East of England Science and Innovation Audit

Appendix 3 – Advanced Materials and Manufacturing

Advanced Materials and Manufacturing: Information Sources

National Context, Regional Background & Statistics

1. HM Government. “Building Our Industrial Strategy”. Green Paper January 2017
2. Greater Cambridge Greater Peterborough LEP. http://www.gcgp.co.uk/wp-content/uploads/2017/04/gcgp-consultation-doc-FINAL.pdf
3. Competition and Markets Authority. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/606013/cma-response-to-industrial-strategy.pdf
4. http://www.newanglia.co.uk/wp-content/uploads/2017/04/2017-04-12-New-Anglia-LEP-response-to-Building-Our-Industrial-Strategy-Green-Paper-SUBMITTED.pdf
5. http://www.universitiesuk.ac.uk/policy-and-analysis/reports/Pages/response-industrial-strategy-green-paper.aspx.
6. CBI. “Now is the Time to Innovate: the Road to Three Percent”. Pub CBI. March 2017
7. https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths
8. Keen, R. “Research and Development in the UK”. House of Commons Briefing Paper SN04423, 17 June 2015.
9. St John’s innovation Centre. “East of England Technopole Report” http://www.stjohns.co.uk/wp-content/uploads/2011/11/EastEnglandTechnopole.pdf
10. St John’s Innovation Centre. “Cambridge Technopole Report 2013 v1.5”. https://www.google.co.uk/?gws_rd=ssl#q=eeda+technopole+report.
11. Todeva, E & Rakhmatullin, R. “Industry Global Value Chains, Connectivity and Regional Smart Specialisation in Europe” JRC Science for Policy Report. ISBN 978-92-79-61508-5, 2016.
12. Todeva, E. “Market-Driven Clusters as Prerequisites and Consequences of Smart Specialisation” J Knowl Econ DOI 10.1007/s13132-014-0221-8, 2014.
13. Burfield, N. “Commercialising Innovation: A Briefing Paper on Historic Trends and Policy Context”. East of England Local Government Association 2012.
14. EEF Manufacturing fact card 2016: https://www.eef.org.uk/campaigning/campaigns-and-issues/manufacturing-facts-and-figures
15. http://www.camclustermap.com/#?&coll=%7B%22company-type%22%3A%22cambridge_based%22%7D
16. Essex Economic Commission. “Enterprising Essex: Opportunities and Challenges.” Pub. January 2017.
17. Zacharewicz, T. et al. “The Internationalisation of Research and Technology Organisations”. JRC Report 2017. ISBN 978-92-79-65449-7.
18. Jonathan Haskel, Alan Hughes and Elif Bascavusoglu-Moreau. “The Economic Significance of the UK Science Base” (Campaign for Science and Engineering: 2014) http://www.sciencecampaign.org.uk/resource/UKScienceBase.html
19. Statistical Bulletin: “Business enterprise research and development, UK, 2015” (Department for Business Energy and Industrial Strategy: 2016) https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/businessenterpriseresearchanddevelopment/2015#employment-in-uk-businesses-on-performing-rd.
20. https://www.gov.uk/government/statistics/uks-participation-in-horizon-2020-february-2017
21. Minguillo, D., Tijssen, R. & Thelwall, M. “Do science parks promote research and technology? A scientometric analysis of the UK”. Scientometrics DOI 10.1007/s11192-014-1435-z. 2014.
22. http://www.newanglia.co.uk/our-priorities/sector-groups-and-contacts/advanced-manufacturing/
23. http://tradeinvest.babinc.org/britam/uk-regions/england/eastern-england/

Aerospace & Defence

1. IfM Cambridge 2014. “The Defence and Security Technology Competency Report”. http://www.ifm.eng.cam.ac.uk/resources/ifm/the-defence-and-security-technology-competency-report/
2. Aerospace Technology Institute “Technology Strategy and Portfolio Update”. Pub. ATI 2016.
3. Rhodes,C. Hough, D. & Ward M. “The Aerospace Industry: Statistics and Policy” Parliamentary Research Briefings, SN00928. Pub. March 4, 2015.

Automotive

1. Henry, I. “The future of UK automotive manufacturing in 2025 and beyond”. Long-term forecast paper for The Society of Motor Manufacturers and Traders (SMMT). https://www.smmt.co.uk/wp-content/uploads/sites/2/AutoAnalysis-report-the-future-of-UK-automotive-manufactuing-October-2015.pdf
2. McKinsey: “Automotive revolution – perspective towards 2030”. January 2016 https://www.mckinsey.de/files/automotive_revolution_perspective_towards_2030.pdf
3. Gao,P. Hensley, R. & Zielke,A. “A Roadmap to the future for the auto Industry”. http://www.mckinsey.com/industries/automotive-and-assembly/our-insights/a-road-map-to-the-future-for-the-auto-industry

Building Construction

1. Reeve,A “Built Environment Subsector report” CleanTech East, Pub. Hethel Innovation, 11/2016.
2. BRE: "Meeting Construction 2025 Targets” https://www.bre.co.uk/filelibrary/pdf/rpts/87198Construction2025v3web.pdf
3. Laing O’Rourke Centre for Construction Engineering and Technology. http://www.construction.cam.ac.uk/about
4. CITB: “Faster, Smarter, More Efficient: Building Skills for Offsite Construction”. April 2017

Off-shore Renewable Energy

1. http://www.ukerc.ac.uk/publications/building-our-industrial-strategy-response-to-the-green-paper-from-the-uk-energy-research-centre.html
2. http://c.ymcdn.com/sites/www.renewableuk.com/resource/resmgr/publications/RenewableUK_response-_Buildi.pdf
3. RCUK. “Delivering Transformative Academic Research for a secure Low Carbon Future” Supergen Programme Review, 2016. http://www.rcuk.ac.uk/documents/energy/supergenreviewreportspreadweb-pdf/
4. East England Energy Group: http://www.eeegr.com
5. Energy for New Anglia: Enterprise Zone Summary http://www.newanglia.co.uk/wp-content/uploads/2014/05/EZ-Summary_03.11.11.pdf

Advanced Materials

1. Advanced materials leadership Council 17/11/2016: https://www.ktn-uk.co.uk/perspectives/a-vision-of-the-opportunities-for-advanced-materials-short-vision-papers-from-the-advanced-materials-leadership-council?_33_redirect=https%3A%2F%2Fconnect.innovateuk.org%2Fweb%2Famlc%2Famlcnews%3Fp_p_id%3D101_INSTANCE_okNCIW6dT09i%26p_p_lifecycle%3D0%26p_p_state%3Dnormal%26p_p_mode%3Dview%26p_p_col_id%3Dcolumn-1%26p_p_col_count%3D1%26_101_INSTANCE_okNCIW6dT09i_currentURL%3D%252Fweb%252Famlc%252Famlcnews%26_101_INSTANCE_okNCIW6dT09i_portletAjaxable%3D1
2. Philips,O. “Advanced Composites: Sector Development”. Pub. Hethel Innovation. 19/09/2016.
3. Research Councils UK: ‘Advanced Materials: a Smart Future’. http://www.rcuk.ac.uk/documents/documents/rcuk-advanced-materials-timeline-web-pdf/

Advanced Manufacturing

1. IfM Cambridge. “Application of Digital Technologies to Innovation in Manufacturing”. HVM Landscape Interim Report. September 2016.
2. IfM Cambridge. “Anticipating Manufacturability Needs and Challenges to Support the Pathway to Impact”. April 2015. http://www.ifm.eng.cam.ac.uk/resources/briefings/anticipating-manufacturability-needs-and-challenges-to-support-the-pathway-to-impact/
3. IfMCambridge:http://www.ifm.eng.cam.ac.uk/resources/technology/organising-for-breakthrough-innovation/
4. IfM Cambridge:http://www.ifm.eng.cam.ac.uk/resources/international/making-the-right-things-in-the-right-places/
5. PACEC “Anglia Ruskin University: Need and Demand Analysis for Innovation Support (Advanced Manufacturing)”. September 2016.
6. Allwood, J. & Skelton, A. “Industrial metamorphosis: a response to the green paper on building our industrial strategy”. https://www.repository.cam.ac.uk/bitstream/handle/1810/263494/Final-pages.pdf?sequence=1&isAllowed=y

Structural Integrity

1. Lloyd’s Register: “Foresight review of structural integrity and systems performance”. November 2015.
2. http://www.nsirc.co.uk
3. https://www.cranfield.ac.uk/facilities/structural-integrity-laboratory
4. http://www.twi-global.com/capabilities/integrity-management/

Advanced Materials and Manufacturing SWOT Analysis

Strengths	**Weaknesses**
• Regional AM&M innovation activity is excellent as measured by grants from Innovate UK and R&D spend. • Cambridge and Cranfield Universities have global reach in a wide range of disciplines; Hertfordshire, Anglia Ruskin, UEA and Essex have significant centres of excellence and an ability to develop wider AM&M coverage. • The region has world-class research institutes, including BRE and TWI. • There are established clusters of activity in aerospace & defence, automotive, advanced energy, marine, healthcare and electronics, and the region has an active and widespread construction sector. • Significant ICT innovation capability to support AM&M development.	• Regional AM&M activity is widespread, but the region lacks historical coherence and linkages are weak. • Major research centres are nationally and internationally focused, or only cover a relatively small area of the region. • Large companies have their value chains outside the region. • Resources to support regional linkages and technology transfer are limited.
Opportunities	**Threats**
• Improve Eastern AM&M coherence to connect sources of expertise to a wider range of industry. • Develop regional centres of excellence to enhance the region's ability to attract innovative companies and start-ups. • Link regional ICT and AM&M information assets to enhance the region's global significance and develop new knowledge resources to underpin region and national innovation. • A concerted Technology Transfer effort to help regional SMEs and value chains innovate as AM&M industry patters evolve. Regional SMEs have demonstrated their wish to engage in such activity. • Replacement of R&D zero-sum approaches with collaboration between institutions.	• Continued fragmentation of activity and failure to realise regional potential, both intellectually and industrially. • Lack of incentive for regional engagement among world class centres. • Loss of companies with high growth potential to regions offering a more supportive environment. • Zero-sum approaches to R&D inhibiting innovation potential, which could be significantly increased by collaboration.

This analysis draws in part on the PACEC study undertaken for Anglia Ruskin University. "Anglia Ruskin University: Need and Demand Analysis for Innovation Support (Advanced Manufacturing)". September 2016

Advanced Materials and Manufacturing PESTLE Analysis

Trends and drivers		Summary assessment for the AM&M Theme in the Eastern Region
Political trends and drivers	1	*Govt. R&D Strategy (Green Paper)and accompanying R&D support policies*
	2	*Influence of legislation and taxation on industrial R&D investment*
	3	*Post-Brexit focus on national and global links*
Economic trends and drivers	1	*Evolving global supply chains driven by OEMs*
	2	*Accessing credit and finance in times of austerity*
	3	*National Infrastructure investments*
Social trends and drivers	1	*Ageing workforce and population: skills shortages*
	2	*Affluence increasing the pace of change*
	3	*Poor public awareness and perception of engineering & manufacturing*
Technological trends and drivers	1	*Digitalisation of all areas of manufacture*
	2	*Shortening product lifecycles and increased system complexity*
	3	*Introduction of Autonomous systems*
Legal/regulatory trends and drivers	1	*Impact of H&S regulation on new technologies (e.g. additive manufacture, nanotechnology etc)*
	2	*Enhanced demand for risk-free operations and products*
	3	*Impact of green legislation on products, materials and processes*
Environmental trends and drivers	1	*Reducing carbon footprint and energy content of processes and products*
	2	*Economic use, reuse and safe disposal of materials*
	3	*Substituting for scarce or hazardous materials*

Sub-theme: Aerospace and Defence

Contributor: Cranfield University

The East of England's strengths in Aerospace and Defence draw on both its heritage in early aeronautics and its future in key, high-value technologies and innovations. The region has a strong history of Aerospace and Defence innovation most notably centred around its airfield and airbase sites such as RAF Marham, Cambridge Airport, Cardington Airship Sheds and Cranfield. Today, the region has a vibrant industry base in this sector which actively draws on the specialist expertise from key world-class research centres. Aerospace companies are spread across the region from KLM Engineering in Norwich to Marshall in Cambridge to Hybrid Air Vehicles in Cardington. There are substantial defence industry clusters around Stevenage, Bedford and in Essex. The East of England is a dominant region for emerging technologies which allow Aerospace and Defence companies across the UK to gain competitive advantage in the global market place sector. Underlying technologies such as materials, composites, sensors and integrated vehicle health management feed into all aspects of this sector. New light aircraft and unmanned/autonomous aircraft will radically change the way in which we fly, and expertise in the management of manufacturing promotes the rapid flow of technologies to market.

1. **Local science and innovation assets.**

Innovation organisations fall into 4 main groups:

1) Research organisations
   Major organisations are TWI, ARA, Cambridge University, and Cranfield. TWI specialises in joining techniques and technologies, structural integrity and material properties. ARA (Aircraft Research Association) is an independent research and development organisation providing a range of specialist services to the aerospace industry.

2) Corporate R&D
   See list of major companies below all of which are heavily involved in innovation activities on their sites in the region.

3) MoD related innovation
   Most notably the facilities development at Marham in preparation for the F-35s. This is a £142m development, where the main contractor is Lockheed Martin and BAE and Balfour Beatty are subcontractors. The site will include large scale engineering and training facilities, significantly increasing jobs and engineering innovation in the region.

4) SMEs
   With the more favourable regulatory environment currently being introduced, there is a growing SME sector in the region outside of the major corporate companies. Growth in new aerospace related industries such as UAVs, sensor and surveillance technology, and materials are particularly significant.

Key Universities:

- Cambridge University carries out world-leading research in many technology areas of relevance to the Aerospace and Defence industries. Most notably its research in turbomachinery, materials, autonomy, cyber security and manufacturing management provide state-of the-art innovation to support the region's industry base alongside its national and international links.

- Cranfield covers the full range of technologies of relevance to the Aerospace and Defence sectors. Cranfield's strongest interests are in aircraft design, propulsion,

materials, sensor technology, vehicle health management, autonomy and manufacturing.. Our subsidiary company Cranfield Aerospace Ltd is a market leader in rapid prototyping of new aerospace concepts.

- UEA covers electronic and mechanical engineering with strong links locally to KLM engineering and Essex has significant strengths in computation and electronic engineering of relevance to the sector.

Airfield and airbases related centres:

- RAF bases at Marham, Wittering, Molesworth.
- Cambridge and Cranfield airports.
- Cardington Airfield (Cardington Airship Sheds).

The Aerospace Technology institute, which is based at Cranfield, supports the wider Aerospace sector both regional and nationally. Using government funding from InnovateUK, ATI supports industry-led projects that encourage technology leadership.

2. Local industry strengths and capacities.

Major corporates in the Aerospace and Defence sector in the East of England are:

- Marshall (Aerospace) – Cambridge
  Leading independent aerospace and defence company, specialising in the conversion, modification, maintenance and support of civil and military aircraft, defence vehicle engineering, shelter manufacture, composite solutions and the provision of personnel, training and advice.
- KLM UK Engineering (Aerospace) –Norwich
  Regional aircraft and narrow body MRO, wholly owned by AFI KLM E&M Network. Based at Norwich International Airport for 40 years and employs approximately 400 people and provides line maintenance support throughout the UK.
- MBDA (Defence) – Stevenage
  International missile systems company with head office in Stevenage, with sites across the UK as well as internationally.
- Airbus Defence and Space (Aerospace and Defence) – Stevenage
  Design and manufacture site for advanced satellites and systems for telecommunications, earth observation, and navigation and science programme for this international company.
- Lockheed Martin (Aerospace and Defence) – Ampthill
  Largest and fastest growing Lockheed Martin facility in the United Kingdom. Focus is on strategic investment in technology for complex mission systems integration, system design and development and the implementation of electronic architecture.
- BAE (Aerospace and Defence) – Marham
  Bae is an international defence company that is currently leading the facilities development at Marham.
- Leonardo (Aerospace and Defence) – Basildon
  Major engineering company in aerospace, defence and security. Largest inward investor in UK defence sector, generating £1.3bn in exports for the UK economy per year. UK head office in Basildon.
- Raytheon (Aerospace and Defence) – Harlow
  Global defence and cybersecurity company with UK head office in Harlow.
- Aircraft Research Association (Aerospace) – Bedford
  ARA is at the forefront of the UK's aerospace research and development capabilities housing key national testing facilities.

Notable SMEs that are examples of the key technologies being developed in the region include:

- Hybrid Air Vehicles (Aerospace) – Cardington
  Airship design and manufacture.
- Cranfield Aerospace Ltd (Aerospace and Defence) – Cranfield
  Market leader in new aerospace concepts.
- Satavia (Aerospace) – Cambridge
  Innovative solutions to support aviation weather hazard situational awareness.
- E-Go (Aerospace) – Cambridge
  Light, single seat aircraft.
- Herotech8 (aerospace) - Cranfield
  Drone docking technology.
- Aveillant (Aerospace and Security) - Cambridge
  Holographic radar.

3. Regional, national and international engagement.

By its nature, the aerospace and defence industry is an international business, which makes a substantial contribution to UK exports. Regionally the focus is around emerging technologies, and the key airbase sites. The key research organisations and research intensive universities operating in this area are listed above, and all these groups operate both on a national and international scale.

In the aerospace and defence sector most work ultimately feeds into the products of major corporates, which operate at both an international and national level. The major national and international links of the key corporates in the East of England are listed above.

4. Future opportunities and gaps that can be addressed.

Within the Aerospace and Defence industry the single, most significant shift over the next 10 years is likely to be the large scale impact of digital technologies. This will include the use of Big Data and IoT type systems alongside the business process and integrated vehicle health management systems. It will also underpin developments in autonomy in the aerospace sector, both in small drones and larger aircraft, and enable future concepts in urban air mobility. The East of England has unique capabilities to contribute to the development of these new technologies, not least due to it being the only region in the UK which retains whole aircraft, platform level capability as exemplified by companies such as Marshall and Hybrid Air Vehicles. Digital technologies will also underpin major areas of technology development for defence, such as in communication, visualisation and surveillance systems. This will involve many companies in East of England including Raytheon, Curtis Wright and Lockheed Martin.
More widely, the Aerospace and Defence sectors are already heavily utilising novel manufacturing technology including smart materials, additive manufacturing, and sensors. We anticipate that the market pull for this technology will continue increase, alongside the world-class innovation capability that is being led by organisations in the East of England. Similarly to other high capital value sectors, the servitisation of manufacturing is also increasing in the Aerospace and Defence sectors, with maintenance responsibility to the manufacturers. To meet this market demand manufacturers are seeking a step change in their understanding the life-cycle of their high value products, in particular;

- life extension with optimum cost (both new and legacy products)
- product in- service degradation
- efficiency and effectiveness of maintenance

Whilst there is substantial strength in the region there is little regional-based sector scale activity. Although the area is highly attractive to international companies for inward investment due to the technology and skills available, rapid transfer of new and enabling technologies to the commercial setting of remains a gap. Regional based initiatives have the potential to strengthen international companies ties to the region and therefore to the UK as a whole.

Sub-theme: Automotive

Contributor: Hethel Innovation

Manufacturing Centres:

- Ford - Dagenham
  - Capacity to produce 1.4M diesel engines a year.
- IBC Vehicles (Vauxhall) - Luton
  - Capacity to produce 100,000 Vauxhall vans a year. Currently producing the Astra and Vivaro Van. 4500 staff.
- Perkins Caterpillar - Peterborough
  - Capacity to produce 500,000 diesel engines a year.
- Delphi - Sudbury
  - The facility specialises in the manufacture of injector nozzles and has major capabilities in precision grinding, electro-discharge machining (EDM), automatic injector assembly, and high-pressure testing. The site also manufactures other direct and indirect injection nozzles (for instance for common rail systems), and filters.
- Napier Turbochargers - Lincoln
  - Large scale turbochargers for industrial uses.
- Paxman Diesels (owned by MAN B&W) - Colchester
  - Diesel Engines for Large Vehicles.
- Lotus Cars - Hethel
  - Capacity for 2000 cars.

Infrastructure:

- Millbrook Proving ground is one of Europe's leading locations for automotive development.
- Cranfield Technology Park, home of Nissan European Technical Centre.
- Lotus' FIA approved test track.
- Hethel Engineering Centre, home to 10+ businesses supporting automotive research and development.
- Snetterton circuit, operated by MSV.
- RAF Wittering is used by McLaren and other OEM's for testing.

Engineering Strengths

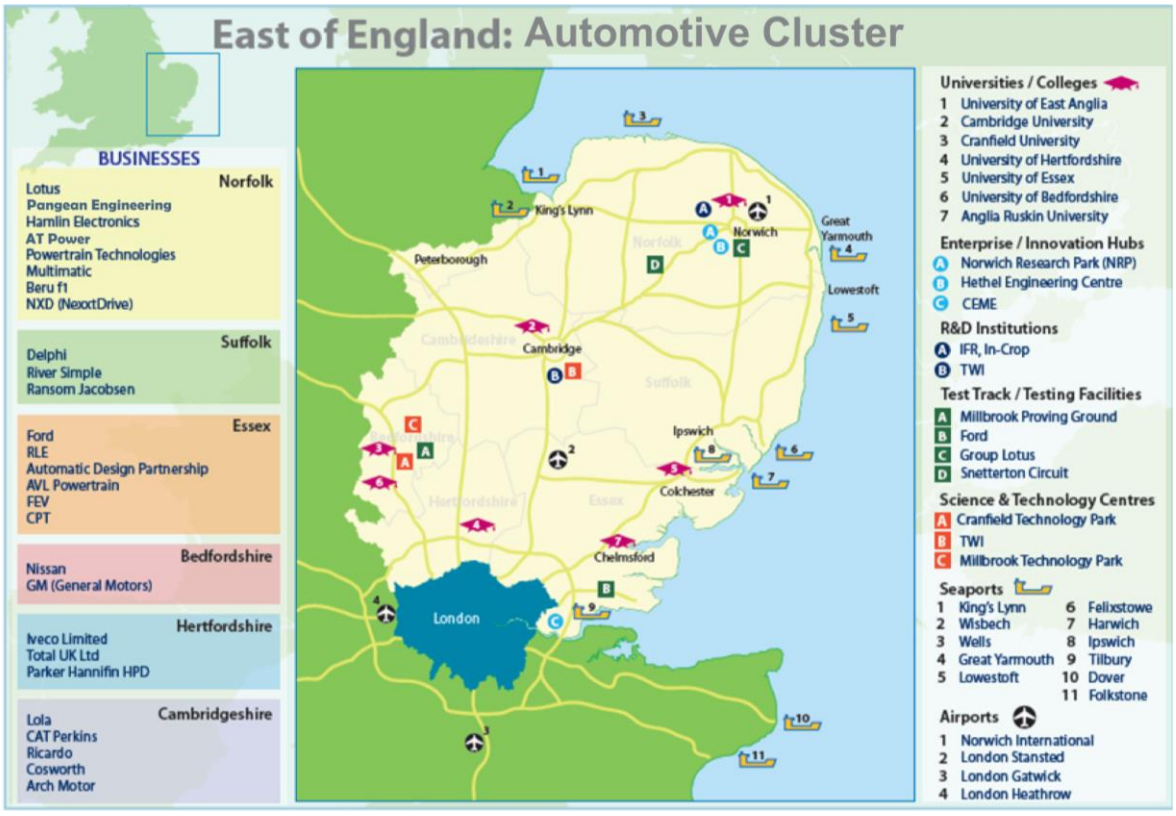
- Lotus Engineering.
- Ricardo - Cambridge are working on drivetrain development, including engine design, transmission design. Their specialities include vehicle systems engineering and hybrid control.
- Cosworth Electronics (formerly Pi technology) develop and produce, control systems and data loggers for use in automotive and motorsport applications.
- Ford Dunton technical Centre employs 5000 staff on their site in Essex and is a major automotive research and development facility.
- Emerald automotive, owned by the Chinese multinational automotive manufacturing company Geely has facilities in Essex which specialise in the design, development and production of lightweight, low emission and long range advances hybrid commercial vehicles.
- Tech Mahindra.

Knowledge hubs

- Cranfield University, beside the links with Cranfield Technology Park and Nissan, Cranfield University is home to the Advanced Vehicle Engineering Centre, which include wind tunnel and impact testing as well as a strong knowledge and expertise everything from advanced and alternative powertrain solutions to the development and application of lightweight materials.
- University of Hertfordshire offers a range of automotive engineering courses for undergraduates through to postgraduates. Priding themselves for their hands-on engineering approach.
- TWI is supporting the automotive sector with their knowledge in welding processes, light weighting, material joining and numerical modelling.

SME Strengths

- Connected Energy & future transport systems, these Hethel based sister companies are developing the technology to integrate EV's into the grid.
- MSF Technologies, provides highly efficient, high torque and high speed motor technology working in conjunction with their control systems to meet the requirements of tier 4 and Euro 5 & 6 regulations. Their IP comes their control systems and the use of non-rare earth magnet motors.
- Equipmake have been awarded multiple Innovate UK grants for their collaborative research into lightweight all electric vehicles including a recent lightweight electric bus project.
- Osprey Engines, Snetterton, is developing highly efficient diesel and petrol engines for use as range extenders in electric/hybrid vehicle.



High Value Manufacturing and Advanced Engineering Automotive Sector Map

Network Development and Supply Chain

- City/Town
- Automotive Research Organisations (x 6)
- Vehicle Manufacturer (x 10)
- Automotive Components (x 28)
- Automotive Engineering Companies (x 7)
- Automotive Consultancy (x 2)
- Automotive Teir 1Supplier (x2)
- Automotive Focused University

Sub-theme: Building and Construction

Contributor: BRE

Regional Overview

The region, just like others has its own challenges and needs in terms of new build and refurbishment of assets, both buildings, infrastructure, towns and cities. However, this review focuses on those specific aspects which are nationally or internationally leading and focused on growth.

The launch of the Garden-cities movement in the region (Letchworth, Hitchin and Hatfield) at the late 1890s created a new blueprint for urban planning, creating self-contained communities surrounded by 'greenbelts', containing proportionate areas of residences, industry, and agriculture. Many of the principles of this concept have made a positive impact on urban developments nationwide ever since. BRE and the University of Cambridge have continued to engage with

Compare this with alternative approaches adopted in the many town extensions which emerged in the region over the last 50 years (Harlow, Stevenage, Hatfield, Luton and more recently Cambourne) and the contrast is stark. The successes and lessons learnt over the last 100 years in this region in relation to urban planning and construction practices are now being evaluated and translated to the roll out of the Government's current New Towns initiative.

This has, however, generated a regionally based construction sector which currently houses 10 of the top 25 major contractors, and whilst they operate at a national and international level they also have a strong presence in delivering buildings and infrastructure in the region, which also supports a strong local supply chain.

There is a number of key academic Institutes in the region which have strong capabilities relevent to the R&D of materials and manufacturing in the built environment. These include Cambridge, Hertfordshire, Anglia Ruskin and East Anglia. All also have active teaching programmes which support this sector both regionally, nationally and internationally.

Also, the presence of BRE (The Building Research Establishment), an ex-government lab which founded in 1921 that has supported Government policy and the £100billion pa national construction industry ever since. Other Research and Technology Organisations with relevent capabilities include TWI and Rothamsted Research.

The region also hosts CITB (**The Construction Industry Training Board)** is the national body supporting the construction sector as part of the Sector Skills Council, and is located near Kings Lynn in Norfolk. An industry levy provides funding for the development of standards, training provision and also research to evaluate new materials, products and methods which could impact on the industry in the future.

The review is divided by the various types of organization that contribute to the supply chain for this sector, covering:

- Research and Technology Organisations
- Innovation and Enterprise

- Training and Skills Providers
- Industry – OEMs
- Industry SMEs.

In each section it will provide an initial summary of the primary focus and strengths and then information on specific key players in the region.

Research & Technology Organisations

There is a number of key academic Institutes in the region which have strong capabilities relevant to the R&D of materials and manufacturing in the built environment. These include Cambridge, Hertfordshire, Anglia Ruskin and East Anglia. All also have active teaching programmes which support this sector both regionally, nationally and internationally.

Also, the presence of BRE (The Building Research Establishment), an ex-government lab which founded in 1921 that has supported Government policy and the £100billion pa national construction industry ever since. Other Research and Technology Organisations with relevant capabilities include TWI and Rothamsted Research.

There are a number of specific research and innovation topics which differentiate the capabilities of this region and also align with national and international priorities. These include the production and use of low carbon and renewable materials (crop-based and recycled materials waste and Low CO2 concretes), the development of integrated mixed material sub-assembly products and their validations of modern methods of construction.

Also, the use of integrated sensing systems as well as product track and tag technologies has contributed to the development of optimized real time and whole life asset monitoring for structural integrity and control of the performance of assets. The review includes details of those organisations in the region that are recognized leaders in both the development and adoption of best practice. As the drivers for improved resource efficiency, reduced environmental impact and resilience to external societal and climatic changes, both nationally and globally, the need for effective and affordable solutions become more prevalent. Examples of specific capabilities and significant programmes are summarized below:

Materials:

University of Cambridge, School of Architecture, Dr Michael Ramage

Structural Bamboo Products (SBP)

The project is in collaboration with MIT, UBC and Cambridge Architectural Research and sets out to develop a code of practice for structural design and building construction with Structural bamboo Products (SBP). The group also have significant expertise in the design and use of other renewable materials including timber and rattan. Much of their work focuses on international applications where local renewable sources are prevalent but there is an opportunity for other regionally-based organisations to form research and business links through this group.

University of East Anglia, The Adapt Low Carbon Group, Enterprise Centre

This has involved a range of national programmes over the last 10 years, including In-crops, a collaboration with BRE and end users to evaluate the benefits from natural materials sources in construction products. 70% of the studwork for the building came from kiln-dried Corsican Pine sourced locally from the Thetford Forest. This had never been done before and Adapt, through its InCrops project, worked with BRE and the Forestry Commission to test and demonstrate kiln-dried Corsican Pine's properties and establish the supply chain for construction. The intention of stimulating the market for British wood is gaining traction with

Grown in Britain looking at how their licence can add value and build on projects such as the Enterprise Centre.

BRE, Building technology Group, Dr Andrew Dunster
Low Carbon Cementitious Materials
Over the last 10 year over £2m of funded work has been carried out by BRE and its University Centre of Excellence for Sustainable Construction Materials at Bath, This was also deployed by Lafarge on the build of much of the concrete structures at the 2012 Olympic Park in Stratford, achieving over 600% of the carbon reduction targets set for the build. These products are now being deployed in a number of industry partnership projects considering the manufacture of more sustainable buildings and infrastructure.

BRE is also active in the development of standards for the assessment of a range of sustainable products used in the built environment and also stewardship of responsible sources for these materials by the launch of BES 6001.

Manufacturing and Structural Integrity
University of Cambridge, Centre for Smart Infrastructure and Construction, Professor Robert Mair,
As a world-leading Centre of Excellence, CSIC's key objective is to develop robust and innovative solutions to meet challenges in the infrastructure and construction industry and to accelerate and enable knowledge transfer and exploitation of these emerging technologies.

Specifically this is focusing on innovative sensing technologies to monitor materials and structural performance in real time, supporting optimized re-construction and real-time life monitoring. Have an active link into the crossrail project and have over 20 International/national industry partners are core contractor and engineering firms based in the UK.

University of Hertfordshire, School of Engineering, Professor Rodney Day.
Significant capabilities and track record in the development of new and optimized manufacturing methods for a range of engineering materials including composites. This has broad sector relevance, in automotive, aerospace and also construction. The use of automation technologies robotics, digital representation and design etc) is also a speciality.

Also has a Smart Systems Lab, sponsored by Samsung and supported by companies such as Microsoft, Gemalto, Mitsubishi and BRE, has developed a range of smart technologies to power our future built environment, from Internet of Things embedded systems to smart energy applications. It has created InterHome, an intelligent platform that reduces energy usage, and InterLiving, an assisted living platform that supports older people by employing technologies such as smart door locks and health monitors. The Lab links the smart built environment sector in the East of England with China, having established partnership with a new Smart Systems Lab and research team at Changzhou Institute of Technology in Jiangsu.

The UoH is a BRE Strategic research partner in the demonstration of new approaches to built environment and will be a core partner in BRE’s Connected built Environment Centre being launched in 2017.

Anglia Ruskin University, Global Sustainability Institute, Professor Aled Jones
A strong research group who have been involved in a number of large collaborative projects with industry to develop and implement optimized approaches to sustainable delivery. They consider the role of people in developing societies and in acting to support future sustainability. This can support decision making in future investment in the built environment and manage the risk associated with its resilience.

Innovation and Enterprise
University of East Anglia, Enterprise Centre
The Enterprise Centre (TEC) is one of the UK's most sustainable buildings, a centre for student entrepreneurship, and a regional hub for innovators and businesses that are committed to a low carbon future. At its earliest stage, the Enterprise Centre was an academic exercise to consider what would Britain's greenest commercial building look like? How could this idea be delivered, given location and cost restraints? What new skills and materials could add to the project's targeted minimal-carbon usage, could this project be used to kick start or improve local trades and businesses?

The revenue element of The Enterprise Centre construction project delivered business support to the construction sector within the East of England region. Over 290 businesses were supported, with the knowledge dissemination resulting in 7 new start-up businesses and 180 businesses integrating new products or services, as well as further demonstrable benefits.

The Green Triangle is a partnership which has been formed through a collaboration of BRE, Rothamsted Research, The University of Hertfordshire, St Albans City and District Council and Oaklands College. It aims to harness the excellence within the partner organisations to develop a world renowned centre of excellence for Green Technology within Hertfordshire. As such the Green Triangle provides the infrastructure linking green research, science, engineering and technology enterprises.

It is intrinsically involved in the Hertfordshire EnviroTech Enterprise Zone which launches in April 2017. New Innovation Hubs will be located at the BRE & Rothamsted sites in order to facilitate knowledge transfer between knowledge-intensive SMEs and the world-renowned technical organisations. This will be enhanced by grow on space located near Hemel Hempstead. It is expected to deliver over 8,000 new jobs, 800 new businesses and an uplift in land values of £120m.

BRE is focusing on attracting complementary businesses in the built environment sector to locate on the site. Examples of existing tenants includes:

- Sonobex: A designer of noise reduction solutions who relocated from Warwickshire to BRE's site having used test and certification services for some years. Sonobex employ 8 people in design and research activities, bringing high value knowledge-based jobs to Hertfordshire.
- Geolabs: A UKAS approved soils, rocks and aggregates laboratory that has been based at BRE since 1995 and now agreed to a further 10 years at the BRE campus. They have invested significantly in disused buildings on the site and now intend a further £300,000 of their own money to build a mezzanine floor, offices and state-of-the-art laboratories.
- Aquobex: A developer of flooding related products and solutions. They located to the BRE site in 2011 to set up a flood tank laboratory to develop and test new flood protection products. The company now employs 4 staff on the site and works closely with the Centre for Resilience team at BRE.

17 of the Green Triangle Members have built environment relevance.

The BRE Innovation Park is now 10 years old and features over 300 construction innovations and emerging technologies, attracting thousands of visitors from around the world every year. This model has now been extended with a Park in Scotland and now abroad in China and Brazil. New partnerships have also been formed with the Universities of Tsinghua (Beijing), Brasilia linked to these initiatives. BRE has provided services to over 650 organisations and firms from the east of England in the last year, resulting in over £3.5m revenue to BRE.

Training and Skills Development

The Construction Industry Training Board (CITB) is the national body supporting the construction sector as part of the Sector Skills Council, and is located near Kings Lynn in Norfolk. An industry levy provides funding for the development of standards, training provision and also research to evaluate new materials, products and methods which could impact on the industry in the future.

Whilst a national delivery organization, their presence in the region enhances the access to training provision and also collaboration with other research and innovation organisations. Recent estimates of the need for over 4000 new qualified entrants each year to the construction sector in the East of England to meet expected demand. The need covers a range of trades, supporting house building and major infrastructure.

The University of Hertfordshire delivers over 800 undergraduate courses, postgraduate courses, Continuing professional development (CPD), online distance learning and short courses. Having a track record in supporting the built environment, the UoH has launched a new BEng in Civil Engineering, being delivered in partnership with BRE at both sites. This will create core civil engineering skills and also consider new technologies used in the monitoring of structures to support whole life asset management.

The BRE Academy was launched in 2015, building on its longstanding training programmes focused on aspects of sustainability. In the last 2 years over 5000 have graduated through various face to face and online courses. The online business has grown over 500% in the last 9 months, particularly relevant to its new courses in Building Information Modelling (BIM). BRE is the national deliverer of BIM training aligned with the Government's specification that all publically procured construction products will need to follow BIM principals. This will result in over 3000 professionals being trained in the next 3 years.

Other significant training providers who are increasing their provision to support the development of trade skills for construction sector include **Oaklands College** and **North Hertfordshire College**. They have both partnered with the BRE Academy to promote and extend their outreach to relevant industry partners.

Whole House Energy - Fabric First Institute

Fabric First Institute project, a £200k grant funded project, aimed at up skilling construction tradespeople in East Anglia in low energy building techniques.

The aim of the project is to support Norwich City Council's plan to deliver 100's of homes to the Passivhaus standard over the next three years, through their Fabric First Framework. Whole House Energy will deliver a one day training course to SME contractors or subcontractors, with a focus on best practices in relation to insulation, airtightness and ventilation; the key elements of achieving the Passivhaus standard. In addition a pilot, one week module is being developed to be delivered to the construction students at the College which, as part of the project, aims to become a City and Guilds accredited Level 3 qualification and become nationally available to other construction learning Centres.

The Construction Industry

The UK Government Construction Strategy focuses on 4 key targets to maintain and grow the capabilities of the sector for the benefit of the UK and overseas export:

- 33% reduction in construction costs,
- 50% reduction in delivery time,
- 50% reduction in green-house gas emissions, and
- 50% reduction in the trade gap between total exports and total imports for construction products and materials.

This will require significant development and uptake in innovations related to materials and manufacturing at all levels in the supply chain. These targets are driven by the need for our industry to deliver effective and affordable assets that meet national needs.

By striving to achieve these targets those companies who extend their own capabilities or optimize the products and skills of others will also extend their own competitiveness internationally. Whilst the sector structure has historically been fragmented, the increase in overseas acquisition of traditionally UK companies has brought a new vision on the adoption of vertically integrated supply chain models more common in the automotive and aerospace sector.

This brings both national and international opportunities to deliver more integrated offerings to clients, resulting from collective investment in the adoption of innovations.

OEMs - International

This region houses the head offices or main offices of 10 of the top 25 leading contractors for turnover in the UK, (Skanska, BalfourBeatty, Vinci, Keir, Laing O'Rourke, MorganSindall, Mace, VolkerWessels and Sir Robert McAlpine). The collective turnover of these companies alone is over £30billion pa, nearly 20% of the whole UK construction sector annual turnover.

All are active in research and development to different degrees in partnership with universities and other RTOs, with funding from the Research Councils, InnovateUk and the EU Commission supporting this.

Laing O'Rourke has invested significantly in developing offsite manufacturing methods for concrete structures (they have their own factory in the Midlands also working on this) and also in structural sensing and monitoring. This is primarily for large scale non-domestic and infrastructure applications. Laing O'Rourke is currently also sponsoring professorships at Cambridge and Imperial supporting these initiatives.

Skanska (Hertfordshire) appointed a Director for Innovation 7 years ago and since then have extended their active involvement in research and development projects. In the last five years Skanska have led or been a partner in 12 InnovateUK projects worth over £2.5m. They have a strategic research partnership with BRE and a number of BRE's academic Centres of Excellence (Bath & Loughborough), focusing on aspects of modern methods of construction and structural monitoring.

Balfour Beatty (Bedfordshire) is a leading international construction group who finance, develop, build and maintain assets across transport, power and energy, water plant, and buildings for Commercial, Defence, Education, Healthcare, Judicial, , Residential housing, ,student accommodation and public spaces. They have a strong and active programme focused particularly on innovation for new products, Operational efficiency and Social performance**.**

Mace also have a strong relationship with BRE, having sold its Health and safety business (YellowJacket) to BRE in 2016. Others are becoming increasing active in collaborative projects funded by InnovateUK.

Vinci Technology Centre at Leighton Buzzard provides testing & Understanding, Foresight & Innovation of new and emerging applied technology and a range of other technical services. Their R&D policy focuses on, urban expansion, energy performance, infrastructure sustainability, eco-design, development of technically, economically and environmentally efficient products, processes and constructive solutions.

The Centre also has historic expertise in concrete formulation, developing specialist materials for the build of the major UK nuclear facilities in the 1950s (as Taylor Woodrow). They were also the first company in the UK to carry out full testing of cladding and curtain walling systems and are the founding sponsors of the Centre for Cladding & Windows Technology (CWCT).

Kier Group plc (Bedfordshire): is a leading property, residential, construction and services group. Kier Harlow received a commendation in 2012 in recognition of its ongoing commitment to the local community through work placement schemes and support for young and vulnerable residents. Kier works closely with Essex County Council, European Social Fund, Harlow Education Employer Partnership (HEEP) and the Harlow Educational Consortium (HEC) on a number of initiatives which offer support and help to residents in the area. Keir has been involved in 1 Innovate UK funded project in the last 5 years with a modest funding level of £75k.

Volker Fitzpatrick (Hertfordshire): one of the leading engineering and construction companies in the UK and provide specialist building, civil engineering and rail expertise to a range of markets to provide a truly integrated service to clients.

AECOM (Harlow), a global consultancy that design, build, finance, operate and manage projects and programs, delivering buildings and infrastructure to the residential, health, education, commercial, water, oil & gas, transport, power, leisure and sports sectors in more than 150 countries. Global turnover was £12billion in 2016.

Dupont UK Ltd (Stevenage), part of the global US firm, have their headquarters in Stevenage, with a significant in construction materials and products, including Tyvek, Corian, Kevlar and Sentriglas. They have been an active partner in the BRE Innovation Park, including integrated PV wall and roofing systems. Their turnover was in excess of £135m in 2016.

OEMs - National

The R G Carter Group (Herts, Cambs, Beds), founded in 1921, is a family owned business across domestic, non-domestic and civil engineering projects. Servicing national and regional clients from a network of offices based throughout the Central and Eastern regions of the United Kingdom, we provide design, sustainable, partnered construction and project management services for private and public sector clients on projects ranging from £50 to over £50 million.

Hanson Heidelberg (Bedfordshire): Hanson UK is a leading supplier of heavy building materials to the construction industry. Aim to be a leading sustainable business, trusted and respected by stakeholders for the ethics they adopt and the products they supply.

Sir Robert MacAlpine (Hertfordshire): leading UK building and civil engineering company. Their progressive and responsible approach is key to our sustained success and we pride ourselves on finding ever better ways to deliver excellent results with greater efficiency.

Willmott Dixon (Hertfordshire): They are experts in construction, residential development and property support services. Across the country Willmott Dixon teams work closely with our partners and local people to deliver sustainable developments and effective services

OEMs Regional (particularly active in developing and adopting new approaches)
Countryside Properties Plc (Essex): "Through research and development with industry partners they keep abreast of innovative product design, adaptation, mitigation and environmental best practice. This ensures that they continue to have a pro-active approach to developing homes and neighbourhoods that create a positive legacy, and to help mitigate future impacts of climate change.

Hopkins Homes (Suffolk): Hopkins Homes has grown significantly over the years to become the largest independent property developer in East Anglia providing homes throughout Suffolk, Norfolk, Cambridgeshire and Essex and has made a significant contribution to the regional and wider economy through creating and supporting jobs, providing exceptional new homes and building sustainable communities.

McCarthy & Stone (Hertfordshire): Their team of in-house and external architects continue to strive for design innovation in every development they create. From trialling the design features recommended by the Government's HAPPI Panel (Housing our Ageing Population: Panel for Innovation) to working with RIBA (Royal Institute of British Architects) to find new design talent – they are at the forefront of retirement property design.

Swan New Homes (Essex): Delivering effective services, enterprising solutions and exemplary homes and communities. Housing for ageing populations

Telford Homes (Hertfordshire): Telford Homes is committed to doing its best to adopt advanced construction methods, improve energy efficiency and reduce the ecological impact of its outputs. Our most recent schemes aim to achieve a minimum of 10% of energy from sustainable sources. Also the use of a cross laminated timber panelling system saving 306,150 kg of carbon in the construction process compared to a concrete frame.

SMEs
Hemcore Ltd – first UK company to develop and launch a construction product based on hemp waste – a demonstrator where this is deployed is the renewable House on the BRE innovation Park.

Granta Design, Cambridge
Work in a range of industries e.g. Aerospace and Defence to Healthcare Products to Wind technology and also now construction.

Granta helps hundreds of engineering enterprises to manage information on the materials (metals, plastics, composites, and more) that are essential to their businesses. They also provide supporting resources to thousands of university educators worldwide as they teach the next generation of engineers, scientists, and industrial designers about materials, processes, and sustainability.

Step Up
They offer three core areas of capability, each strengthening the other.
Testing & Understanding – Reducing Risk
Foresight & Innovation – Delivering applied technology
Technical Services – Cost effective solutions
Became the first company in the UK to carry out full testing of cladding and curtain walling systems. We are founding sponsors of the Centre for Cladding & Windows Technology (CWCT). The Technology Centre was the first to develop the application of cathodic protection (CP), an electro-chemical process which arrests the spread of corrosion.

Sub-theme: Off-shore Renewable Energy

Contributor: Orbis Energy

The UK faces a significant challenge in delivering a secure, affordable and low carbon energy supply. Offshore renewable energy is key to the UK and many international government's energy strategies with offshore wind energy already a rapidly growing and increasingly critical source of future energy supply.

The UK is at the forefront of offshore renewable energy and the global leader in installed capacity for offshore wind. However, there is no indigenous turbine manufacturer and the globally lead vessel based nature of the projects leave them open to overseas and European competition.

Offshore Renewable Energy is identified as an important subsector within Advanced Materials and Engineering in the East of England Science and Innovation Audit. The Smart Specialisation Hub's analysis, part of Innovate UK, identifies business innovation in offshore renewables as a particular strength.

The UK has more installed capacity of any other country in the world. Around 60% of the UK's offshore wind generating capacity is installed off the coast of the East of England with a significant pipeline of offshore projects under construction and in planning and consenting process, including some of the world's largest offshore wind projects.

The region has unrivalled capabilities and innovation strengths in the installation, operations, maintenance and repair of these important energy system assets. It also has world-class engineering capabilities that drive innovation in the design of wind turbines and other renewable energy systems.

It is clear that the East of England coast remains well placed to play a leading role in the growth of the sector because it is at the centre of the world's largest market for offshore wind energy, with substantial wind farm developments between the Humber, Greater Wash and Thames Estuary.

The region's international comparative advantage in offshore renewable energy, in particular offshore wind, flows primarily from the sheer scale of existing and potential operations together with its research strengths which, in addition to the universities and the industry itself, includes Cefas which is a world-leader in developing innovative solutions in marine sciences.

The East of England coastal region's ability to support this market is largely derived from the last 50 years offshore gas and maritime industries, with an established offshore energy supply cluster of more than 800 companies. This same region also has significant expertise in composite materials, electrical components, automotive and aerospace. These are essentially service and engineering based sectors and thereby offer significant potential for extensive supply chain expansion and diversification in related sectors such as offshore wind.

The New Anglia region offers the broadest mix of resources for energy production and distribution in the UK, with the "All Energy" East of England Energy Zone sector employing more than 18,800 people. Centres for Offshore Renewable Engineering (CORE) – Great Yarmouth and Lowestoft have been awarded CORE status by the UK Government. CORE status is awarded through recognising the existing port infrastructure, skills, supply chain and local Government support to enable rapid growth within the offshore wind sector. The Great Yarmouth and Lowestoft Enterprise Zone has already attracted 39 companies employing 1,895 people and £30.6m of private sector capital investment. An extension to the existing Enterprise Zone announce in March 2016 will create space for 30 more business and 1,219 jobs.

The region's coast has unrivalled and strategically located ports offering direct access to more than 69% of the UK's installed capacity. Proximity to the physical market is a key consideration of any wind farm developer and of the supply chain.

The East of England's competitive advantage in offshore renewables arises from a number of factors:

- Proximity to offshore wind development areas - the world's largest market.
- Extensive shallow sea coastal resource.
- The Southern North Sea (SNS) having the best and most reliable wind patterns in Europe.
- Existing grid connections to populations of high energy demand.
- Strategically located ports with a variety of features.
- Unrivalled experience in offshore construction and O&M in the unique conditions of the SNS.
- An imbedded culture of safe and effective working in the offshore environment
- An established offshore support supply chain.
- A leading international innovation and incubation hub in OrbisEnergy, partnering with technology and innovation bodies such as the Offshore Renewable Energy Catapult.
- An established industry organisation in EEEGR and supportive local authorities and public sector agencies in Suffolk and surrounding counties of Norfolk, Essex and Kent.

Offshore renewable energy is naturally an international industry. The East of England actively collaborates with other regions of the world. For example, ECOWindS is an EU-funded collaborative R&D project between South Denmark, East of England, North-West Germany and Norway. The project focusses on cost reduction through improving the innovation capacity of the European offshore wind servicing sector; generating and validating innovation and research needs over the next 10-20 years.

A new project, Inn2POWER (Innovation to Push Offshore Wind Energy Regions) - due to officially launch in June 2017 – is building a North Sea network of innovation clusters to strengthen SME collaboration, develop novel concepts for offshore logistics, facilitate access to test and demonstration facilities, and improve innovation-related skills. UK partners include Nautilus Associates (East of England), and Kent County Council (South East of England), working with clusters in Belgium, the Netherlands, Germany and Denmark.

OrbisEnergy is the hub for offshore renewable energy in the East of England. Owned by Suffolk County Council, and managed by Nwes in partnership with Nautilus Associates. OrbisEnergy is a purpose-built innovation and incubation centre in Lowestoft, Suffolk. Its prime objective is to maximise the innovation and supply chain opportunities associated with the rapid development of offshore renewables in the North Sea, and to help small and medium sized enterprises take advantage of the many opportunities the growing sector offers.

Since opening in 2008, OrbisEnergy has supported more than 140 tenant businesses which have created more than 800 new jobs in the region. It has developed an international profile for innovation and supply chain clustering, as well as developing major investment programmes such as the SCORE fund, which has invested more than £3.7m across 79 SME-led innovation projects and created more than 111 new jobs. The current (fourth generation) SCORE programme – launched in 2016 – is a £6m grant scheme investing in innovation and R&D in offshore renewable energy. www.scoregrants.co.uk

Examples of the region's research and innovation capabilities are

- University of East Anglia (UEA) - a world leading university in the fields of environmental, climate change and low carbon research. The Energy Materials Laboratory is a state-of-the-art centre bringing together chemistry, physics, environmental science and biology to address the energy needs of the 21st century. http://eml.che.uea.ac.uk/
- Cambridge University has one of the largest integrated engineering departments in Europe, which includes the Institute for Manufacturing. http://www.ifm.eng.cam.ac.uk/ It provides a unique environment for the creation of new ideas and approaches to modern industrial practice - from understanding markets and technologies, through product and process design to operations, distribution and related services. Other Energy research at Cambridge is distributed across many disciplines and covers supply, conversion and demand, including socio-economic, technology, policy and materials-based cross-cutting themes at the University.
- Cranfield University is an international leader across energy supply, transport and demand applications. Its Energy Technology Centre has been instrumental in the Energy Technologies Institute funded Novel Offshore Vertical Axis project and also in projects such as: Helm Wind, Deepwater Turbines and ReDAPT. https://www.cranfield.ac.uk/themes/energy-and-power Together with Durham University, Cranfield leads the EPSRC Centre for Innovative Manufacturing in Through-Life Engineering Services that provides world-class capability to enable industry to deliver high value products with outstanding availability, predictability and reliability with the lowest life cycle cost. https://www.through-life-engineering-services.org/index.php/home
- The University of Suffolk specialises risk management, on and offshore transportation and logistics, and energy technology. https://www.uos.ac.uk/
- TWI renowned engineering research centre leads in advanced fabrication technology, corrosion protection standards, failure investigations and structural integrity assessments. https://www.twi-global.com/
- Cefas (Centre for Environment, Fisheries & Aquaculture Science) is an internationally renowned research and advisory centre working in fisheries management, environmental protection and aquaculture based in Lowestoft.

Key businesses based in the region include ScottishPower Renewables, Vattenfall, RWE Innogy, SSE plc, James Fisher & Sons Plc, Fred Olsen Windcarrier, Seajacks UK, and the 3Sun Group.

Conversations with stakeholders have highlighted a number of challenges of relevance to the sector:

- The local supply chain around offshore wind is not currently well-developed with component manufacturers mostly based outside the UK.
- The region lacks a clear 'offer' or market proposition relating to the energy sector generally – the strengths of its business and research base is not well-defined nor is it understood at the national level.
- Businesses need to be better connected to the research base and the quality and ease of access of support (including access to finance) for SMEs needs to be improved.
- There are skills shortages in key areas - one major off-shore wind servicing business located in the area indicated that the vast majority of their technicians were not from the LEP area.
- Employers feel that local schools and FE Colleges are not teaching the right kinds of skills for technician roles – too focused on manufacturing rather than O&M.
- A lack of consistency in Government policy – this is a national issue but locally relevant.

- Historic under-investment in vital infrastructure including access to the ports (road and rail) and in connectivity to the National Grid. Privately owned ports in the UK suffer in comparison to European ports which are publically owned and receive noticeable investment.

However, stakeholders also note a number of opportunities to grow and develop the sector, namely:

- Developing the region as the world-leading centre for innovation in assembly, operations and maintenance, offshore servicing and logistics: this would be achieved through a cohesive and targeted approach to exploit the area's locational, industry and research strengths in order to respond to fast-changing industry requirements.
- Identifying 'niche' component manufacturing opportunities: whilst our consultations suggest a particular focus on operations, maintenance and offshore logistics, niche component manufacturing opportunities should be explored (parallels have been identified with the Oil & Gas horizontal drilling developed in Lowestoft).
- Identifying and exploiting opportunities for innovation that arise through linking energy with other sectors, particularly ICT, advanced manufacturing and life sciences.
- Development of a wave and tidal energy testing facility to enable full-wave testing.
- Making the most of opportunities arising from the Government's new 'contracts for difference' (CfD) model.
- Assess the feasibility of test and demonstration facilities that would support prototyping and proof-of-concept work.
- Development of a Centre for Excellence' training facility with strong collaboration between skills providers and employers drawing from the previous 'EPIScentre' proposals.

The strength of the existing assets and the planned investment in the region suggest that there are major opportunities in this sector which require support and intervention. The confluence of different energy sector specialisms, along with proximity to port facilities and other sectors such as ICT, advanced manufacturing and life sciences means that there is a distinct offer which can be developed.

Crosscutting sub-theme: Advanced Materials (additional information and context)

Contributor: TWI

Introduction
Both existing and new materials are important for AM&M, as innovation can depend on the more effective use of existing materials, as well as the development, characterisation and use of entirely new materials.

Materials do not stand alone. To find effective industrial use, they have to be developed in parallel with advances in manufacturing processes and structural integrity These three cross-cutting themes develop separately at the TRL1-3 level, but then become interdependent, being integrated in the TRL4-6 innovation space to provide the information required for industrial development.

The evidence gathered in this study supports the overall AM&M hypothesis that regional materials resources could be combined more effectively to support innovation.

National & global trends and markets
Materials provide the physical basis for innovation in all major UK industry sectors: built environment (£103bn), transport (£55bn), aerospace & defence (£44bn), oil & gas (£40bn), power generation (£8bn) and medical applications (£5bn). Markets for conventional materials are well established and large, and the UK metals industry is estimated to produce goods worth some £50bn annually. The global metals market is around £682bn, the majority of which is consumed in construction. Advanced ceramics are expected to expand to around £55bn by 2020, the majority of usage being as fibres for composites and ballistic protection. By 2020, the market for advanced polymer composites is projected to have reached nearly £10bn.

The impact of materials on future industries will be profound, drivers for change in all sectors including increasing functionality while reducing costs and environmental impact.

The size of the global markets involved is large. Energy efficiency systems are projected to be worth £168bn and energy storage is expected to expand very rapidly from 0.34GW in the UK to over 40GW by 2022, giving a global market of £461bn by 2040. Figures for the global nuclear sector are similarly high at £470bn, with nuclear decommissioning, which places extreme demands on materials for long term storage amounting to £ 196bn.

The international market for biomaterials is currently £34bn, projected to grow at 15% annually, while the global market for smart materials, an important component of innovation in many applications, is subject to varying estimates conservative projections giving a total of £56 billion by 2022, with an estimated CAGR of 14.9% from 2016 to 2022.

Regional science and innovation assets
TRL1-3 science and innovation assets in the region include Cambridge University, where the Department of Metals and Materials has over 100 research fellows, postdoctoral scientists and visiting scientists, and more than 140 PhD students, a current research income of more than £4 million per year and 10% annual growth rate. Further University research and graduate-level teaching in materials is carried out at Cranfield, Hertfordshire, East Anglia, Anglia Ruskin and Essex.

Regional TRL4-6 RTO activity in materials involves TWI and BRE, who are globally active in materials joining, structural integrity and the application of materials in construction.

Regional industrial strengths
Regional companies with heavy materials involvement include Johnson Matthey, (£3b sales and £188m research budget) with particular strength in environmental and medical fields; Hexcel, a £1.6bn company and leading producer of carbon fibre reinforcements, resin systems and adhesives, and Xaar, an international leader in the application of PZT for inkjet printing.

The East is particularly strong in materials characterisation and information, which is crucial for making the correct decisions as processes and products evolve. Linkage and development of this resource will allow increased AM&M innovation, both in the region and nationally.

Granta Design is a Cambridge University spin-out that has grown over 20 years into a world-leading materials information, selection and design resource, employing over 130 staff. It acts as a central node in a worldwide network of materials information sources, providing a gateway for materials information for use in design, specification of conventional and novel materials for all sectors and manufacturing processes. Granta also provides educational support to over 100 university clients.

Links to other themes
The combination of the region's materials information resources with the manufacturing management models of IfM Cambridge, the design capability of companies such as ARM and the ICT resources of the region's digital companies could have a major impact on AM&M innovation in sectors ranging from aerospace to healthcare.

- Materials innovation is critical in healthcare, where biomaterials are the focus of intensive research. A centralised biomaterials database has been cited as a development that would fill a current gap in information supply for researchers, clinicians and industry.
- Advanced materials in the form of semiconductors and electrical materials are basic enablers of innovation in the ICT field. Data and information regarding materials properties and performance are again crucial requirements in the development of new devices.
- Agritech equipment shares many of the requirements of the automotive sector, and the sector has potential to provide feedstock for composites, reducing the carbon footprint of products, especially in the construction sector.

Crosscutting sub-theme Advanced Manufacturing (additional information and context)

Contributor: IfM/TWI

Relevant IfM reports:

- The High Value Manufacturing Landscape report (2016)
- Digital Application for Innovative Manufacturing.
- Defence and Security Competency report.
- Roles of National Institutions in Supporting Innovation.
- National Additive Manufacturing Strategy.

Links to national Sector and Technology Reports:

- Synthetic Biology Roadmap for the UK
    - http://www.ifm.eng.cam.ac.uk/roadmapping/case-studies/synthetic-biology/
    - http://www.ifm.eng.cam.ac.uk/uploads/Roadmapping/Synthetic_Biology_Roadmap_-_TSB.pdf
- Stratified Medicine
    - http://www.ifm.eng.cam.ac.uk/uploads/Resources/Stratified_Medicines_Roadmap.pdf
- Other IfM ECS Sector and National Technology reports may be found here
    - http://www.ifm.eng.cam.ac.uk/roadmapping/case-studies/

Extract from The High Value Manufacturing Landscape report (2016):

"Innovation has an impact across the HVM landscape and is driven by business capabilities and manufacturing competencies in concert. For example, the ability to manufacture a meta-material with novel properties (a manufacturing competency) could lead to improved product performance or the development of new products as long as the business is able to integrate the material into a production line (another manufacturing competency) and take the products to existing or new markets (a business capability).

Potential HVM challenges have been identified, defined as a significant opportunity or threat to UK industries' and firms' ability to create value in the global market place in 2030, which requires all of the following:
• new/enhanced business capabilities (to meet the above opportunities/threats)
• new/enhanced manufacturing competencies (to create the capabilities)
• new/enhanced action(s) by one or more institutional actor(s) to deliver on UK value potential.

Examples of the challenges identified are summarised below:

*1. **Pervasive challenges**, which will have an impact across the whole manufacturing economy, particularly as regards the digitalisation of the manufacturing supply chain, smart and reconfigurable manufacture, automation, product/electronics integration and exploitation of new materials, for example:*
• Exploitation of ICT in increased flexibility of product manufacturing for product customisation, new product introduction and end-of-life management.
• Smart reconfigurable factories, driven by simulation and modelling, for example, in aerospace/defence/automotive to cost-effectively manufacture complex and difficult high value products and components.
• Exploiting the various routes to 3D manufacture of printed electronics to integrate functionality into a new breed of smart devices.

• Building new cross-discipline collaborations in robotics and automation to increase UK investment in fully automated and robot-assisted manufacture.
• Multifunctional and super-performing textiles with functionality through physical properties and built-in sensing and intelligence, to create high added value and offset downward pressures on the traditional sector.
• Improving the acceptance of and UK innovation in smart and wearable devices, including through enhanced validation and regulation in, for example, diagnosis and treatment in healthcare.
• New materials design, qualification and integration, connecting the innovation chain from lab to market to capture value for the UK from new materials development.

2. ***Challenges associated with national infrastructure investment priorities*** *in areas such as rail, energy and building and construction, for example:*
• New railways including HS2, lightweight mobility, infrastructure and network optimisation to minimise environmental impact.
• New energy storage devices for power grid smoothing as demands for security and sustainability of supply increases.
• 'Active buildings' with energy capture, storage and control, to improve environmental efficiency
• Strengthen the UK value capture in small and medium nuclear reactor design and build.

3. ***Challenges identified in sectors such as aerospace, automotive and defence****, particularly around strengthening the supply chain, as well as new product and process innovation that may have potential for spin-out benefits in other sectors, for example:*
• Building new models of innovation across the supply/value chain in aerospace and defence (including SMEs), sharing innovation responsibility across tiers to increase the speed of introduction and uptake.
• Integrating design for manufacturing and new manufacturing processes across the automotive supply chain, strengthening the potential for value capture by UK manufacturers.
• Advanced, fuel-efficient automotive vehicle power units, exploiting new materials and coatings and smart technology to respond to emission reduction and efficiency demands.
• Unmanned automotive vehicles building in sensing, autonomy data analysis and modelling to reduce congestion and emissions.

4. ***Sector-specific challenges,*** *particularly as regards the bioeconomy2, healthcare and food, reflecting continued and/or growing importance of manufacturing in those sectors within the wider economy:*
• New, sustainable food manufacturing processes, reducing energy and water usage mitigating increasingly volatile resources in the low carbon economy.
• Intensified manufacturing, digital design and sustainable analysis of new and existing pharmaceuticals and biopharmaceuticals: pulling new products through development into UK rather than overseas manufacture.
• Point-of-care production, delivering tailored pharmaceuticals and biopharmaceuticals to individual patients supporting of cost-effective care, given pressures on ageing population, primary care and rising energy and transport costs."

Regional science and innovation assets

Science and innovation assets in advanced manufacturing can be found in the regions universities, research organisations, and SME incubators. Of particular note are:

- Cranfield University for aerospace and automotive manufacture.
- University of Cambridge for advanced manufacturing and for the management of advanced manufacturing.
- BRE: for the building and construction industries.
- TWI: for fabrication technologies and SME technology transfer.
- Hubs and incubators across the region such as Hethel Innovation.

Links to other themes

Advanced manufacturing links to each of the other SIA themes:

- Life sciences: innovative manufacture of medicines and medical devices.
- Agritech: the manufacture of advanced machinery (including robotics).
- ICT: both the manufacture of components and the use of ICT to facilitate advanced "digital" manufacture.

Crosscutting sub-theme: Structural Integrity (additional information and context)

Contributor: TWI

Structural integrity comprises the technologies and approaches that determine the fitness for purpose of all manufactured products. It covers and integrates the issues that affect the design, service life and integrity of components and structures.

It includes materials science, design for safe operation, manufacturing specification and process selection, inspection and repair during production and service, and the associated management approaches. These factors often interact and correct choices must be made to ensure the safe operation of all types of products and structures which are found in all parts of the economy.

Failure often results from a lack of understanding of structural integrity in the life cycle of a product or structure. Vulnerable sectors range from transport (aircraft, trucks, cars, trains and bridges), through energy (oil and gas, nuclear, conventional and green power generation), to communications equipment, consumer products and healthcare devices. The interconnected nature of the systems involved means that even a minor failure in one area can cause widespread disruption. While much of the literature on engineering failure focuses on the monetary cost of failure, the human impact in terms of stress, unhappiness, a degraded environment and overall lower quality of life can be very substantial.

Headlines tend to be occupied by spectacular structural failures, such as that of the Banqiao Reservoir Dam in China, which failed in 1975 killing up to 230,000 people, destroying nearly 6m homes and rendering 11 million homeless; the collapse of the Alexander Kielland oil rig, which killed 123[1]; the Challenger Space Shuttle explosion, which resulted in the loss of seven astronauts and severe damage to the US space programme; the Deepwater Horizon oil spill, which killed 11 and damaged the ecology of the Gulf Coastal waters or the March 2012 North Sea gas leak from Total's Elgin platform well head failure, which resulted in the substantial gas cloud and the shutdown of the platform, with costs currently estimated at £234m.

While these are large in scale, major failures are not restricted to big engineering structures. The failure of an artificial heart valve, caused by fatigue of a fillet weld, resulted in over 350 fatalities and eventually cost the manufacturer hundreds of millions of pounds once all the legal cases were settled[2]. The failure of breast implants remains an area of ongoing concern, with rates of up to 33% for the PIP product, posing a severe risk to physical and mental health in the women affected. Cases resulting from this failure are ongoing, covering up to 300,000 women in 65 countries.[3]

[1] http://www.twi-global.com/news-events/case-studies/alexander-l-kielland-accommodation-platform-145/

[2] http://www.lawyersandsettlements.com/articles/bjork_shiley_heart_valves/bjork-00170.html#.U05pqP1hprc

[3] http://www.bbc.co.uk/news/world-europe-38692678

MOL Comfort brittle failure. July 2013. 248 general cargo ships have foundered worldwide since 2002 with the loss of over 800 crew. 226 of the vessels were 15 years old or more, 139 were over 27 years old.

Three key interacting elements to structural integrity have a profound influence on the safe operation of all classes of plant, equipment, infrastructure and manufactured goods:

- Material properties, including environmental performance.
- The existence or formation (initiation and growth) of defects.
- Loads, stresses and other environmental factors arising during manufacture and experienced in service.

Structural Integrity studies involve a range of academic disciplines (Engineering, Materials, Chemistry, Mathematics, Physics, etc.), and covers topics ranging from materials selection and design, through manufacturing and testing to long-term asset management. The consequences of errors in the management of structural integrity are either product failure or wasteful overdesign, both of which have significant commercial impact. Apparently minor mistakes can have catastrophic consequences. Structural integrity is often embodied in standards and codes of practice, and is also built into product design as a part of its intellectual property.

Traditionally, expertise in the structural integrity field has been acquired via practical experience in industry, with staff often taking many years to reach a satisfactory level of competence. Today, there are acute shortages in relevant graduate and especially postgraduate supply, while retirement of experienced personnel is shrinking the pool of skilled staff. TWI and a number of industrial partners, working partners in collaboration with more than 20 UK universities, have established the Structural Integrity Research Foundation and National Structural Integrity Research Centre to address this problem by producing postgraduates who have an overall grasp of the structural integrity field, thus accelerating their ability to operate safely and at a high level in industry. By developing a critical academic mass in this field, SIRF/NSIRC provides an ongoing supply of skilled personnel, generate innovative and enhanced structural integrity technologies and help convert them into appropriate standards and regulations.

This project has a unique ability to promote private sector innovation, while safeguarding public safety and the country’s immense investment in both public and private equipment and infrastructure.

Regional science and innovation assets

Key world-class structural integrity assets can be found in:

- Cranfield university: aerospace and automotive, particularly in the field of impact damage.
- University of Cambridge: material defects, civil engineering and aeroengine applications.
- BRE: buildings and construction.
- TWI: welded structures across a range of industries from electronics to power generation and oil & gas.