsible for the most KTPs delivered in region over this period.[116]

6.12 Nottingham and Wolverhampton were also both in the top ten UK universities in terms of the number of KTPs delivered over the 2010-2016 period, with Nottingham ranked third in the UK (behind only Sheffield and Queens University Belfast), and Wolverhampton ninth (out a total of 167 institutions).

University – Industrial collaboration

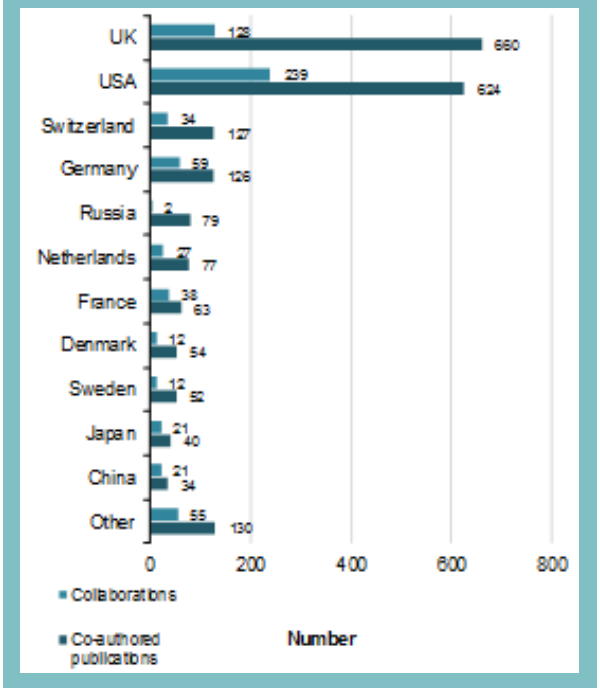
6.13 Universities across the Midlands Engine collaborate extensively with industry partners across the UK and internationally. Given the scale of our university base, with 27 institutions, including some of the largest multi-disciplinary Russell Group universities in the country, it is not possible or helpful to list all of these collaborations and partnerships.

6.14 However, to provide evidence on the breadth and scope of industrial collaboration, we have accessed Sci Val's 'collaborations' database which records collaborations between universities and industry that have led to co-authored publications.

6.15 The Sci Val data indicate that over the 2013-15 period, the ME 25 universities co-authored publications with over 250 separate industrial partners, leading to over 2,000 co-authored publications (with multiple collaborations across multiple universities for some firms).

6.16 The collaborations were with both UK and international partners, as shown opposite. For example, over 600 publications were co-authored with industrial partners based in the USA, from over 200 separate collaborations. It is notable that collaborations that led to co-authored publications with USA-based partners were more common than with UK-based firms, although on average these collaborations produced fewer publications.

Co-authored publications by ME 25 universities by location of partner 2013-15 (Source: Sci Val)



6.17 The industrial partners with which ME 25 institutions have co-authored publications include some of the most innovative and globally competitive firms in their respective fields. The 25 firms[93] that co-authored the most publications with ME 25 universities over 2013-15 are set out in Table 6-3, grouped (in broad terms given that many of these firms will span market areas) by the four Market Driven Priority areas.

Table 6-3: Industrial partners with highest number of co-authored publications with the ME 25 (2013-15)

Next Generation Transport
- Rolls-Royce
- Jaguar Land Rover
- Airbus Group
- Alstom
- BAE Systems

Medical Technologies (and wider life sciences)
- GlaxoSmithKline
- AstraZeneca
- Novartis
- Pfizer
- Merck
- deCODE Genetics
- Genentech Incorporated
- Novo Nordisk AS
- Bristol-Myers Squibb
- Eli Lilly
- Boehringer Ingelheim GmbH
- Johnson & Johnson

Future Food Processing
- Unilever
- Syngenta

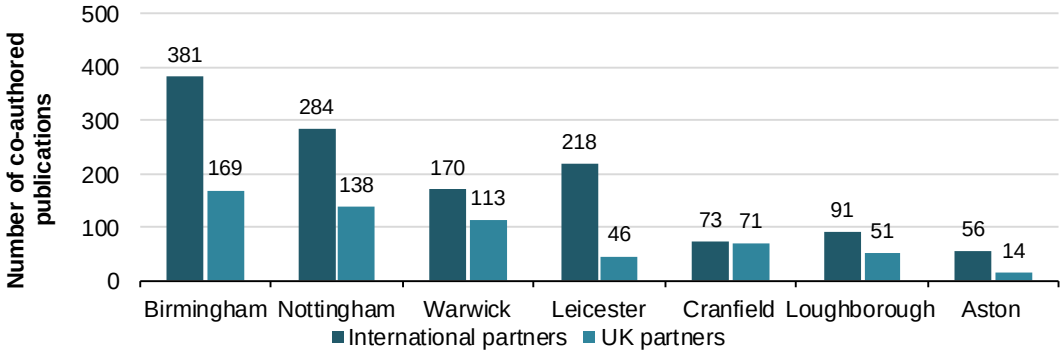
Energy
- BP
- Rolls-Royce

Other / cross-cutting
- General Electric
- IBM
- Microsoft USA
- Johnson Matthey Plc
- QinetiQ

Source: Sci Val

6.18 Of the 2,000 co-authored publications with industrial partners recorded in the Sci Val data, the majority (91%) involved collaborations between industry and one or more of the six Midlands Innovation universities, or Cranfield University; the number of co-authored publications by these universities is set out below.

Figure 6-1: Co-authored publications with industry for the 'Midlands Innovation' universities, and Cranfield University (2013-15)



Source: Sci Val

6.19 However, to provide an indication of the spread of collaborative activity with industry across the university base in the region as a whole, Figure 6-2 highlights collaborations leading to co-authored publications between universities in the Midlands Engine and five example firms: Rolls-Royce; AstraZeneca; Unilever; IBM; and Jaguar Land Rover.

Figure 6-2: Examples of collaborations leading to co-authored publications between firms and universities in the Midlands Engine (2013-15)

University	Rolls-Royce	AstraZeneca	Unilever	IBM	JLR
Aston University		✓	✓		✓
Birmingham City University	✓				
Coventry University				✓	✓
Cranfield University	✓		✓		✓
De Montfort University				✓	
Harper Adams University College	✓			✓	
Keele University		✓			
Loughborough University	✓	✓	✓	✓	✓
Nottingham Trent University		✓			
Open University Milton Keynes	✓			✓	
Staffordshire University				✓	
The University of Buckingham		✓			
University of Birmingham	✓	✓	✓	✓	✓
University of Derby	✓			✓	
University of Leicester	✓	✓	✓	✓	
University of Lincoln				✓	
University of Nottingham	✓	✓	✓	✓	✓
University of Warwick	✓	✓	✓	✓	✓

Source: Sci Val

6.20 It is important to recognise that the data set out above focus on the number of collaborations, not their quality or impact. However, the data indicate how our different universities across the region are engaged extensively in industrial collaboration activity, both in the UK and internationally.

6.21 The region also has strong university and industrial links with other UK science and innovation assets. For example, there are links with the Hartree Centre at Sci-Tech Daresbury in the Liverpool City Region: Aston University and the University of Warwick recently collaborated with the Hartree Centre to test the scalability and runtime behaviour of software, which aims to improve the efficiency and cost effectiveness of fibre optic cables.

6.22 Our regional institutions also work widely with the UK's Catapult network. Further to the Centres that are based in our region (High Value Manufacturing, Energy Systems, and Transport Systems), collaborations include:

- *Cell and Gene Therapy Catapult*: Loughborough University are working with the Catapult on innovative manufacturing, to develop robust processes and new manufacturing and delivery techniques, removing the barriers associated with turning cell-based therapies into products, and providing training and skills development. The University of Birmingham, with Cancer Research UK and the Catapult have formed a spin-out company

to commercialise innovative new CAR-T cell therapies aimed at treating cancer in novel ways.

- *Digital Catapult*: the Catapult is working on the Milton Keynes Low Power Wide Area Network Project, one of the first large-scale, pilot/demonstrators for IoT telecommunications in the world, with a consortium that includes the Future Cities Catapult, Milton Keynes Council, The Open University and BT. The Catapult also works with the Horizon Digital Economy Research Institute at University of Nottingham to support the training of digital economy researchers.

External relations - evidence from the e-consultation

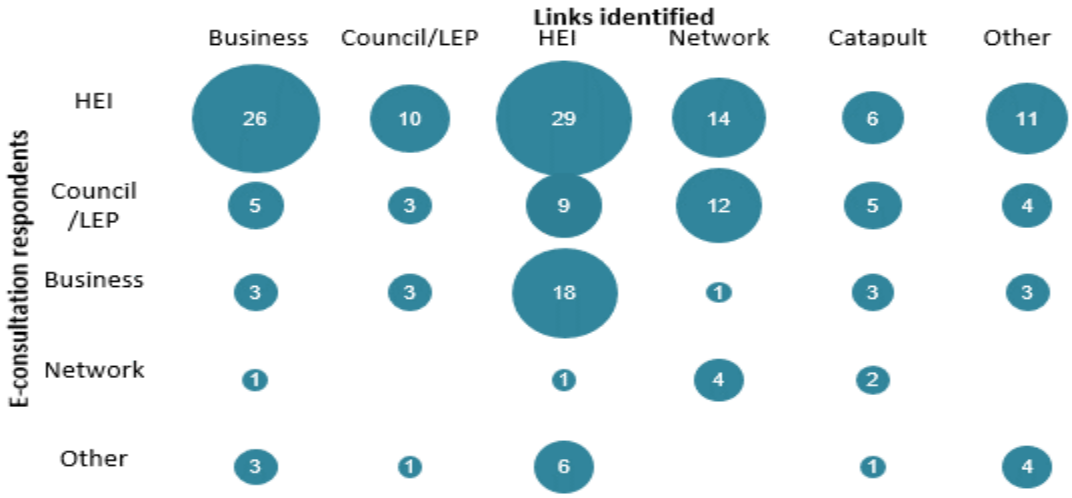
6.23 The e-consultation engaged over 65 institutions across the Midlands Engine, each with their own bilateral and multilateral partnerships within the region, with partners elsewhere in the UK, and with international partners. Respondents were asked to identify their three most important scientific research and/or innovation partnerships/relationships with others in the Midlands Engine, and an equivalent list for those outside the region, both in the UK and internationally.

6.24 Whilst this does not provide a comprehensive mapping of all scientific research and/or innovation partnerships/relationships operating across the Midlands Engine (and the intensity of these links has not been analysed in any detail), the survey evidence does provide valuable insight into the scale and breadth of engagement in shared innovation activity by regional institutions.

Linkages within the Midlands Engine geography

6.25 The e-consultation identified links between actors from across the Midlands Engine innovation ecosystem. Although not based on an exhaustive list, the chart below indicates that HEIs are particularly active in developing scientific research relationships and/or innovation partnerships with other players in the Midlands Engine, especially fellow HEIs. HEI respondents also identified a large number of links with Midlands Engine businesses, whilst, in turn, business respondents were most likely to cite links with HEIs. The chart also identifies the important supporting role played by local councils and LEPs, as well as existing networks which range in size from city specific, e.g. Birmingham Science City Alliance, to regional, e.g. Medilink East Midlands and Medilink West Midlands.

Figure 6-3: Midlands Engine organisations as key scientific/innovation partners



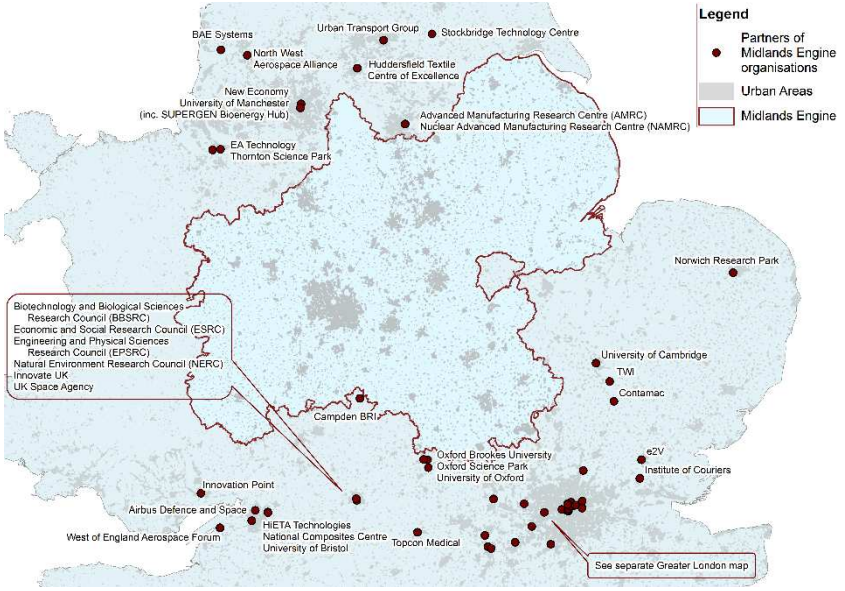
Source: SQW analysis of e-consultation responses

Linkages outside the Midlands Engine

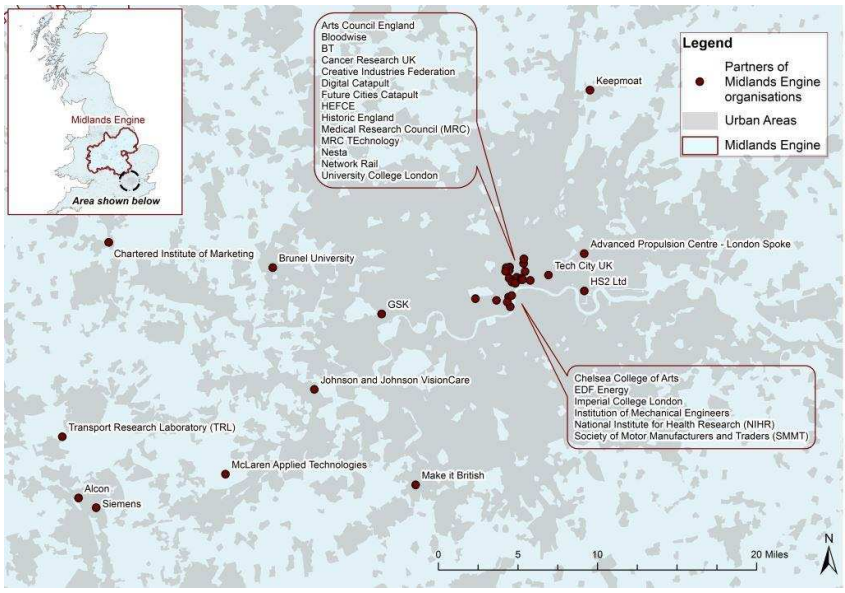
6.26 The e-consultation identified a wide range of scientific research and/or innovation partnerships between respondents in the Midlands Engine and others elsewhere across the UK. The organisations cited by respondents across England and Wales are set out in the maps below; the feedback identifies linkages with leading research intensive universities including Bristol, Cambridge, Imperial College London, Manchester, Oxford, and University College London, Catapult Centres and other RTOs, as well as leading private sector firms.

Figure 6-4: UK organisations outside of the region as key scientific/innovation partners

Links with organisations across England and Wales ...



... with a particular concentration in London



Source: Produced by SQW 2016. Licence 100030994. Contains OS and National Statistics data © Crown copyright [and database right] [2016]

6.27 Respondents to the survey also identified over 30 organisations outside of the UK with whom they have key scientific research and/or innovation partnerships/relationships. The full list of organisations identified is presented in Annex I; organisations of particular relevance to the SIA and its Market Driven Priorities include Boeing, Ford, and the European Space Agency (Next Generation Transport), and the Fraunhofer Institute for Environmental, Safety, and Energy Technology and the International Energy Agency (Energy and Low Carbon).

Implications for the Midlands Engine

6.28 The headline review of the Midlands Engine's key networks and networking activity reveals three important messages:

- First, there is considerable good practice across the plethora of geography, sector and institution-specific networks that exist within the Midlands Engine, and the SIA process itself has demonstrated the importance and value-add of establishing effective cross-sector alliances through which ideas and knowledge can be shared more easily between different communities. However, feedback from stakeholders at the six thematic workshops and through the e-consultation exercise suggests that there is **scope to strengthen both our formal and informal networks within and across the region**.
- Second, the evidence presented shows the breadth of world-class innovation and scientific research activity occurring across the Midlands Engine. However, when compared to some of the leading high-tech regions globally (such as the 'Golden Triangle' in the UK, Silicon Valley and Singapore etc.), it is clear that **more could be done to showcase and champion our capabilities nationally and internationally**, which will help us to build new relationships, strategic partnerships and land more inward investment. This message is consistent fully with the 'Promoting the Midlands Engine' strand of the original Midlands Engine prospectus.
- Third, as the Smart Specialisation '*connectedness'* imperative calls for, the Midlands Engine must build, maintain and strengthen relationships and alliances with the leading centres and sources of innovation elsewhere – both in the UK and internationally; and the evidence from the e-survey, whilst partial, indicates that we are already collaborating with some of the world's leading universities, innovation assets, and firms. We must **continue to be outward facing and leverage these links so they can help us achieve fully our core productivity and innovation intents**.

7. Next Steps – unlocking our productivity potential

7.1 The Midlands Engine provides the heartbeat to the UK economy. It is built on a globally leading and internationally connected manufacturing base, with demonstrable strengths across multiple sectors and technology areas, drawing on world leading science and innovation capabilities.

7.2 We are home to more than a quarter of the UK's total manufacturing capability, with major strengths in logistics, transport (automotive, rail, aerospace and space) and energy, as well as truly distinctive capabilities in health, food, and the digital and creative sectors. The Midlands Engine is a £230 billion economy, generating 15% of the UK's GVA and with five million employees. Our key strengths are world-renowned and ensure that we provide the bedrock for UK manufacturing exports. Our 27 universities deliver incredible academic and entrepreneurial firepower to sustain and renew these strengths, as evidenced by their performances in UK and world rankings, from research power through to income and impact.

7.3 Despite these strengths, and like many other parts of the UK, we underperform on productivity – me must get better at leveraging our considerable assets, science and innovation, businesses and people to secure increased productivity growth. This audit of science and innovation strengths and opportunities in the Midlands Engine area has sought to identify concrete market opportunities and underpinning competencies that offer real potential for the Midlands Engine to tackle its productivity deficit and drive growth across our region and the UK more widely. Additionally, the SIA demonstrates how our region can contribute fully to an exciting and vibrant UK-wide industrial strategy.

Market opportunities

7.4 This audit process has identified four specific market areas where there are clear growth opportunities and very strong alignment with the Midlands Engine's strengths and distinctive capabilities:

- **Next Generation Transport**: there are immediate opportunities around technology development (simulation and modelling; advanced digital design and validation; advanced materials and manufacturing; digital manufacturing, supply chain and service management) for **aerospace/space, automotive, high value motorsport and rail**, including significant complementarities and cross-overs with the Energy and Low Carbon opportunity presented below
- **Medical Technologies and Pharma**: distinctive opportunities exist around **diagnostics and imaging**, sustaining our activities in **pharmaceuticals**, drawing on the region's **stable ethnic diversity as a living laboratory for improving health outcomes**, growing our success in **trauma and rehabilitation**, and **combining health and environmental data** to support innovation as next generation transport and low carbon economy opportunities are progressed
- **Future Food Processing**; the Midlands Engine region is the source of a significant proportion of the UK's primary food production. Opportunities for major productivity growth are particularly attractive in **efficient food processing**, **zero-waste food chains**, and **food product innovation**.
- **Energy and Low Carbon**; the recently launched Energy Research Accelerator represents a major investment in energy in the Midlands Engine. We need to build on this and

capitalise on our opportunities in **geo energy, thermal energy systems, nuclear, energy storage and smart integrated energy systems**.

7.5 These four areas describe specific near term opportunities for growth that the Midlands Engine will deliver on quickly, with the right support. The audit has also identified (Table 2-2) a range of possible priorities for investment over the slightly longer term. It will be for the Midlands Engine to think these through further in order to identify how best to align them to our future industrial strategy and ensure that impact can be maximised.

Underpinning competences

7.6 **Systems integration** is a core enabling competence across the Midlands Engine, from logistics to health and on to integrated smart transport systems. Our very strong science and innovation base across engineering, the natural and social sciences, together with our undisputed competencies in **advanced manufacturing and engineering** and in **digital technologies and data**, position us strongly to deliver that integration, both technological and societal, and turn this international excellence into lasting productivity growth for the UK.

A proactive region already focused on Industrial Strategy

7.7 This SIA has created the opportunity for the key players around the Midlands Engine area to come together and identify clear and current opportunities for growth. Unsurprisingly, in a region of the reach and vibrancy of the Midlands, significant efforts are already underway that provide a close match to some elements of the market opportunities we have identified. In particular:

- Midlands Innovation's thinking on '*Transport Innovation for a Low Carbon Economy*' that takes forward aspects of the Next Generation Transport theme
- The proposed National Space Park, which would bring a step change to space research and space-enabled data service provision
- Proposals for Life Science Opportunity Zone status for the former AstraZeneca site at Charnwood
- Emerging proposals for building on the significant investments made in the region through the Energy Research Accelerator (ERA).

7.8 These projects are welcome early steps in taking forward key elements of this ambitious audit. However, in order unleash our full productivity potential and deliver the economic transformation that this SIA has shown is possible, more will need to be done.

Unlocking our future productivity

This audit has created a new and effective focus, drawing together the main economic actors across the Midlands. It has crystallised a shared set of opportunities, channelled energy and ambition, and illustrated where our true strengths and potential lies. The baton has now passed to the Midlands Engine to take these analyses and the head of steam created around them, and configure them into major strategic priorities framed in the Government's developing Industrial Strategy. This is a task that the Midlands Engine will take forward over the coming months so that a truly transformative proposition can be brought to deliver on our full productivity potential.

[1] Subregional Productivity: Labour Productivity (GVA per hour worked and GVA per filled job) indices by UK NUTS2 and NUTS3 subregions (data for 2014); Subregional GVA (Income Approach) Reference Tables (data for 2014); Population Estimates (data for 2015); Business Register and Employment Survey (BRES) (data for 2014); and Research and Development in UK Businesses (data for 2014)
[2] Subregional Productivity: Labour Productivity indices (data for 2014)
[3] UK Regional Trade in Goods Statistics (data for Q1 2016)
[4] Subregional Productivity: Labour Productivity indices (data for 2014)
[5] Subregional Productivity: Labour Productivity indices; BRES; and Regional level employment by Broad Industrial Group (all data for 2014). Note that data are presented by GVA per employee, rather than GVA per job filled as data on jobs filled by NUTS 3 area by industrial sector is not publicly available.
[6] BEIS appointed Technopolis to provide support to the five first wave SIAs, including providing consistent datasets across the SIAs and a template for the report structure.
[7] Population Estimates (data for 2015); UK Business Counts – Local Units (data for 2015); Subregional GVA (data for 2014)
[8] The Geography of Creativity in the UK, Nesta, 2016
[9] https://ec.europa.eu/jrc/en/research/foresight/ilv2025
[10] Business Register and Employment Survey (data for 2014)
[11] https://www.top500.org/
[12] Higher Education student enrolments by Higher Education provider, level of study, mode of study and domicile, Higher Education Statistics Agency (HESA) (data for 2014/15)
[13] Gateway for Research (data for 2010-2015)
[14] Category A staff are defined as academic staff with a contract of employment of 0.2 FTE or greater and on the payroll of the submitting HEI, and whose primary employment function is to undertake either 'research only' or 'teaching and research.'
[15] Research power incorporates the volume of researchers and tells us something about the total capability of an institution, whereas research quality looks at the average quality of researchers and their outputs.
[16] http://www.topuniversities.com/university-rankings/world-university-rankings
[17] http://www.shanghairanking.com/ARWU2015.html
[18] https://www.timeshighereducation.com/world-university-rankings/2016
[19] University College Birmingham and University Campus Milton Keynes are not included in Sci Val
[20] Field-Weighted Citation Impact (FWCI) in SciVal indicates how the number of citations received by an entity/group's publications compares with the average number of citations received by all other similar publications in the data universe. A FWCI of 1.00 indicates that the entity/group's publications have been cited exactly as would be expected based on the global average for similar publications; a FWCI of more than 1.00 indicates that the entity/group's publications have been cited more than would be expected based on the global average for similar publications; for example, a FWCI of less than 1.00 indicates that the entity/group's publications have been cited less than would be expected based on the global average for similar publications.
[21] Further information on science parks across the region can be found at http://www.ukspa.org.uk/
[22] http://www.the-mtc.org/academic-founders
[23] The APC has spokes at the Universities of Nottingham (Power Electronics), Loughborough University (London) (Digital Engineering and Test), and Warwick (Energy Storage).
[24] National Space Policy, UK Space Agency, 2015, page 13: "The Government will, as part of our wider national infrastructure strategy, develop further clusters around existing and new space assets in industry and academia, replicating the "Harwell effect.""
[25] https://www.gov.uk/government/news/uk-national-space-propulsion-facility
[26] Research and Development in UK Businesses, 2014 – Datasets (data for 2014)
[27] Which are in the Midlands Engine geography, but not the West Midlands or East Midlands administrative areas
[28] UK Innovation Survey 2015, Statistical Annex (data for 2012-2014)
[29] Benchmarking Local Innovation, Enterprise Research Centre
[30] Innovate UK funded projects since 2004, https://www.gov.uk/government/publications/innovate-uk-funded-projects
[31] European Patent Office PATSTAT (data for 2004-2013)
[32] Data provided to the Steering Group by the Transport Systems Catapult, Warwick Manufacturing Group and the Manufacturing Technology Centre
[33] Research and Development Tax Credits Statistics, HM Revenue and Customs, 2015.
London and the South East have particular concentrations of head offices. Also note that this data is based on registered office location, which may not be where the actual R&D activity is carried out.
The number of claims made is higher than the number of companies who made claims. This is because a company can make more than one claim in the same year, either because they claim under different schemes or because they have more than one accounting period ending in the year.
[34] Data provided to the Steering Group by the West Midlands Science Park Alliance

[35] BRES (data for 2014). A map setting out the location of key employment sites across the region has not been provided owing to data disclosure issues.
[36] BRES (data for 2014).
[37] The Evolution of the High Performance Technology and Motorsport Cluster, SQW, 2016
[38] Five of the seven Local Authority Districts in the Northamptonshire LEP are also in the South East Midlands LEP
[39] BRES (data for 2014)
[40] UKTI data provided to the SIA Steering Group
[41] BRES (data for 2014)
[42] UK Business Counts – Local Units (data for 2015)
[43] UKTI data provided to the SIA Steering Group
[44] BRES (data for 2014). THE ME SIA adopted a tight SIC code definition for medical technologies: 21.1 Manufacture of basic pharmaceutical products, 26.6 Manufacture of irradiation, electromedical, and electrotherapeutic equipment, 26.701 manufacture of optical precision instruments, and 32,5 Manufacture of medical and dental instruments and supplies
[45] UKTI data provided to the SIA Steering Group
[46] http://www2.le.ac.uk/offices/press/press-releases/2016/june/university-of-leicester-announces-four-new-beacons-of-excellence-research-institutes
[47] UKTI data provided to the SIA Steering Group
[48] https://www.gov.uk/government/news/new-180-million-fund-to-accelerate-energy-research-across-the-midlands-engine
[49] http://www.era.ac.uk/why-era/
[50] The Future of Rail 2050, Arup, 2015
[51] Flightpath 2050: Europe's Vision for Aviation, European Commission, 2011
[52] Energy Systems and Electric Vehicles, Urban Foresight, 2016
[53] The Future of Rail 2050, Arup, 2015
[54] The Future of Rail 2050, Arup, 2015
[55] KPMG's Global Automotive Executive Survey, KPMG, 2015
[56] The Connected C@r 2014 Study, PWC, 2014
[57] Lightweight, heavy impact, McKinsey&Company, 2012
[58] Rail Outlook Study 2013-2022, Frost and Sullivan, 2013
[59] http://data.worldbank.org/indicator/IS.AIR.PSGR
[60] Flightpath 2050: Europe's Vision for Aviation, European Commission, 2011
[61] The China Challenge, ADS Group, 2015
[62] Reach for the skies: A Strategic Vision for UK Aerospace, Aerospace Growth partnership, 2012
[63] KPMG's Global Automotive Executive Survey, KPMG, 2015
[64] The Connected C@r 2014 Study, PWC, 2014
[65] Fast Track to the Future, Rail Supply Group, 2016
[66] https://news.markets/shares/toyota-remains-the-worlds-biggest-car-company-9737/
[67] https://www.theguardian.com/technology/2016/aug/24/self-driving-taxis-roll-out-in-singapore-beating-uber-to-it
[68] 2016 Auto industry trends, PWC, 2016
[69] Precision Agriculture: An Opportunity for EU Farmers – Potential Support with the CAP 2014-2020, EU, 2014
[70] The Future of Food and Farming, The Government Office for Science, 2011
[71] Technology Transforming Irish Agri-Food and Bioeconomy, Teagasc, 2016
[72] Sustainable manufacturing for the future: Investigating the current and future landscape across the food and drink industry in Great Britain, Cranfield University and Coca Cola Enterprises, 2015
[73] The Future of Food and Farming, The Government Office for Science, 2011
[74] Sustainable manufacturing for the future: Investigating the current and future landscape across the food and drink industry in Great Britain, Cranfield University and Coca Cola Enterprises, 2015
[75] Technology Transforming Irish Agri-Food and Bioeconomy, Teagasc, 2016
[76] Technology Transforming Irish Agri-Food and Bioeconomy, Teagasc, 2016
[77] Technology Transforming Irish Agri-Food and Bioeconomy, Teagasc, 2016
[78] World Packaged Food - Market Opportunities and Forecasts, 2014 – 2020, Research and Markets, 2015
[79] Technology Transforming Irish Agri-Food and Bioeconomy, Teagasc, 2016
[80] Reformulation Guide: Spotlight on Sugars, Leatherhead Food Research, 2016
[81] World Packaged Food - Market Opportunities and Forecasts, 2014 – 2020, Research and Markets, 2015
[82] http://www.igd.com/Research/Retail/Global-grocery-markets-our-forecasts-to-2020/
[83] Global Food Security 2030, European Commission, 2015
[84] World Packaged Food - Market Opportunities and Forecasts, 2014 – 2020, Research and Markets, 2015
[85] The CEO's 360 Degree Perspective: Healthcare 2020, Frost and Sullivan
[86] Life & Health Sciences Northern Ireland Capability Assessment & Foresight Report, Matrix Northern Ireland Science and Industry Panel, 2015
[87] Medical Devices: Equipped for the Future? A. T. Kearney, 2014
[88] The Future of Medtech, Arthur D Little, 2013

[89] World Preview 2015, Outlook to 2020 4th Edition, Evaluate MedTech, 2015
[90] Medical Devices: Equipped for the Future? A. T. Kearney, 2014
[91] World Preview 2015, Outlook to 2020 4th Edition, Evaluate MedTech, 2015
[92] The Future of Medtech, Arthur D Little, 2013
[93] The European Medical Technology Industry in Figures, MedTech Europe, 2015
[94] World Preview 2015, Outlook to 2020 4th Edition, Evaluate MedTech, 2015
[95] World Preview 2015, Outlook to 2020 4th Edition, Evaluate MedTech, 2015
[96] World Preview 2015, Outlook to 2020 4th Edition, Evaluate MedTech, 2015
[97] Life & Health Sciences Northern Ireland Capability Assessment & Foresight Report, Matrix Northern Ireland Science and Industry Panel, 2015
[98] Energy to 2050: Scenarios for a Sustainable Future. OECD/IEA, 2003
[99] Sustainable Energy Horizon Panel Report, Matrix, 2013
[100] Energy to 2050: Scenarios for a Sustainable Future. OECD/IEA, 2003
[101] World Energy Outlook. IEA, 2014
[102] The Future of energy 2050. Oracle, 2011
[103] Low-Carbon Energy Futures: A Review of National Scenarios, Trottier Energy Futures Project, 2013
[104] Sustainable Energy Horizon Panel Report, Matrix, 2013
[105] Energy to 2050: Scenarios for a Sustainable Future. OECD/IEA, 2003
[106] Russian Science and Technology Foresight: 2030. Ministry of Education and Science of the Russian Federation, National Research University Higher School of Economics, 2015
[107] The Outlook for Energy: A View to 2040. ExxonMobil, 2015
[108] REthinking Energy: Towards a new power system. IRENA, 2014
[109] World Energy Outlook. IEA, 2014
[110] 2016 Utilities Industries Trends, PWC, 2016
[111] 2016 Utilities Industries Trends, PWC, 2016
[112] Global Energy Storage Market Overview & Regional Summary Report 2015, Energy Storage Council, 2015
[113] Global Energy Storage Market Overview & Regional Summary Report 2015, Energy Storage Council, 2015
[114] 2016 Utilities Industries Trends, PWC, 2016
[115] http://www.businessgreen.com/bg/opinion/2424086/can-the-uk-be-a-global-leader-in-energy-storage-not-without-a-clear-government-strategy
[116] Innovate UK funded projects since 2004