East of England Science and Innovation Audit

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

21st September 2017

GREATER CAMBRIDGE GREATER PETERBOROUGH ENTERPRISE PARTNERSHIP
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Cover page images

Top left: Quadram Institute (under construction), Norwich Research Park.

Bottom left: Public Health England Headquarters, Harlow (to open 2019).

Top right: Cambridge Biomedical Campus - An artist's impression of how the Campus may look on completion of Phase 2.

Bottom right: Rothamsted Research, Harpenden.

Contents

In separate volumes:

Foreword

From the Chairman of GCGP LEP Area Science Industry & Innovation Council

The East of England is an amazing place. It is a region rich in science and innovation assets and awash with the finest talent – but our **audit demonstrates that we could go even further, driving translation and capitalising on our research excellence for the benefit of the region and the country.** We must continue to invest in our scientific and industrial research base, develop our local skills base and attract the very best minds and investment from around the globe. We have sought to determine, in the chosen four Themes of Life Sciences, Agri-Tech, Advanced Materials & Manufacturing and ICT, what is the very best of our region and present to Government and industry the findings in a coherent and useful fashion, so that the true contribution that our science and innovation makes to the local and national economy is understood. We also aim to widen the economic benefit throughout our region, which is by no means uniformly affluent.

Professor Nigel Slater, FREng FIChemE

From the East of England Science and Innovation Audit Steering Group

The Steering Group is proud to present this survey of science and innovation in our region, which has been marshalled, edited and presented by SQW.

Collaboration has been the watchword of the Audit, with equal representation from all four Themes and all four LEP areas. One of the main drivers for bidding to conduct an SIA was to refresh our collective knowledge of our own region's science and innovation strengths, and to catalyse useful activity within, and between, those clusters.

The East of England is uniquely placed to explore and exploit areas of convergence, given the confluence of world-class universities and industry with wide and in-depth sectoral expertise, and our exceptionally strong innovation ecosystem. With a strong focus on enhancing commercialisation and collaboration across the Themes, just some of those exciting opportunities are suggested in the illustrative proposed interventions contained in this report.

Pascal Soriot, CEO of AstraZeneca, which has moved its Global HQ to the region, very recently said: "*As a long-standing investor in UK science, we believe Cambridge offers a tremendously vibrant academic and life-sciences ecosystem that can truly catalyse discovery and innovation. Together with our partners, we will push the boundaries of science to deliver innovative medicines that transform patient care around the world*." Further compelling quotations from Dr Andy Richards, and from Marshall of Cambridge, BT plc, Agri-Tech East and One Nucleus about the East of England region are provided below.

We have committed to continuing to work together in partnership to implement the vision of the SIA consortium.

Steven Wilson, Head of Innovation

Greater Cambridge Greater Peterborough LEP (Chair)

Paul Witcombe, Enterprise & Innovation Manager

Hertfordshire LEP

Jane Locke, Economic Development & Strategy

Norfolk County Council (for New Anglia LEP)

Paul Dodson, Head of Commissioning, Growing Essex

Essex County Council (for South East LEP)

Dr. Martino Picardo, CEO

Stevenage Bioscience Catalyst

Dr. Andrew Spencer, Head of Knowledge Exchange and Commercialisation

Rothamsted Research

Jonathan Legh-Smith, Head of Partnerships & Strategic Research

BT Technology, Service and Operations

Peter Oakley, Associate Director

TWI Ltd

Reflections on the East of England's Science and Innovation Audit…

Dr Andy Richards CBE

Life-science entrepreneur and investor

"The East of England Science and Innovation Audit has been a really significant piece of work creating a core data set on which an ambitious ' industrial strategy' can be formulated; its importance especially for the life-science sector cannot be overemphasised. What it reveals is a deep, vibrant and concentrated cluster with determined intent to translate world class research into products and services that will ensure sustained global impact. The connected nature of this ecosystem makes it a key engine of growth for the UK economy: delivering science into protectable and investable ventures, propelling quality start-ups to scale-ups and accelerating ambitious scale-ups to be the independent global players of the future; and with additional direct benefits for the health of UK patients. It is perhaps at its most exciting at the interfaces where biology combines with the physical sciences, where medicine melds with data science and where entrepreneurs and investors interact openly with uncompromisingly excellent researchers. The output of the Audit is impressive but the true asset is its people and here it only hints at future potential that this talent pool can create"

Harriet Fear

Chief Executive

One Nucleus

"It is immensely exciting to witness the continued significant growth of the East of England. One could claim that it is the jewel in the UK life science and healthcare crown – a hotbed of vibrant innovation, creativity and delivery. The region is home to a disproportionate share of the primary therapeutics companies in the UK and attracts an even more disproportionate share of raised capital. This illustrates not only the innovation strength of the cluster, but is also a reflection of the entrepreneurial ecosystem that exists locally where seasoned life science entrepreneurs interact seamlessly with more recent science graduates and PhDs with high aspirations and an appetite to learn.

Add into the mix the pivotal moves we have seen in the last 3 years – not least AstraZeneca's R&D and Corporate Headquarters' move to a consolidated new location at the Cambridge Biomedical Campus but also Gilead, Illumina, Dr Reddy's and others have significantly expanded into new facilities. There continues to be some truly mind-blowing financial and M&A activity too. The IPOs for Cambridge based Horizon Discovery and Abzena have demonstrated the tangible interest once more in the sector from the public markets.

What also works for the region is the great strength of the communities – not purely the globally-acknowledged Cambridge, but also Stevenage, Norwich and Harlow to name but three. All have their own distinct unique selling points. Place a lens over the region as a whole and it makes for a super-cluster of enormous current impact – and vitally a super-cluster of compelling future opportunity for the UK as a whole – and the wider international sector – bearing in mind that organisations here 'think global' from Day One.

But there are challenges – challenges that the region seeks to address itself but which could be fantastically accelerated with support from HM Government. The heady mix of brilliant science, entrepreneurial spirit, collaborative values and innovative thinking, especially regarding the convergence of technologies and the personalisation of healthcare, have to place Cambridge and the wider region at the centre of the UK's life science and healthcare future. Together we can not just make a difference. We can be the difference."

Dr. Belinda Clarke

Director

Agri-Tech East

"Primary food production is the biggest industry in the world. The East of England is one of the most fertile regions in the UK and is home to many progressive farmers, ground-breaking technologists, innovative companies and centres of world leading research. Agri-Tech East is the catalyst, bringing these elements together to accelerate the transfer of knowledge from lab to field and stands by to support the implementation of the SIA report."

Robert Marshall

Group Chief Executive

Marshall of Cambridge

"Marshall of Cambridge was very much in favour of an East of England Science and Innovation Audit with a wide scope, when the concept was originally proposed. We appreciate the assets and capability of the region in Life Sciences, Agri-tech and ICT but, as an advanced engineering company which has been operating in the region for more than a hundred years, it is the Advanced Materials and Manufacturing Theme which captured our specific interest. Marshall already has regional technical support and supply chains which are continually developing, but we realise there is significant untapped potential available in this, the most innovative region in the UK. Perhaps this untapped potential is because we do not have some of the traditional engineering infrastructure of other regions. To counter this, the results of the SIA convince us that identifying, co-ordinating and converging the assets we have will result in more effective support for manufacturing in the region in general, and for Marshall in particular. Although we are a very well established company, we seek to continually develop our technology and productivity. The aerospace and defence sector is already important to the region, and it has very a significant increased future with the combination of world-class science and innovation assets, and commercial enterprises. This is repeated for our other regional engineering sectors. The SIA is not an end in itself, but an important starting point for us all to build on"

Professor Tim Whitley

Managing Director

BT Research & Innovation; and Adastral Park

"The East of England's Science and Innovation Audit has uncovered an extraordinary depth of world-class ICT capability in our region. It demonstrates that the region's expertise has contributed to the UK's position as the largest digital economy of the G20 nations, underpinned by a world-class digital infrastructure. The research and innovation undertaken in universities and businesses across the East of England in areas such as data science, predictive analytics, cybersecurity and AI continue to impact on every aspect of our society. I am confident that if we focus on open, collaborative innovation across the region then the East of England will remain at the heart of the UK's economic prosperity"

Glossary of Terms (non-technical explanations)

Agglomeration	→	The economic advantages of scale and critical mass arising from the co-location of economic activities (e.g. firms)
Build to buy	→	A financing model found increasingly in Life Sciences whereby major pharma businesses take an exclusive option to acquire early stage businesses at an agreed price triggered by the achievement of specific milestones. The major business may hold no equity in the company prior to its purchase but support R&D costs
Cluster	→	A form of industrial organisation which is often localised and characterised by co-operation and competition, underpinned by shared norms and behaviours
Convergence	→	The process through which different academic disciplines and traditions come together across boundaries to create opportunities for innovation
East of England	→	The area included in the SIA – i.e. the areas covered by Greater Cambridge Greater Peterborough Enterprise Partnership, Hertfordshire LEP, and New Anglia LEP; and that part of the area covered by South East LEP which is north of the Thames
East of England (GOR)	→	The area defined on the boundaries linked to the (old) Government Office Region. Compared to the SIA area, this includes Luton and the former county of Bedfordshire, but excludes Rutland and two districts in Lincolnshire
Innovation	→	New ideas, devices or methods which result in better solutions to existing needs and/or that address new or unarticulated needs
Innovation ecosystem	→	The network of relationships and assets that together define and enable the process of innovation
Open innovation	→	A distributed innovation process in which the boundaries between a firm and its environment are permeable
Scale-up	→	An established, but small, enterprise that achieves sustained and relatively rapid growth to at least medium size
Translational research	→	The process of turning fundamental scientific discoveries into improvements in human health and/or other economic, social and/or environmental benefits

List of Abbreviations

AM&M	→	Advanced Materials and Manufacturing
ARU	→	Anglia Ruskin University
BEIS	→	Department of Business, Energy, and Industrial Strategy
BRES	→	Business Register and Employment Survey
CAGR	→	Compound annual growth rate
CBC	→	Cambridge Biomedical Campus
HESA	→	Higher Education Statistics Agency
IfM	→	Institute for Manufacturing (University of Cambridge)
LEP	→	Local Enterprise Partnership
LMB	→	Laboratory for Molecular Biology
NRP	→	Norwich Research Park
REF	→	Research Excellence Framework
RTO	→	Research and Technology Organisation
SBC	→	Stevenage Bioscience Catalyst
STEM	→	Science, Technology, Engineering and Mathematics
UEA	→	University of East Anglia

Executive Summary

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. In the **East of England**, a consortium was formed to focus on our strengths in **Life Sciences, Agri-tech, Advanced Materials and Manufacturing (AM&M)** and **ICT**[1]. This report presents the results which includes broad-ranging analysis of the region's capabilities, the challenges and the substantial opportunities for future economic growth.

The assets and potential of the East of England's innovation ecosystem

2. The East of England is, demonstrably, home to some of the **world's foremost scientific assets**. It also has **strong and distinctive innovation capabilities**. Together, these constitute a world class resource. The potential linked to them is outstanding.

3. With resources of this calibre come responsibilities, both for partners across the East of England and for UK government. These resources must be used to maximum effect. Already, the region is contributing very significantly to the wider UK economy in terms of economic impact and, through its scientific advances, people's lives are being changed for the better worldwide. The East of England is, for example, home to ARM Holdings (the world's leading producer of the microprocessors that are found in 95% of smart phones) and to MedImmune (which accounts for half of AstraZeneca's pipeline). Although both have seen ownership changes, the origins of these world-leading businesses are firmly within the region's innovation ecosystem. And today, the region continues to be a prolific source of innovative, knowledge-based businesses that attract the interest of investors from around the world; on one estimate, for example, over £500m has been invested in Life Sciences companies located at the Babraham Research Campus over the last two years alone. Outside of the Cambridge area, BT and GSK both continue to base the vast majority of their UK research and development activities in the East of England; and in both cases, there is a strong and tangible commitment to open innovation which is creating its own growth dynamic. Moreover, the region's credentials in relation to translational research are continuing to grow: the Quadram Institute (Norwich Research Park) is due to open fully in 2018 and, drawing in the expertise of the world-renowned Institute of Food Research, it will immediately offer outstanding translational research in the field of microbiome, a prospect that is already attracting the attention of major food businesses worldwide.

4. The region's scientific assets – whether vested in universities, research institutions or private sector R&D – and innovation capabilities have a distinctive geography. The Cambridge area is outstanding in terms of the breadth and depth of its scientific assets and credentials – and the power it can exercise in attracting the very best talent. It does, genuinely, compete with the best in the world. Elsewhere, Hertfordshire is a major focus for private sector R&D

[1] These were chosen because they were considered by the Consortium to be particular strengths of the East of England that might usefully be examined through the Science and Innovation Audit. The case for them was made in an Expression of Interest and supported by BEIS

(particularly in Life Sciences); there is a cluster of world-class research intensive institutions in Norwich (focused on Life Sciences and Agri-tech); Adastral Park is a nationally significant asset for ICT; and there are emerging opportunities linked to the University of Essex and its Knowledge Gateway. Outside the Cambridge area, the scale, density and overall critical mass of the asset base is different. These observations are not judgements, but statements of fact – and the consequences of very distinctive and sustained patterns of past investment over decades (and indeed centuries).

5. What matters now is the future ability of the region to harness its breadth and depth of scientific assets to drive future growth and the steps that need to be taken to make this happen. In this context, there is a job to be done. The region has a high incidence of start-up businesses, but it is faltering in the quest for "scale up". This is a matter for concern and a missed opportunity. The region also performs poorly on basic metrics of productivity.

The Audit process

6. It was from this premise – of substantial research strengths and innovation capabilities, but also some weaknesses and unmet potentials – that **the East of England Science and Innovation Audit examined processes of commercialisation and collaboration** across four Themes: **Life Sciences, Agri-tech, Advanced Materials and Manufacturing (AM&M)** and **ICT**.

7. The Audit itself was conducted in a devolved manner and engaged well over 200 stakeholders between January and May 2017. It relied on both primary and secondary evidence and data, and it was rigorous. It adhered to the guidance provided by central government.

The findings from the Audit

> *"I believe the active investors here – who are coming from all over the world – are investing in artificial intelligence, big data software, machine learning and then into the life sciences, bioinformatics and medical technology, and bringing it all together"*
>
> *"The focus here, in the universities and in the business communities, on artificial intelligence, machine learning and robotics, combined with genetics and genomics, presents huge possibilities. Connecting that up in a small place like this could be dramatic"*
>
> *East of England SIA stakeholder consultations, March/April 2017*

8. The region's overarching aspiration for science and innovation over the next decade is to sweat its assets hard **to enable translation through convergence in a manner which is precise, smart, connected and world-leading – to deliver sustained economic growth and to achieve wider impacts.** This aspiration ought to be achievable: the region has outstanding and world-class science ensconced within an effective innovation ecosystem, and it continues to attract substantial investment and talent from around the world.

9. However, the Audit has pointed to four **future-facing "gaps".** These must be addressed if the region's potential is to be realised fully for the economic benefit of the UK and for wider societal benefit around the world. These "gaps" are evident in commercialisation processes across all four Themes. They may be summarised in terms of:

- **Unlocking investment in the process of convergence** – recognising that although game-changing, convergence can also be a complicated investment proposition

- **Providing skills, particularly relating to data** – acknowledging that middle-high level skills in all aspects of computer and data science are in very short supply across the region as demands for the same skillset from across all four Themes grow very quickly

- **Enabling co-location and clustering** – recognising that convergence can be accelerated through proximity and that "*serendipity can be engineered*" by co-locating scientists, investors and entrepreneurs plus – in the domain of Life Sciences – clinicians and patients

- **Increasing connectivity** – acknowledging that the safe and rapid transfer of large volumes of data will be a crucial underpinning for the innovation ecosystem of the future and that this asset will be equally powerful across all four Themes.

10. To fill these gaps, **eight key interventions** are identified. Broadly, these fall into two groups:

- three interventions that are, in principle, **region-wide ventures which are concerned with building hard and soft infrastructures and capacities for sustained innovation, particularly in relation to data**

- five interventions which are focused on **specific clusters and/or sectors with the aim of accelerating convergence and/or translation**.

11. All eight interventions are grounded in rigorous evidence and endorsed fully by the Science and Innovation Audit Steering Group (and its constituent members) and by GCGP's Science Innovation and Industry Council (which has overseen the whole exercise). The table below lists the interventions (in no particular order) and provides a very brief description of them. It also shows how they map onto the principal "gaps" identified through the Science and Innovation Audit.

Table 1: Priority interventions identified through the Science and Innovation Audit

Key "gaps" to be addressed in unlocking the full potential of the East of England's Innovation Ecosystem → Priority interventions…	Unlocking investment in convergence	Providing skills, particularly in data	Enabling co-location and clustering	Increasing connectivity	Brief description....
A: Building hard and soft infrastructures and capacities for innovation across the East of England					
Building Innovation Capacity	✓	✓			Cross-cutting venture to build innovative capacity, particularly among SMEs in the ecosystem
East of England Innovation	✓	✓		✓	Initiative to encourage technology transfer, particularly for SMEs outside the main clusters
Smart Enabling Technologies Testbed	✓			✓✓✓	Infrastructure project to achieve high speed and high capacity connectivity

B: Cluster and/or sector-specific ventures to encourage convergence and/or translation					
Centre for AgriFood automation	✓	✓		✓	Venture to provide a regional resource in automation, at Holbeach
MedTech Hubs	✓		✓✓✓		Project to accelerate the development of emerging Hubs and to build synergies
Microbiome Hub	✓		✓✓✓		Innovation Centre anticipating the opening of the new Quadram Institute, on Norwich Research Park
Precision medicine cancer ecosystem	✓		✓✓✓		Radical new approach to precision medicine, building on foremost science
Cell & Gene Therapy R&D Centre	✓		✓✓✓		Provision adjacent to the Cell and Gene Therapy Manufacturing Centre, at Stevenage Bioscience Catalyst

12. In addition, there is an overarching requirement to address **major issues relating to skills – particularly those relating to data science and computer science**. The Audit found shortages across all four Themes – and the scale of the problem is such that unless addressed, it will stymie business growth across the East of England.

13. In moving forward, these eight interventions – plus the commitment to skills in data science and computer science – will need to be advanced as part of a **wide-ranging and long term commitment to the East of England's innovation ecosystem** from both regional partners and UK Government. The impacts that are delivered as a consequence will be genuinely transformational at both national and global scales.

1. Introduction to the East of England Science and Innovation area

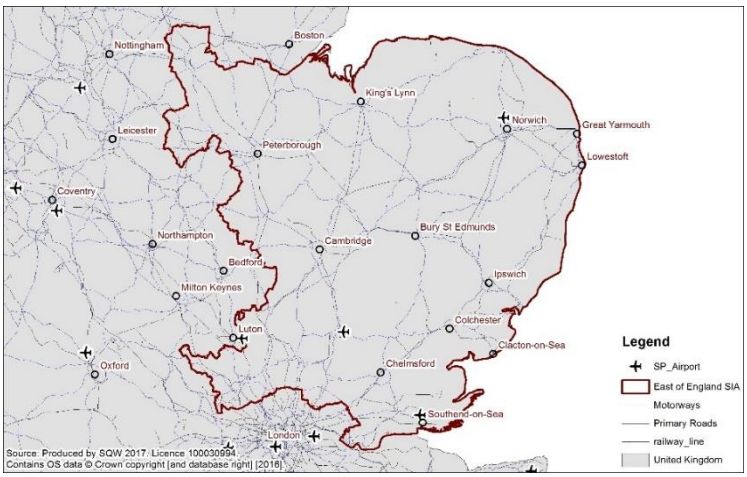
Chapter Summary:

- The East of England has some of the UK's foremost science and innovation assets, with a dynamic private sector, world-class universities and research institutions, and vibrant communities of entrepreneurs and investors.
- The composition and character of its science and innovation ecosystem is in part a function of its polycentricity, defined around compact historic cities and New Towns, and an extensive rural area and coastline. However, its wider connectivity is also a defining feature.
- Despite the strength of its assets, the region's overall productivity performance is currently below the national average – suggesting unfilled potential and major opportunities.
- Substantial future growth is planned region-wide, and a vibrant innovation ecosystem will be imperative.

1.1 The East of England[2] – defined in relation to four Local Enterprise Partnership geographies[3] – is home to some of the UK's foremost scientific research strengths and innovation capabilities. These are vested in a dynamic private sector and across world class universities and research organisations, and they are being animated through more-or-less formal networks (of entrepreneurs, investors and researchers) which are now well-established within a distinctive innovation ecosystem. These assets – and the full range of commercial possibilities and potentials linked to them – form the focus of this Science and Innovation Audit report.

1.2 This introductory chapter describes the wider regional setting which provides the context for the process of innovation across the East of England.

Figure 1-1: The geography of the East of England Science and Innovation Audit area[4]



[2] The East of England defined here is not the same as the (old) Government Office Region with the same name. Some data are only available at the level of GORs and where that is the case, tables/charts/maps are labelled accordingly
[3] Greater Cambridge Greater Peterborough Enterprise Partnership; Hertfordshire Local Enterprise Partnership; New Anglia Local Enterprise Partnership; and that part of South East Local Enterprise Partnership which is north of the River Thames
[4] Larger versions of all maps in Chapter 1 are available in Annex E (with more detail on datasources)

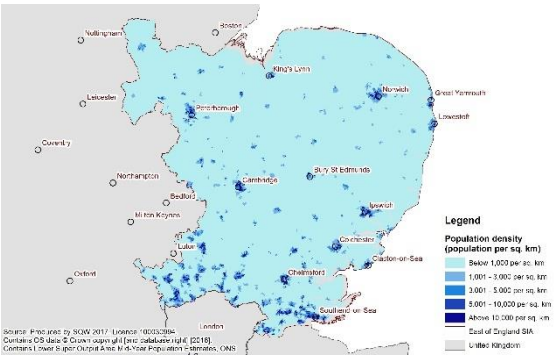
Looking inside the East of England…

1.3 Data from various ONS datasets suggest that the East of England is home to 5.69 million people, of whom 3.50 million are of working age. The region can claim a total of 239,800 enterprises while the number of jobs in the East of England (including both employee jobs and those associated with self-employment) is around 2.86 million. The GVA generated by the East of England (GOR) is estimated to have been £132 billion in 2015 (at current basic prices) and on the same geography, overall GVA per job (productivity) was £48.2k, below the England-wide average.

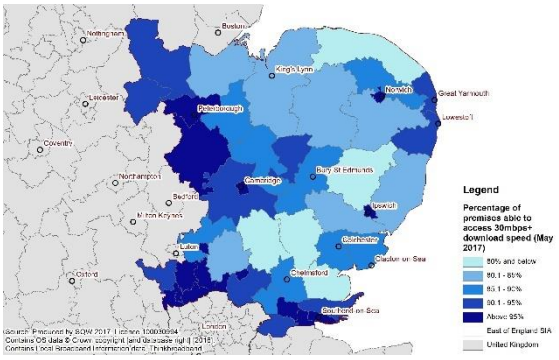
1.4 These region-wide data however mask substantial contrasts. The East of England's population grew by 14% between 1991 and 2015, but – perhaps surprisingly – this was four percentage points lower than the growth seen England-wide (+18%). However, within the East of England, are some of the fastest-growing areas nationally. Some 15 local authority districts/unitary areas saw population growth of more than 25%; these ranged from districts on the edge of Cambridge (East Cambridgeshire (+43%), South Cambridgeshire (+27%)) to Watford in the London fringe (+29%), South Norfolk, immediately to the south of Norwich (+27%), and Colchester (+26%). At the same time, three districts (Brentwood and Castle Point (Essex), and Waveney (Suffolk)) saw population growth of below 10%. The East of England is therefore characterised by fast growth areas, many surrounded by Green Belt and under a good deal of pressure, *and* rural and coastal areas where growth has typically been much slower.

Figure 1-2: Socio-economic conditions in the East of England

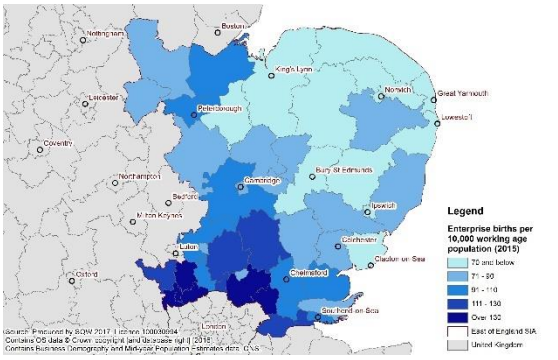
A: Population density, 2015



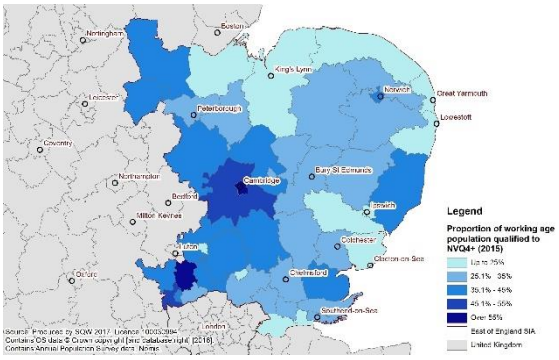
B: Access to >30mbps download speeds, 2017



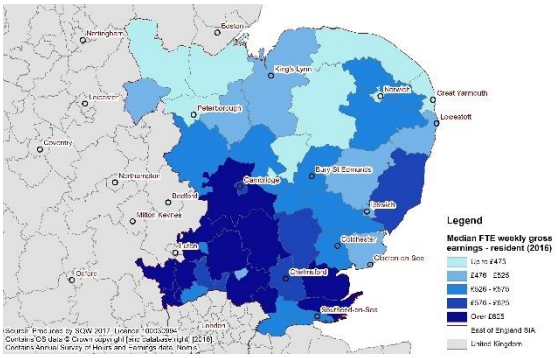
C: Enterprise births per 10,000 WAP, 2015



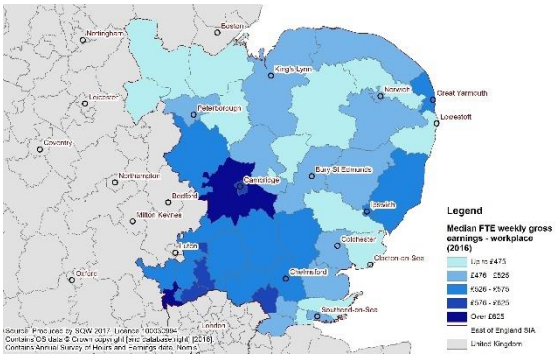
D: Proportion of the WAP qualified to NVQ4+, 2015



E: Median residence-based FTE employee earnings, 2016



F: Median workplace-based FTE employee earnings, 2016



Source: Data from various ONS sources (see Annex E for more detail), other than Map B where the data are sourced from Thinkbroadband (www.thinkbroadband.com); Note that WAP = working age population; FTE = full time equivalent

1.5 Underpinning these patterns of growth is a distinctive set of socio-economic conditions. Most fundamentally, the south of the region – which forms the London fringe – is densely populated, including through an array of New Towns which are home to some of the region's foremost private sector scientific research. Elsewhere, the region is characterised by stand-alone cities of medium size (noting that Norwich, Cambridge, Peterborough, Chelmsford, Colchester and Ipswich all have populations of between about 100,000 and 250,000 people[5]), which are generally home to the region's universities. These are surrounded by extensive, thinly populated, rural areas. The East of England does not have a major city – other than London – and this is fundamentally significant in understanding its economic character, including the attributes of its innovation ecosystem. The region might therefore be defined around its polycentricity, its rurality, its historic cities and New Towns, and its proximity to a buoyant but – in many respects – highly demanding world city (see below).

1.6 Various consequences follow. One is that the south of the region is heavily influenced by London, not least in relation to commuting flows. Map E shows residence-based earnings. There is a strong correlation between high earnings and the *de facto* London commuter belt. These are not, however, mirrored by strong workplace earnings (Map F), and in Essex and Hertfordshire, the differential is an on-going challenge, particularly for local employers seeking to recruit and grow. Further north, labour markets are typically more self-contained and the differentials are less stark – although earnings are also a good deal lower.

1.7 A second consequence is vastly different situations regarding key infrastructures. Increasingly, digital infrastructures are critical. Within the East of England, these are reasonably strong in the densely populated areas and weak in the rural districts to the north and east, other than where the public sector has intervened (see Map B). More generally, key infrastructures are under pressure. Although there have been important improvements over recent years (e.g. A11) and others are planned or underway (e.g. A14), major trunk roads and railway lines are at, or over, capacity and in need of investment, and rail services require improvement. Across the piece, the affordability and availability of housing is a challenge.

[5] On "built up area" definitions rather than administrative boundaries

1.8 Two of the indicators mapped in Figure 1-2 – enterprise rates (Map C) and higher qualification levels (Map D) – are proxies for productivity drivers and they define the fundamental underpinnings of the knowledge economy. In both cases, the region's performance is strongest in the south and around Cambridge, and weakest in coastal and rural areas. There are some important exceptions to this general pattern: Norwich performs strongly in relation to higher level qualifications and Suffolk Coastal fares well on both indicators.

1.9 Looking ahead, the region is set for significant planned growth. Most of the regional cities – Cambridge, Norwich, Peterborough, Colchester, Ipswich, Chelmsford – are set for substantial development, although in several cases, this will be in adjacent local authority districts, owing to historic under-bounding. In the densely-populated south, patterns of growth are more fragmented, reflecting the existing settlement structure and Green Belt constraints – although a notable recent development relates to new Garden Towns (particularly Harlow & Gilston on the Essex-Hertfordshire border). Whilst the growth agenda tends to be dominated by debates around housing, the region is also gearing up for substantial employment growth, notably through a network of Enterprise Zones. These include Great Yarmouth and Lowestoft on the east coast; Alconbury (near Huntingdon); the Envirotech Enterprise Zone (in south west Hertfordshire); Harlow Enterprise Zone; Space to Innovate (Norfolk and Suffolk); and Cambridge Compass.

The East of England in its broader national and international context…

1.10 The region abuts London to the south, and relationships with London are increasingly strong and important ones. These are evidenced through flows of people, ideas and money – in both directions. They have been accelerated through major – and highly complementary – investments in London. The location of the Francis Crick Institute and Alan Turing Institute are especially notable in relation to the Themes examined through the SIA. The East of England has the physical capacity to commercialise knowledge to a level that London cannot, and this in itself is a substantial asset and strength[6]. Links with London are being developed through many different initiatives – not least the work of the London Stansted Cambridge Consortium and through groups like MedCity.

1.11 In addition, connections to Oxford and across the wider Golden Triangle are highly significant. There are major infrastructure issues currently – although plans for both East-West Rail and the Oxford-Cambridge Expressway could be transformational. The region's links to the Midlands and North (on the East Coast Mainline, A1(M) and A14 especially) are also important in terms of its economic character.

1.12 Crucially, the East of England must be understood in terms of its international connectivity. It is a global region and – as evidenced through the Audit – global connectivity is an integral feature of its innovation ecosystem. The region has major gateways – through both ports (Felixstowe, Harwich, etc.) and airports (particularly Stansted Airport, which is set for growth). It is also close to both Heathrow Airport and St Pancras International. These are, in effect, key regional assets.

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[6] For a discussion of the relationship between the East of England and London in relation to science and technology see "*Mapping London's Science and Technology Sectors",* Final Report to the Greater London Authority by SQW, October 2015

2. Strengths in science and innovation

Chapter Summary:

- The East of England has outstanding science, research and innovation assets within its universities, research institutions and businesses.
- The region's eight universities are all part of the wider innovation ecosystem. The latest Research Excellence Framework – which measured five of the East of England's HEIs – found evidence of world-leading research at all five. However, the scale of the different institutions varies enormously: for example, the University of Cambridge accounts for 88% of collaborative research income in the region.
- The private sector is an extremely important contributor to R&D activity – and integral to the innovation ecosystem. The East of England (GOR) has the highest level of business enterprise R&D expenditure per capita in England.
- The region has a vibrant investment community and it also benefits from London proximity. Nevertheless, early-stage finance continues to be a challenge, and the "scale up" process also needs to be supported.
- Across all four Themes, there is a need to improve commercialisation and collaboration. Only in this way will the East of England meet its overarching aspiration for science and innovation over the next decade – namely, **to enable translation through convergence in a manner which is precise, smart, connected and world-leading – to deliver sustained growth and to achieve wider impacts.**

Excellence in science and research

Overview

2.1 The East of England has substantial pedigree in terms of its excellence in science and research. Gateway to Research – developed by Research Councils UK – identifies "*research active*" organisations. Measured simply (and maybe simplistically) in terms of the "*number of participations*", the top twenty research organisations in the East of England are listed in the table below and categorised as either a university, a Research Institute (or major Research and Technology Organisation (RTO)) or a private company (noting that there is a grey area between the latter two categories). Two points stand out: the dominance of the University of Cambridge in absolute terms; and the significance of research institutes/RTOs and private companies in the research landscape defining the East of England more broadly.

Table 2-1: Top 20 research active organisations in the East of England from Gateway to Research (with "number of participations")[7], by type and their primary location

Universities	Research institutes / RTOs	Private companies
1: University of Cambridge (3,656) – Cambridge	3: John Innes Centre (628) – Norwich	10: GlaxoSmithKline plc (184) – Stevenage
2: University of East Anglia (861) – Norwich	4: Rothamsted Research (444) – Harpenden	11: BAE Systems (133)

[7] Note that these data are "taken as read", but in practice, the database appears to include multiple entries for the same organisations – so the significance of BRE, TWI and NIAB is under-recorded in the table. In addition, there are some key research active organisations that do not appear in the table at all (e.g. BT – which is significant in the East of England – accounts for 135 Research Council projects and 19 Innovate UK projects but is not picked up because these are spread across: BT Limited, BT Laboratories, BT PLC, BT Innovate, BT Group, British Telecommunications, British Telecommunications public limited company).

Universities	Research institutes / RTOs	Private companies
5: University of Essex (348) – Colchester	6: Babraham Institute (333) – Cambridge (south)	16: Microsoft Research Ltd (93) – Cambridge
9: University of Hertfordshire (187) – Hatfield	7: Institute of Food Research[8] (285) – Norwich	18: e2v Technologies plc (59) – Chelmsford
	8: NERC British Antarctic Survey (203) – Cambridge	19: Toshiba Research Europe Ltd (57) – Cambridge
	12: EMBL – European Bioinformatics Institute (132) – Cambridge (south)	20: Schlumberger Cambridge Research Ltd (53) – Cambridge
	13: TWI Ltd (121) – Cambridge (south)	
	14: National Institute of Agricultural Botany (97) – Cambridge	
	15: MRC Laboratory of Molecular Biology (96) – Cambridge	
	17: BRE (72) – Watford	

Source: Gateway to Research – data sourced by Technopolis

2.2 A similar pattern is apparent if the focus shifts to indicators surrounding the impact of research. As one example, the table below provides evidence from across universities in the East of England in relation to the incidence of spin-outs and start-ups linked to the region's research base. It is important to note that these data relate to one year only and hence provide a snap shot[9]. The dominance of the University of Cambridge is clear in relation to some categories of spin-outs while the UEA performs strongly in relation to graduate-start-ups.

Table 2-2: Spin-outs and start-ups from universities, 2015/16

	Some HEI ownership		Formal, no HEI Ownership		Staff Start-up		Graduate Start-up	
	Rank	*Number*	*Rank*	*Number*	*Rank*	*Number*	*Rank*	*Number*
Anglia Ruskin University	56	0	12	0	24	0	107	0
Norwich Univ. of the Arts	56	0	12	0	24	0	29	34
University of Suffolk	56	0	12	0	24	0	107	0
University of Cambridge	6	5	12	0	4	3	97	2
University of East Anglia	16	2	6	1	24	0	11	106
University of Essex	56	0	12	0	24	0	107	0
University of Hertfordshire	34	1	12	0	24	0	54	17
Writtle University College	56	0	12	0	24	0	107	0

Source: Data taken from Funding Benchmarks database which collates the Higher Education Business and Community Interaction Survey (HEBCIS) data submitted annually to HEFCE by all universities

[8] Note that as of April 2017, the Institute of Food Research transitioned into Quadram Institute Bioscience
[9] Note that survey based data on the incidence of university-related spin-outs and start-ups is available from www.spinoutsuk.co.uk. Although there may be some gaps, the data are from 2000 and hence the perspective is longer term. From this source, the number of spin-outs based on university IP is identified as being 102 linked to the University of Cambridge, nine from UEA, ten from University of Hertfordshire and six from University of Essex

The region's universities

2.3 There are **eight universities** in the East of England[10]. Of these, two are Post-1992 institutions; one is firmly within the Russell Group; and two – University of Suffolk and Writtle University College – did not become full independent universities until 2015/16. The eight universities therefore cover the spectrum of higher education institutions and they are notably diverse. Five of the eight have wide-ranging science-based strengths and key data relating to aspects of their scale and character are provided in Table 2-3 overleaf.

2.4 According to the **Times Higher Education World University Rankings**, the University of Cambridge was ranked fourth overall globally (and second in the UK) in 2016/17; University of East Anglia was ranked 165th globally (and 25th nationally); both University of Essex and Anglia Ruskin University[11] were ranked between 301 and 350 (joint 38th nationally); and University of Hertfordshire was ranked between 501 and 600 globally (joint 59th nationally). Data from the **Complete University Guide** also point to the strengths of the region's higher education institutions. From this set of metrics, the University of Cambridge is ranked 1st nationally and University of East Anglia is ranked 12th.

2.5 Data from the **Research Excellence Framework (2014)** provide some indication of the quality of research, although – given substantial differences in the scale and nature of individual institutions – REF data need careful interpretation. A rating of 4* signifies research of a quality that is world-leading in terms of originality, significance and rigour. In REF 2014, all five universities included in Table 2-3 achieved a rating of 4* for at least 10% of outputs in at least four "*units of assessment*" (i.e. broadly defined subject areas). This is important, for it signals a broad base of excellence. Some institutions scored more highly than others – both in consistency of excellence and the breadth – but all five can point to research excellence. The overall breadth – geographically and by subject – is a substantial asset in fuelling knowledge-based economic growth[12].

2.6 Data from **HESA** (Higher Education Statistics Agency) suggest that in 2015/16, the eight institutions' combined income from collaborative research (involving public funding) summed to £106.8m, 8.3% of the UK total. Of this, the University of Cambridge accounted for 88%, University of East Anglia for 7% and the University of Essex for 3%. In the same year, the total value of contract research income was £56m, 4.5% of the UK total. On this indicator, the University of Cambridge accounted for 55% of the regional figure, University of Essex for 24% and University of Hertfordshire for 12%.

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[10] There are various other universities with campuses in the region (e.g. Royal Veterinary College (part of the University of London) and the University of Lincoln), and there are universities which are functionally part of the innovation ecosystem even though they are located just outside the nominal boundary (Cranfield University is especially important)

[11] Note however that the report "*Class of 2030: Which universities will rise – and how will they do it?*" focuses on "*challenger*" universities, which are mainly new institutions rapidly rising up the world rankings and expected to rival the elite group of more established universities within the next 10-20 years. Anglia Ruskin is the only UK university to feature in the top 20

[12] It is important to note that the region benefits from research strengths which go beyond the immediate focus of this Science and Innovation Audit. This provides an important depth of resource and asset base which is highly germane to the process of convergence. For example, the University of Essex is host to a number of national data initiatives including the UK Data Archive, which is the largest collection of digital data in the social sciences and humanities in the UK; the ESRC Business and Local Government Data Research Centre, exploring the use of innovative and complex smart data to provide insights for business and local government.; and the ESRC Human Rights, Big Data and Technology programme, analysing the challenges and opportunities presented by the use of ICT and big data from a human rights perspective.

Table 2-3: Breadth and depth of research excellence in the region's major universities, and perspectives on scale

Institution	REF: Top 3 units of assessment in terms of the proportion of outputs rated as 4* (i.e. research of a quality that is world-leading in terms of originality, significance and rigour)	REF: Other units of assessment with at least 10% of outputs rated as 4*	Students, 2016/17 (and % that were international)	Collaborative research income, 2015/16	Contract research income, 2015/16	No. of REF Impact Case Studies	Times Higher Education World University Ranking – Globally (and in UK)	Complete University Guide – overall UK ranking	REF 2014 overall ranking on GPA / Research Power
Anglia Ruskin University (ARU)	• Geography, Environmental Sciences and Archaeology (13%) • Music, Drama, Dance and Performing Arts (12%) • Communication, Cultural and Media Studies, Library and Information Management (12%)	1	16,740 (25%)	£1.3m	£1.0m	32	301-350 (38=)	118	100 / 81
University of Cambridge	• Electrical and Electronic Engineering, Metallurgy and Materials (69%) • Business and Management Studies (60%) • Psychology, Psychiatry and Neuroscience (58%); AND (separately) Clinical Medicine (58%)	28	18,605 (35%)	£94.1m	£33.0m	227	4 (2)	1	5 / 3
University of East Anglia (UEA)	• Social Work and Social Policy (48%) • English Language and Literature (45%) • Allied Health Professions, Dentistry, Nursing and Pharmacy: A - Pharmacy (45%)	21	13,997 (28%)	£7.8m	£2.3m	64	165 (25)	12	23 / 36
University of Essex	• Politics and International Studies (68%) • Psychology, Psychiatry and Neuroscience (40%) • Modern Languages and Linguistics (40%)	10	10,154 (44%)	£2.8m	£13.2m	48	301-350 (38=)	32	35 / 45
University of Hertfordshire	• History (45%) • Allied Health Professions, Dentistry, Nursing and Pharmacy: B - Allied Health Professions and Nursing (24%) • Philosophy (19%)	3	17,552 (27%)	£0.8m	£6.5m	30	501-600 (59=)	79	83 / 73

Source: REF 2014 (Note GPA=Grade Point Average); HESA 2017; Times Higher Education World University Rankings, 2016/17; Complete University Guide – University League Tables 2018. Data sourced in Spring 2017.

2.7 These data point to the different roles and attributes of the region's higher education institutions. The University of Cambridge is world class on every measure and it is an enormous asset for the region. Elsewhere there is genuine excellence, but the scale is smaller and the breadth is generally narrower. All eight institutions are however playing a role within the region's wider innovation ecosystem. In relation to the Science and Innovation Audit, this role must be understood on various dimensions. The strength and breadth of their scientific (and wider) research activities is obvious, but it is important also to recognise the role played by specialist university bodies linked to the commercialisation process (e.g. Cambridge Enterprise). It is also essential to acknowledge the contribution made by all eight universities in generating a well-qualified future workforce. Data suggest that the region's universities are producing around 7,000 graduates each year from within core scientific disciplines and that around 40% of these are employed within the East of England shortly after graduation[13].

The region's research institutes and Research and Technology Organisations (RTOs)

2.8 Alongside the universities, a group of **research institutes** which rely on substantial funding from the Research Councils and/or major charities (e.g. Cancer Research UK and Wellcome Trust) are a very significant part of the region's scientific asset base. In addition, the region is home to several major organisations that originated as **Research and Technology Organisations** (RTOs) – notably BRE and TWI. The roles of the research institutes and RTOs are discussed in more detail in all four of the Theme-specific narratives, but outstanding – and important – examples are listed in Table 2-1 above.

The region's private sector R&D

2.9 The third component of the region's scientific excellence is vested wholly in the **private sector**. Each year, ONS estimates businesses' expenditure and employment relating to research and development. These data are available for Government Office Regions, but not generally at finer levels of granularity[14]. Overall, in 2015, the East of England (GOR) accounted for 35,000 private sector R&D jobs (17% of the UK's business employment in R&D) and business enterprise expenditure on R&D which was estimated at £4.2bn. This translates into £703 per capita, a figure which is 30% higher than the second best performing region. In addition, as a proportion of total regional GVA, business expenditure on research and development in the East of England (GOR) is higher than in any other region. These statistics are explained in terms of major centres of business research such as BT's Global Research and Development HQ at Adastral Park in Suffolk, GlaxoSmithKline (GSK) in Stevenage, and Ford's major research facility at Dunton in Essex; each of these accounts for 2,000-5,000 jobs and they constitute nationally-significant hubs of science-based R&D.

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[13] Data relate to 2014/15 and are taken from Heidi Plus (HESA)
[14] Although a special analysis was completed as part of a study for then-BIS in 2015. Across 39 LEP areas, Hertfordshire was ranked second and Greater Cambridge Greater Peterborough fifth on Business Enterprise R&D Expenditure (BERD) by Full Time Equivalent in 2013 (Source: *Mapping local comparative advantages in innovation*, Study led by Liverpool John Moores University for BIS, March 2015)

2.10 Investigating these data further is not easy – and it is not possible through ONS sources. An analysis of Bureau Van Dijk's FAME database provides some further insights – although these data need to be treated carefully. From that source, companies registered in the East of England (GOR) account for R&D spend summing to £1.2bn – although this excludes all three of the major players referenced above (as their registered addresses are elsewhere)[15]. Nevertheless, from FAME, it is possible to distil the spatial distribution of R&D spend (insofar as it correlates with registered addresses). Overall, just under half of the regional (GOR) total is in Cambridgeshire (and ARM is the major contributor, accounting single-handedly for 30%) and well over a third is in Hertfordshire.

2.11 Wherever their registered address, it is important also to acknowledge the role played by major research-intensive businesses in relation to the region's specialist labour market. The likes of GSK, BT and Ford play a crucial role in training graduates and apprentices. Over time, these people become a core part of the region's asset base – whether they remain with major firms or find their way to other employers within the wider ecosystem[16].

Innovation strengths and growth points

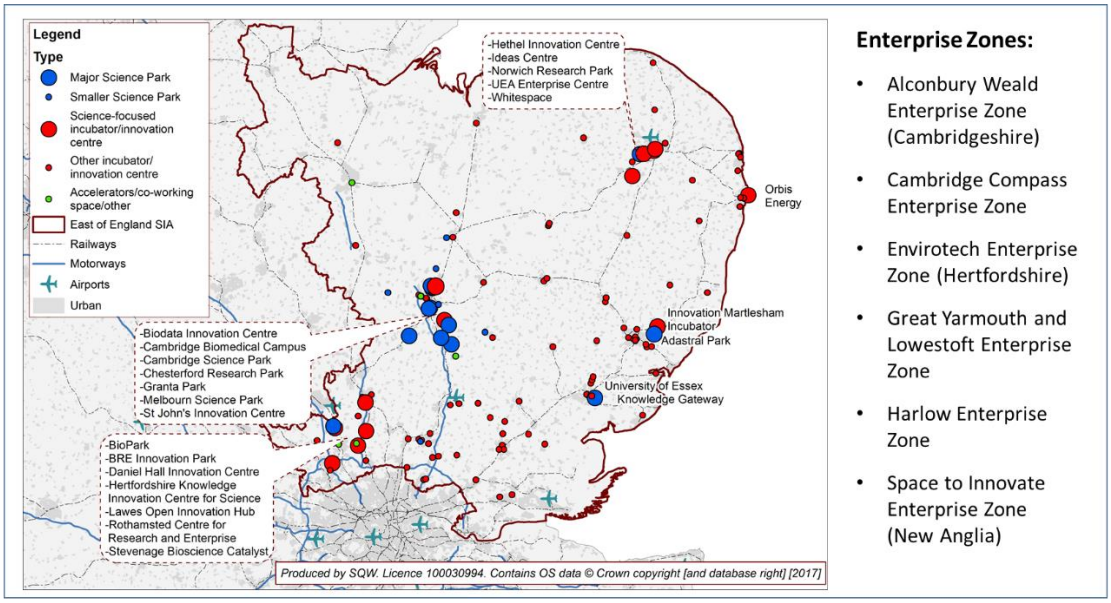
2.12 "Innovation" is much harder to measure and evidence than "research". The region has substantial innovation strengths which need to be understood at many different levels. These are examined in depth in the Theme-specific analyses that follow. Overall, innovation is risky, as is the related (but different) process of enterprise. Years ago, the comment was made that Cambridge had become "*a low risk place to do high risk things"* and the same can now be said of much of the East of England. There are various aspects of "de-risking" to consider.

2.13 The East of England has a well-developed **network of science parks, innovation centres, incubators and accelerators** which are playing a crucial role in the process of innovation. Some of these (e.g. Cambridge Science Park, St John's Innovation Centre, Norwich Research Park) are seen as exemplars around the world. Others are still being developed. From the map below (Figure 2-1), three observations stand out:

- the region's five strongest universities (in terms of THES rankings) all now have one or more science park(s)/innovation centres that are co-located or nearby
- there is more broadly-based provision developing around some of the major research intensive businesses and research institutions/RTOs identified in Table 2-1
- the overall consequence is a distinctive geography – the Cambridge area has substantial assets, as does west Hertfordshire, and there are notable concentrations around each of Norwich, Ipswich and Colchester.

[15] Noting that these are very significant contributors – e.g. BT accounts for £210m in salaries alone
[16] The role of larger companies in respect of the specialist labour market is considered later – see for example paragraph 6.30

Figure 2-1: Science Parks, incubators, innovation centres and accelerators in the East of England



Source: Data drawn from the UKSPA Directory, "Accelerators and Incubators in the UK" (Nesta, 2017); and local knowledge

2.14 Alongside – and often working with – the "hard infrastructure" to support innovation is a range of more-or-less formal **networking/cluster groups**. These vary in terms of their maturity, spatial footprint and sector focus, but they have strong private sector memberships and are supporting the process of innovation. Examples include Agri-Tech East, Cambridge Cleantech, Cambridge Network, Cambridge Wireless, One Nucleus, Tech East and SyncNorwich. Through networks, trust is built up, learning takes place and a basis for co-operation and collaboration is achieved, all of which contribute to "de-risking". Formally or informally, networks also contribute materially to processes of, and possibilities for, technological and scientific convergence.

2.15 In this context, formally-constituted networks – like the **Academic Health Science Networks –** are very much part of the innovation ecosystem. Latterly, central government has also played a hand through the establishment of **Catapults** (whether or not they are physically based within the East of England). Their purpose is to provide technical capabilities, equipment, and other resources required to take innovative ideas from concept to reality.

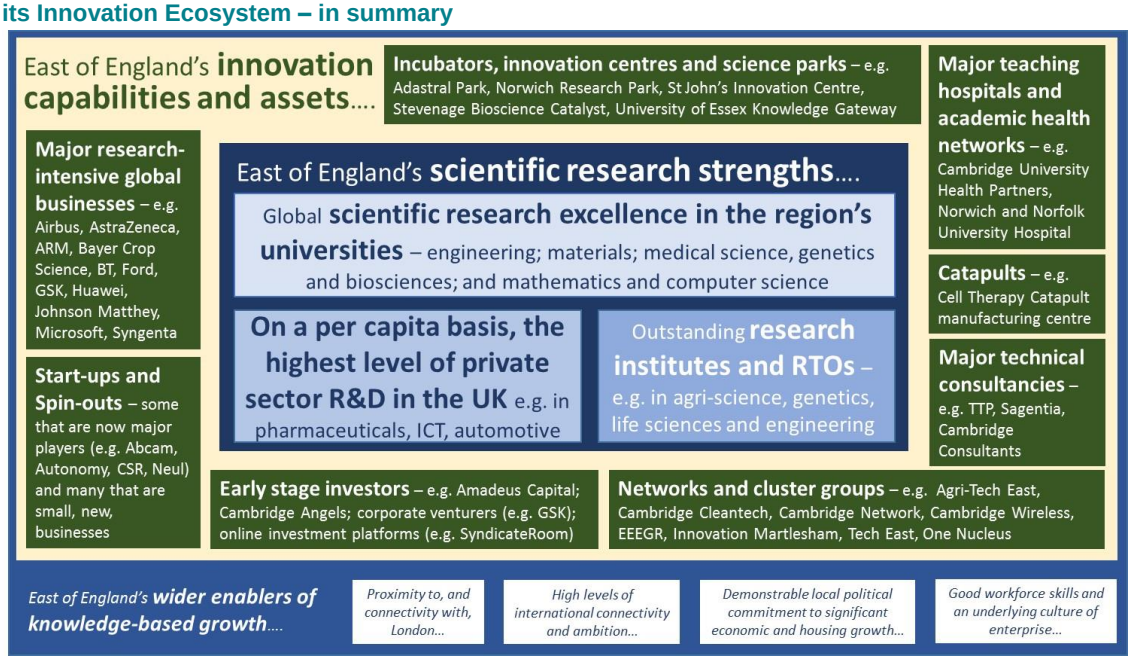
2.16 Underpinning all of this, a crucial, but invisible element of the innovation ecosystem is **early stage finance**. Particularly as entrepreneurs seek to take research concepts into the commercial domain such that they are "*revenue generating*" rather than "*research grant consuming*", early stage finance has a critical role to play. The "*valley of death*" accounts for the demise of many a would-be business and there are a host of well-evidenced market failures. In the East of England there are established networks of early stage investors, mostly in Cambridge (e.g. Cambridge Angels, Amadeus Capital); whilst the "valley of death" challenge has not been "solved", elements of it have been de-risked locally. There are also new solutions emerging which are linked, for example, to crowd-funding. However, the financing of growth continues to a be an issue, both at the earliest stages of commercialisation and – just as acutely in the East of England – in relation to the scale-up process; it is in this domain that there are major opportunities looking ahead and the Science and Innovation Audit is itself helping to define a response.

2.17 A final component of the region's innovation ecosystem is unique to the East of England. It relates to the role of a group of **technical consultancies** which have "grown up" with the innovation ecosystem in Cambridge and are now an integral element of it, both in Cambridge and more generally. Companies like Cambridge Consultants, The Technology Partnership (TTP), PA Consulting and Sagentia (formerly Scientific Generics) have long played a key role in the technology transfer process and are themselves a prodigious source of spin-outs.

Conclusions – and implications for the SIA

2.18 **The East of England is, demonstrably, home to some of the world's foremost scientific assets. It also has strong and distinctive innovation capabilities. Together, these constitute a world-class resource – and the potential linked to them is outstanding**. Drawing on evidence presented both here and in Chapter 1, key elements of the wider ecosystem are captured in Figure 2-2.

Figure 2-2: The East of England's scientific strengths and innovation capabilities which define its Innovation Ecosystem – in summary



Source: SQW – drawing on information gathered through the SIA process

2.19 **With resources of this calibre come responsibilities and challenges, both for partners across the East of England and for UK government. Particularly given the uncertainties and risks (upside and downside) linked to Brexit, it is essential that these resources are used to maximum effect**.

2.20 What is also apparent is that **the region's scientific assets – whether vested in universities, research institutions or private sector R&D – and innovation capabilities have a strong focus on Cambridge**. This is not to suggest that the remainder of the region is devoid of assets. It demonstrably has research and innovation strengths elsewhere – for example, Hertfordshire is a major focus for private sector R&D; there is a cluster of research intensive institutions in Norwich; Adastral Park is a nationally significant asset for ICT; and there are emerging opportunities linked to the University of Essex and its Knowledge Gateway. However, the scale, density and overall critical mass of the asset base is clearly different.

These observations are not judgements, but statements of fact – and the consequences of very distinctive and sustained patterns of past investment over decades (and indeed centuries).

2.21 **What matters now is the future ability of the region to harness its breadth and depth of scientific assets to drive future growth and the steps that need to be taken to make this happen**. In this context, the picture is less positive. Data from the Enterprise Research Centre (ERC) suggest that all four LEP areas within the East of England had a high-growth firm incidence rate that was below the national average between 2012 and 2015; while the proportion of £1-2m turnover businesses growing to at least £3m from 2012 and 2015 was very close to it. The East of England does not, in general, have a start-up or enterprise problem but "scale up" is another matter – and that judgement applies region-wide. In part, it reflects challenging supply side conditions, particularly in the south and west. In the more rural and peripheral areas, there may also be a demand side element. But whatever the cause, the fact that the East of England is faltering in the quest for "scale up" is a matter for concern and a missed opportunity.

2.22 It is from this premise – of substantial research strengths and innovation capabilities, but also some challenges and unmet potentials – that **the East of England Science and Innovation Audit focuses on two key challenges, one relating to commercialisation, the second focused on collaboration**. These challenges are apparent across the four Thematic areas. In all four, the region has outstanding and world-class science, and it continues to attract substantial investment. But in all four, partners believe – and the evidence confirms – that the assets could be sweated harder to deliver more consistent economic (and societal) impact.

2.23 These challenges relate to the inherent functioning of the innovation ecosystem. **Only by addressing them will the East of England meet its overarching aspiration for science and innovation over the next decade – namely, to enable translation through convergence in a manner which is precise, smart, connected and world-leading – to deliver sustained growth and to achieve wider impacts.**

3. Theme 1: Life Sciences

Chapter Summary:

- The East of England's Life Sciences sector is already world class, with outstanding research in universities, research institutions and businesses (both major corporates and spin-outs/start-ups); it is also seeing substantial investment (from national and international sources).
- It has huge assets – in the context of fast-growing markets – for personalised medicine (including drug discovery, development and diagnostics); regenerative medicine; genomics; medtech; and food, health and microbiome.
- Innovation models are changing, accelerating the process of open innovation – and the innovation ecosystem is evolving in response.
- The cluster around Cambridge is exceptional. Substantial further investment is underway and planned, and this is creating opportunities which are being realised as translational pathways evolve.
- The region is well positioned to capitalise on emerging opportunities in medtech – which are best understood as "*clinical data plus hardware*". Life Sciences firms in Cambridge, the A1(M) Corridor in Hertfordshire, and south/mid Essex are connecting with the region's ICT and data analytics resources – and working with healthcare providers – to create products and services that could transform healthcare delivery.
- In relation to food, health and microbiome, the Quadram Institute on Norwich Research Park will open in 2018, and it is already generating much interest from the business community, this will incorporate and build upon the long-established research excellence of the Institute for Food Research.
- Convergence is driving innovation. It is also creating some challenges. Investors can find "convergence" difficult, particularly when it does not translate into patentable intellectual property. A proliferation of 'build to buy' models is a barrier to growing talent and scaling-up world class businesses. There is a need for skills in "deep computer science" to allow key elements of the industry to grow.

Scope – and core hypothesis

Figure 3-1: Summarising the East of England's Innovation Ecosystem in Life Sciences

Source: SQW – drawing on information gathered through the SIA process

3.1 The East of England has world-leading assets in Life Sciences and it is now home – through organic growth, acquisition and inward investment – to some of the world's highest profile businesses. With first rate academic research, an outstanding group of Research Institutes, major teaching hospitals/academic health networks and Catapult-related activity, it is a world-leading hub for science and innovation. Key elements of the innovation ecosystem within the region are summarised in the graphic above.

3.2 Within this context, the Science and Innovation Audit has focused on five main elements: **personalised medicine (including drug discovery, development and diagnostics); regenerative medicine; genomics; food, health and microbiome; and medtech** (although as the Audit has progressed it has become clear that the genomics and medtech themes are best regarded as cross-cutting).

3.3 The hypothesis that has shaped the Audit is that:

> *The East of England's life sciences cluster is already world class, with a strong record in terms of the quality of scientific research and the commercialisation of it. In the future, it will retain its pre-eminence through greater collaborative links within and between personalised medicine; regenerative medicine; genomics; food, health and microbiome; and medtech.*

National and international trends, and size of global markets

3.4 There is a substantial body of literature describing national and international trends in Life Sciences. In headline terms, healthcare spending as a proportion of GDP is increasing globally because of the ageing population in developed countries, and greater affluence and/or changing national priorities in (some) developing ones. The incidence of chronic diseases is rising, fuelled by rapid urbanisation, sedentary lifestyles, poor diets and rising levels of obesity; and in this context, cardiovascular disease, cancer, respiratory disease, diabetes and dementia are dominating global healthcare expenditures and, in turn, creating substantial opportunities across all Life Sciences sectors.

3.5 Although growth slowed in the immediate aftermath of the credit crunch, rapid sales growth is anticipated globally through to 2020 and beyond. Drawing on various sources, it is estimated that by 2020, worldwide pharmaceuticals sales will exceed $1.2 trillion (compared to less than $1 trillion in 2013); global revenue in biotechnology will increase from $264 billion in 2010 to nearly $315 billion; and medical technologies will increase from $350 billion in 2011 to almost £480 billion[17]. A parallel analysis completed for the UK pointed to growth of 3-7% per annum between 2013 and 2018 in pharmaceuticals (which in 2013 accounted for sales of £29bn); 9% per annum in biotechnology (from £4.2bn sales in 2013); and 4.5% per annum in medical technologies (from £17.6bn in 2013)[18].

3.6 Life Sciences are, then, set for medium term growth. **However, the pace of growth is expected to be greatest in the still-emerging segments of biotechnology and medical technologies – the main focus for the Life Sciences strand of this Science and Innovation Audit**. The former is driven by rapid developments in personalised medicine and genomics

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[17] *2017 Global Life Sciences Outlook – Thriving in today's uncertain market.* Deloitte, 2017
[18] Strength and Opportunity, UK Government 2013

while the latter reflects the growing preference for (and cost advantages of) minimally invasive procedures; advances in digital health applications; and the rapid growth in diagnostic imaging. Moreover, there is a growing relationship between the two which will open up new commercial opportunities.

3.7 **In response to these technological and market-driven changes, translational research models are evolving quickly**. In the mainstream pharmaceuticals sector, patent expiries, cost pressures from major purchasers (such as the NHS) and the spiralling costs of drug discovery have been on-going catalysts for change over the last decade. Pharmaceuticals companies are less insular than they were, and increasingly, open innovation models are being favoured in which big pharma works within collaborative networks of researchers and small (often spin-off) companies; sometimes involving licensing, sometimes based on formal collaborations (through joint ventures, etc.), and sometimes – and perhaps increasingly – through open sourcing (in an ecosystem model that is becoming more like that shaping the ICT sector). **This shift in focus is increasing the imperative for clustering and collaboration – including across sectoral boundaries (which is where innovation is most likely to occur). This is a process that is already very active in the East of England**.

Local science and innovation assets

3.8 The East of England demonstrably has substantial science and innovation assets in the realm of Life Sciences in general, and in relation to the Sub-Themes that provide the focus for this Audit. For example:

- In terms of the quality of **academic science**, the region's credentials are dominated by the University of Cambridge: based on the **Research Excellence Framework** (2014), its rank on **research power** (by unit of assessment) is second in the UK in "*biological sciences*", and fifth in each of "*clinical medicine*", "*psychology, psychiatry and neuroscience*", and "*public health, health services and primary care*". "*Biological sciences"* at the University of East Anglia is ranked 20th and "*public health, health services and primary care*" is ranked 25th. In terms of **grade point average (GPA)**, University of Cambridge ranks second in "*clinical medicine*" and third in both *psychology, psychiatry and neuroscience*", and "*public health, health services and primary care*"[19].

- According to Gateway for Research, the East of England accounted for 17% of total UK **Research Council funding** (by value) in omic sciences and technologies (genomics, proteomics, metabolomics) between 2004-16; 15% in genetics and development; and 13% in biomolecules and biochemistry. Analysis by Technopolis – based on semantic text analysis powered by SpazioDati – suggested that the East of England's profile in the detailed Sub-Themes was yet higher. Specifically, East of England participants accounted for 24% of UK funding linked with regenerative medicine; 20% of that

[19] Note that regional research excellence in engineering and physical sciences, and mathematics, is also very relevant to this Theme, particularly in the context of convergence. The region's depth and breadth of research excellence in these disciplines is considered in detail in Chapters 5 (AM&M) and 6 (ICT).

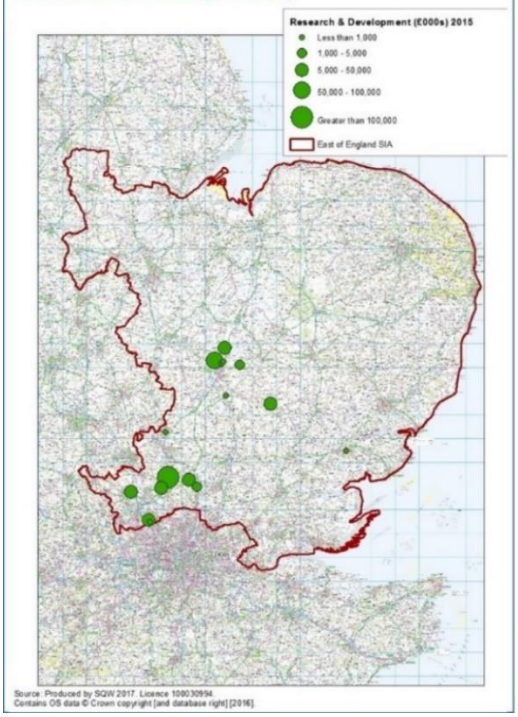
associated with microbiome; 26% in the realm of personalised medicine; and 21% in the (much bigger) sphere of drug discovery.

- An analysis of **EU funding** (from both Framework Programme 7 and Horizon 2020) paints a similar picture. It indicates that the region accounted for 23% of the UK total in regenerative medicine; 19% in microbiome; 14% in personalised medicine; and 20% in drug discovery.

- Data from the European Patent Office (PATSTAT) suggest that between 2004 and 2014, inventors in the East of England filed 22% of the UK's **patents** in pharmaceuticals; 21% in biotechnology; and 16% in medical technology.

- **Private sector investment in R&D** in Life Sciences summed to over £400m in 2015 alone, across businesses with registered addresses in the East of England (and noting that this overlooks some major investors); the spatial distribution of this investment is shown in the map opposite.

Figure 3-2: Map showing private sector R&D spend in Life Sciences for companies with registered addresses in the East of England (data from Bureau van Dijk/FAME)



3.9 However, data of this nature convey very little in terms of how the Life Sciences ecosystem in the East of England actually "works", or how effective it is currently, or what it could achieve in the future, in translating world-class science into tangible commercial and/or social outcomes. **Far more important than the component parts are its ecosystem characteristics, particularly given the transition to open innovation and the imperatives linked to translational research in personalised medicine; regenerative medicine; and microbiome.** These ecosystem characteristics have evolved and matured substantially over the last two decades and they define and capture much of the East of England's asset base. At the core of the ecosystem are the people working in it: day-to-day relationships between scientists, clinicians, entrepreneurs and investors are, simply, critical[20].

3.10 These assets and relationships are best illustrated – in depth and scale – by the ecosystem centred on the southern fringe of Cambridge. The scale of the cluster within a radius of 20 miles from Cambridge has been estimated to include 352 companies, 87% of which employ fewer than 50 people[21]. The ecosystem has been the subject of various research reports[22], but the summary in Box 3-1 conveys something of its historic evolution – institutionally,

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[20] Based on comments made at one of the six Life Sciences workshops/round table discussions conducted as an input to the Audit in March/April 2017
[21] *Cambridge Biopharma Cluster*, Bidwells/LetsCellIt, 2016
[22] See, for example, "*The Cambridge Bioscience Impact Study*", Report to Institute of Public Health, University of Cambridge on behalf of NIHR Cambridge Biomedical Research Centre, by Cambridge Economic Associates and Cambridge Econometrics, October 2015

attitudinally and scientifically. It also describes the foundations that that have been put in place for "*translation through convergence*" looking ahead (the overall focus of the Science and Innovation Audit). The narrative is complex and it is evolving continually but it is important insofar as it communicates convergence, translation, world-leading impact – and substantial future potential. It has been driven out of research excellence, but it has increasingly attracted commercial interest and clinical application.

Box 3-1: The "*translational research ecosystem*" on the southern fringe of Cambridge

The quality, volume and range of translational medicine and medical research on the southern fringe of Cambridge is outstanding in global terms.

Defined around ever-closer interfaces between basic and clinical research, and downstream to different forms of drug discovery and an array of therapeutics, the "translational research ecosystem" has developed substantially over the last 20 years. It is now large and intricate, with many different elements and interfaces. It is already a substantial economic driver, and it is gaining momentum.

A study published in 2000 provides a useful benchmark in terms of the distance travelled[23]. At the time, three locations on the southern fringe were recognised in relation to Life Sciences. One was the site of Addenbrooke's hospital and the co-located Laboratory for Molecular Biology (which at the time was space-constrained in a 40-year-old building which was "*showing its age and expensive to run*"); the second was the Wellcome Trust Genome Campus at Hinxton (home of the Sanger Centre); and the third was the National Institute of Animal Physiology and Genetics at Babraham. Subsequently all three of these have seen substantial investment and growth.

In **funding** terms, the research councils have played a pivotal role throughout (particularly the **Medical Research Council (MRC)** and **Biotechnology and Biological Sciences Research Council (BBSRC))**. The major medical charities have also been central to the growing ecosystem, notably **Wellcome Trust** and **Cancer Research UK (CRUK)**. In addition, the private sector has played a progressively greater role through major companies (like **AstraZeneca, GSK** and **Pfizer**) and also through a growing number of spin-off businesses.

Central to the developing ecosystem has been the changing role of the **University of Cambridge**. In the sphere of translational medicine, the nature of the University's current role owes much to the vision of Keith Peters, Regius Professor of Physic in the 1980s. He conceived of a modern research facility where clinical and basic science could converge to study the molecular mechanisms of disease. In what was a radical departure, the **Cambridge Institute for Medical Research** was formed, drawing together researchers (around 40% of whom were clinicians) from medical genetics, immunology, infectious diseases, haematopoiesis, oncology, biochemistry and structural biology; and located in the then-new Wellcome Trust/MRC building. Subsequently, CIMR promoted collaborative working, and over the last 15-20 years, its researchers have either established or been integral to many other research institutes in Cambridge. These include, *inter alia,* the **CRUK Cambridge Institute,** the **Wellcome Trust-MRC Institute of Metabolic Science,** and the **Wellcome Trust-MRC Cambridge Stem Cell Institute**. All of these ventures have complemented – and built upon – the University's outstanding strengths in basic life sciences research (notably biological/biomedical science) and the work of bodies like the **Wellcome Trust/CRUK Gurdon Institute** (which is focused on the biology of development and how normal growth and maintenance go wrong in diseases such as cancer).

The creation of the **Cambridge Biomedical Campus** (CBC) has been instrumental in the development of the ecosystem – alongside, particularly the growth of **Babraham Research Campus**, the **Genome Campus at Hinxton** (see Box 3-2 below), and (further south) **Granta Park**. Increasingly, **Cambridge Science Park** (to the north) is also part of the mix.

The development of CBC has allowed for the continuing co-location and growth of world-leading research and clinical excellence. It resulted from a masterplan that was developed in 1999 by Addenbrooke's Hospital (now part of Cambridge University Hospitals NHS Foundation Trust) in partnership with the University of Cambridge and MRC. Entitled "*Addenbrooke's: the 2020 Vision*", this advocated the extension of the hospital site into the Green Belt, allowing for the growth of clinical facilities and making provision for commercial activities. The 2020 Vision was incorporated in the 2003 Cambridgeshire and Peterborough Structure Plan as part of wider ambitions for Cambridge's southern fringe. The planning system therefore played its part in the development of the cluster. Subsequently, planning permission was secured for AstraZeneca's new global R&D centre, and for the New Papworth Hospital; currently, both sets of buildings are under construction.

[23] *The Cambridge Phenomenon Revisited – Part One,* Segal Quince Wicksteed (June 2000)

The "*translational research ecosystem*" is continuing to evolve very quickly and it is genuinely world-leading. Many different illustrations could be cited, but to take two:

- In April 2017, it was announced that the University of Cambridge would be one of six centres that will form the UK Dementia Research Institute (which is led by the MRC). The new centre will be based on CBC and it will draw on the University's research strengths in chemistry, biophysics and cell biology. In announcing it, Science Minister Jo Johnson said "*this is exactly the type of project our Industrial Strategy will build on to ensure the UK remains at the forefront of global science".* This will run alongside the Cambridge Drug Discovery Institute, part of the Alzheimer's Research UK Drug Discovery Alliance (which includes Institutes at the University of Oxford and University College London); it draws together academic science and high quality, innovative drug discovery technologies with the aim of accelerating the delivery of effective therapeutics for neurodegenerative diseases. Both ventures are, clearly, responding to global concerns: in 2013, the G8 Dementia Summit committed to achieving disease-modifying therapies by 2025 in the context of an estimated 47 million people suffering from different forms of dementia worldwide at a cost of US$ 818 billion (1.1% of world GDP). The "translational research ecosystem" on the southern fringe of Cambridge is a key part of the global response.

- The CRUK Cambridge Institute opened in 2007 as a joint venture between CRUK and the University of Cambridge. Its Annual Report states that its location on CBC is "*designed to nurture collaborations between the CRCUK CI, the University of Cambridge, the surrounding biotechnology cluster and the 1,100-bed Addenbrooke's Hospital".* Its research strategy spans basic research into the cellular and molecular biology of cancer through to clinical investigations. It is closely linked to, but separate from, the CRUK Cambridge Centre. In 2012, the latter achieved Comprehensive Cancer Centre status (part of a European network to improve translational research); and it was the first in Europe to do so based around a general hospital. Its formal partners are Cancer Research UK, the University of Cambridge (particularly through the School of Clinical Medicine and the School of Biological Sciences), and Cambridge University Hospitals NHS Foundation Trust. It "*unites over 550 basic and clinical researchers through a comprehensive and highly-interactive set of 12 programmes that each include laboratory scientists and cancer physicians"* with the result that it *"rapidly translates knowledge acquired into patient benefit"*[24]. In December 2016, it was announced that the CRUK Cambridge Centre would receive further investment of £41m over five years to develop its work in translational research[25].

In addition, various new ventures are being put in place with a focus on personalised medicine and the translational models described in paragraph 3.7. The **Cambridge Academy of Therapeutic Sciences (CATS)** is facilitating academic/industrial interaction in the generation of new therapies[26]. This a new partnership between disciplines and between the University of Cambridge, companies and policy makers not only in research facilitation but also in education, training and policy development. It is the home for **CAMS** (**Cambridge Alliance for Medicine Safety**) as an active research programme linking academia with pharmaceutical and other companies with interest in medicine safety and toxicology for knowledge exchange and research translational activities. Initial CAMS partners are University of Cambridge, GSK, AstraZeneca and MRC Toxicology Unit. CATS also involves several other University based health related translational centres e.g. the Milner Institute.

The **Milner Therapeutics Institute** itself is being set up as a global therapeutic alliance defined around a new "*open borders*" paradigm. It consists of research laboratories at CBC (due to open in 2018) – which will house robotics for customised drug screening as well as gene editing and bioinformatics support – and an outreach programme. The latter is "*designed to establish a Cambridge ecosystem for therapeutic research and drug discovery*" which in turn will "*enable the development of multiple disease models and the pursuit of drug discovery using diverse modalities, including small molecules and antibodies*"[27]. The **Milner Therapeutics Consortium** has been active since June 2015. It is based on a research agreement signed by the University of Cambridge, the Sanger Institute and the Babraham Institute, and four pharmaceutical companies (Astex, AstraZeneca, GlaxoSmithKline and Shionogi).

Source: SQW – drawing on relevant websites, Annual Reports, press releases and other published material

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[24] Cancer Research UK Cambridge Institute Annual Report 2015
[25] "*Cambridge scientists set to get £41million boost from Cancer Research UK"* University of Cambridge Press release, 14th December 2016
[26] See www.ats.cam.ac.uk
[27] See http://www.milner.cam.ac.uk/institute

Box 3-2: Sanger Institute, European Bioinformatics Institute (EMBL-EBI) and Wellcome Genome Campus

The Sanger Institute, European Bioinformatics Institute and Wellcome Genome Campus are key elements of the southern Cambridge Life Sciences ecosystem. They are located at Hinxton, roughly 10 miles to the south of CBC.

During the 1990s, one third of the human genome was sequenced for the first time at the **Wellcome Trust Sanger Institute**, and these data were stored and shared through **EMBL-EBI** (which is co-located on the Wellcome Genome Campus). From this foundation, the Sanger Institute is now concerned more broadly with research into the impact of genetics on health and disease and the application of genomics research to develop new diagnostics and precision treatments for patients. Specifically, it is focused on innovation in aggregation, analysis and interpretation of large quantities of genomic data. Currently the Sanger Institute employs around 1,000 people. It receives core funding from the Wellcome Trust in addition to research grants from the UK Research Councils, the EU and major charities. Its sister organisation, the Earlham Institute on Norwich Research Park, complements its activities, carrying out sequencing of microbes and plants (see Box 3-5 below).

The Sanger Institute is located within the wider **Wellcome Genome Campus** which is a major hub for genomics and biodata. It is home the 100,000 Genomes Project, Open Targets and the Centre for Global Pathogen Surveillance. In addition to the research institutes, various businesses are located on the Campus. These are focused on wet and dry lab science, basic research and the delivery of bioinformatics. The **Biodata Innovation Centre** opened in 2016. In total, it is estimated that 2,600 people currently work at the campus.

Source: Based on information from https://www.wellcomegenomecampus.org/ and http://www.sanger.ac.uk/

3.12 The narrative surrounding the Life Sciences ecosystem that is centred on Cambridge's southern fringe is, in part, an evolving "*tale about a place*" – and the links to spatial planning have been crucial. But it also provides a window on how Life Sciences as a sector and a supply chain has evolved. One perspective on this can be gleaned from patenting behaviour. An analysis based on data from 1985 and 2011 observed a significant growth in the volume of patenting through the 1990s which plateaued in the 2000s and subsequently declined. In the process, the composition of patents changed. Patents in medical technology became relatively more important while those in biotechnology declined and the number of pharmaceuticals patents was reasonably stable[28]. There are all sorts of reasons for this pattern – but the shifting composition says something about the evolving nature of Life Sciences in and around Cambridge, and the changing characteristics of innovation processes: it is now defined less around patents and more around translational interfaces (which are very difficult to protect through patenting).

3.13 A very different – but equally innovative – ecosystem is identifiable further south, broadly along the A1(M) Corridor in the area around Stevenage. Here, the "*crowding in*" process has been in the opposite direction: the underpinning asset base and initial impetus was provided by big pharma and it is the university researchers that have been drawn in more recently as the imperatives relating to translational research have grown. In addition, a huge range of collaborations has been developed, many concerned – more-or-less directly – with the use of data in drug discovery and healthcare. At the heart of this ecosystem is GSK. A synopsis of its evolving role is provided in Box 3-3 below.

[28] "*The Cambridge Bioscience Impact Study*", Report to Institute of Public Health, University of Cambridge on behalf of NIHR Cambridge Biomedical Research Centre, by Cambridge Economic Associates and Cambridge Econometrics, October 2015 – pages 20-21

Box 3-3: The evolving innovation ecosystem linked to big pharma in and around Stevenage

GlaxoSmithKline plc (GSK) is the world's sixth largest pharmaceuticals company with a market capitalisation of £81bn (August 2016). Although headquartered in Isleworth (London), **one of its two global R&D hubs is at Stevenage (Hertfordshire); and two further, smaller, research centres are at Harlow (Essex) and Ware (Hertfordshire)**. Overall, it has 13,000 staff engaged in research and development worldwide, of whom about 2,500 are based at Stevenage. Stevenage (with Harlow and Ware) is therefore a major global centre for pharmaceuticals research.

GSK has a deep portfolio of innovation, focused on six core areas: vaccines, respiratory diseases, infectious diseases/HIV, immuno-inflammation, rare diseases and oncology. However, over the last decade or so – and prompted in part by the trends identified in paragraph 3.7 – its approach to drug discovery has evolved substantially.

In 2008/09 – against a backdrop of the credit crunch – it investigated the idea of developing a major campus, premised on principles of open innovation. The intention was that this should be developed in stages, creating an ecosystem in which companies could collaborate and share facilities and advice, allowing them to grow. At the time, demand-side assessments noted a change in the nature of early stage Life Sciences spin-outs: there were fewer of them than previously; they were shifting to more translational research, often conducted with a partner that was active in the commercialisation process; and they were often combining some level of service provision with core research interests to sustain a revenue stream.

Through a £38m partnership with then-Department of Business, Innovation and Skills, Wellcome, then-Technology Strategy Board and then-East of England Development Agency, GSK provided land and investment to build and launch what is now **Stevenage Bioscience Catalyst (SBC)**. This formally opened in 2012. By spring 2017, Phase 1 was at capacity and SBC had 49 tenants. These included blue chip companies (such as **GE Healthcare, Johnson & Johnson, Eli Lily** and **Sanofi**), but also small start-ups and inward investors such as **Aglaris Limited** (see Box 3-4 below). Translational laboratories have also been established at SBC by both the **University of Cambridge** and **University College Londo**n (UCL) and **MRC Technologies** has relocated all of its drug discovery operations (and 70 staff) from London to Stevenage. SBC has also been selected by the UK Cell and Gene Therapy Catapult as the site for its **Cell and Gene Therapy Manufacturing Centre**.

The open innovation ecosystem that has been created in and around GSK and SBC has therefore developed – and is continuing to develop – very quickly. It is defined around many different forms of collaboration, most of which are directed at some level of both translational research and convergence. Some of these are on site; some are contained within the geography of the East of England (noting that links to Cambridge are especially important); and some are premised on wider national and international alliances. All of them are pushing the boundaries in approaches to drug discovery and healthcare. Three examples are provided below:

- GSK has a – now well-established – affiliation with **McLaren**. This has involved various collaborative projects, one of which has seen McLaren's sensor and telemetry expertise adopted to monitor recovery in stroke victims and among patients with severe arthritis. The collaboration is taking McLaren's capabilities in predictive analytics and biotelemetry into drug discovery and healthcare.
- In 2016, working with the **European Bioinformatics Institute**, the **Wellcome Trust Sanger Institute** and **Biogen**, GSK launched an "*open access "Google"-type engine that extensively searches, evaluates and integrates the mountain of genetic and biological data now being generated*". Located on the Genome Campus at Hinxton (near Cambridge), the **Centre for Therapeutic Target Validation (CTTV, now called Open Targets)** is an open innovation consortium that is committed to sharing its data with the scientific community. The logic underpinning it is that by applying computational biology and genetic research to target validation – and sharing the results publicly – the success rate of clinical trials should increase.
- Also in 2016, GSK and **Google** launched a joint venture to research, develop and commercialise bio-electronic therapies. The new company, **Galvani Bio-electronics**, is based in Stevenage and will have a second research hub in San Francisco. The companies will combine their existing intellectual property rights and invest up to £540m over seven years if the collaboration meets certain goals.

Source: SQW – drawing on relevant websites, Annual Reports, press releases and other published material

Box 3-4: Case Study of Aglaris Limited

Aglaris Limited is a Spanish company – and an inward investor – which is developing innovative, automated cell culture platform technologies in the East of England.

Aglaris was set up in 2014 to solve the cell culture bottleneck in cell and tissue manufacturing. This is acting as a brake on the wider application of cell-based therapies within regenerative medicine. The company is developing fully automated cell culture bioreactors, which are expected to increase the speed, yield and cost-effectiveness of cell and tissue manufacture. Aglaris believes its technology has the potential to transform cell and tissue manufacturing across the East of England and elsewhere, with consequent impacts on the development of cell therapies for unmet medical needs. During the development of the platform, Aglaris has developed several cell culture technologies and products, which have potential in other applications too.

The company has its roots in a programme of collaborative research, focused on bioreactors and cell therapy, between two leading research institutions in Barcelona and Madrid. Its technology has attracted investment of over €3 million to date from private capital and public bodies including business angels, venture fund Cross Road Biotech Inversiones Biotecnológicas (CRB Inverbío SGEIC SA), grant funding and collaborations with universities, research institutes and other businesses. Partners include Oxford University Innovation (product and strategy development), University of Extremadura, NIMGenetics (Spain) and Merck KGaA. Grant funding has also been received from the Horizon 2020 programme.

The company moved to the UK in 2016, initially based at the London Bioscience Innovation Centre. It then moved to Stevenage Bioscience Catalyst, attracted by the incubator's collaborative open innovation ethos and strong cell therapy focus, in addition to access to research facilities and industry leaders. Many of SBC's tenants are focused on cell therapy, the Cell and Gene Therapy Catapult's Manufacturing Centre is being located there, and GSK, also located on the campus, is active in this area. Activities that Aglaris focuses on in the UK are business development, automation engineering and biologics.

Aglaris now has eight staff in the UK (15 in total), and is recruiting. Aglaris remains highly networked – it is looking to develop new collaborations and is applying for new grant funding.

The company chose to move the business to the East of England because of its world-class ecosystem, with five of the world's leading universities (in regenerative medicine) based in the East of England, London and the South East. The cell and gene therapy hub at Stevenage Bioscience Catalyst, particularly the Cell and Gene Therapy Catapult Manufacturing Centre, made it a very compelling location – Aglaris has described the Catapult, with which it is working, as a 'magnet'. The UK also has many investors, like-minded businesses and demonstration facilities, factors that have drawn Aglaris to Stevenage. Aglaris has a clear aspiration to make cell therapy a reality. The company continues to progress on its strategic goals and aims to start beta testing at various sites.

Source: Information provided to the East of England Science and Innovation Audit

3.15 Life Sciences within the A1(M) Corridor is not confined to GSK: BioPark (at Welwyn Garden City) occupies a former Roche Laboratory, and is full (see Box 3-6); and Japanese-owned Eisai now has a significant presence in Hatfield. In addition, it is important to recognise the growing role played by the **University of Hertfordshire**. Research at the university is driven by the Centre in Topical Drug Delivery and Toxicology (TDDT), and the Centre for Health Services and Clinical Research. These have generated £10m in research income since 2014; produced three patents or patent applications; and launched a first spin-out company, Fluid Pharmaceuticals, focused on precision medicine, having secured £0.5m in venture capital funding. All of this is supported by laboratories in a new £52m science building which provides dedicated research facilities for precision medicine[29].

3.16 A third innovation ecosystem within Life Sciences is different in focus. It too is growing in response to the global drivers identified in paragraph 3.4, and major new investment is underway. It is summarised in Box 3-5.

[29] Based on information provided to the Science and Innovation Audit by the University of Hertfordshire

Box 3-5: An emerging translational ecosystem linked to food, health and microbiome research in Norwich

Science research at **Norwich Research Park** began in the 1960s, with the founding of the **University of East Anglia** (UEA) in 1963. This was followed by the relocation of the John Innes Institute in 1967 and Plant Breeding Institute in 1994 to create the **John Innes Centre.** The Institute of Food Research (IFR) was built in 1968 and transitioned into **Quadram Institute Bioscience** in April 2017. Further additions include **The Sainsbury Laboratory** in 1988, the **Earlham Institute** (formerly The Genome Analysis Centre) in 2009 and the **Norfolk and Norwich University Hospital** (NNUH) which opened in 2001. Norwich Research Partners LLP (NRP LLP) was established in 2012 to manage development of the cluster at the Park. NRP LLP is a partnership between the six on-site organisations plus the **John Innes Foundation** and the **Biotechnology and Biological Sciences Research Council (BBSRC).**

In relation to Life Sciences – and also both Agri-tech and ICT – the **Earlham Institute** is a key asset that focusses on plants and microbes. It operates two BBSRC National Capability laboratories (National Capability in Genomics and Single-Cell Analysis, and Plant and Microbe DNA Foundry). The Earlham Institute is especially renowned for deploying large shared-memory supercomputer platforms for Life Sciences, and it deploys and maintains some of the largest HPC systems for Life Sciences research in Europe. It also delivers open systems for data access and analysis.

Building on all this, the £81m **Quadram Institute** is due to open at the site in 2018[30]. The concept for the Institute is "*to enable a step-change in food and health science research by providing new insights and accelerating innovation that will deliver new food and treatments as well as proactive health and lifestyle interventions, for the benefit of society and the bioeconomy"*[31]. With funding from BBSRC, NNUH, IFR and UEA it will have capacity for 300 research staff and 40,000 patients p.a. and will be engaged in fundamental and translational food, health and microbiome research. Located at the centre of the Park, the Quadram Institute will focus on four cross-disciplinary research programmes: food innovation and health; food microbes and public health; gut microbes and health; and microbes in the food chain. It will bring together research teams from Quadram Institute Bioscience (formerly IFR), UEA's Faculty of Science, and Norfolk and Norwich University Hospitals' regional gastrointestinal endoscopy unit. Its activities will therefore extend from fundamental scientific research through to clinical practice. Specific examples of on-going research projects include:

- the development of **microbiome therapies to fight superbugs** – based on new approaches to the transplant of healthy microbiome to combat resistance to infections; this stream of research is reliant on expertise in gut microbiology, physiology and clinical research
- the development of **biomarkers for Inflammatory Bowel Disease (IBD)** – based on the profile of gut microbes and intended to inform the development of microbiome therapies in the treatment of IBD (which affects one in 250 people in the UK)
- the use of **probiotics in the treatment of Clostridium perfringens in poultry** with the aim of reducing the use of antibiotics in farming and improving food safety.

Although clearly early days, the plans for the Quadram Institute are generating much commercial attention. Already the deal flow is good and major companies – such as Nestle, Unilever and investment specialist Seventure Partners – have expressed interest[32].

Overall, with more than 75 businesses and 12,000 employees based on-site (including 3,000 scientists, researchers and clinicians), research activity at **Norwich Research Park** is focused on agri-biotech, food and health, genomics, med biotech and industrial biotech[33]. Managed by **Norwich Research Partners LLP** the Park provides a supportive environment for innovation and commercialisation. The Centrum is a hub for researchers and entrepreneurs to meet and collaborate, with facilities including café, meeting and seminar rooms. The Centrum and Innovation Centre provide fully fitted office and lab accommodation for start-up businesses and there is land for additional development. In April 2016, the 52 hectare area designated for commercial development was awarded Enterprise Zone status as part of New Anglia LEP's multi-site **Space to Innovate Enterprise Zone**[34]. Other notable developments are the **Enterprise Centre** (incubator), the **Bob Champion Research and Education Building** (medical research) and **Leaf Systems International** (pharmaceutical production in plants).

Source: SQW – drawing on relevant websites, Annual Reports, press releases and other published material

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[30] *Tech Nation 2017: Norwich*, Tech City UK website, March 2017 (accessed via: http://www.norwichresearchpark.com/meetingandnetworkingspace.aspx); http://technation.techcityuk.com/cluster/norwich/)
[31] www.bbsrc.ac.uk
[32] Based on comments made at one of the six Life Sciences workshops/round table discussions conducted as an input to the Audit in March/April 2017
[33] *Sectors*, Norwich Research Park website (accessed via: http://www.norwichresearchpark.com/aboutnorwichresearchpark/spotlight.aspx)
[34] *Enterprise Zones*, New Anglia LEP website (accessed via: http://www.newanglia.co.uk/enterprise-zone/)

Local science and innovation talent

3.17 Meaningful secondary data in relation to local science and innovation talent are in seriously short supply. However, as part of the SIA process, six workshops/roundtable discussions were held with expert stakeholders from across Life Sciences in the East of England. Through these discussions, the wider issues relating to "talent" generated much comment. In general terms, it was acknowledged that the Life Sciences workforce in the East of England is a global resource and there are real concerns surrounding the possible consequences of Brexit. In addition, there are already some very challenging skills shortages; a comment from one of the workshops was that "*healthcare informatics skills are lost to the cluster*" which is particularly frustrating given the emphasis on both translation and convergence. A second workshop also observed that the principal skills issues facing Life Sciences in the East of England are increasingly those linked to "*data, artificial intelligence and bioinformatics".* More positively, however, it was noted that the cluster – particularly in and around Cambridge – provides a "*portfolio effect"* for jobs and this in itself reduces risks and must be seen as an asset. Moreover, the cluster is, fundamentally, about people – and "*the quality and calibre of the people in Life Sciences is simply amazing".*

3.18 On the supply side, most of the region's universities are producing graduates with relevant specialisms: data suggest that in 2014/15, six universities in the region produced 1,875 new graduates in biological sciences[35]. This obviously includes the University of Cambridge and University of East Anglia, but the smaller and newer universities are playing a key role too. Data suggest that – in general – their students are more likely to be employed locally following graduation. For example, Anglia Ruskin University has faculties relating to both Medical Science and Health and Social Care and it identifies itself as the largest provider of health, social care and education courses in the East of England; it was recognised in the Witty Review (October 2013) as the sixth biggest provider of graduates in STEM subjects allied to medicine; and looking ahead, it is seeking to establish a School of Medicine on its Chelmsford Campus[36].

Local industrial strengths and capacities

3.19 The region has long been recognised as a focal point for drug and medicines design, discovery and development, and for a clustering of medical device, diagnostic and medtech industries[37]. Recent analysis completed by the Office for Life Sciences (based on data for 2016 and published in April 2017), points to the continuing prevalence of the East of England (GOR) within four life sciences sectors. This is particularly evident in relation to "*core biopharma*" where the region accounts for well over 15,000 jobs and has a Location Quotient (relative to all employment and UK-wide) of 2.8. In the other three life sciences sectors, the East of England (GOR) also features strongly – and it is the only region to have a LQ above 1.0 across all four sub-sectors[38].

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[35] Data from Heidi Plus (HESA)
[36] Based on information provided to the Science and Innovation Audit by Anglia Ruskin University
[37] Encouraging a British Invention Revolution: Sir Andrew Witty's Review of Universities and Growth: Final Report and Recommendations, Sept 2013
[38] Specifically, in "*biopharma service and supply*", it is home to just under 8,800 jobs with a LQ of 1.9; in "*core medtech*", it accounts for about 9,800 jobs with a LQ of 1.2; and in "*medtech service and supply*", it can claim just under 4,000 jobs and a LQ of 1.6

3.20 Data from a different source – the Business Register and Employment Survey – point to a similar picture: about 31,000 jobs region-wide, with the greatest concentrations, in absolute and relative terms, in and around Cambridge and along the A1(M) Corridor in Hertfordshire. The BRES data indicate that overall, the sector has seen employment growth over recent years in the East of England – in contrast to the national picture. At local authority district/unitary level, the pattern of growth rates may be spurious[39] – although the inclusion of Norwich within the fastest growing areas is, perhaps, noteworthy.

Table 3-1: Largest, most specialised (by location quotient), and fastest growing (by compound annual growth rate) districts by BRES employment, with East of England Science and Innovation Audit area and England comparators, for Life Sciences (based on 2012 and 2015 three year rolling averages, i.e. 2010-2012 and 2013-2015)

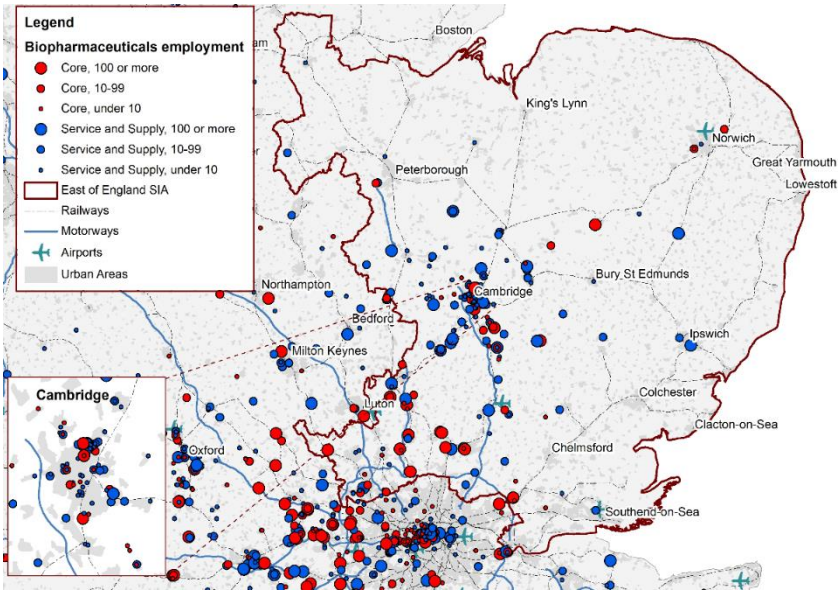
Largest employment	Most specialised (LQ)	Fastest Growth (CAGR)
• South Cambs (9,100)	• South Cambs (18.9)	• Norwich (36.2%)
• Cambridge (4,000)	• Cambridge (6.0)	• Colchester (18.8%)
• *East Herts, Stevenage and Welwyn Hatfield*	• *East Herts, Stevenage and Welwyn Hatfield*	• South Kesteven (18.7%)
		• Suffolk Coastal (18.3%)
East of England (31,000)	**East of England (1.9)**	**East of England (2.7%)**
England (165,900)	**England (1.0)**	**England (-1.1%)**

Source: ONS, Business Register and Employment Survey (2015); Note that some data cannot be published due to ONS BRES non-disclosure rules. Where district level data are disclosive, districts with a high rank are grouped and listed

3.21 Within this overall context, the maps below provide an indication of the distribution of Life Sciences businesses across the East of England (weighted to reflect the scale of employment), based on data from the Office for Life Sciences. The pattern that emerges is wholly consistent with the ecosystem narratives presented above. In *biopharmaceuticals*, the spatial distribution is dominated by two sub-areas: the Cambridge sub-region and the A1(M) Corridor in Hertfordshire. The case studies which follow examine, first, the growing relationship between the two, and second, the factors which led to AstraZeneca's investment decisions in the Cambridge area.

[39] This is because a slight change in small absolute numbers can translate into a huge growth rate, a problem that is compounded by anomalies in BRES data

Figure 3-2: Distribution of Life Sciences businesses in the East of England: Biopharmaceuticals companies (weighted by employment)



Source: Based on data from the Office of Life Sciences. Map prepared by SQW. Licence 100030994. Contains OS data © Crown copyright [and database right] [2016]. Contains Office for Life Sciences data

Box 3-6: Case Study of BioPark and Heptares

In 2005, Roche – the major Swiss pharmaceuticals firm – transferred its R&D functions from Welwyn Garden City to Switzerland, with the consequent loss of around 300 jobs. With backing of £8m from government, the University of Hertfordshire acquired the Roche facility and converted the building into a bio incubator dedicated to healthcare research. Subsequently, the 100,000 sq. ft. **BioPark** complex has incubated and grown many life sciences firms and, in the process, preserved wet lab capacity.

One of Biopark's tenants has been **Heptares**. Its growth narrative illustrates the growing links across the Life Sciences ecosystems in the Cambridge sub-region and along the A1(M) corridor.

Heptares was founded in 2007 to develop and commercialise research from the MRC Laboratory of Molecular Biology (in Cambridge) and the National Institute of Medical Research (based in London). With additional venture funding, Heptares moved to BioPark in 2009 where it developed its unique StaR® technology platform that enables it to design drugs precisely based on a detailed understanding of the structure of the drug target.

Originally employing 15 people, Heptares expanded rapidly and in 2015 was acquired by Japanese company, Sosei, for US$180 million in cash and up to US$ 220 million contingent upon the successful progression of the company's pipeline and platform. Heptares ostensibly remains under the control of its founders and is managed as an autonomous subsidiary of Sosei, with founder Dr Malcolm Weir as the Chief Executive Officer.

The company continues to grow and develop strong collaborations in the East of England. It has recently signed major collaborative agreements with AstraZeneca and MedImmune[40]. Having laid the foundations for success in BioPark, the company has quadrupled in size and outgrown BioPark. It has therefore taken 30,000 sq. ft. (2,787 sq. m) at Granta Park, to the south of Cambridge.

Source: Based on evidence provided to the East of England Science and Innovation Audit by Hertfordshire LEP, and a review of websites

[40] See for example "*Heptares & AZ enter agreement to develop novel immuno-oncology treatments for a range of cancers*" http://www.pharma-integrates.com/heptares-az-enter-agreement-to-develop-novel-immuno-oncology-treatments-for-a-range-of-cancers/

Box 3-7: Case Study of AstraZeneca

AstraZeneca's (AZ) decision to set up a new global headquarters and major R&D facility on Cambridge Biomedical Campus was announced in 2013. It was a substantial milestone in the development of the Life Sciences ecosystem. The Cambridge sub-region already had world-class credentials in relation to its science, but until the AZ decision, it had not attracted HQ functions linked to global-scale players. AZ's new home is currently under construction on CBC. It will become AZ's largest centre for oncology research, and it will host scientists focused on cardiovascular and metabolic diseases; respiratory, inflammation and autoimmune diseases; and conditions of the central nervous system.

Through acquisition, AZ has had a long history in the Cambridge area. Cambridge Antibody Technology (CAT) was founded in 1989. It was initially based in the MRC Laboratories in Cambridge and then at the Babraham Institute before moving first to Melbourn Science Park and then to Granta Park. It was acquired by AZ for £702m in 2006. Subsequently AZ acquired US-based MedImmune. CAT was integrated into MedImmune, AstraZeneca's global biologics R&D arm. At this point, MedImmune employed around 500 people on Granta Park.

In addition to staff based at MedImmune (on Granta Park), AZ has already relocated over 1,500 jobs to different sites in and around Cambridge – including Melbourn Science Park, Babraham Research Campus, Chesterford Research Park and Cambridge Science Park.

In explaining why Cambridge was chosen, Pascal Soriot, CEO of AZ stated that "*AZ's decision to make Cambridge the location of our global HQ and the beating heart of our research and development efforts reflects the importance we place on scientific excellence and the unique position of this amazing city as a hotbed of biopharmaceutical innovation. In Cambridge, we work side by side every day with world-leading scientific experts and collaborate with world-renowned academic research institutions, pre-eminent hospitals and cutting-edge biotech companies"*[41].

Three main factors have been identified by AZ[42]: building on the world-leading protein engineering capabilities which were already established locally through MedImmune; the strength of the existing bioscience cluster defined around academic research institutions, pre-eminent hospitals and leading-edge companies; and access to academic, health and industry networks, scientific talent and partnering opportunities.

Looking ahead, the third of these factors is especially important, not least because it will reinforce the first two. Already, many collaborations – of different forms – have been established. Collaborators include Bicycle Therapeutics (a spin-out from LMB), the Babraham Institute and Heptares[43]. In addition:

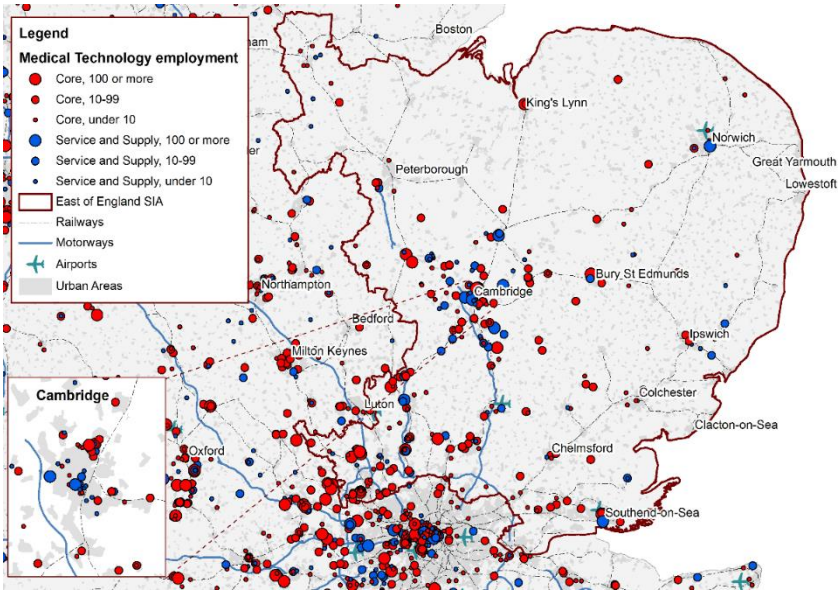
- through its UK Centre for Lead Discovery (UKCLD), AZ is working with the Medical Research Council and Cancer Research UK, using the same labs, the same IT infrastructure and the same technology (including NiCoLA-B, the most advanced drug discovery robot in the world). This collaboration will see the creation of a joint research facility at AZ's R&D centre in Cambridge
- as part of a new integrated genomics initiative to transform drug discovery and development, AZ has entered into a partnership with the Wellcome Trust Sanger Institute
- AZ is working with Microsoft in Cambridge to develop a cloud-based tool to model key signalling pathways in cancer cells.

Source: Based on evidence provided to the East of England Science and Innovation Audit by AstraZeneca, and a review of websites

3.22 In relation to *medtech*, the significance of the Cambridge sub-region and the A1(M) Corridor is again evident from Figure 3-3, but there is significant activity elsewhere – particularly in south west Hertfordshire and across Essex. This is illustrated in the map below and explained in Box 3-8 which follows.

[41] Pascal Soriot, Chief Executive Officer, quoted in "*AstraZeneca in Cambridge", Astra Zeneca,* 13th March 2017
[42] *Leading in science, returning to growth",* Presentation by Shaun Grady, VP Business Development Operations, AstraZeneca (16th June 2015) – available at http://www.cambridgeahead.co.uk/2015/07/why-astrazeneca-chose-cambridge-for-its-global-hq-and-rd-centre-180615/
[43] "*Seeing through the skills agenda*", Cambridge Business, March 2017

Figure 3-3: Distribution of Life Sciences businesses in the East of England: MedTech companies (weighted by employment)



Source: Based on data from the Office of Life Sciences. Map prepared by SQW. Licence 100030994. Contains OS data © Crown copyright [and database right] [2016]. Contains Office for Life Sciences data

Box 3-8: The growth of medtech in the East of England

Historically, the medtech sector has had strong links to the Advanced Manufacturing and Materials (AM&M) Theme – and these continue to be very important – but in addition, it is developing very close links within Life Sciences. Locally, hubs have been identified in and around Cambridge (engineering and medical device design; biomarker and disease diagnostics discovery), Harlow (digital health and next generation medtech, global manufacturing and marketing), West Hertfordshire (global manufacturing and marketing) and King's Lynn (global manufacturing and marketing)[44].

Substantial investment is already underway to support the further growth of medtech. For example, **Anglia Ruskin University** established the **MedBIC** on its **Chelmsford** campus in 2014 with support from Essex County Council and Chelmsford City Council. The MedBIC is an innovation centre which specialises on supporting the needs of medtech and advanced engineering companies. It was fully occupied (90%) within a year of opening and is currently supporting 23 growing businesses to develop new products and services by facilitating access to expert support from professional, academic and clinical specialists, R&D facilities, routes to market and funding. Work is underway to develop phase II of MedBIC Chelmsford. ARU is now working with Essex County Council, Harlow Council and **Harlow Enterprise Zone** to develop another MedBIC innovation centre on the **Harlow Science Park** which, subject to final feasibility checks, will see its first occupants moving in by September 2018. Public Health England will also be relocating its facilities to the former GSK site in Harlow, where there is an opportunity for the facility to support the growth of medtech[45]. Separately and in addition, some £19.89m has been awarded to build a medtech facility in **Southend** to support the prototyping, development and testing of new medtech products, including via the Anglia Ruskin Clinical Trials Unit and research facilities (e.g. Gait Analysis Lab and Simulation Suites)[46].

From across the region, there are many examples of highly innovative medtech businesses raising substantial early stage funding to drive commercialisation and growth. One example is **Owlstone Medical Ltd** – a Cambridge-based diagnostics company developing a breathalyser for disease – which has just raised £9.3m[47]. A second example is **Inotec AMD Ltd,** a spin-out from the University of Cambridge's Department of Materials Science and Metallurgy, which is developing new technologies for wound care[48]. Investors in the company include Cambridge Capital Group, Cambridge Enterprise, Cambridge Angels and Amadeus Capital Partners[49].

Source: Based on evidence provided to the East of England Science and Innovation Audit by ARU, and a review of websites

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[44] Evidence submitted by the University of Hertfordshire to the East of England SIA
[45] Evidence submitted by Anglia Ruskin University to the East of England SIA
[46] Evidence submitted by Anglia Ruskin University to the East of England SIA
[47] *"Owlstone Medical raises $11.55 million"* Business Weekly, 6th January 2017
[48] "*Oxygen bubbles heal wounds"* Cambridge Material Eyes, Summer 2016, Issue 29
[49] See http://www.inotecamd.com/about-inotec-amd#investors

National and international engagement

3.23 The Life Sciences ecosystems across the East of England are increasingly networked – locally, regionally, nationally and globally. Different examples of (more-or-less formal) collaboration have already been cited. Many others could be added.

3.24 The process of collaboration continues to be facilitated by some key networking/cluster groups. An important example is **One Nucleus** which was formed in 1997 following the merger of the Eastern Region Biotechnology Initiative (ERBI) and the London Biotechnology Network (LBN). One Nucleus is based near Cambridge. Currently it has 470 member organisations (including pharmaceuticals, biotechnology, medical diagnostic companies), 80% of which are located between Cambridge and London. It is highly influential within Life Sciences. It is connected nationally with groups like the Bioindustry Association, BioNow (NorthWest) and MediWales.

3.25 A second example is **MedCity**. This was set up as a collaboration between the Mayor of London, Imperial College Academic Health Science Centre, King's Health Partners, UCL Partners, Cambridge Health Partners and Oxford Academic Health Science Centre. It was conceived as a Golden Triangle construct and designed to facilitate and support collaboration across a broader geography – although in practice, it has to date been strongly focused on London. The **London Stansted Cambridge Consortium** is not sector-specific, but it has worked extensively in the Life Sciences sphere and in 2013, it produced an influential sector report[50].

3.26 These examples – and indeed the footprint and history of Cambridge-based One Nucleus – point to the significance of links to London. These are large and growing, particularly with the opening of the £700m Francis Crick Institute at St Pancras. Life Sciences in the East of England really does need to be understood in the context of this wider geography – a fact that is well recognised by all the main businesses, universities, research institutions and investors.

3.27 There is another group of networks that is far more local in focus. One example is the **M11 Health Enterprise Forum** which is promoting and supporting the growth of the medtech sector in and around Harlow.

Developments in the wider funding landscape

3.28 Across Life Sciences in general and the areas shaping this Audit in particular – i.e. personalised medicine (including drug discovery, development and diagnostics); regenerative medicine; genomics; medtech; and food, health and microbiome – the funding landscape is, and has always been, complicated. As the three ecosystem narratives indicate, funding has long been a cocktail formed from publicly-funded research budgets (whether from the UK government or from EU sources); major charities; healthcare budgets; and the private sector. As the focus of the ecosystems shifts further towards translation and convergence, all four of these sources will continue to play major roles. Science funding – both from UK Government and from EU sources – has been significant over the last few years and the scale of it is unlikely to be sustained, particularly given Brexit. Health budgets are also under increasing pressure. So,

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[50] *London Stansted Cambridge Consortium: Sector Profiles – Life Sciences* Produced by Athey Consulting Limited (2013)

the "big picture" funding landscape may be less favourable in the future than it has been in the past.

3.29 Latterly, local funding sources have been largely disconnected from the major national funding streams. At times, this has been a challenge. Nevertheless, all four Local Enterprise Partnerships have used the resources available to them – principally through Local Growth Fund and the European Structural and Investment Funds – to support the functioning of the wider Life Sciences ecosystem. Specific illustrations include the support from Hertfordshire LEP for the Cell and Gene Therapy Manufacturing Centre at SBC; investment into the Enterprise Zone at Harlow, linked to medical technologies (SELEP); the awarding of Enterprise Zone status to NRP and the creation of "Innovation New Anglia" within funding from ERDF (New Anglia LEP); and GCGP's investment in the Cambridge Biomedical Incubator (re-using an old LMB building on CBC).

3.30 For small and new businesses, early stage finance is an on-going challenge. That said, the East of England is better placed than most regions and the Cambridge "brand" is very significant in this context; the area benefits from serial entrepreneurs and groups like Cambridge Angels which are active in Life Sciences. The scale of early stage investment in life science businesses has been substantial over recent years, particularly in Cambridge. It has, for example, been reported that over £500m has been invested in life sciences companies based on the Babraham Research Campus alone over the last two years. Investors have included Chinese venture capital, The Wellcome Trust, Bill and Melinda Gates Foundation, Woodford Investment Management and a series of corporate venture capital investments (e.g. Johnson & Johnson, Pfizer, Google, Takeda, Biogen Idec)[51].

Conclusions – and future potential

3.31 Life Sciences is one of the East of England's most distinctive business sectors and the region, demonstrably, has world-class science capabilities and innovation assets. These have benefitted from substantial investment over recent years, and all the evidence suggests that they are gaining momentum in terms of their economic and societal impacts. Forecasts always need to be treated with a good deal of caution, but one – focused on the Cambridge bioscience cluster – suggested an increase of 10,800 jobs and £1.14bn GVA between 2013 and 2030[52] on a central projection. In practice, the numbers could be significantly higher – although there are considerable risks and uncertainties.

3.32 A series of workshops/roundtable discussions were convened as part of the Science and Innovation Audit. These were attended by over 100 expert stakeholders, including investors, entrepreneurs, researchers and clinicians. These were asked to discuss "*what will it take for the East of England to continue to be world class in relation to the Life Sciences Science and Innovation Audit Themes?*" Their principal observations are summarised in the table below. These are a core element of the overall SIA evidence base.

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[51] *"Over £500 million invested in Babraham biotechs in last two years"* Business Weekly, 30th November 2016
[52] "*The Cambridge Bioscience Impact Study*", Report to Institute of Public Health, University of Cambridge on behalf of NIHR Cambridge Biomedical Research Centre, by Cambridge Economic Associates and Cambridge Econometrics, October 2015 – pages 20-21

Table 3-2: Principal observations from six workshops/roundtable discussions focused on Life Sciences in the East of England, March-April 2017

Observations		Implications
1: The growing importance of data and data analytics in all aspects of Life Sciences – including, crucially, skills		
There are many examples of data analytics (often involving clinical data) being used in Life Sciences in the East of England in a manner that simply would not work elsewhere (e.g. through Iesо Digital Health, a company first backed by Cambridge Angels). The region in general – and Cambridge in particular – has unique assets in these terms.	→	"Convergence" is well underway in the East of England and it is, demonstrably, a key element of the route to translation. This momentum needs to be sustained and accelerated. The opportunity to create medtech start-ups with expertise in data and devices (hardware) is probably unique.
It is vital that NHS/genomics data are not "*locked up in exclusive deals*". Instead data need to be available to be used. Within the East of England there are various pioneering projects, not least CTTV/Open Targets (see Box 3-3). Moreover, the East of England "*has access to the biggest biobank in the UK"* – but awareness of this is very low.	→	The importance of convergence is again emphasised, and in this context, there is a clear read-across to the SIA ICT Theme. Specifically, in relation to the biobank, there is a need to ensure that more SMEs and start-ups have effective access to it. There is potential to create new types of medtech companies if ethical and regulatory issues can be resolved. This presents an opportunity to build and grow activities at the Wellcome Genome Campus and Addenbrooke's and it could contribute to the growing ecosystem in the "medtech corridor", particularly at Harlow. The University of Hertfordshire is also currently developing its strategy in this space.
The key skills issues linked to the Life Sciences sector are increasingly those associated with data, artificial intelligence and bioinformatics. There is also a need for advanced manufacturing skills if cell and gene therapy is going to continue to be world-class (with links to the AM&M Theme).	→	The provision of high level skills linked to "data, artificial intelligence and bioinformatics" merits further examination – possibly in dialogue with those who are responsible for the ICT Theme. Specifically, there is a need for statisticians and bioinformaticians.
There continue to be ethical and regulatory concerns relating to the use of patient data.	→	This is a general challenge, not a regional one BUT it may be that patients in the East of England are more sympathetic to the issues than those elsewhere and partly for this reason, the region is well placed to develop responses.
2: The challenge of investing in "convergence"		
Activities in the domain of "convergence" may not generate intellectual property in a form that can be translated into patents. This in turn may provide a deterrent to investment among some venture capitalists (which tend to be "sector specialists" rather than cross-cutting specialists) [53].	→	Financing business growth at the point of convergence can be difficult and mechanisms need to be found to de-risk it; better information and knowledge may well be part of the response.
Under pressure from investors, "build to buy" models are becoming more common. These don't grow talent and don't help in relation to scale-up ambitions – two of the big challenges for the East of England.	→	The implication is that patient forms of long term investment must still be encouraged, nested within a vibrant ecosystem. The long-term risks of the "build to buy" model will need to be watched.
3: The growing opportunities linked to medtech		
There are rapidly emerging opportunities in medtech – described as "*clinical data plus hardware*" – and this need to be pulled firmly into the Life Sciences ecosystem as part of the translational process.	→	This represents a tremendous opportunity for the East of England given the strength in depth of ICT competence and knowledge; the different elements need to be joined up. The East of England ought to be playing a leadership role nationally.

[53] Note that this viewpoint was expressed through the workshop discussions in the East of England. However in written comments, BEIS provided an alternative view – that investors may sometimes have the broadest perspective and the greatest understanding of the possibilities linked to convergence

Observations		Implications
4: The importance of links to Agri-tech		
In relation to food health and microbiome, the region's credentials in relation to Agri-tech could be very powerful.	→	There needs to be a strong dialogue with the SIA's Agri-tech Theme going forward.
5: The importance of "ecosystem functionality"		
In Life Sciences, clusters need to be spatially concentrated to work – and proximity is crucial.	→	Physical provision ought to be made to ensure that the principal hubs in the Life Sciences ecosystem can evolve and expand. Through ventures like CBC, SBC and NRP, there is much good practice and this needs to be recognised on an on-going basis.
The CEOs of start-ups in the Life Sciences sector are increasingly committed to growth – but the East of England needs some "*Billion-dollar high growth companies in Life Sciences*" (as referenced by Professor Sir John Bell in his Industrial Strategy work).	→	All elements of the ecosystem need to be aligned to this challenge and opportunity. This is about building "Innovation Capacity".
The strength of the region's science assets in Life Sciences is truly outstanding – BUT the focus should not be on the research coming out of the universities but the needs of clients/patients. The depth of research excellence can itself be a source of inertia.	→	If this assessment is correct, then the emphasis on translation should itself help to mitigate and manage the risks. Moreover, the treatment of Life Sciences in ecosystem terms should help in terms of checks and balances. It will result in more "commercial pull", rather than "science/technology push".
Life Sciences start-ups tend to be run by relatively old people (unlike tech start-ups) and there is a real need to encourage a younger generation.	→	This may have implications for skills development and patterns of mentoring (formal and informal) across the ecosystem – and it is certainly an issue that needs to be watched going forward. Specifically, there is a strong case for focusing entrepreneurial skills training on those in their late (rather than early) 20s, once they have some business experience.

Source: SQW – primarily on notes from six Life Sciences workshops/roundtable discussions held in March and April, 2017; and also data and commentary submitted via e mail and e-surveys initiated through the Life Sciences SIA process

3.33 Overall, these comments are broadly supportive of the hypothesis set out at paragraph 3.3. The East of England's Life Sciences cluster is already world class, in many different respects. Its pre-eminence is not however pre-ordained. Greater and deeper collaboration along translational interfaces is likely to be crucial in the future. This in turn raises two key imperatives.

- First, **the region's existing ecosystems must be allowed to evolve and grow**. As part of this, succession to the next generation must take place in a manner that allows knowledge and relationships to be strengthened rather than dissipated (and financing models will play a key role). In addition, embryonic businesses must be tooled to scale-up and grow.

- Second, **the more sophisticated and consistent use of data must become commonplace – and the concept of "open innovation" (which was path breaking 5-10 years ago) must evolve to something more like "open sourcing"**. There are major opportunities relating, for example, to the convergence of clinical patient data, deep/machine learning, communication technology and connected medical and wellness devices, and the region has huge assets and capabilities in this sphere. Whilst this raises ethical and regulatory issues, the East of England should be reasonably well placed to navigate them. It also raises questions relating to the cluster's skills base and particularly whether it has sufficient scale and depth of resources in, for example, bioinformatics and artificial intelligence. As the Life

Sciences ecosystem looks forward to the next decade, its ability to navigate this growing skills chasm is likely to be tested fully.

3.34 The key interventions identified in Chapter 7 have been identified in response to both imperatives[54].

[54] Note that in taking these forward, the East of England Consortium will – as appropriate – look to work with other SIA Consortia. For example, in the context of medtech, this is likely to involve Leeds City Region (as referenced in our summary outline Business Case in Annex B)

4. Theme 2: Agri-tech

Chapter Summary:

- There are many institutions in East of England with a strong track record in research and commercialisation relating to crop agriculture and horticulture, and food processing.
- Distinctive – and in some cases world-renowned – expertise covers genomics, genetics, agronomy and plant breeding, big data, robotics and automation, nutrition and the circular bioeconomy.
- The region is positioned to capitalise on global trends and drivers, such as sustainable intensification, the use of technology to increase productivity and reduce dependency on low-skilled labour, and resilience to climate change.
- There have been more than 1,000 research projects linked to Agri-tech led by organisations in the region; the largest contributions are from Rothamsted Research, the John Innes Centre, the University of Cambridge and the Institute for Food Research.
- There is a very strong Agri-tech industry, with particular expertise in plant breeding, agronomy services, agricultural engineering and food processing; and at the interfaces between Agri-tech and ICT, robotics, artificial intelligence and big data.
- Interactions with other themes (for example in the fields of robotics, Big Data and the Internet of Things (IoT)) will enhance the region's expertise in precision crop management and rhizosphere modification and could drive advances in new biologics and other forms of sustainable plant protection.

Scope – and core hypothesis

4.1 Over the last decade, the East of England has led the way nationally in recognising the scope, potential and wider significance of Agri-tech. In part this reflects its strong heritage in crop-based agriculture and horticulture[55]. But equally important is the depth and calibre of scientific research in the field – *and* the recognition that new disciplines (perhaps most especially informatics and automation) have a crucial future role to play. Key elements of the innovation ecosystem within the region are summarised in Figure 4-1 overleaf.

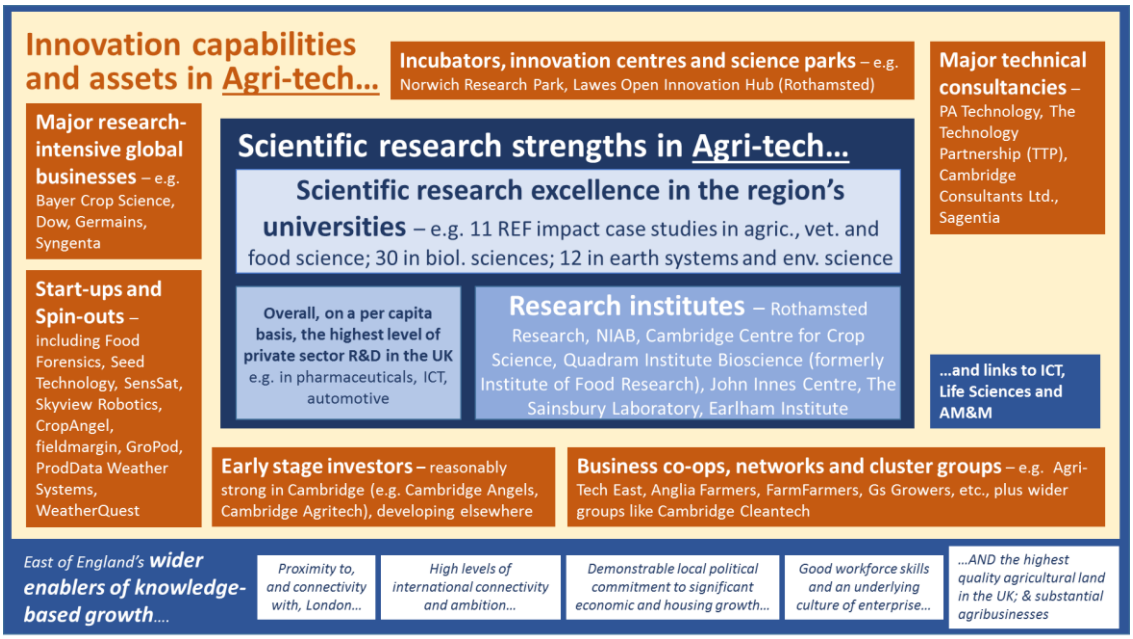
4.2 Within this context, the Agri-tech theme focuses on four main elements: **tools and techniques to improve agrifood productivity; enabling technologies in engineering, robotics, ICT and data; primary production, food manufacture and logistics;** and the **circular bioeconomy.**

4.3 The region's scientific research strengths and innovation capabilities are summarised in this chapter to test the following hypothesis:

> *The region has world-renowned research strengths in Agri-tech, and increasing expertise and experience in the process of commercialisation. Further strengthening of the mechanisms for commercialisation will bring major economic benefits to the region and to the national economy.*

[55] Although not considered in detail as part of the Audit, it is worth noting also the national significance – and scientific expertise – linked to the equine cluster at Newmarket

Figure 4-1: Summarising the East of England's Innovation Ecosystem in Agri-tech



Source: SQW – drawing on information gathered through the SIA process

National and international trends, and size of global markets

4.4 The **key trends and drivers** affecting Agri-tech at national and international levels are summarised in Box 4-1 below. Innovation in Agri-tech is responding to these through: agricultural practice (agronomy); development and application of agricultural inputs; varietal improvement (breeding); automation (robotics, precision agriculture and contained production); precision agriculture approaches including use of big data; and reduction in inputs (Smart Ag).

Box 4-1: Key trends and drivers shaping Agri-tech

- Pressure for **sustainable intensification**, producing more food on less land with fewer inputs to meet the food security needs of an expanding global population. 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[56].
- Increasing **use of technology such as 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 and to counter water scarcity[i57].
- Reducing the burden of **diet related disease** in human, livestock and poultry through improved nutrition.
- Resilience to **climate change**[58], and protection for the environment and biodiversity.
- **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[59].

[56] Technology Transforming Irish Agri-Food and Bioeconomy, Teagasc, 2016
[57] Precision Agriculture: An Opportunity for EU Farmers – Potential Support with the CAP 2014-2020, EU, 2014
[58] The Future of Food and Farming, The Government Office for Science, 2011
[59] 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

- Changes in **values and ethics resulting in a stronger health and nutrition focus**[60]. Examples include the acceptability of modern technology (e.g. genetic modification), the value placed on animal welfare, the importance of sustainability, and reformulation to reduce salt, sugar and fat in food products.
- A need to **reduce the requirement for low-skilled labour** in primary agriculture (noting that China is now the World's largest investor in robotics). In the UK this issue is rapidly increasing in importance in anticipation of the consequences of Brexit in a sector which has for over 20 years been very dependent on EU migration to meet its labour needs.

Source: Based on evidence provided to the East of England Science and Innovation Audit, and a review of websites

4.5 (Then-)UKTI estimated that the **global market for Agri-tech** in 2011/12 was worth £142 billion, supplied by 212,000 businesses and employing 4.7 million people[61]. This assessment used a definition of Agri-tech which excluded livestock feeds and most fertilisers. Nevertheless, 39% of the global market (by value) was linked to agri-engineering; 8% was associated with sensor technologies; and 7% to each of plant breeding and plant health. In all four of these areas, the East of England has significant strengths.

4.6 UK agricultural policy has promoted the need for sustainable intensification with key reports emphasising the need to increase production whilst addressing the sector's environmental footprint (e.g. *Food 2030* (2010) and the *Foresight Report* (2011)[62]). In addition, the NFU report *Feeding the Future* (2012, currently being updated[63]) identified priorities for agricultural research over the next two decades including, for example, use of modern technologies to improve the precision and efficiency of key agricultural management practices, and applying modern genetic and breeding approaches to improve the quality, sustainability, resilience and yield-led profitability of crops and farm animals.

4.7 Given the growth in demand for agricultural technology and the UK's strong research base, the UK government launched a *UK Strategy for Agricultural Technology*[64] in 2013. This recognised Agri-tech as a key growth sector alongside a further 10 sectors in the government's Industrial Strategy. These 11 priority growth sectors are enabled by *Eight Great Technologies*, which include agriscience as well as others which are directly relevant to Agri-tech, such as big data, robotics and energy storage[65].

Local science and innovation assets

4.8 The East of England's scientific capabilities and innovation assets of relevance to Agri-tech may be quantified as follows:

- According to the **Research Excellence Framework** (2014), the University of Cambridge is ranked in the top 10 and the University of East Anglia in the top 25 nation-wide across *all "units of assessment"* that are relevant to Agri-tech on **research power**. In terms of **grade point average (GPA)**, UEA is ranked 8th in "*agriculture,*

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[60] *The Future of Food and Farming*, The Government Office for Science, 2011
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
[61] UKTI (2013), *AgriTechnology Sector: Market Trends and Opportunities Report* Note that UKTI was replaced by Department for International Trade (DIT) in July 2016
[62] Foresight report (2011), Global Food and Farming Futures
[63] http://www.nfuonline.com/cross-sector/science-and-technology/research-and-innovation-news/feeding-the-future-four-years-on-a-review-of-innovation-needs-for-british-farming/
[64] Her Majesty's Government (2013), UK Strategy for Agricultural Technologies
[65] BIS (2015), Smart Specialisation in England: submission to the European Commission

veterinary and food science"; and University of Cambridge is ranked 2nd and UEA 10th in "*earth systems and environmental sciences*".

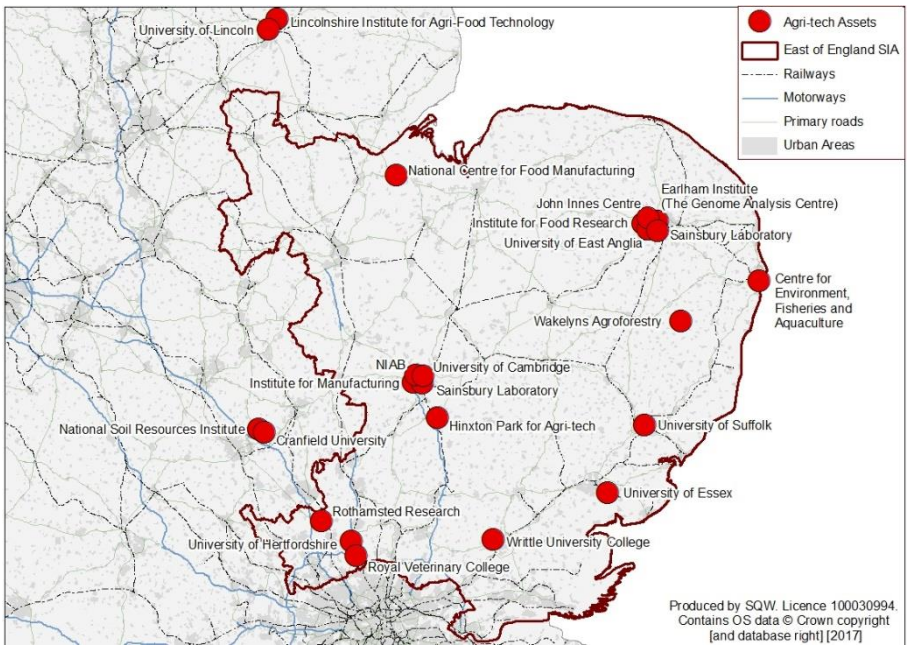
- Data from Gateway to Research suggest that **35% of UK Research Council funding in "*plant and crop science*"** was invested in the East of England between 2004 and 2016; this amounts to over £41m. In addition, the region has benefited from **24% of UK Research Council funding in "*agri-environmental science*"** and **16% in "*food science and nutrition".***

- Data provided by Technopolis from Gateway to Research and based on semantic analysis powered by SpazioDati suggest that **over 1,000 research projects** linked to Agri tech have been led by organisations in the East of England. The biggest contributors have been **Rothamsted Research** (20% of the regional total); **John Innes Centre** (17%); **University of Cambridge** (16%); and **Institute for Food Research** (12%).

- Data from Bureau van Dijk's FAME database suggests that **private sector R&D spend by Agri-tech businesses registered** in the East of England summed to nearly £14m in 2015 (total private sector R&D spend will be higher again).

- In relation to patents, agri-tech is difficult to identify but **inventors in the region accounted for over 14% of UK patents in "*analysis of biological materials*"** over the period 2004-14, according to data from the European Patent Office.

Figure 4-2: Major Agri-tech assets in the East of England (or close to it, and functionally part of it)[66]



[66] These are described in more detail in the Agri-tech Appendix of additional evidence provided to the Science and Innovation Audit

4.9 Underpinning these data are eight Universities, five BBSRC research centres, three independent research centres, and three Agricultural Colleges; key institutions are mapped in the graphic above. Many of these are working collaboratively. One example is the **Cambridge Centre for Crop Sciences (3CS)**. This is a new initiative between the University of Cambridge and the National Institute for Agricultural Botany (NIAB) that will provide leadership in crop sciences, fostering a flexible and dynamic research environment, whilst training the next generation of expertise needed to deliver sustainable yields for the future. 3CS will work with partners across the region to become a hub for addressing the challenges in Agri-tech research.

4.10 In addition, the region has **Agri-Tech East**, the longest established and largest membership organisation and networking body for Agri-tech. It is an independent, business-focused cluster organisation, which is seeking to improve the international competitiveness and sustainability of plant-based agriculture and horticulture by bringing together members of the value chain from discovery research to the farm gate.

4.11 Many UK national industry representative bodies and industry led research organisations also have their base in the region including, for example, the Institute of Agricultural Engineers (IAgri), the Agricultural Engineers Association (AEA), Agricultural Industries Confederation (AIC), British Beet Research Organisation (BBRO), British Society of Plant Breeders (BSPB), Crop Protection Association (CPA), the Processors and Growers Research Organisation (PGRO) and the UK Irrigation Association (UKIA).

Areas of distinctive expertise

4.12 A stakeholder survey undertaken to gather evidence for the SIA revealed distinctive areas of expertise, and a high regard among business respondents for the research institutions and universities in the region. As one consultee put it, "*the Eastern region is in a unique position with expertise spanning the full range of Agri-tech from the identification of needs, joint development of solutions and farmscale utilisation*". Within this context, stakeholders concluded that the region's most significant and distinctive expertise is in:

- **Genomics, Genetics, Agronomy and Plant Breeding:** The region hosts world leading academic research centres whose research outputs directly support major plant breeding, agronomy and agrochemical companies based in the region (e.g. KWS, Limagain, Monsanto and Syngenta). This in turn supports the competitiveness of arable crop production, feed, livestock and food producers. It helps preserve the agricultural land quality and reduce the environmental impact of primary food production.

- **Big data:** The region hosts world-leading research in the capture, processing, management and deployment of big data outputs for Agri-tech applications. This supports the development and integration of new technologies into sensors, machinery and devices (including diagnostics) used in agricultural practice. It generates data that inform agricultural management, protecting yields, increasing productivity, and reducing energy usage and the environmental impact of agriculture.

- **Robotics and automation:** The region hosts research expertise in robotics, artificial intelligence and soft robotics both in academic research centres and in the

engineering and IT sector. This includes the robotics and AI group at the University of Essex; one of the largest groups of agri food robotics expertise worldwide at the University of Lincoln; plus the expertise of the University of Cambridge. Key SMEs in the region include Dogtooth Robotics (developing crop harvesting robotics, and funded by the Cambridge Angels), Cambridge Consulting Group, OAL Ltd (food manufacturing robotics), Hummingbird Technologies (UAVs and AI), Garford Engineering (robotic weeding technology), etc.

- **Nutrition**: The region hosts world leading academic research centres whose research outputs direct the development of primary and secondary food and feed production. This underpins the growth, quality, economic and societal impact of healthy diets, reducing the burden of diet related disease on human and animal health.

- **Circular bioeconomy:** The East of England is enabling improved sustainability and reuse of primary and secondary outputs of biological production (plants, animals, microbes) for food or non-food end use, as evidenced by research and activities implementing Europe-wide strategic goals. This includes examples of big industry enabling highly efficient use of both feedstocks and outputs; together with small industry activities either individually or in groups.

4.13 These distinctive areas of Agri-tech expertise are supported by the region's capabilities in enabling technologies such as machine learning and artificial intelligence, data analytics, robotics and sensors. They are also underpinned by – and contributing to – the region's growing credentials in relation to cleantech[67]. This is defined more broadly, but includes, *inter alia*, biofuels, biomass, local distributed energy, and specialist PV for horticulture. The East of England is extremely well placed to develop and exploit these technologies.

Local science and innovation talent

4.14 The region's universities, colleges and research institutes provide a wide variety of education and training focused on Agri-tech or closely related areas. This ranges from colleges dedicated to, or strongly focused on, agriculture (e.g. Writtle[68], Easton and Otley, Oaklands, Shuttleworth) through university undergraduate and postgraduate courses to substantial PhD programmes. However, it is impossible to provide a definitive figure for the scale of education and training in Agri-tech undertaken in the region because much of it crosses academic disciplines. Many non Agri-tech topics get grouped together in the broad agriculture category used by HESA, and many students in other disciplines across engineering, environment and IT fill jobs in the Agri-tech sector. Examples from across the region of education and training focused specifically on agri-tech are provided in Box 4-2 below.

[67] See "*Sector Profile: Low carbon, cleantech, and environmental goods and services*" (Draft report) – part of the review of key sectors in the London – Stansted – Cambridge Corridor (October 2014)
[68] Note that Writtle achieved University College status in 2016

Box 4-2: Education and training related to Agri-tech in the East of England[69]

- **Rothamsted Research** currently has 60 PhD students on site, and plans to increase this to nearer 100, with students registered at a range of Universities.
- **Department of Plant Sciences, University of Cambridge**, contributes to all three years of the Undergraduate Natural Sciences Tripos, and offers postgraduate research and training opportunities in plant and microbial science, including 20 four year BBSRC Studentships in 2017.
- **NIAB** is a partner in the BBSRC Doctoral Training Programme led by Cambridge University and hosts PhD students undertaking research in crop agronomy and production, crop genetics and pathology.
- The Norwich Biosciences Doctoral Training Partnership (DTP) is funded under the BBSRC Doctoral Training Partnership Scheme and was announced in January 2012. The Norwich Biosciences DTP is one of 14 across the UK and supports over 600 PhD projects across the Norwich Research Park over a three-year period. The **John Innes Centre** is coordinating the programme, which also involves the **University of East Anglia, The Sainsbury Laboratory, The Institute of Food Research and The Earlham Institute (formerly The Genome Analysis Centre)**.
- Hertfordshire Science Partnership will fund 30 PhD researchers in agri-technology and drug development on a new four-year programme towards a 'PhD with Industrial Experience' degree. The funding has been secured by the **University of Hertfordshire**, including £2.5m from the Hertfordshire Growth Deal via the Hertfordshire Local Enterprise Partnership and £1.5m of ERDF funding.
- The **Centre for Agriculture, Food and Environmental Management (CAFEM)** is a partnership established in 2015 between the **University of Hertfordshire, Royal Veterinary College[70], Rothamsted Research** and **Oaklands College**. It is a virtual Centre with a focus on collaborative research between the partners and delivery of undergraduate and post graduate education.
- The **Lincoln Institute for AgriFood Technology (LIAT)** is a cross-University initiative to conduct post graduate and applied research linked to the agrifood industry. Established in 2015, it has already secured over £15m of industry linked projects with a major focus on automation, water for agriculture and disease prevention and control. LIAT involves over 25% of all staff in the College of Science and runs a new MSc in Agri-Food Technology.
- In addition, **Lincoln University** trains over 230 professional people each year including 24% (c. 50 people per year) of all the BASIS trained students across the UK. This is the basic qualification required by all agronomists to enable them to legally trade (i.e. recommend pesticides to customers).
- **Cranfield University** has 70 MSc students a year on agrifood courses, including food chain systems, future food sustainability and applied bioinformatics. It also runs many short courses for professionals, including subjects such as agricultural life cycle assessments, agroforestry for land use intensification, and applied food mycology.

(Source: Based on evidence provided to the East of England Science and Innovation Audit)

Local industrial strengths and capacities

4.15 Using a broad definition, ONS data show that there are nearly 5,400 enterprises employing around 86,700 people in agrifood and food processing in the East of England. Using a narrow definition reduces the number of enterprises slightly to 4,700, but it reduces estimated employment substantially to 50,100. This is because the narrow definition excludes the manufacture of food products and beverages, which tends to be dominated by a small number of large employers. Under both definitions, across the region there was a steady growth in enterprises and jobs 2010-15, close to the national average[71].

[69] Some of these institutions are just outside the geography of the East of England SIA area, but they are functionally part of Agri-tech in the region
[70] Noting that this has a campus in Hertfordshire
[71] The SICs included in the broad and narrow definitions are included in the Agri-tech Appendix of supporting evidence and data (separate volume)

4.16 Table 4-1 shows, for both broad and narrow definitions of Agri-tech, the districts with the largest employment, those that are most specialised, and those where Agri-tech employment is growing fastest. Districts in Cambridgeshire, Hertfordshire and the Fens occur most frequently. Both Cambridge – which is almost entirely urban – and South Cambridgeshire are included in the lists, reflecting the concentration of research and technology organisations linked to Agri-tech in and around the city.

Table 4-1: Largest, most specialised (by location quotient), and fastest growing (by compound annual growth rate) five districts by BRES employment, with East of England Science and Innovation Audit area and England comparators

A: for Agri-tech 'broad definition' (based on 2012 and 2015 three year rolling averages, i.e. 2010-2012 and 2013-2015)

Largest employment	Most specialised (LQ)	Fastest Growth (CAGR)
• South Cambs. (9,800)	• South Holland (8.5)	• Broxbourne (23.6%)
• South Holland (7,200)	• South Cambridgeshire (5.4)	• Forest Heath (8.4%)
• Huntingdonshire (4,300)	• East Cambridgeshire (4.7)	• St Albans (7.8%)
• Cambridge (4,300)	• Fenland (4.1)	• South Cambs.(7.0%)
• Waveney (3,700)	• Waveney (3.7)	• Breckland (6.9%)
East of England (86,700)	**East of England (1.4)**	**East of England (1.2%)**
England (619,400)	**England (1.0)**	**England (1.3%)**

B: for Agri-tech 'narrow definition' (based on 2012 and 2015 three year rolling averages, i.e. 2010-2012 and 2013-2015)

Largest employment	Most specialised (LQ)	Fastest Growth (CAGR)
• South Cambs. (8,900)	• South Cambridgeshire (10.0)	• Broxbourne (25.3%)
• Cambridge (4,200)	• East Cambridgeshire (8.8)	• South Kesteven (7.7%)
• Huntingdonshire (3,100)	• Stevenage (3.9)	• Forest Heath (7.6%)
• East Cambridgeshire (3,100)	• Huntingdonshire (3.5)	• South Cambs. (7.3%)
• Welwyn Hatfield (2,100)	• Cambridge (3.4)	• Uttlesford (6.6%)
East of England (50,100)	**East of England (1.7)**	**East of England (1.2%)**
England (304,600)	**England (1.0)**	**England (1.7%)**

Source: ONS, Business Register and Employment Survey

4.17 In addition to analysing the scale and location of employment in Agri-tech in the region, it is possible to assess the characteristics and location of the largest Agri-tech companies in the region using Bureau van Dijk's FAME database which is based on information kept by Companies House[72]. The particular strengths of Agri-tech companies in the East of England are summarised in Box 4-3.

[72] The analysis is provided in an accompanying Agri-tech Appendix (separate volume)

Box 4-3: Strengths of Agri-tech businesses in the East of England

- **Plant breeding** – there are 24 plant breeding companies in the East of England, including Germains Seed Technology, LimaGrain, Elsoms, RAGT Seeds, Saaten Union (UK), Floranova. In addition the British Society of Plant Breeders (BSPB) is located in Ely.
- **Agronomy services, agrochemicals and a robust agricultural supply chain** – including, for example, Agrii, Hutchinisons, Velcourt, Berry World, Gs Growers, Produce World, Anglia Farmers, FRAM Farmers, CamGrain, Fen Grain, Frontier, AgroVista, 3663 Food Group (Bidvest Foodservice), Sentry Farms, Bayer Crop Science, Briar Chemicals, Dow, DuPont, HL Hutchinson, Monsanto, Syngenta, etc.
- **Agricultural engineering** – including some larger and or very progressive companies such as Cousins of Emneth, GT Bunnings, Standen Engineering, Garford Engineering, Lemken, Lite Trac, PMC Harvesters, Richard Western, Sands Agricultural Machinery, Stocks Ag. The region also has both Perkins Engines, which is a global tractor engine manufacturer, and CNH Tractors in Essex which exports 85% of its output from its 140 acre site, making it a top 10 UK exporter across all sectors.
- **Interfaces between Agri-tech and information and communications technology (ICT), robotics, artificial intelligence (AI) and big data.** Examples of firms working at these interfaces include Kisan Hub (analyses datasets on farm operations, irrigation, agro-chemical applications, satellite and drone imagery, etc. to provide data-driven decision points for farmers); Fieldmargin (an app that allows remote farm management); Dogtooth Technologies (building smart autonomous robots for harvesting soft fruits); SmartBell (sensor arrays and machine learning in Agri-tech); and PBD Biotech (diagnostic technology for veterinary and agriculture sectors).
- **Food manufacturing and processing** – ranging from major multi-nationals and well known regional brands to small niche producers. Examples include: 2 Sisters Food Group, AB Inbev UK ltd, ABF (Associated British Foods), Adnams, Albert Bartlett, Bernard Matthews, Anglia Malting Ltd (Ragleth Ltd), Arla Foods, British Sugar, Britvic, Coca Cola Enterprises Ltd, Colman's, Fenmarc, Frank Dale Foods, Greencore Group (UK Convenience), Greene King, Greenery UK ltd, Heinz Frozen and Chilled Foods ltd, Hilton Food Group PLC, Kerry Foods (Kerry Group), Kettle Foods, Kinnerton Confectionery, LifeCrown Investments Limited, MBM Produce Ltd, Mars UK Ltd, McCains, MM UK Ltd, Muntons PLC, Pasta Foods Ltd, Pauls Malt Ltd, Pinguin Lutosa Foods UK, Premier Foods, Princes, Smithfield Foods Ltd, Jordans and Ryvita Company ltd, Total Produce Ltd.

Source: Based on evidence provided to the East of England Science and Innovation Audit

4.18 Links between industry and the research base are being strengthened further. Examples include:

- the **new Innovation Hub, managed by NIAB at Hasse Fen near Soham**, which is dedicated to reducing crop and food waste or channelling that waste into higher grade end products. It also works on improving resource use efficiency in the horticultural and fresh produce supply chains. The Hub, which is the first of its kind in the UK, is equipped to run as a field/test station, where NIAB can work with local and national businesses to carry out commercial scale pilot studies. The aim is to increase productivity and reduce crop wastage along the value chain, especially before produce reaches the processor and retailer.
- **AgRIA**, a trend-setting Agricultural Research and Innovation Accelerator supporting up to 21 innovation projects over a period of 6 to 18 months and involving academics and businesses. Through a physical hub at **Rothamsted Research**, AgRIA will provide research and innovation mechanisms for SMEs, drawn from multiple sectors, to co-create solutions to problems in agri-food alongside experts from three leading scientific institutions. AgRIA will contribute to the Hertfordshire Enviro-Tech Enterprise Zone and help develop the next generation of entrepreneurs.

4.19 Early stage businesses (start-ups and SMEs) are implementing these innovations for agricultural applications including precision agriculture (KisanHub, Hummingbird, uVue, Blue Bear), harvesting automation, soft robotics (Dogtooth) and contained/urban farming

(GroPod, Aponic, Leaf Systems International)[73]. In addition, the strength of the region's research and innovation assets is attracting inward investment (see Box 4-4).

Box 4-4: Case Study of Plant Impact

Plant Impact was formed in Preston, Lancashire in 2005. Since then, the company has developed effective and commercially successful technology, forged partnerships with agchem industry giants and, in 2012, it relocated to the Rothamsted Research. Currently, most of its 70 staff are employed in Hertfordshire. It also has offices in Sao Paulo, Buenos Aires and Raleigh, USA.

Plant Impact conducts research and development for new products, as well as upgrades of existing product at its primary research facility at the Rothamsted Centre for Research and Enterprise (RoCRE) in Harpenden, United Kingdom. At RoCRE, it has on-demand access to glasshouses, controlled growth environments, a 250 hectare research farm, as well as advanced imaging and analytical equipment. The company also conducts field efficacy and analytical trials with contract research organizations in multiple countries. Each year, it typically commissions 50 trials with 25 independent trialists.

"*Plant Impact's decision to relocate its head office and research effort to Rothamsted has been transformational for our strategy as a plant science innovation business*" – John Brubaker, CEO, Plant Impact.

The company combines research and development in crop enhancement with industry expertise to produce efficient, cost effective products focused on improving yields in crops such as soybean and wheat in a concerted effort to help reduce the yield gap and improve food security worldwide. Plant Impact distributes product via regional agrochemical distributors and global strategic partners that growers trust, such as Bayer Crop Science and Arysta LifeScience. Through these channels, Plant Impact crop enhancement products are available in over 20 countries including Brazil, USA, Argentina, Paraguay, Turkey, Ivory Coast and Cameroon.

Source: Evidence provided to the East of England Science and Innovation Audit

National and international engagement

4.20 **Agri-Tech East** is a commercial organisation, funded through membership subscriptions, event revenues and sponsorship, and is a network bridging academic research with agri-tech enterprise and farmers and growers in the region and beyond. Engagement has focused on linking R&D with farming and technical enterprises to explore, innovate and create new products aligned with market need. It has increased visibility of activities within the sector and stimulated growth through partnership. Academic centres both in the region and across the UK collaborate at a national level, attracting complementary expertise to support innovation. Engagement activities are extended through a suite of events and a leading national conference, as well as close working with members such as the Agriculture and Horticulture Development Board (AHDB).

4.21 Academic research organisations within the region have global reach, both through training of international students and collaborative research. For example, the John Innes Centre has formed a partnership with two institutes of the Chinese Academy of Sciences to establish the Centre of Excellence for Plant and Microbial Science (CEPAMS) in Shanghai[74], and Rothamsted Research has long-established links with many developing countries.

4.22 Government funding (BBSRC, Newton and Global Challenges Research Funds) has enhanced international collaboration and extended that established through the EU (Horizon 2020, European Research Council). Academic international partnerships and relationships are

[73]For further information see http://www.AgriTech-east.co.uk/about/publications/
[74] https://www.jic.ac.uk/news/2016/09/launch-joint-john-innes-centrechinese-academy-sciences-shanghai-laboratory-bolsters-uk-china-scientific-collaboration/

increasingly supporting the development of commercial opportunities for regional Agri-tech companies.

Developments in the wider funding landscape

4.23 **Globally**, agri-tech venture capital funding increased during the first quarter of 2017 following a decline in the amount of funding in 2016. The increase in deal activity reflects the growing number of programmes and resources available to start-ups, including new venture funds, accelerators and incubators[75].

4.24 Given the small number of dedicated funds, the sector depends on non-agriculture focused investors throughout, but particularly at the later stages. Much of this finance has come from family offices and big name Silicon Valley VCs. For example, in 2016, Google Ventures made five investments across the sector, all at Series B round, while Khosla and Kleiner Perkins, Caufield & Byers both made three.

4.25 **Globally**, the **Food Marketplace/Food E-Commerce category** dominated global Agri-tech funding during 2016, accounting for 40% of total funding and $1.29 billion in investment. **Biotechnology** start-ups serving the agriculture sector collected the second largest portion of funding with 22% of funding and $719 million across 84 deals. Crop technologies dominated the category, raising $523 million across 61 deals. Of these, 22 were researching the microbiome for biological products and three were using gene-editing technologies. Investment in **precision agriculture technologies**, which include data-capturing devices and farm management software showed a 39% decline on 2015[76].

4.26 **Within the UK**, research published in July 2016 on public and private sector investment in agri-tech R&D[77] shows that public sector investment in 2012-2013 was £320m, and the private sector investment was £496m. BBSRC accounted for 51% of the public sector spend (31% research and 20% capital), with Department for International Development (DFID) and Department for Environment, Food and Rural Affairs (Defra) accounting for a further 29%. Of the private sector spend, 78% was by 10 large companies (over 1000 employees); cut another way, 83% was by multinational companies.

4.27 UK Government funding for Agri-tech has been increasing and take up has been good. The Catalyst Fund (£60m) is now fully committed and the Sustainable Agriculture and Food Innovation Programme (SAFIP – £90m) is fully spent. In addition, SARIC, CIRC, HAPI are industry linked programmes with government and industry funding which have been fully subscribed, and Innovate UK has run specific calls for Agri-tech each year since 2013 (each circa £10-15m), each of which has been fully taken-up. The sector has also been successful in competitions for Horizon 2020 funding at UK level.

4.28 The **East of England** benefits from access to Europe's main centre for VC funding, London. In addition, Cambridge has one of the strongest VC and seed fund sectors outside London, including the likes of Amadeus Capital, Cambridge Capital Group and Cambridge Angels. There

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[75] https://agfunder.com/research/agtech-investing-report-2016, and CB Insights Agritech Market
[76] https://research.agfunder.com/2016/AgFunder-Agtech-Investing-Report-2016.pdf
[77] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/536414/bis-16-17-private-and-public-sector-funding-of-agritech.pdf

are also funding sources more specifically focused on the Agri-tech sector in the East of England (Box 4-5).

Box 4-5: Agri-tech funding sources in the East of England

- **Eastern Agri-Tech Growth Initiative –** a £3.2m fund which provides grants of between £10,000 and £150,000 to businesses based in Cambridgeshire, Peterborough, Norfolk, Suffolk, Rutland, North Hertfordshire South Lincolnshire, and Uttlesford. The funding has been provided through the Regional Growth Fund and is divided into two parts; the Research, Development and Prototyping fund supports R&D of new products or processes with grants of between £10,000 and £60,000 and the Growth fund offering grants between £25,000 and £150,000 to support product development and improve agricultural productivity. To date, 65 grant applications have been approved, including food and drink producers and growers, bespoke equipment and chemical manufacturers and innovative IT companies who supply to the agricultural sector[78].
- **Cambridge Agritech** – a syndicate composed mainly of private investors who are either owners or directors of some of the largest food and agricultural businesses in the UK. They invest in innovative SMEs in the agricultural sector in Europe and the US[79].
- **Agri-Innovation Venture Capital Fund** – launched in 2014 as a co-investment pot in response to the recognised need for investment into early and medium stage agri-tech enterprises in the UK. It was operated by the Adapt Group at the University of East Anglia in concert with the Tsukuba Technology Seed Co Ltd (TTS) in Japan, but is now on hold.
- **Adapt Cocoon** – a joint venture between the Adapt Group at the University of East Anglia and Cocoon Networks, Europe's largest start-up ecosystem backed by Chinese capital. The focus is on UK-based Green-Tech companies with growth potential in the Asian markets.
- **Anglia Capital Group** – a group of Angel Investors who invest in start-ups and early growth-stage businesses with innovative and potentially disruptive technology at their core. New Anglia Local Enterprise Partnership has co-invested with Anglia Capital Group to encourage agri-tech deals.

Source: Based on evidence provided to the East of England Science and Innovation Audit

Conclusions – and future potential

Opportunities

4.29 Over the next five years, the region will need to increase the economic impact of its assets through their deployment in three main areas:

- **Robotics:** the region hosts outstanding research expertise in robotics, artificial intelligence and soft robotics both in academic research centres and in engineering and IT firms. Mechanisation of agricultural production will be critical to increase labour, crop and livestock productivity and efficiency. In field, this will reduce the requirement for manual labour, and increase the efficiency, speed and precision of harvesting. Processing and packaging efficiencies will be improved and it will underpin the progression to contained production (vertical farming) for horticultural crops, ensuring continuity and scalable production to meet consumer need. There will be a large skills requirement to enable the industry, both technology developers and end users, to adopt new robotic systems.
- **Rhizosphere modification:** the regional research expertise in microbiology, genomics and agronomy has driven rapid advances in our ability to characterise microbial plant interactions in the rhizosphere. In the next five years, the early

[78] http://www.gcgp.co.uk/agri-tech-grants/
[79] https://www.camagritech.com/about.html

successes will be translated into new biologics, either microbial inoculum or natural products. They provide environmentally sustainable plant protection and performance, thereby increasing agricultural productivity and sustainability.

- **Sensors and Diagnostics:** genomics has revolutionized our ability to identify and discriminate between micro-organisms, pests and plant varieties. The region is a world leader in this emerging technology (pathogenomics). A new generation of sensors and diagnostics are set to transform our surveillance ability, evaluating potential threats from pests and pathogens and targeting mitigation.

4.30 These can be delivered by existing regional assets. The deep science knowledge in **data and ICT, genomics, genetics and plant breeding and microbial research** will act as a foundation for the discovery and translation of technology and innovation. These strengths will drive the development of improved crop varieties fitted for UK production both in field and in emerging contained production systems. Improved varieties will be developed by regional plant breeding companies, grown by regional farmers and processed to food and animal feed by manufacturing businesses.

4.31 This will be complemented by the outputs of plant and microbial research that will generate the **new chemistries (agrochemicals) and micro-organisms (biologics)** providing crops with protection from pests and pathogens, increasing nutrient use efficiency (fertilizers) and resilience to environmental stress (temperature and drought) from climate change.

4.32 **New surveillance technologies** arising from advances in genomics linked to sensors and diagnostics will feed back into the development of new resistant varieties and plant protection products safeguarding crop productivity. Collectively these outputs will improve quality and yield, safeguard productivity and reduce the environmental impact of agricultural and horticultural production. Improved varieties will play an increasingly important role in improving human and animal health through diet. This will support UK healthcare, reducing the burden of lifestyle disease arising from obesity and diabetes.

Box 4-6: Looking across Science and Innovation Audits: East of England and Oxfordshire

An example of links between different SIAs which are important to the wider UK economy is the inter-relationships between Agri-tech in the East of England and the "*space-led data applications*" which have been considered through the Oxfordshire SIA.

The Harwell Space Cluster in southern Oxfordshire is the largest in the UK, comprising 75 companies, government and university-related organisations. Companies include growing SMEs (e.g. Oxford Space Systems, Rezatec), divisions of multi-nationals (e.g. Airbus Defence and Space, Thales Alenia Space, Telespazio Vega, Lockheed Martin, Elecnor Deimos); government-funded facilities include the Satellite Applications Catapult, STFC's RAL Space and the ESA Centre for Satellite Applications and Telecommunications (ECSAT). The Harwell Space Cluster is developing and applying new technologies such as small satellites constellations, which increases functionality and reduces end user costs, enabling a much wider range of potential applications.

The East of England has a national leadership role in Agri-tech, reflecting both a strong heritage in crop-based agriculture and horticulture, and the depth and calibre of related scientific research in the region's universities and in research institutions such as NIAB in Cambridge, the John Innes Centre in Norwich and Rothamsted Research in Hertfordshire.

The East of England is therefore well-placed to apply, and benefit from, new technologies in precision and smart agriculture, including the application of robotics, sensors and diagnostics, for example, to increase the efficiency, speed and precision of applying fertilizers and pesticides, and of harvesting.

Precision and smart agriculture rely on the rapid processing of large amounts of data, much of which is gathered from satellites. There is therefore a strong inter-relationship and complementarity between the expertise in space led applications in Oxfordshire and in the processing and application of data from space in the East of England to increase the efficiency and environmental performance of agriculture.

Source: Based on evidence provided to the East of England Science and Innovation Audit and to the Oxfordshire Science and Innovation Audit

Perspectives from businesses

4.33 As part of the Audit, businesses were asked to identify both opportunities and challenges for Agri-tech in the East of England. Their views resonate strongly with those expressed above. They are summarised in Box 4-7 below.

Box 4-7: Opportunities and challenges identified by Agri-tech businesses in the East of England

Opportunities

- Engineering, data and IoT are expanding globally at circa 10-15% per annum and are already worth nearly half of the total Agri-tech market.
- Information technologies will enable precision agriculture. Sowing, watering, fertilising and harvesting will all be computer-controlled, consequently more efficient, less wasteful, and more productive.
- Convergence of technologies through ICT and Engineering, such as smart sensors and bio-detection, will enhance the region's expertise in precision crop agriculture/horticulture.
- Increased automation can boost productivity of the agri-food sector while maintaining high sustainability standards and low environmental impact.
- Smart crop protection and nutrition can reduce crop losses and waste whilst enabling growers to reduce input costs and to reduce environmental impact.
- Maintaining and improving the soil to enable crops to achieve higher yields to feed a growing population.

Gaps identified by businesses in Agri-tech in the East of England

- Better transport and internet connectivity are needed, otherwise people cannot commute nor work from home. These are "*really fundamental but sadly overlooked and will be the downfall of UK innovation*".
- Need for more investment in practical research projects which improve crop yields while also ensuring that the environment is protected (sustainable intensification).
- Need to invest in human and physical assets to exploit the opportunities created by digitally enabled technology for agriculture and the food chain.
- More resources need to be focused on networking industry and research. There are still too many scientists not talking to industry and too few industry members talking to scientists.
- More collaboration between education and research bodies and the commercial sector is needed to close the commercialisation gap.
- Need more support for start ups and extension support to get new automation technologies adopted on farms.

Source: SIA Agri-tech stakeholder survey

4.34 The hypothesis that was to be tested in relation to Agri-tech was that:

> *The region has world-renowned research strengths in Agri-tech, and increasing expertise and experience in the process of commercialisation. Further strengthening of the mechanisms for commercialisation will bring major economic benefits to the region and to the national economy.*

4.35 The Audit has demonstrated that the region has world renowned research strengths in Agri-tech, and considerable strengths in commercialisation. However, there is a need to improve further the processes and effectiveness of commercialisation to achieve greater impacts. Priority interventions which will help to achieve this outcome are set out in Chapter 7.

5. Theme 3: Advanced materials and manufacturing (AM&M)

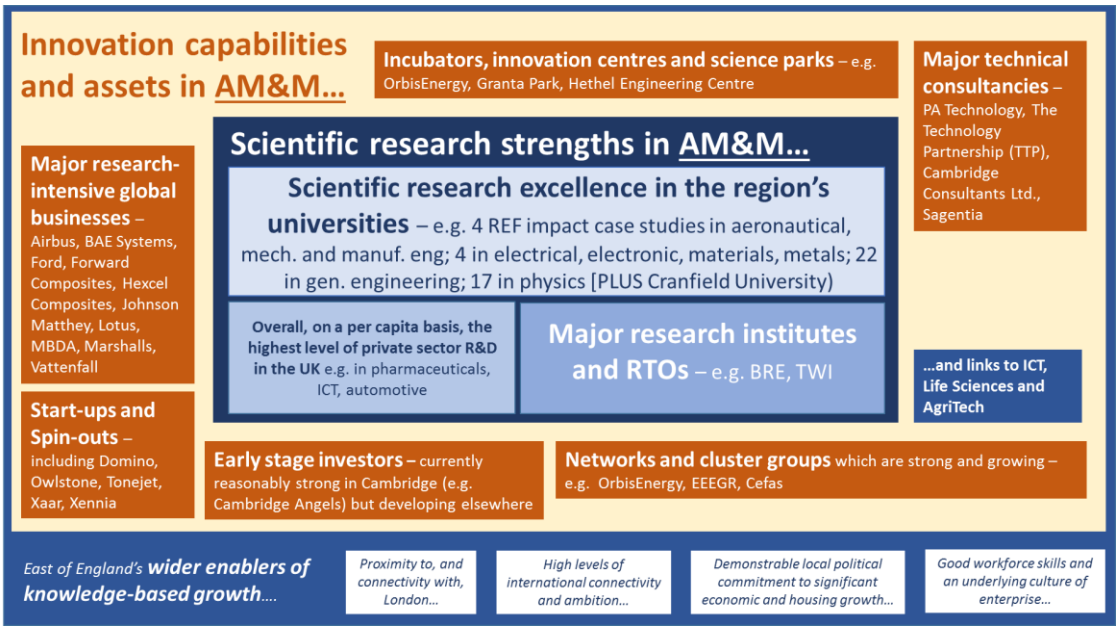
Chapter Summary:

- The East of England has world class research strengths in AM&M, particularly at the University of Cambridge and Cranfield University (just beyond the region's western boundary); in RTOs; and within technical consultancies and major corporates.
- The AM&M sector is distributed region-wide although there are four main "hubs" within the East of England and a fifth nearby; all are part of a wider functional economic geography that extends to the west of the region.
- The links between the region's research strengths/innovation capabilities and its business community are patchy – they are outstanding on a localised basis, but the picture is inconsistent.
- The AM&M sector is in the process of being transformed – particularly through digitalisation (Industry 4.0) and the adoption of advanced materials; businesses within the region are spearheading this revolution.
- Looking ahead, radical approaches to innovation and technology transfer that cross institutional and sectoral boundaries will be needed region-wide, and high level digital skills will be paramount.

Scope – and core hypothesis

5.1 The East of England has world class scientific assets and innovation capabilities in the domain of Advanced Materials and Manufacturing (AM&M). These are distributed across universities, businesses, specialist technical consultancies and within some major Research and Technology Organisations (RTOs). Spatially, AM&M differs from other Themes insofar as world class excellence – with wide application across most sectors of the economy – is distributed across the region. The innovation ecosystem is therefore complex and dynamic – and dispersed geographically. The principal elements of it are summarised in Figure 5-1.

Figure 5-1: Summarising the East of England's Innovation Ecosystem in AM&M

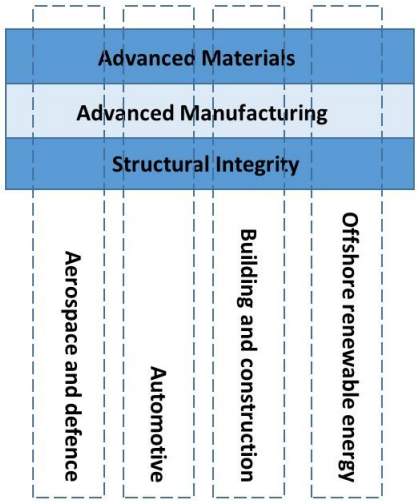


Source: SQW – drawing on information gathered through the SIA process

5.2 In relation to AM&M, the Science and Innovation Audit has focused on points of intersection between three technologies/competencies and four sectors, illustrated in the graphic opposite. Within this context, the hypothesis that has shaped the AM&M Audit is that:

> *The East of England's strengths in AM&M have grown organically – some map onto the research base but others have emerged within their sectoral context. AM&M is therefore very fragmented. Better planning, networking and co-ordination would create coherence and identity, and it would help achieve critical mass. This in turn would enable market expansion, both nationally and internationally.*

Figure 5-2: Focus for the Science and Innovation Audit within the AM&M Theme



National and international trends, and size of global markets

5.3 AM&M covers a huge range of activities. It is the foundation of much of the rest of the economy. In its Foresight report on **The Future of Manufacturing**, the Government Office for Science identified four main future characteristics of manufacturing. These were "*faster, more responsive and closer to customers*" (through mass personalisation and using technologies such as additive manufacturing, new materials, computer-controlled tools); *"exposed to new market opportunities"* (reflecting the growth of the BRIC nations and the "Next Eleven" (N11), and highlighting the imperative for UK manufacturers to focus on high tech sectoral strengths); *"more sustainable"* (reflecting the need for efficiency and resilience in the short term, and for new systems and materials over the longer term); and, as a consequence, *"increasingly dependent on highly skilled workers"*[80]. These future characteristics are wrapped up with **Industry 4.0** – a phrase coined in Germany to describe a fourth industrial revolution which goes well beyond simple automation to encompass inter-operability (through Internet of Things) and the extensive collection and use of data to allow highly bespoke and intelligent manufacturing processes.

5.4 Within this overall context, defining the scale and potential of **advanced manufacturing** is a challenge. It cuts across every manufacturing sub-sector, including the four that are the focus for this Audit. A study published recently by the Institute for Manufacturing (IfM) however estimated that high value manufacturing contributes in the order of £275 billion of GVA to the UK economy each year[81]. The scale and growth potential of each of the sub-sectors within AM&M is estimated in Table 5-1 below.

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[80] *The Future of Manufacturing: The new era of opportunity and challenge for the UK – Summary Report.* Foresight (2013), Government Office for Science, London
[81] *High Value Manufacturing Landscape 2016: Interim Report* Institute for Manufacturing, University of Cambridge

Table 5-1: Major trends and drivers of relevance to AM&M sub-sectors in the East of England – and the size of global markets

Sub-sector	Key observations
Aerospace and defence	
Market size and outlook	Defence budgets are increasing given national security threats and *"the commercial aerospace sector is expected to continue its decade-long trend of above average growth rates"*[82].
Science and technology trends and drivers	Internet of Things is starting to transform aerospace – assembly, manufacture, safety, etc. Wider drivers relate to the increasing intersection of materials and computer sciences; composites; energy storage; and in time, quantum information systems[83]. The regulatory environment is demanding in aerospace (e.g. regulations surrounding avionics systems are changing).
Automotive	
Market size and outlook	According to PwC, worldwide sales reached 88 million vehicles in 2016, up 4.8% on the previous year[84]. However, rates of return on capital are low and this is prompting cost cutting and some rationalisation of capacity.
Science and technology trends and drivers	Innovation-related challenges are "*redistributing profits between automotive and tech companies*" [85]. The "*transition from automotive into smart mobility"* was noted by stakeholder consultees. The transition to electric drive – through hybrids or battery-driven vehicles – is increasing: *"the German automotive industry will invest over €40 billion in alternative powertrains by 2020"*[86].
Building and construction	
Market size and outlook	In the UK, the construction sector is set for substantial growth reflecting the commitment to house building (set out in the Housing White Paper, 2017) and to major infrastructure projects.
Science and technology trends and drivers	Production and use of low carbon and renewable materials (crop-based and recycled materials, and low CO_2 concretes) – noting that the East of England has particular expertise in this sphere. Use of integrated sensing systems, and product track and tag technologies leading to whole life asset monitoring.
Offshore renewable energy	
Market size and outlook	The UK has more installed capacity of offshore wind power than any other country, with about 60% generated in the East of England[87]. Offshore Renewable Energy in the East of England is projected to receive about £13.1bn of capital investment by 2020, with a further £18bn projected between by 2030[88].
Science and technology trends and drivers	Advances in modular offshore substations and other advances in grid connections are reducing weight and simplifying maintenance, while offshore wind projects such as the 714MW East Anglia ONE are using 66kV systems to transport more power than traditional 33kV infrastructure[89]. Advances in robotics may allow for developments in more difficult-to-access/higher risk areas, where autonomous agents can provide maintenance to infrastructure[90].

[82] "2016 Global aerospace and defense sector outlook: Pointed for a rebound", Deloitte, January 2016
[83] *"Aerospace Industry CTOs on Future Technologies"*, Aviation Week, May 2016
[84] "2017 Automotive Trends: The Future depends on improving returns on capital" PwC
[85] "2017 Automotive Trends: The Future depends on improving returns on capital" PwC
[86] President of the German Association of the Automobile Industry, speaking at New Year reception, January 2017
[87] OrbisEnergy, *Summary of Offshore Renewable Energy in the East of England,* submitted as part of the East of England Science and Innovation Audit call for evidence, April 2017
[88] Nautilus Associates and 4C Offshore, *Welcome to OrbisEnergy presentation*, November 2016
[89] European Commission, *JRC Wind Energy Status Report – 2016 Edition*, March 2017 (accessed via: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC105720/kjna28530enn.pdf)
[90] BP, *8 technology breakthroughs that may change the energy landscape*, November 2015 (accessed via: http://www.bp.com/en/global/corporate/bp-magazine/innovations/8-technology-breakthroughs-that-may-change-the-energy-landscape.html)

5.5 Global innovation in **advanced manufacturing, materials and structural integrity** cuts across all of these industry sectors. Manufacturing generates 70% of exports from developed and emerging manufacturing economies and attracts up to 90% of commercial R&D expenditure.[91] However, international competition is significant. As an example, the Indian '*Make in India*' programme projects a manufacturing sector of £7.7 billion by 2025[92]. If this is achieved, the sector would account for 25-30% of the country's GDP and create up to 90 million domestic jobs.

5.6 The market for **advanced materials** is projected to grow to be worth £80 billion by 2024, up from £33.4 billion in 2015.[93]. While these figures are inevitably speculative, they do point to the underlying opportunities for competitive businesses in the East of England. The global impact of **structural integrity** activity is more difficult to quantify, as a large component of this work is the prevention of failure. Costs can easily run into £millions, and the field can be viewed as a desirable insurance against failure that can range from minor to catastrophic.

5.7 Key trends and drivers that are likely to find application across all four of the vertical sectors within this Audit, and be advanced within the East of England innovation ecosystem, are summarised in Box 5-1 below.

Box 5-1: Overarching technology trends and drivers in respect of advanced materials (and structural integrity) of relevance to advanced manufacturing sectors in the East of England

- Intelligent manufacturing, otherwise known as Industry 4.0, involves pervasive digitalisation, the integration of new materials, coatings and electronics with new manufacturing technologies and implementation of new quality and management systems.
- This provides significant competitive innovation opportunities for all industry sectors, providing increased functionality, reducing costs and environmental impact while enhancing reliability. Failure to exploit the potential of these approaches will expose UK manufacturers to cheaper overseas competition, or render them functionally obsolete.
- The field is highly interdisciplinary and interdependent. Some of this is wrapped up with emerging specialisms in the region in respect of cleantech which has cross-cutting application across AM&M and more generally.
- The East of England is well placed to develop better linkages between its existing and emerging R&D assets in the field and thus use them more effectively to supply regional industry with AM&M innovation support.

Source: Based on evidence provided to the East of England Science and Innovation Audit

Local science and innovation assets

5.8 The East of England has world class scientific and innovation assets in the sphere of AM&M, as evidenced below:

- In terms of **academic science**, the University of Cambridge is outstanding across all "units of assessment" which relate directly to AM&M. In terms of **research power,** it was ranked 1st in "*physics*" through the **Research Excellence Framework** (2014); 2nd in both "*general engineering*" and "*chemistry*"; 7th in "*electrical and electronic engineering, metallurgy and materials*"; and 11th in "*aeronautical, mechanical, chemical and manufacturing engineering*". University of Hertfordshire was ranked 23rd in "*physics*" and University of East Anglia was ranked 26th in "*chemistry*". In

[91] Mckinsey Global Institute: Manufacturing the future: the Next Era of Global Growth and Innovation. 2012
[92] https://www.ibef.org › Industry
[93] *Transparency Market Research Advanced Materials Market (Product - Ceramics, Glasses, Polymers, Composites, and Metals & Alloys; Application - Medical Devices, Automotive, Aerospace, Electricals & Electronics, Industrial, and Power),* Global Industry Analysis, Size, Share, Growth, Trends, and Forecast 2016–2024, December 2016

addition – although technically just outside the SIA area – Cranfield University has very substantial strengths: it was ranked 2nd nationally on research power in "*aeronautical, mechanical, chemical and manufacturing engineering*". In terms of **grade point average (GPA)**, the University of Cambridge was the highest ranking institution nationally in each of "*aeronautical, mechanical, chemical and manufacturing engineering*", "*electrical and electronic engineering, metallurgy and materials*" and "*chemistry*".

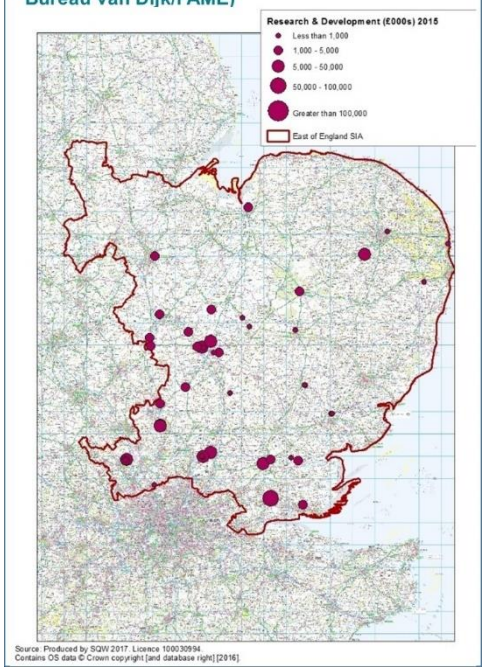
- Between 2004 and 2016, the **UK Research Councils** invested £3,530 million into the East of England (excluding Cranfield University) in fields linked to AM&M. This included £61 million focused on "*materials sciences*", 12% of the UK total. In addition, the region accounted for 10% of UK funding linked to "*materials processing*", and 10% linked to "*systems engineering*".

- Through **Horizon 2020**, the region has benefited from 31% of the UK total EU funding in "*advanced materials*" since 2014.

- Data from the **European Patent Office (PATSTAT)** suggest that between 2004 and 2014, inventors in the East of England accounted for over 16% of UK patents in "*microstructural and nanotechnology*"; 14% in "*surface technology and coating*"; and 13% in "*thermal processes and apparatus*".

- According to Bureau van Dijk's FAME database, **AM&M companies with registered addresses in the East of England** spent £256m on **R&D** in 2015. The distribution of these companies is shown in Figure 5-3 with an indication of the scale of spend. The spatial pattern is dispersed region-wide; it is significantly different from the other three Themes.

Figure 5-3: Map showing private sector R&D spend in AM&M for companies with registered addresses in the East of England (data from Bureau van Dijk/FAME)



5.9 Underpinning these data are scientific capabilities and innovation assets of international acclaim. These include the region's **universities**. Of particular relevance to the AM&M Theme is the **University of Cambridge's Engineering Department** (and within this, the **Institute for Manufacturing (IfM)**) and its **Department of Materials Science and Metallurgy** (Box 5-2). A second university which is crucially important is **Cranfield University** – even though it is (just) to the west of the SIA area. Cranfield University is a very different institution; it is postgraduate-only and its outstanding engineering credentials reflect substantial and long-term industry collaborations (across, for example, aircraft design, propulsion, materials, sensor technology, vehicle health management, autonomy and manufacturing[94]).

[94] Evidence submitted to the East of England SIA AM&M Theme

Box 5-2: Advanced Materials and Manufacturing, and the University of Cambridge

Institute for Manufacturing, Department of Engineering

The Institute for Manufacturing (IfM) is a division of the University of Cambridge's Department of Engineering. The Department is the highest ranked engineering and technology department in the UK and ranks fourth in the world behind Stanford, Caltech and MIT[95].

Research at IfM addresses new technologies and production processes as well as the management and policy dimensions of manufacturing. It currently has 16 research programmes, 70 researchers and more than 100 PhD students looking at manufacturing-related topics such as: fluid and laser-based manufacturing process technologies; how digital manufacturing technologies and data analytics can be used to transform business models, factories and supply chains; and how new technologies can be scaled up into successful businesses.

Engineering undergraduates at the University of Cambridge can opt to take the two-year Manufacturing Engineering Tripos in their third and fourth years. IfM also offers a taught MPhil in Industrial Systems, Manufacture and Management. In partnership with Cranfield, it also runs the Centre for Doctoral Training in Ultra Precision Engineering.

Embedded within IfM is a knowledge transfer company – IfM Education and Consultancy Services Ltd (IfM ECS) – which transfers the new ideas and approaches developed by researchers at the IfM to companies of all sizes and to national and regional governments. It does this through consultancy and executive and professional development. IfM ECS is wholly owned by the University of Cambridge and its profits are gifted to the University to fund future research.

Department of Materials Science and Metallurgy

Like IfM, the Department of Materials Science and Metallurgy is based in a new building on the West Cambridge site. The Department's major research themes include: device materials, electron microscopy, materials chemistry, medical and pharmaceutical materials, structural materials, and energy and sustainability.

The Department generates research income of more than £4m per annum. Latterly, it has developed large-scale working relationships through Corporate University Technology Centres – examples include the Pfizer Institute for Pharmaceutical Materials Science and the Rolls Royce UTC in nickel-base superalloys. More generally, it works with four main industry sectors (aerospace, automotive, energy and medical/pharmaceuticals), all of which are central to the SIA[96].

The Department has been an important source of spin-out businesses in sectors ranging from medtech (e.g. Inotec AMD) to cleantech (e.g. CamGaN, which was subsequently acquired by Plessey[97]). Some of these have grown outside the region (see case study below). It has also seen many licencing arrangements (e.g. recycling technologies linked to lead-acid batteries[98]) which have allowed its research to be commercialised.

Source: Based on evidence provided to the East of England Science and Innovation Audit

[95] Times Higher Education World University Rankings 2015-16, https://www.timeshighereducation.com/news/world-university-rankings-2015-2016-by-subject-engineering-and-technology-results-announced
[96] See https://www.msm.cam.ac.uk/
[97] See https://www.enterprise.cam.ac.uk/news/cambridge-spin-out-camgan-acquired-by-plessey/
[98] *"Greening lead-acid batteries"*, Cambridge Material Eyes, Winter 2017, Issue 30

Box 5-3: Case study of Metalysis – a company created from the East of England's innovation ecosystem and now generating jobs elsewhere in the UK

Metalysis is a company that is based in South Yorkshire. It is commercialising a revolutionary process for the cleaner/greener, more efficient production of metal powders.

The process was invented by Prof Derek Fray's research group in the Department of Materials Science and Metallurgy at the University of Cambridge. The FFC (Fray, Farthing and Chen) process is based on a solid state reduction process that takes place at a lower temperature and requires less energy than conventional methods of metal production. Details of the process were initially published in 2000, and early development work was undertaken in Cambridge.

Metalysis was set up to commercialise this game changing technology. Although initially operating in the Cambridge area, Metalysis moved to one of the UK's areas of primary metal production, South Yorkshire, in 2005. It has grown subsequently and now employs around 65 people. It is an example of the East of England innovation ecosystem creating employment elsewhere in the UK

Source: Based on evidence provided to the East of England Science and Innovation Audit

5.10 Other universities also play a significant role in relation to AM&M. Stakeholders commented that **University of East Anglia** "*covers electronic and mechanical engineering with strong links locally to KLM engineering*" and also that the **University of Essex** has significant strengths in computation and electronic engineering of relevance to the sector. Reflecting its historic links to British Aerospace at Hatfield, the **University of Hertfordshire's** pedigree in advanced engineering is also widely acknowledged, particularly within the business community[99].

5.11 Alongside outstanding university strengths, the AM&M research and innovation ecosystem also relies on two **Research and Technology Organisations (RTOs)**, **TWI and BRE**. These are both research centres in their own right, but they also work extensively with industry, in the region and elsewhere.

Box 5-4: Research and Technology Organisations in the East of England and working with AM&M businesses

BRE

BRE – formerly the Building Research Establishment – is based in south west Hertfordshire. It has a 90-year history of building and materials research.

It is a substantial organisation with over 600 members of staff. Its expertise relates to all aspects of sustainable construction and the built environment. Its annual R&D spend sums to about £3m per year and its research specialisms span materials, sustainability, energy, waste, fire and intelligent buildings, with innovation activities also covering testing and certification[100]. BRE has been responsible for the certification of 14,500 products.

BRE holds 26 million records on UK housing – itself a substantial resource. Moreover, it is working in 73 countries and funding 140 PhD students.

BRE's Innovation Park includes 11 full-scale demonstration buildings[101] where new technology and research can be demonstrated, and companies can provide training and knowledge sharing opportunities[102]. Recent innovations at BRE Innovation Park include, a ZEDpods modular housing[103], the ZeroBills Home, the Weinerberger e4 brick house and Userhuus[104].

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[99] See for example "The evolution of the high performance technology and motorsport cluster" Report by SQW, commissioned by MEPC and partners, May 2016
[100] BRE website, *Research & Innovation*, (accessed via: https://www.bre.co.uk/page.jsp?id=1849)
[101] BRE Innovation Park, *Buildings*, (accessed via: https://ipark.bre.co.uk/parks/england/buildings)
[102] BRE Innovation Park, *Why Have an Innovation Park* (accessed via: https://ipark.bre.co.uk/)
[103] ZEDfactory website, *ZEDpods* (accessed via: http://www.zedfactory.com/zed-pod)
[104] BRE Innovation Park, *Buildings*, (accessed via: https://ipark.bre.co.uk/parks/england/buildings)

Tenants of BRE's Innovation Park include:

- **Sonobex:** A designer of noise reduction solutions which relocated from Warwickshire having previously used BRE's test and certification services.
- **Geolabs:** A UKAS-approved soils, rocks and aggregates laboratory.
- **Aquobex**: A developer of flooding related products and solutions which works closely with the Centre for Resilience team at BRE.

In 2015, BRE – in partnership with Rothamsted Research, the University of Hertfordshire, St Albans City and District Council and Oaklands College – launched the Green Triangle, which aims to develop a centre of excellence for Green Technology within Hertfordshire by linking green research, science, engineering and technology enterprises[105].

TWI

TWI is an independent research and technology organisation which was first established in 1946. It currently has around 900 employees, and it has industrial members across 70 countries[106]. It works across three main pillars of applied engineering: integrity management, materials and joining technologies.

In 2015, TWI opened three new laboratories near Cambridge, including facilities for the National Structural Integrity Research Centre, a dedicated postgraduate centre for industry-led engineering research. This will deliver more than 500 engineers into industry by 2025.[107] TWI also runs a substantial training and examinations programme, focused on welding and inspection technologies.[108]

TWI has secured substantial research funding from Innovate UK. This summed to £10.8m between 2010 and 2017[109].

At its Cambridge site, TWI hosts several innovation centres. These include the Brunel Innovation Centre (with Brunel University), London South Bank Innovation Centre (with South Bank University), the Smart Asset Management Innovation Centre (linked to the Transport Systems Catapult), and the Lancaster Innovation Centre (with University of Lancaster). In each case, teams of researchers are co-located with TWI and – together with industry partners – are delivering research projects funded through various sources (notably Horizon 2020 and Innovate UK)[110].

TWI is involved in delivering technology transfer support to engineering and manufacturing businesses, some of which are within the East of England. Recent examples include:

- **EcoTechnilin**, a bio-composites materials business which needed advice in relation to adhesive bonding
- **TRB Lightweight Structures**, a firm which manufactures composite parts for cabin interiors in the aerospace and rail industries and needed advice on fabrication methods
- **Enocam**, a manufacturing company which required adhesives consistent with the stringent requirements of potential aerospace customers.

Source: Based on evidence provided to the East of England Science and Innovation Audit

5.12 A third – and very distinctive – element of the innovation ecosystem surrounding AM&M relates to the **technical consultancies**. These are strongly concentrated around Cambridge. They have been a prolific source of spin-out businesses, many of them in the AM&M field. Over 50 years, Cambridge Consultants, for example, claims to have produced 20 companies, five of which have gone on to be listed on the London Stock Exchange (including CSR, Domino and Xaar) whilst others (e.g. Inca Digital) have been acquired. In 2015, TTP Group – based at Melbourn – launched a new spin-out, TTP Meteor, which had developed advanced print head driver systems; while earlier this year, TTP Ventus was launched, aimed at the medical and

[105] *The Green Triangle Case Study*, provided as part of the East of England Science and Innovation Audit call for evidence
[106] TWI, available at: http://www.twi-global.com/about/, accessed on 03.05.2017.
[107] TWI, Research and Innovation, available at: http://www.twi-global.com/what-we-do/research-and-innovation/, accessed on 03.05.2017.
[108] TWI, available at: http://www.twi-global.com/about/, accessed on 03.05.2017.
[109] Note that TWI was awarded IRO status in June 2016 which means it can now receive research council funding. It is in the process of submitting applications with university collaborators.
[110] TWI Innovation Centres, available at: http://www.twi-global.com/news-events/news/innovation-centres-at-twi-deliver-progress-for-industry/, accessed on 03.05.2017.

industrial markets. The technical consultancies are major science and innovation assets within the East of England – although their footprint (in terms of customers) is much broader.

5.13 Finally, there are some major businesses in the East of England in the AM&M sphere, some of which undertake significant R&D. In the field of **advanced materials**, significant research-intensive businesses within the East of England include Hexcel, Xaar and Johnson Matthey, a company with a sizeable operation in Royston (Hertfordshire) and an overall budget for R&D of £188m[111]. In addition, Granta Design, a spin-out from the University of Cambridge's Engineering Department, has significant expertise in relation to materials intelligence; it works across all four AM&M sectors; and it has been identified as a regional asset (see Box 5-5). Across the four vertical sectors, there are some major research-intensive businesses including, for example, Airbus and MBDA (aerospace and defence) and Ford (automotive). Local industrial strengths and capacities are considered more fully later.

Box 5-5: Granta Design

Founded in 1994 by Professors Mike Ashby and David Cebon as a spin-out from Cambridge University Engineering Department[112], Granta Design in Cambridge employs about 130 people and develops materials information technology for engineering businesses to improve decision-making in R&D and the product lifecycle[113], and by academics as a resource for improved teaching and education[114]. The company is owned by its founders, employees, the University of Cambridge (through Cambridge Enterprise) and ASM International (the world's largest professional society for materials science and engineering, which made a $1.6m investment in the company in 2000 and a further strategic agreement in 2006[115]).

Working in collaboration with its shareholder partner organisations and other industry consortia, including the Material Data Management Consortium, the EMIT Consortium and the Automotive Material Intelligence Consortium[116], Granta Design's primary product for industry is its GRANTA MI software. With version 10 released in December 2016[117], GRANTA MI provides businesses with a centralised database of materials information and helps inform materials selection, substitution and avoids research duplication. The software is also embedded in tools including Computer Aided Design (CAD) and Product Lifecycle Management (PLM). With access to Granta Design's extensive catalogue of materials reference information, the software aims to help businesses make informed decisions about product performance, cost, manufacturing, risk and sustainability[118]. The software is based on Granta's intellectual property covering materials data, materials selection charts (or Ashby charts) and the performance index concept, which uses property charts to identify optimal materials for a given application[119].

Since 2010, Granta Design has received Innovate UK funding for four projects, covering lightweight vehicle structuring, aerospace industrial strategy and technologies, and materials and manufacturing[120].

Working with Cambridge University Engineering Department and Department of Materials Science & Metallurgy, the company develops new engineering databases and product concepts, with frequent PhD exchanges, post-doctoral level research and internship opportunities for students[121]. Across education and training more broadly, Granta's CES EduPack provides teachers and students with industry-standard data and data handling tools for materials information in the fields of engineering, design and science[122].

Source: Based on evidence provided to the East of England Science and Innovation Audit, and a website review

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[111] See http://www.matthey.com/innovation/research_and_development-/about_our_r_d
[112] Granta Design website, *History* (accessed via: https://www.grantadesign.com/company/history.htm)
[113] Granta Design Website, *Mission* (accessed via: https://www.grantadesign.com/company/mission.htm)
[114] Granta Design website, *Education* (accessed via: https://www.grantadesign.com/education/)
[115] Granta Design website, *Ownership* (accessed via: https://www.grantadesign.com/company/partners/investors.htm)
[116] Granta Design website, *Granta Consortia & Projects* (accessed via: https://www.grantadesign.com/consortia/)
[117] TenLinks website, *Granta Design Announces GRANTA MI v10*, December 2016 (accessed via: http://www.tenlinks.com/news/granta-design-announces-granta-mi-v10/)
[118] Granta Design website, *Granta for Industry*, (accessed via: https://www.grantadesign.com/solutions/index.htm)
[119] Granta Design website, *History* (accessed via: https://www.grantadesign.com/company/history.htm)
[120] Innovate UK data on funded projects from 2010/11 to March 2017, analysed by SQW
[121] Granta Design website, *Ownership* (accessed via: https://www.grantadesign.com/company/partners/investors.htm)
[122] Granta Design website, What is CES EduPack? (accessed via: https://www.grantadesign.com/education/edupack/index.htm)

5.14 Across AM&M, these different constituencies are working together in respect of many of the trends and drivers identified in Table 5-1 above. Evidence provided to the SIA for example suggested that in relation to sustainable business and construction:

> *"The region has already attracted a significant proportion (35-40%) of UK government funding for TRL 1-6[123] R&D into these topics in the last 10 years through a portfolio of collaborative programmes involving industry, RTOs and academe. This has resulted in an increasing number of real asset exemplars which allow further evaluation to support the development of transferable innovation and business models in both the UK and internationally"[124]*

5.15 This observation is corroborated by the data in Table 5-2 which show the three largest participants in research projects across six domains of direct relevance to AM&M, as defined here. Two points stand out. First, there is a wide mix of innovation actors – RTOs, universities, private companies (ranging from multi-national companies to SMEs) and local authorities. Second, the spatial distribution of project participants in funded innovation projects is heavily skewed towards Cambridge, other than in relation to buildings (where Hertfordshire features more strongly). Given the distribution of industrial capabilities (see below), these observations are important.

Table 5-2: Three largest project participants (by grant value) 2010/11-2014/15 from the East of England in Innovate UK projects of direct relevance to AM&M

Innovate UK Area Budget Holder / Major project participants (by grant value)	Advanced materials	Buildings	High value manufacturing	Low impact buildings	Nano-technology	Urban Living
Alquist Consulting Limited (Cambridge)				**XXX**		
Arecor Limited (Cambridge)			**XXX**			
BRE (Watford)		X		XX		X
Cambridge Environmental Research Consultants Ltd						X
DZP Technologies Limited (Cambridge)	X					
Element Energy Limited (Cambridge)						X
Ford Motor Company Limited (Basildon)			XX			
Nanomerics Limited (St Albans)					XX	
Peterborough City Council				**XXX**		
Skanska Technology Limited (Hertfordshire)		X				
Total Scientific Limited (Cambridge)					X	
TWI Limited (Cambridge)	XX		**XXX**		X	
University of Cambridge	X	X				

Key: XXX grant award of >£1m; XX grant award of £500k-£1m; X grant award of £100k-£500k
Source: Data from Innovate UK

[123] "Technology Readiness Levels" relate to technology maturity. TRL1 relates to basic research. TRL9 relates to the actual application of technology in its final form. Between TRL 6 and 7, technology moves into application
[124] Evidence submitted to the East of England Science and Innovation Audit by BRE

Local science and innovation talent

5.16 Within the East of England, there is a depth of talent in relation to AM&M, in part reflecting the teaching specialisms of the region's universities. Overall, the region produced 1,210 new graduates in mathematics, and engineering and technology in 2014/15 – although less than a third of these were in employment in the region shortly after graduation[125].

5.17 However there are skills issues and gaps, none of which is unique. As AM&M becomes more advanced and more digitised – consistent with Industry 4.0 – there is increasing demand for advanced IT skills. In this context, the comments from a consultation undertaken with a major company in the AM&M field in the course of this Audit are incisive:

> *"I would look beyond automotive. What are the most valuable skills going forward? Software skills, data management skills, automation skills, robotics, artificial intelligence, machine learning. Bringing users to new services through a smart compelling interface… There is a really hard set of computational skills to bring…"*[126]

5.18 This specific observation has also been translated into more general terms by industry commentators. Again in relation to automotive, for example, it has been observed that:

> *Many of the new features going into cars require the expertise of software engineers, who by and large prefer the ostensibly more dynamic work environments of Silicon Valley start-ups to those of the automotive industry"*[127]

5.19 Similar issues – and challenges – are writ large across all four of the vertical sectors that define AM&M.

Local industrial strengths and capacities

5.20 The region's business base across AM&M is diverse, differentiated and spatially distributed. The table below draws on data from BRES to measure employment in sectors that might be defined as "advanced materials and manufacturing" (recognising that SIC-code mapping is inevitably imperfect). At face value, it points to four main hubs region-wide (although these are loosely defined); importantly, these are consistent with the pattern of private sector R&D spend reported in Figure 5-2. One relates to south Essex – which is home to Ford's major technical testing facility and has long been recognised as one of the region's industrial heartlands. A second relates to the Cambridge area – which includes, for example, a group of composites businesses in and around Huntingdon, as well as some major aerospace and design engineering companies (and noting that the major technical consultancies will be included in these data). A third relates to the A1(M) corridor, which has long been the primary focus of the region's aerospace and defence sector, particularly through Airbus and MBDA. The fourth is smaller, but identifiable through the data, and it relates to the east coast of Norfolk (Great Yarmouth especially) and Suffolk, which is home, *inter alia*, too much of the region's on-shore activities linked to offshore renewable energy. Locally, Peterborough also has important strengths in related sectors.

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[125] Data from Heidi Plus (HESA)
[126] Stakeholder consultation, March/April 2017
[127] "2017 Automotive Trends: The Future depends on improving returns on capital" PwC

Table 5-3: Largest, most specialised (by location quotient), and fastest growing (by compound annual growth rate) five districts by BRES employment, with East of England Science and Innovation Audit area and England comparators, for Advanced Manufacturing and Materials (based on 2012 and 2015 three year rolling averages, i.e. 2010-2012 and 2013-2015)

Largest employment	Most specialised (LQ)	Fastest Growth (CAGR)
• South Cambridgeshire (5,900)	• South Cambridgeshire (2.7)	• North Norfolk (12.5%)
• Basildon (4,800)	• Great Yarmouth (2.2)	• East Cambridgeshire (8.1%)
• Cambridge (4,700)	• Rochford (2.0)	• East Hertfordshire (7.9%)
• Huntingdonshire (3,700)	• Stevenage (2.0)	• Southend-on-Sea (7.0%)
• Great Yarmouth (2,600)	• Basildon (1.9)	• Brentwood (6.9%)
East of England (69,900)	**East of England (1.0)**	**East of England (-0.3%)**
England (760,300)	**England (1.0)**	**England (3.1%)**

Source: ONS, Business Register and Employment Survey

5.21 These data do not include the unitary authority areas in the former county of Bedfordshire or Luton (which were within the former East of England on GOR boundaries but are outside the SIA area). Boundary issues aside, this area would in effect constitute a fifth hub – with a strong concentration of both aerospace-related and automotive expertise, and strength in depth in advanced engineering – some of which is linked to motorsport and much of which relates, directly or indirectly, to Cranfield University[128].

5.22 Underpinning these data are a series of sectoral narratives. Based principally on stakeholder evidence gathered during this Audit, reflections on "*local industrial strengths and capacities*" – and the implicit opportunities for the future (consistent with Industry 4.0, referenced above) – are summarised in Table 5-4.

Table 5-4: Local industrial strengths and capacities – and future opportunities

Aerospace and Defence	**Local strengths and capacities** • Key businesses include: Airbus Defence and Space (Stevenage); Marshall (Cambridge); KLM UK; Engineering (Norwich); MBDA (Stevenage); BAE (Marham, Norfolk); Leonardo (Basildon); Raytheon (Harlow); Selex (formerly BAE Systems Avionics, Basildon) • RAF bases – e.g. at Marham, Wittering, Molesworth, Lakenheath, Mildenhall and Alconbury – have been important historically to the sector's growth. • In and around Hatfield, the legacy of British Aerospace continues to be important. • The East of England benefits from some specialised supply chain companies, particularly in relation to composites. **Future opportunities** • Potential opportunities to localise parts of the supply chain within place-based clusters to encourage open innovation – although to be tested. • Possibilities relating to the use of advanced materials linked to aerospace in all sorts of medical devices – convergence is key.

[128] See *"The evolution of the high performance technology and motorsport cluster"* by SQW (2016) for MEPC and a wider group of partners and stakeholders. It provides a detailed description of the evolution of a cluster which is defined around Silverstone but extends across Central Bedfordshire and draws substantially on the area's underpinning credentials in relation to aerospace and the key role of Cranfield University. It provides detailed case studies of various businesses that are relevant to the AM&M Theme – perhaps most notably Hybrid Air Vehicles (near Bedford)

Automotive	**Local strengths and capacities** • Key businesses include Ford (Basildon); Lotus (Norwich); Cosworth (Cambridge); Ricardo's Control and Electronics Technical Centre (Cambridge) • Industrial specialisms identified within the region include: lightweight structures; vehicle dynamics; engine design; and composites. **Future opportunities** • Possibilities relating to the use of advanced materials linked to automotive in all sorts of medical devices – convergence is key. • Advanced manufacturing within automotive is being transformed through data.
Building and construction	**Local strengths and capacities** • Key businesses include: Higgins (Essex); Skanska (Hertfordshire); Willmott Dixon (Hertfordshire); Vinci (Hertfordshire); Volker Fitzpatrick (Hertfordshire): Sir Robert MacAlpine (Hertfordshire): Countryside Properties Plc (Essex); Galliard Homes (Essex); Halsbury Homes (Norfolk); Hopkins Homes (Suffolk). • The sector is fragmented, although it is a major employer and it is growing quickly. • The Envirotech Enterprise Zone in south west Hertfordshire will support the growth of sustainable construction businesses; new construction industry training centre at WATA Huntingdon. **Future opportunities** • Development of certified products and processes to extend and optimise the use of appropriate materials combinations that can be manufactured affordably at scale.
Offshore Renewable Energy	**Local strengths and capacities** • The Offshore Renewable Energy cluster has been mapped, particularly through the trans-national EcoWindS innovation project. The region has an established offshore energy supply cluster of more than 800 companies. The "All Energy" East of England Energy Zone sector employs more than 18,800 people and provides the broadest mix of resources for energy production and distribution in the UK. • Great Yarmouth and Lowestoft have been awarded Centres for Offshore Renewable Engineering (CORE) status by the UK Government – in recognition of the existing port infrastructure, skills, supply chain and local Government support to enable rapid growth within the offshore wind sector. • Harwich and Brightlingsea have CORE status too (as part of an enlarged South East CORE) in recognition of their role in providing specialist logistics, assembly and construction services to the offshore wind industry. • Great Yarmouth and Lowestoft Enterprise Zone will play a key role in the cluster's growth. **Future opportunities** Stakeholders have identified major opportunities which include: • developing the region as the world-leading centre for innovation in assembly, operations and maintenance, offshore servicing and logistics. • identifying 'niche' component manufacturing opportunities. • identifying and exploiting opportunities for innovation that arise through linking energy with other sectors, particularly ICT, advanced manufacturing and life sciences. • test and demonstration facilities that would support prototyping and proof-of-concept work.

Source: SQW – based on material submitted to the East of England SIA

5.23 In addition, within the East of England, it is important to recognise the relationship between all of the AM&M sectors and low carbon technologies and cleantech. This links firmly to the third (of four) future characteristics of manufacturing identified in **The Future of Manufacturing** (see paragraph 5.3) and it cuts across all four of the AM&M sectors. Moreover,

it is an area in which the East of England has genuine strengths which have been championed by organisations like Cambridge Cleantech (see Box 5-6).

Box 5-6: Cleantech in the East of England

Cleantech has been defined in terms of three broad sub-sectors – renewables, environmental and low carbon[129]. These overlap substantially with AM&M as defined here (and with Agri-tech, and there are also links to Life Sciences and ICT).

A major study of relevant sub-sectors across the East of England and London identified major businesses within the region[130]. Of particular relevance to AM&M in the East of England are:

- Low carbon buildings (building fabric and renewable energy for buildings) – e.g. Vinci, Volker Wessels
- Low carbon vehicles – e.g. Cosworth, Lighting Car Company
- Wind power – e.g. Renewable Energy Systems
- Sustainable manufacturing (low energy use, higher resource efficiency, recycling) – e.g. O-I Manufacturing Ltd

Overall, the same study estimated that low carbon, cleantech and environmental goods and services accounted for 250,000 employees and 14,000 businesses across London and the East of England.

Source: Based on evidence provided to the East of England Science and Innovation Audit

5.24 Complementing these high level sectoral perspectives are insights directly from AM&M businesses, taken from an SIA esurvey. Whilst not of statistical significance, they point to an AM&M business community across the East of England that is confident about the future and reasonably well-networked. This in turn provides an important foundation on which to build.

Box 5-7: Insights from the region's AM&M businesses

As part of the East of England SIA process, an e-survey was conducted across AM&M businesses. It generated 34 completed responses. The responding businesses were mostly SMEs – although three employed more than 500 people locally and 11 employed between 100 and 500. The businesses varied hugely in terms of longevity – the oldest was formed in 1850 and the newest was set up in 2013; in total, nine had been formed in 2000 or later. Responding businesses were distributed across the region – although eight had Peterborough postcodes and seven had a Norwich postcode. Sectorally, the businesses were diverse; five linked themselves to the "*energy sector*" and four to "*general engineering*", but 20 identified themselves as "*other*".

Most of the 34 businesses were engaged in some level of collaboration. Some 26 claimed to benefit from "*informal collaboration and networking with other Advanced Manufacturing and Materials businesses*" and 26 said they benefited from "*informal collaboration and networking with researchers from universities and research organisations*".

In general, "*partners elsewhere in the UK*" were the most frequent collaborators, although it did vary. Local collaborations were more in evidence than national ones in respect of *"informal collaboration and networking with researchers from universities and research organisations*". Some 16 said they engaged in "*informal collaboration and networking with other Advanced Manufacturing and Materials businesses*" from outside the UK.

Overall, 24 businesses considered themselves – more-or-less strongly – to be "*part of a community of Advanced Manufacturing and Materials researchers, businesses and innovators*".

In general, businesses were positive about growth prospects: 24 expected their headcount to grow over the next three years.

Source: SQW – based on responses to an esurvey of AM&M businesses in the East of England, March/April 2017

5.25 Finally, it is important also to recognise the role played by different organisations in facilitating parts of the AM&M innovation ecosystem. Elements of this relate, simply, to the provision of business space. But in both examples below – one focused on automotive and the second on offshore renewables – the role of the two organisations is considerably greater.

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[129] Greater Cambridge Cleantech Action Plan, published May 2010, available at http://www.cambridgecleantech.org.uk/definition-of-cleantech

[130] "*Sector Profile: Low carbon, cleantech, and environmental goods and services*" (Draft report) – part of the review of key sectors in the London – Stansted – Cambridge Corridor (October 2014) – page 4

Resources of this nature are an integral part of the region's local industrial strengths and capacities.

Box 5-8: Supporting Advanced Materials and Manufacturing in the East of England

A: Hethel Engineering Centre

With support and investment from Norfolk County Council, South Norfolk Council, New Anglia LEP and Group Lotus[131], Hethel Engineering Centre was established in 2006 to provide workspaces and conference facilities to businesses focused on innovation in the engineering and manufacturing sector in the East of England[132].

Over the last 10 years, the centre has worked with 155 new start-ups and incubated 180 businesses with 89% of start-ups still operating after 5 years[133]. At present, the centre is home to about 45 companies working across engineering and manufacturing industries[134].

In 2010, Hethel Engineering Centre and Norfolk County Council established Hethel Innovation Ltd, which received a £7.3m grant from the European Regional Development Fund 2010-2015 to build the 40,000 sqft Low-Carbon Advanced Manufacturing Centre (LCAMC) at Hethel Engineering Centre. Completed in 2014, the site consists of 2,500 and 5,000 sqft units which can accommodate 8-12 manufacturing businesses[135]. Hethel Innovation also provides business-support as part of the Innovation New Anglia programme[136].

B: OrbisEnergy

Based in Lowestoft, Suffolk, OrbisEnergy is a hub for companies working in the offshore renewable energy industries. Opened in 2008, the hub's principal asset is a £9.4m 3,300sqm five-storey building that provides office accommodation, meeting rooms and conference facilities, with virtual tenancy also available. The project received funding from the East of England Development agency, the European Union and Waveney District Council.[137] At present, about forty companies are based at OrbisEnergy[138].

In partnership with Nwes, Nautilus Associates and the Offshore Renewable Energy Catapult, OrbisEnergy is delivering the £6m SCORE programme, which is part funded by the European Regional Development Fund. SCORE provides grants of between £2,500 and £50,000 for up to 40% of eligible costs to SMEs developing new technologies in offshore renewable energy that will generate economic benefits in Cambridgeshire, Essex, Norfolk or Suffolk.[139] OrbisEnergy is also working in partnership with New Anglia LEP, Suffolk County Council and Finance East to deliver Growing Business Fund grants, which provide between £5,000 and £500,000 to businesses seeking investment in capital, skills or new staff in the local area.[140]

Source: Based on evidence provided to the East of England Science and Innovation Audit

National and international engagement

5.26 Within the East of England, the AM&M sector is strongly – if perhaps inconsistently – networked at local, regional, national and international levels.

5.27 Many of the key businesses and research organisations within the sector – including relatively small ones – are **internationally connected**. Some (e.g. Airbus, Ford) are part of multinational companies which have headquarters outside of the UK. Many are involved in international research collaborations. Most are trading outside of the UK. It is worth noting also that there are wider patterns of international engagement that extend beyond the scope of individual organisations (whether firms, universities or research institutions). One

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[131] Hethel Engineering Centre website, *Our Partners* (accessed via: http://hethelcentre.com/about/our-partners/)
[132] Hethel Engineering Centre website, *About Us* (accessed via: http://hethelcentre.com/about/)
[133] Hethel Engineering Centre website, *Homepage pop-up banner* (accessed via: http://hethelcentre.com/)
[134] Hethel Engineering website, *Our Tenants* (accessed via: http://hethelcentre.com/about/our-tenants/)
[135] Hethel Innovation website, *Hethel Innovation ERDF Project 2010-2015* (accessed via: http://hethelinnovation.com/hethel-innovation-erdf-2010-2015/)
[136] Hethel Innovation website, *Support* (accessed via: http://hethelinnovation.com/support/)
[137] The Lowestoft Journal, *£9.4m Orbis Energy Centre opened*, November 2008 (accessed via: http://www.lowestoftjournal.co.uk/news/9-4m-orbis-energy-centre-opened-1-507953)
[138] OrbisEnergy website, *Tenants* (accessed via: http://www.orbisenergy.co.uk/tenancy/tenants/)
[139] SCORE Programme website, '*What's the big idea'* (accessed via: http://www.scoregrants.co.uk/)
[140] OrbisEnergy website, '*Growing Business Fund'* (accessed via: http://www.orbisenergy.co.uk/funding-grants/growing-business-fund/)

example, referenced already, is the collaborative R&D project (funded under Framework Programme 7), ECOWindS (European Clusters for Offshore Wind Servicing); this used a smart specialisation approach to map four partner regions/countries using the EU's RIS3 methodology.

5.28 The volume of engagement **within the UK but outside the East of England SIA area** is also substantial. In many respects, the economic footprint of the AM&M sector extends from south Essex and old-East Anglia, through Hertfordshire and Cambridgeshire, and then west into former-Bedfordshire, Northamptonshire, Oxfordshire and the Midlands. This wider area is essentially where manufacturing excellence "meets" engineering and (increasingly) digital capabilities (discussed in Chapter 6) and it defines a crucial functional economic geography for the UK as a whole; elements of it are discussed in the Midlands Engine Wave 1 SIA report. Companies like Cosworth illustrate why this is so[141], and Cranfield University sits at its functional core.

5.29 Levels of **local engagement** are variable. Parts of the AM&M sector function as local clusters – offshore renewable energy is one (around Great Yarmouth and Lowestoft), inkjet printing (around Cambridge) is a second, and composites (in the Huntingdon area) is a third. But other elements are much less "cluster-like". Within the East of England, there is limited evidence (to date) of clustering linked to sustainable construction, or aerospace, or mainstream automotive. These could, potentially, benefit from more active local networks and collaborations.

5.30 However there are examples of bilateral collaborations between specific businesses and universities in the AM&M field. For example, in 2016, Marshall Aerospace and Defence Group signed a memorandum of understanding with Cranfield Aerospace Solutions (owned by Cranfield University) to cover various aspects of aerospace and aviation engineering[142].

Developments in the wider funding landscape

5.31 Within AM&M, spin-outs and start-ups – particularly in the Cambridge area – continue to attract early stage investment funding, from business angels and venture capitalists, and through Government-backed schemes. Recent examples include Immaterial Labs – a nanomaterials spin-out from the University of Cambridge – which received £300k from the Energy Catalyst (backed in part by the High Value Manufacturing Catapult)[143]; while Cambridge Innovation Capital recently invested in both PragmatIC Printing (flexible electronics) and PervasID (a spin-out from the Engineering Department)[144].

5.32 There are various local programmes supporting small manufacturing businesses. One example is a £9.7m Manufacturing Growth Programme which is funded through ERDF, delivered by Economic Growth Solutions, and available region-wide. In principle, its funding can be used for R&D, lean manufacturing and productivity and capacity building.

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[141] See the detailed case study of Cosworth in "*The evolution of the high performance technology and motorsport cluster*" Report by SQW, commissioned by MEPC and partners, May 2016
[142] "*Marshall Aerospace and Defence Group signs MoU with Cranfield Aerospace Solutions",* press release, 1st December 2016
[143] *"Cambridge spin-out shared in £19m Energy Catalyst award"* Business Weekly, 6th December 2016
[144] *"Cambridge Innovation Capital commits £19m across latest six investments"* Business Weekly, 3rd November 2016

5.33 However, for the most part, funding for research and innovation is dependent on the mainstream national funding bodies, particularly the Research Councils and Innovate UK. In this context, there is much speculation as to the likely outcomes from the consultation on the Industrial Strategy Green Paper and the full possibilities linked to the Industrial Strategy Challenge Fund.

Conclusions – and future potential

5.34 A report completed for Anglia Ruskin University across the East of England examined advanced manufacturing region-wide and it concluded that:

> *"The cluster's innovation ecosystem for advanced manufacturing is among the best in the UK as measured by grants from Innovate UK and expenditure on R&D. The presence of internationally recognised organisations such as TWI and IfM drive the region's R&D base. The cluster has a customer base for a range of advanced manufacturing products, e.g. medical devices. The region has a broad range of advanced manufacturing and innovation assets and benefits from close proximity to London and logistics networks"*[145].

5.35 The evidence gathered through the Science and Innovation Audit is largely supportive of these conclusions: the region does have strong scientific capabilities and innovation assets across the ambit of AM&M. Whether it is making the most of them is, however, another matter. In the context of the **Future of Manufacturing** Foresight report – mentioned at the start of this chapter – Professor Sir Mike Gregory (then-Head of the Institute for Manufacturing at the University of Cambridge) commented that *"meeting the implied challenges will require radical new approaches which cross traditional disciplinary and institutional boundaries"*[146]. He therefore largely anticipated the AM&M hypothesis that has shaped this Audit.

5.36 In this context, the following overarching conclusion can be drawn. In general, the region's world class research strengths are nationally and internationally focused, across universities, RTOs and private sector players (such as the major technical consultancies). While innovation networks associated with these resources have been spectacularly successful on a localised basis (most notably in and around Cambridge), cross-regional links are underdeveloped and the region certainly has "cold spots"; comparing Table 5-1 and 5-2 demonstrates the disconnect in some parts of the region. To a far greater extent than is the case for other Themes, AM&M is a region-wide sector in terms of the distribution of businesses. The inference, then, is that there is scope for more widespread technology transfer to new and existing businesses, particularly in those parts of the region which are some distance from the principal research hubs.

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[145] *Need and Demand Analysis for Innovation Support in the Advanced Manufacturing Sector,* Report to Anglia Ruskin University by PACEC (2016)
[146] *The Future of Manufacturing: The new era of opportunity and challenge for the UK – Summary Report.* Foresight (2013), Government Office for Science, London

5.37 The challenge in addressing this is to find methods of growing world class research and innovation capability while at the same time improving linkages to regional industry. This demands action across the entire innovation value chain. The data indicate that there is scope to develop better links between organisations, exchange models of operation and expertise and engage in collaboration to collectively improve regional capability. To do so would involve strengthening links between academic centres, supporting these with enhanced IT capability and making the resulting expertise and innovation potential available to technology hungry companies. The priority interventions that have been identified in response are set out in Chapter 7.

6. Theme 4: ICT

Chapter Summary

- The ICT innovation ecosystem is the product and source of globally competitive businesses like ARM and HP Autonomy – and the excellence of research within it has attracted inward investment from many global ICT businesses (e.g. Microsoft, Huawei, Apple, Google, IBM).
- It is underpinned by outstanding research in the region's universities. The University of Cambridge's Computer Laboratory has been a prolific source of spin-out businesses and the Cavendish Laboratory is significant too. The University of Essex, University of Hertfordshire, University of East Anglia and Anglia Ruskin University also bring considerable research excellence, including in emerging specialisms such as predictive analytics, deep learning, pervasive Internet-of-Things, resilient converged digital network management, and on-line digital gaming and animation. Moreover specialist institutions – notably the Earlham Institute on Norwich Research Park – are major contributors to the asset base.
- There is a large established cluster of activity in Cambridge, and emerging ones elsewhere – notably in and around both Norwich and Ipswich (including Adastral Park, which is home to BT's Global Research and Development HQ and Innovation Martlesham). There is also significant ICT employment in both Hertfordshire and Peterborough.
- There are two major constraints to growth. One relates to the shortage of people who are skilled in "real computer science". The second relates to the ICT infrastructure connecting the region's universities, research institutes and science parks; and in this context, there is scope in the region for a scaleable network test-bed for a new generation of data-intensive research and smart technology trials linked to health sciences, advanced manufacturing and agri-tech.

Scope – and core hypothesis

6.1 Through **ARM Holdings** and **HP Autonomy**, the innovation ecosystem in the East of England has created two of the most influential ICT businesses in the world. Partly as a result, it has attracted substantial interest from some of the most powerful and acquisitive global corporations: **Microsoft, Huawei, Apple, Amazon, Google** and **IBM** are examples. The underpinnings of the innovation ecosystem rest with foremost science – particularly in the **Computer Laboratory** and **Cavendish Laboratory** at the **University of Cambridge**. However, the **University of Essex, University of East Anglia, Anglia Ruskin University** and **University of Hertfordshire** also have considerable expertise, not least in emerging specialisms such as predictive analytics, deep learning, pervasive Internet-of-Things, resilient converged digital network management, and on-line digital gaming and animation. In addition, at **Adastral Park** are both **BT's Global Research and Development HQ** and the core infrastructure linked to the digital superhighway – and this too has attracted substantial international investment. Key elements of the innovation ecosystem within the region are summarised in the graphic below.

Figure 6-1: Summarising the East of England's Innovation Ecosystem in ICT

Source: SQW – drawing on information gathered through the SIA process

6.2 Within this context, the ICT Theme spans seven main elements: **software development (including gamification); digital creative; data analytics and data science; electronics and components; machine learning and AI; robotics and autonomous systems; quantum technology; telecommunications; and smart technology**.

6.3 Evidence relating to the region's scientific research strengths and innovation capabilities in these domains is presented in this Chapter. It is used to test the hypothesis set out below:

> *The ICT sector has seen rapid growth in the East of England, and it benefits from a very strong scientific asset base with a number of recognised ICT clusters. The market is evolving quickly and the demand for digital innovation is relentless. To capitalise, there ought to be greater collaboration across the region to accelerate academic and industry research and innovation activities. As part of this, a high-performance ICT infrastructure interconnecting the key universities and science parks would provide the foundation for pan-region ICT research and innovation that would enable the East of England to consolidate and strengthen its world-class position.*

National and international trends, and size of global markets

6.4 Digital technologies – the product of the ICT innovation ecosystem – are transforming economic, social and cultural life quickly and profoundly. Drawing on published reports by industry commentators (e.g. Deloitte, EY and Accenture) and on stakeholders' responses to the East of England Science and Innovation Audit ICT survey, Box 6-1 below provides a perspective on near term (Internet of Things, autonomous agents, and augmented/virtual reality[147]) and more distant (cognitive/quantum computing[148]) trends and drivers. This

[147] Drawn from responses to the East of England Science and Innovation Audit questionnaire, East of England SIA Consortium, March 2017
[148] *Emerging Technology Trends: the road to the bank of the future*, EY, 2015 (accessed via: http://www.ey.com/Publication/vwLUAssets/EY_-_Emerging_technology_trends/$FILE/EY-emerging-technology-trends.pdf)

summary is not exhaustive but it provides some sense of the global momentum that is shaping an innovation ecosystem that must be recognised as intrinsically and increasingly "restless".

Box 6-1: Technology and market-based trends and drivers which are shaping the ICT ecosystem in the East of England

- **Internet of Things (IoT)** – following early-stage advances in wearables and connected electronics – including the Smart Cities agenda in the public realm – IoT growth is now expected to be driven by B2B applications, with 30bn connected 'things' generating a revenue opportunity of $1.7tr by 2020[149]. However, challenges include developing technology across common rather than exclusive proprietary platforms, and reconciling IoT with personal and data security[150].
- **Augmented/Virtual Reality (AR/VR)** – as AR/VR products reach a tipping point in terms of price and capability in consumer markets, commercial and research applications are likely to broaden as businesses are able to blend real and virtual worlds to develop training scenarios and remote experiences[151]. Interactions with the Internet of Things will allow AR/VR (known as Mixed Reality) to have wide reaching application; this could include a step-change in workers' relationships with increasingly automated workplaces, as smart goggles provide metrics and support when interacting with robots and machines[152].
- **Autonomous Agents** – with the rise of autonomous vehicles capturing headlines – including public-road pilots of vehicles such as Waymo by Google in the US[153] - autonomous agents, understood as technology that can act by itself, are expected to play increasingly important roles in the economy, with opportunities to develop solutions in the workplace and more social interactions, including social-care[154]. With short-term creep towards autonomous agents (e.g. 'Smart' tech such as Siri, Cortana, Google and Amazon's Alexa) showing the opportunities for assisted decision making, longer-term opportunities for Artificial Intelligence and non-human decision-making will be significant. However there will also be a series of ethical and regulatory challenges to navigate.
- **Cognitive Computing** – highlighting the interrelationships between ICT technologies, the expansion of IoT presents new challenges and opportunities in the field of cognitive computing, as Big Data and the overlap of multiple data streams open up possibilities for AI and other machines to respond to their environment without human intervention[155].
- **Quantum Technologies** – BT and partners Toshiba Research Europe, ADVA and NPL have demonstrated practical application of Quantum Key Distribution in securing communications[156]. As the processing power of supercomputers increases to previously unimaginable levels, challenges that could be addressed by such technologies include medicine personalised at the genetic level, climate science simulations and a revolution in the application of technology to probabilistic reasoning in statistics[157]. However, these opportunities also raise regulatory and security challenges, as (for example) the application of quantum computing to finance will make traditional encryption techniques redundant, requiring new cyber-security algorithms[158].

Source: SQW – based on responses to the East of England SIA ICT survey; and on published reports

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[149] *Connecting the IoT: the road to success*, IDC infographic (accessed via: http://www.idc.com/infographics/IoT/ATTACHMENTS/IoT.pdf)
[150] *Top 5 Internet of Things trends for 2017*, IBM, January 2017 (accessed via: https://www.ibm.com/blogs/internet-of-things/iot-2017-trends/)
[151] *Gartner's Top 10 Strategic Technology Trends for 2017*, Gartner, October 2016 (accessed via: http://www.gartner.com/smarterwithgartner/gartners-top-10-technology-trends-2017/)
[152] p50, *Tech Trends 2014: Inspiring Disruption*, Deloitte University Press, 2014 (accessed via: https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Technology/gx-cons-tech-trends-2014-inspiring-disruption.pdf)
[153] *On the Road*, Waymo website (accessed via: https://waymo.com/ontheroad/)
[154] *Top 10 Tech Trends, Autonomous Agents and Things*, ConRes IT Solutions, Feb 2016 (accessed via: https://www.conres.com/it-products-solutions/news-events/top-10-tech-trends-autonomous-agents-things/)
[155] *Top 5 Internet of Things trends for 2017*, IBM, January 2017 (accessed via: https://www.ibm.com/blogs/internet-of-things/iot-2017-trends/)
[156] See http://home.bt.com/tech-gadgets/future-tech/bt-and-toshiba-launch-uks-first-quantum-communication-showcase-11364104924789
[157] *Tech Trends 2014: Inspiring Disruption*, Deloitte University Press, 2014 (accessed via: https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Technology/gx-cons-tech-trends-2014-inspiring-disruption.pdf)
[158] *Emerging Technology Trends: the road to the bank of the future*, EY, 2015 (accessed via: http://www.ey.com/Publication/vwLUAssets/EY_-_Emerging_technology_trends/$FILE/EY-emerging-technology-trends.pdf)

Local science and innovation assets

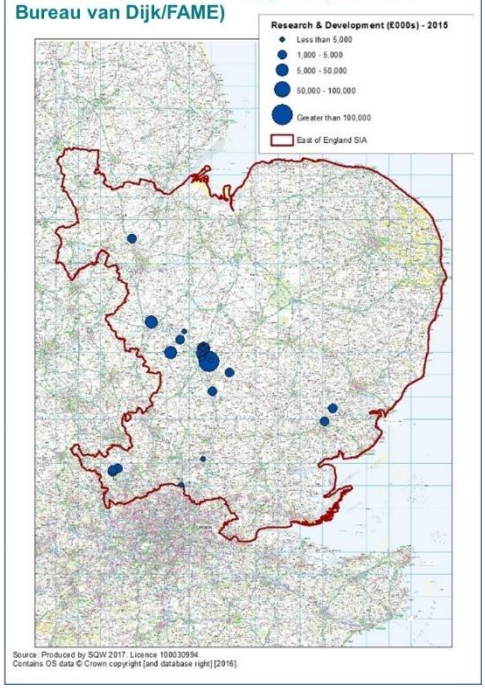
6.5 Within this context, the East of England is home to substantial science and innovation assets. These include, *inter alia:*

- **Four universities which all score well through the Research Excellence Framework (2014) in terms of research power in computer science and informatics.** These are the University of Cambridge (ranked 4th); the University of Essex (ranked 18th); the University of Hertfordshire (ranked 34th); and the University of East Anglia (ranked 39th). In terms of **grade point average (GPA)**, the University of Cambridge was ranked 6th, UEA was 23rd, University of Essex was 36th, and the University of Hertfordshire was ranked 61st nationally. It is also important to note that many of the engineering-related research strengths (reported in the context of AM&M) are directly relevant in the ambit of ICT.

- **Sustained investment in Information and Communications Technologies research.** According to Gateway to Research, UK Research Council investment in ICT research in the East of England summed to £73m between 2004 and 2016. To this should be added €16.5m secured through FP7/Horizon 2020 (source: E-Corda).

- **Significant investment in R&D by private sector ICT companies**. Based on data from Bureau van Dijk's FAME database, ICT companies registered in the East of England invested nearly £420m in R&D in 2015 alone – which clearly dwarfs research funding from either UK government or EU sources. The overall profile is strongly influenced by one company: ARM Holdings. However, in addition, it is important to reflect on the scale of investment in R&D in the region from private sector companies with registered addresses elsewhere. BT is one example. It spends more than £210m on salaries alone and its overall contribution to the region is greater again if capital expenditure is factored in fully.

Figure 6-2: Map showing private sector R&D spend by ICT companies with registered addresses in the East of England (data from Bureau van Dijk/FAME)



- **A substantial share of UK patents in key ICT-related technology areas**. Based on European Patent Office data, between 2004 and 2014, inventors from the East of England accounted for over 17% of all UK patents in each of "*computer technology*" and "*telecommunications*"; 15% in "*audio-visual technology*"; and 14% in "*digital communications*".

6.6 Underpinning these data, the East of England's science capabilities and innovation assets need to be understood in more granular terms. The ICT innovation ecosystem is spatially more dispersed than those in some other Themes (notably Life Sciences) but there are still major concentrations within it as Figure 6-2 above bears out.

6.7 In describing it, the formative role of the **Computer Laboratory at the University of Cambridge** was widely acknowledged by most contributors to the ICT Audit process. This role relates both to the excellence of its research and the extent of its commercial reach – both through collaborations with global ICT businesses since the 1980s (i.e. much earlier than most other UK universities) and the volume and quality of spin-out businesses. Counted within its "Hall of Fame" are ARM Holdings, Acorn and Jagex from among a list that tops 200. In addition, the University's **Centre for Scientific Computing** is a key resource and part of the **Cavendish Laboratory (Department of Physics)**. The **Department of Engineering** is also home to much ICT-related research, and the Electrical Engineering and Information Engineering Divisions are especially relevant (noting that one of HP Autonomy's founders completed his PhD in Signal Processing in Information Engineering; and many IT-based companies (such as Google, MSR, Amazon and Facebook) have strong links with the Department of Engineering). A synopsis of computing research at the University of Cambridge is provided in Box 6-2.

Box 6-2: Computing at the University of Cambridge

A: Computer Laboratory

The Computer Laboratory is an academic department within the University of Cambridge.

Its research specialisms span computer science, engineering, technology and mathematics. Its current research areas include bioinformatics, computer architecture, computer vision, distributed systems, graphics and human-computer interaction, logic and semantics, machine learning, natural language processing, networking and wireless communication, operating systems and virtualization, programming, security, and sustainable computing.

The Computer Laboratory was founded in 1937 (as the Mathematical Laboratory) for work on mechanical calculators and analogue computers. It became involved in digital computing after 1945. In 1980, Professor Roger Needham became head of the laboratory. Towards the end of his tenure, a benefaction was secured from the William Gates Foundation for a new building on the West Cambridge site. Subsequent heads have been Professor Robin Milner, Professor Ian Leslie (later pro-vice chancellor) and Professor Andy Hopper, who has also been a prolific entrepreneur.

The history of the Computer Laboratory is integrally related to the history of the ICT cluster in and around Cambridge, and indeed globally. Since the 1980s – and subsequently – it has had close links to global ICT businesses (e.g. Olivetti, Hitachi, Microsoft). Moreover, it has been estimated that the Computer Laboratory has been the source of at least 200 companies; one of these was formed in the 1960s, six were set up in the 1970s, 22 were formed in the 1980s, 66 in the 1990s, and more than 100 were formed between 2000 and 2012. These have included:

- **Acorn Computers**, founded by Hermann Hauser and Christopher Curry in the late 1970s, and from which **ARM Holdings** was eventually founded in 1990; ARM Holdings was acquired by SoftBank for £24.3bn in 2016
- **RealVNC**, founded in 2002, to provide Virtual Network Computing remote access technology; 300 million licences were subsequently sold across 175; and the company was included in ERF 2014 as an impact case study
- **Jagex**, founded in 2001, with a focus on computer games; Jagex now employs over 300 people in Cambridge; in 2016, it was acquired by Chinese investors
- **Ubisense**, which was founded by Professor Andy Hopper in 2002 and floated on AIM with a valuation of £38.6m in 2011; it was included in REF 2014 as an impact case study
- **X3nSource** was formed in 2005; it was acquired in 2007 by Citrix Systems for US$ 500 million; it was included in REF 2014 as an impact case study
- **Raspberry Pi Foundation**, formed as a charity in 2008, to develop computer-related skills

B: Cavendish Laboratory (Department of Physics)

The Department of Physics operates on a devolved research basis through 15 Research Groups, several of which have interests in computing. One of these is the **Centre for Scientific Computing**. Its research is funded mainly through industry collaborations, notably with Jaguar Land Rover and BAE Systems. In 2013, for example, it was announced that the Laboratory for Scientific Computing would be part of a £10m virtual engineering research programme focused on high performance computing, alongside EPSRC and JLR. In 2017, it was announced that the University of Cambridge will be one of six High Performance Computing centres, funded with £5m. Working with several other universities and the Alan Turing Institute, this will *"provide large-scale simulation and high performance data analytics designed to enable advances in materials science, computational chemistry, computational engineering and health informatics"*[159].

The **Toshiba Research Laboratory** (founded in 1991) and the **Hitachi Cambridge Laboratory** (founded in 1989) are also linked to the Cavendish.

Source: SQW, based on "Cambridge Computing: The first 75 years" Haroon Ahmed (2013), University of Cambridge; the Computer Laboratory website (www.cl.cam.ac.uk); various other websites; and the Research Excellence Framework (2014) database of impact case studies

6.8 However, the ICT narrative in the East of England is not just about Cambridge. Digital technologies are underpinned by the centre of excellence within the University of Cambridge but augmented by, for example, the Artificial Intelligence research groups at the University of Essex, the Earlham Institute, the Agri Metrics Centre at Rothamsted and the major Tier One ICT providers clustered in the region.

6.9 As intimated in paragraph 6.5, there are four universities with significant research strengths in relevant fields. In relation to robotics, Sir Andrew Witty identified the University of Cambridge as the 6th strongest organisation nation-wide; the University of Essex came 7th; and the University of Hertfordshire was ranked 8th[160].

6.10 The **University of Hertfordshire** is a "post 1992" institution. Its specialisms in this – and related fields – are summarised in Box 6-3. The excellence of these was acknowledged through business consultations which were conducted as part of the SIA process. One major Cambridge-based gaming company – which has raised substantial funding, employs over 300 people and is listed on AIM – commented that "*those two universities (University of Cambridge and University of Hertfordshire) are excellent. They are both world-leading in their field. Computer science and digital arts in the University of Hertfordshire's case are very strong"*[161].

Box 6-3: University of Hertfordshire – robotics, games and visual effects

Games and Visual Effects Research Laboratory

The Games and Visual Effects Research Laboratory (G+VERL) is a part of the University of Hertfordshire's Creative Economy Research Centre (CERC) – a multidisciplinary hub for research and business engagement in sectors across the creative industries including film and TV, the dynamics of virtual work, games and VFX, and local heritage[162].

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[159] "*Six High Performance Computing centres to be officially launched*", EPSRC Press Release, 27th March 2017
[160] *Encouraging an invention revolution: Sir Andrew Witty's review of universities and growth.* September 2013
[161] Consultation conducted with businesses and stakeholders as part of the East of England SIA ICT evidence gathering process, March 2017
[162] *Creative Economy Research Centre*, University of Hertfordshire website (accessed via: http://www.herts.ac.uk/cerc)

With a research focus on new methods and techniques for VFX in film and TV, and developing new understandings and paradigms in games, G+VERL is housed in the University's purpose built Film, Music and Media Building. Lab facilities at the site include a motion capture studio full service post-production, 4K cameras and software tools covering Maya, Nuke and the Oculus Rift virtual reality platform[163].

Working with industry – with local SMEs able to access the lab's facilities – G+VERL's recent projects include collaborations with Firepanda and Rewind FX in St Albans to apply virtual reality techniques to medical imaging and developing a 360-degree virtual tour of Elstree Film Studios. The lab also collaborated with British artist Daren Johnson to construct an immersive virtual reality experience at the Barbican Theatre in London[164].

Robot House and the Adaptive Systems Research Group

Based in a suburban house in Hatfield, the Adaptive Systems Research Group's Robot House is home to a range of robots designed to care for people in their home, with the aim of observing how people and machines interact in everyday life. Purchased in 2005, the robots at Robot House include the CareRobot, a medication scheduling/dispensing robot, Sony Aibo robotic dogs[165] and the University's own social robot Kaspar, which is involved in a £250,000 clinical study funded by the National Institute for Health Research to understand the robot's efficacy in supporting children with autism[166].

Building on the asset's existing research potential, a recent £600,000 award from the EPSRC will be used to upgrade to Robot House 2.0. Adding smart home functionality to the house, the grant will also fund a range of new robots, including the modular care-o-bot 4 and less expensive, smaller platforms such as Pepper robot, Turtlebot 2 and Fetch[167] that enable new scenarios and application areas to be tested. Robot House 2.0 builds on the Adaptive Systems Research Group's history of collaboration with other research institutions and industry partners, which have included EU-wide higher education institutions, global robotics companies, NHS trusts and local authorities, with the ambition of Robot House 2.0 becoming a hub for other stakeholders to research smart home and robotics technology[168].

More broadly, other ICT and computing assets at the University of Hertfordshire include the Smart Systems Laboratory, the Cyber Security Centre, the Machine Learning and Biocomputation Research Group, and the Optical Networks and Wireless Laboratory[169].

Source: Evidence submitted to the East of England Science and Innovation Audit

6.11 The **University of Essex** has strengths linked to data analytics. Its School of Computer Science and Electronic Engineering is ranked 8th in the UK for computer science[170], and it has strength in depth in gaming, robotics and AI. The University hosts the UK Data Archive and the ESRC's Business and Local Government Data Research Centre. It has a long pedigree in relation to politics and – combining the two – it is the lead partner in a £5m ESRC-funded project concerned with smart data analytics for business and local government. Historically, the University of Essex has not had a strong infrastructure to support commercialisation processes and hence its role within the innovation ecosystem in the East of England has been quite limited. However, this is changing. The Knowledge Gateway is being developed and an on-campus Innovation Centre is due to open in 2018 (Box 6-4). In addition, the University is actively engaged in delivering innovation within businesses more broadly. It is a top ten UK university (and ranked first in London and the East of England) for delivering the Knowledge

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[163] *Creative Economy Research Centre*, University of Hertfordshire website (accessed via: http://www.herts.ac.uk/cerc/projects/verl-visual-effects-research-lab)
[164] University of Hertfordshire response to the East of England Science and Innovation Audit ICT theme questionnaire, March 2017
[165] *One day in the robot house*, New Scientist, August 2011 (accessed via: https://www.newscientist.com/article/mg21128246-600-one-day-in-the-robot-house/)
[166] University of Hertfordshire response to the East of England Science and Innovation Audit ICT theme questionnaire, March 2017
[167] *Robot House 2.0 – Infrastructure for the Study of Smart Home and Autonomous Robotic Systems*, EPSRC Details of Grant, March 2017 (accessed via: http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=EP/P020577/1)
[168] *Robot House 2.0 – Infrastructure for the Study of Smart Home and Autonomous Robotic Systems*, EPSRC Details of Grant, March 2017 (accessed via: http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=EP/P020577/1)
[169] University of Hertfordshire response to the East of England Science and Innovation Audit ICT theme questionnaire, March 2017
[170] Academic Ranking of World Universities, 2014

Transfer Partnership programme with Innovate UK. The University of Essex currently has 17 live projects, with a further ten which were successfully delivered in the last 12 months (see for example Box 6-5). The University also holds the current Innovate UK award for best UK KTP, won through a data science partnership with London-based Signal Media.

Box 6-4: University of Essex Knowledge Gateway

With an initial investment in 2010 of £12m, the **University of Essex's Knowledge Gateway** research and technology park – based in Colchester – is currently home to 20 SMEs in science, technology and the creative industries[171]. With full access to the rest of the Colchester Campus, Knowledge Gateway's assets include the Parkside Office Village, of which the second phase of development is expected to deliver 7 units (totalling more than 8,000 sq ft) by 2018, and the Essex Business School, a £21m carbon-neutral facility which opened in 2015[172]. The **ESRC's Business and Local Government Data Research Centre** is also located at the site[173]. Planning permission has been approved for a £10m 38,000 sq ft **Innovation Centre**, which aims to accommodate more than 50 start-ups from 2018[174].

In 2017, Knowledge Gateway launched the **Start-Up Hub and the Games Hub**. The former offers hot-desk facilities, mentoring and early-stage financing to student and graduate businesses[175], while the latter, which is being led by games developer Steve Huckle of Shark Infested Custard, offers a 40-week programme of training and mentoring to aspiring games and app developers[176].

Source: SQW – based on a website review

Box 6-5: Embedding a data science capability – a Knowledge Transfer Partnership with the University of Essex

Mondaq was formed in 1994. It delivers insight, opinion and commentary on legal, regulatory and financial topics across 70 countries. Mondaq has accrued an archive of more than 170,000 pieces of structured and unstructured content, with new insights being added daily. It now provides a comprehensive online resource.

The company has seen increasing demand from larger law firms (particularly in the Canadian markets) for added insight through data science and advanced analytics. Through discussion with the **University of Essex** and the **Institute for Analytics and Data Science**, it became clear that **machine learning** could support the extraction of highly valuable – and actionable – data from its constantly growing data sets. Mondaq was aware that this could be fundamental to its growth plans, and as such a collaboration (and application for funding) began.

In 2016, Mondaq and the University of Essex secured Innovate UK funding via a **Knowledge Transfer Partnership (KTP)** for a 30 month collaboration (worth more than £150k) – consulting with academics from the Department of Mathematics and the Institute of Data Analytics – including Professor Maria Fasli, the UNESCO Chair in Analytics and Data Science.

The project was designed to **embed machine learning, data analytics and data visualisation techniques within the company** to exploit the growth potential identified from its current client base. Currently, a Machine Learning post-doctoral Associate is working full time in collaboration with the Academic team to accelerate the embedding and transfer of the analytics capability.

As part of the company's data driven strategy, Mondaq's IT Director, a Senior Data Analyst and Analytics Intern, secured **incubation space** in the **University of Essex Knowledge Gateway**, relocating this function from the London Head Office. As part of the KTP, the post-doctoral Machine Learning Associate is also based within the Incubator. The space is near the university's Institute of Analytics and Data Science, ensuring cross-pollination of ideas and research support.

Mondaq operates in an international environment; it is currently a market leader for services in Canada, India, Australia and Europe, second in the UK and the fourth most used service in the US.

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[171] *Knowledge Gateway*, University of Essex website (accessed via: http://www.essex.ac.uk/business/knowledge-gateway/)
[172] *Parkside brochure*, University of Essex (accessed via: http://www.essex.ac.uk/business/documents/parkside-brochure.pdf)
[173] *Parkside*, University of Essex website (http://www.essex.ac.uk/business/knowledge-gateway/parkside/)
[174] *The Innovation Centre*, University of Essex website (accessed via: http://www.essex.ac.uk/business/knowledge-gateway/innovation-centre/default.aspx)
[175] *University of Essex unveils Start-Up Hub and Games Hub at Knowledge Gateway technology park*, East Anglian Daily Times, February 2017 (accessed via: http://www.eadt.co.uk/business/university-of-essex-unveils-start-up-hub-and-games-hub-at-knowledge-gateway-technology-park-1-4872887)
[176] *Games Hub*, University of Essex (accessed via: http://www.essex.ac.uk/business/knowledge-gateway/games-hub/default.aspx)

Its website is the 5th most visited website for legal information globally and is the leading marketing site for law firms (over 10 million visitors a year and growing at 15% per annum). As firms have looked to enhance their online and digital marketing presence, Mondaq has identified growth opportunities in data analytics.

The KTP project will assist Mondaq in adding layered analytics into developing markets – primarily Canada, China, India and Brazil. There is an opportunity to establish Mondaq as a clear market leader with the major professional firms that are involved in cross-border and international transactions – with the Knowledge Gateway and KTP fully supporting this ambition.

Source: Evidence provided to the East of England SIA ICT Theme

6.12 The **University of East Anglia (UEA)** and **Anglia Ruskin University (ARU)** bring further distinctive sets of strengths. UEA's School of Computing Sciences is profiled in Box 6-6 below[177] while ARU's particular strengths and specialisms linked to ICT are summarised in Box 6-7.

Box 6-6: University of East Anglia – School of Computing Sciences

The School was founded over 40 years ago. It has an outstanding research environment, judged to be 100% "world-leading" or "internationally excellent". This is in areas including Times Series Classification, Statistical Modelling and Data Mining, Machine Learning, Vision Systems and Graphics, Telecommunications, Internet of Things and Cloud Computing. Much of its research is focused on the application of computational techniques to areas as diverse as biology, insurance, medicine, clinical imaging and speech processing. There are collaborations with multi-national companies such as Apple, Disney and Aviva and BT, as well as research institutes on the Norwich Research Park, other international universities, and other UEA Schools.

Graduates are highly employable once they finish their degrees. The latest employment figures show that over 96% of Computer Science undergraduates found work or study within six months of leaving, and of those, 95% were in graduate-level jobs.

An example of a spin-out from UEA's School of Computing Sciences is **Syrinix**. This was formed in 2004 using applied signal processing techniques to develop technology to detect leaks in large pipes and water mains. Solutions developed by the company combine high-resolution data with automated analysis and alerts that monitor a range of variables, including water pressure and flow, and that can precisely detect and locate leaks so that they can be repaired before water loss and damage occurs, extending asset lifetimes and lowering operating costs.

Source: Evidence provided to the East of England SIA ICT Theme

Box 6-7: Anglia Ruskin University

Anglia Ruskin University – with campuses in Cambridge, Chelmsford and Peterborough – has invested over £100 million in recent years to build research infrastructure and business networks in ICT, deeptech and digital creative areas. This has included £45 million investment in a new Science Centre (in Cambridge).

Within ARU, the Department of Computing and Technology delivers undergraduate and MSc courses related to computer science, audio and music technology, electronics, gaming technologies, business technology with close links to various industries and research on Informatics, Computing and Electronics (ICE), Sound and Game Engineering (SAGE), and Virtualisation, Simulation and Infrastructure (VSI).

Anglia Ruskin IT Research Institute (ARITI) researches intelligent decision support systems, data mining, machine learning, image processing, real-time big data processing, digital diagnosis, optimisation, data fusion and mobile solutions in areas of medical informatics, big data & cyber security and intelligent systems and gaming.

In addition, Cambridge School of Art, the Cultures of Digital Economy Research Institute and PIER (a Policing Institute for the Eastern Region) work in transdisciplinary ways to address the fundamental challenge of how we use "technology to make us more human" be this through design thinking creative practice, policing, or virtual reality storytelling through film, music technology, wearables, and gamification. The REACTOR project (£1m 2016-19) is at the crux of this, as is the new Innovation Hub project for cross-disciplinary technology enabled innovation practice between Science, the Arts and Business.

ARU is working with national and international partners in Northern Europe/Scandinavia, North America and China, including Tsinghua. It also has strong local networks. For example, it is leading on the KEEP+ ERDF project-focused around developing local innovation in collaboration with regional businesses and start-ups.

Source: Evidence provided to the East of England SIA ICT Theme

[177] Note also that UEA is close geographically to the Earlham Institute which has foremost related specialisms (see Chapter 3).

6.13 Outside of the universities, the region has other major assets too. An important – if arguably currently underused – one is linked to **Adastral Park** in Suffolk, home to BT's Global Research and Development HQ. As well as providing the focus for a growing business cluster, this is also the site of the world's largest network test-bed[178]. Given insatiable demands for digital connectivity – particularly in an era of big data analytics – this is a major asset for ICT-related science and innovation (see Box 6-9 below).

Local science and innovation talent

6.14 Across the East of England – as elsewhere – the labour market in relation to ICT is under some pressure. One immediate issue is that there is strong competition from employers in London which – as demonstrated in Table 6-1 – pay considerably higher salaries than those in the East of England, and offer the excitement and buzz of a "world city". Across the region's main universities, the University of East Anglia and Anglia Ruskin University perform best in retaining ICT students in employment in the region after they graduate[179].

6.15 Although the number of undergraduate students in the region's universities in disciplines linked to "*Computer Science and Electronic Engineering*" has risen steadily in recent years – from 805 in 2013 to 1,155 in 2016[180] – labour and skills shortages appear to be a chronic concern[181]. In 2016, there were over 3,100 job postings for graduate programmers and software development professionals[182].

6.16 Advanced ICT skills are needed both within the ICT sector and across much of the rest of the economy (including all three of the other Themes) – hence demands are enormous and there are real concerns in relation to them, particularly given additional uncertainties relating to Brexit. Concerns relating to skills were very apparent from the 40 consultations completed with ICT businesses and other stakeholders as part of the ICT Audit process; a flavour of the feedback is provided in Box 6-8 below.

Box 6-8: Reflections on issues relating to ICT science and innovation talent from stakeholder consultees, March 2017

"Educational processes need to reflect the way the world is changing. What do we have in artificial learning, robotics and bio-informatics….? We need to develop the educational process"

"*Our young people are all very good at social media, but what do they know about cyber security, building platforms and coding?"*

"We need to recruit. We need more people. Across the board, programmers are the foundation. It is more difficult to recruit programmers than anyone else"

"There is a lot of concern amongst the people that I meet that we are going to lose talent. People from Europe who would come and fill our skills gaps aren't coming because they don't know what will happen"

"We need more programmers. We need better and better people all the time…. We need a good and better supply of computer science graduates"

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[178] *Research and Development*, BT website (accessed via: http://www.globalservices.bt.com/uk/en/whybt/innovation-in-bt/research-and-development)
[179] Based on data sourced from HEIDI Plus and relating to four academic years
[180] Data from UCAS 2017 relating to the number of undergraduates studying Computer Science and Electronic Engineering in universities in the East of England
[181] It is worth noting, for example, that a 'replacement figure' of 7,000 jobs by 2024 is identified within UKCES Working Futures data
[182] Data sourced from Labour Insight Jobs, Burning Glass Technologies

> *"One of our experiences here in the last five years has been Raspberry Pi – making available a low cost computer that people could learn to programme. This has made a big difference to the number of people enrolling in computer science. I think a major challenge is to make sure enough people are educated in real computer science, not just downloading software"*
>
> *"Cambridge has been involved in the fundamental building blocks of computing…. Artificial Intelligence is a really hot area for Cambridge. But Cambridge could end up being a place that creates hot talent – like a second division football club – which gets blasted off elsewhere"*

Source: Interviews completed with 40 stakeholders as part of the East of England SIA ICT Theme evidence gathering process, March 2017

Local industrial strengths and capacities

6.17 The two tables which follow provide important – but different – perspectives on the region's industrial strengths and capacities. The first draws on the recently-published TechNation report which identifies Cambridge, Ipswich and Norwich as clusters. Of these, the Cambridge cluster is identified as the largest (in terms of jobs and GVA); the most productive; and the cluster with the greatest growth potential. However there is a need for some care in interpretation. All three areas are defined in terms of Travel to Work Areas and, on the 2011 definition, the Cambridge TTWA extends sufficiently far south to include Ware (Hertfordshire) and Harlow (Essex). Both Ipswich and Norwich also have relatively large footprints. As defined, the former includes Adastral Park.

Table 6-1: Perspectives on digital clusters in the East of England, from TechNation, 2017

Indicator	Cambridge	Ipswich	Norwich	London
No. of digital jobs	30,219	9,981	7,589	300,169
Digital GVA (average 2013-15)	£867 million	£163 million	£165 million	£30 billion
Implied GVA/job	*£28.7k*	*£16.3k*	*£21.7k*	*£99.9k*
High Growth Firms	14.8%	n/a	n/a	20%
Start-up Births (average per year 2011-2015)	353	91	111	7,682
Average advertised digital salary	£46,730	£41,025	£40,101	£61,803
Indexed against London	*0.76*	*0.66*	*0.65*	*1.0*
Tech sector growth potential "good"	95%	61%	81%	78%
Other observations included in the TechNation report, 2017	World-leading university, mature technology ecosystem, and presence of major multinationals. Source of some of the UK's most successful businesses Home to games studios as well as data-driven life sciences businesses Apple opened an AI lab in Cambridge in 2016 after acquiring a spin-out business	Home to a strong telecoms sector. BT's global R&D campus, Adastral Park, employs more than 3,000 people Innovation Martlesham is a cluster of over 90 tech businesses, located on Adastral Park, and it includes an incubator New Tommy Flowers Institute University of Suffolk became independent in 2016	Two universities – UEA and Norwich University of the Arts – linked to digital tech businesses Start-ups nurtured by Meetup groups Various recent initiatives – e.g. Barclays opened an Eagle Lab and Norwich University of the Arts opened an Ideas Factory Quadram Institute will open in 2018 on Norwich Research Park.	World leader in digital tech Home to more than a third of Europe's unicorns ($1bn valued businesses) Fintech is very strong 200 co-working spaces and a range of accelerators/ incubators Planned expansion of Google at King's Cross – plus Apple and Amazon

Source: TechNation 2017 – At the forefront of global digital innovation

6.18 Table 6-2 draws straightforwardly on data from BRES and it relates to employment in ICT sectors. An immediate observation is that **in recent years, employment in the ICT sector has grown across the East of England much more quickly than has been the case nationally**. Consistent with the TechNation report, the Cambridge area is well-represented in absolute and relative terms. The relative concentration of ICT employment in Suffolk Coastal district – most of which relates to Adastral Park – is also clear[183]. But on this metric, both Norwich and Ipswich (and their environs) disappear from view. Instead, what is evident from Table 6-2 is the high incidence of ICT employment (in both absolute and relative terms) in the Hertfordshire districts of Welwyn Hatfield (home to the University of Hertfordshire) and Dacorum (essentially Hemel Hempstead). Peterborough also emerges as a significant hub for employment and an area of relatively rapid ICT employment growth.

Table 6-2: Largest, most specialised (by location quotient), and fastest growing (by compound annual growth rate) five districts by BRES employment, with East of England Science and Innovation Audit area and England comparators, for ICT sectors (based on 2012 and 2015 three year rolling averages, i.e. 2010-2012 and 2013-2015)

Largest employment	Most specialised (LQ)	Fastest Growth (CAGR)
• Cambridge (6,600)	• Welwyn Hatfield (2.5)	• Welwyn Hatfield (25.9%)
• Welwyn Hatfield (6,600)	• Dacorum (2.0)	• Peterborough (20.9%)
• South Cambridgeshire (5,000)	• Three Rivers (2.0)	• Brentwood (20.1%)
• Dacorum (4,600)	• Suffolk Coastal (2.0)	• Waveney (19.7%)
• Peterborough (3,800)	• South Cambridgeshire (1.9)	• Watford (18.5%)
East of England (85,400)	**East of England (1.0)**	**East of England (8.2%)**
England (891,700)	**England (1.0)**	**England (3.8%)**

Source: ONS, Business Register and Employment Survey

6.19 Both depictions (from the TechNation report and from BRES data) are valid, but both are partial and they are best considered together. Overall, from both vantage points, the Cambridge area stands out. Hertfordshire is a significant focus for ICT employment, as – increasingly – is Peterborough. There are ICT clusters in and around both Norwich and Ipswich. These are currently relatively small in absolute terms but they are growing. Although relatively small, the Norwich cluster involves two universities (UEA and Norwich University of the Arts). It was described by one stakeholder consultee as "*an amazing and vibrant creative science cluster encompassing digital animation, VfX/UX research and design, film and media production, creative development in software, digital games design and deployment, and UX lab testing"*[184]. A synopsis of Adastral Park – which is defined by TechNation as a key element of the Ipswich digital cluster – is provided in Box 6-9 below.

[183] In this context, the importance of BT needs to be recognised. BT accounts for around 3,000 jobs at Adastral Park, most of which are in R&D. Moreover it has been estimated that BT accounts for well over 10,000 direct jobs across the East of England (GOR) and that within the region, BT and EE (which was acquired by BT) account for "*one in every 10 employees working in the IT and communications sectors*" (Source: *Social Study 2016: The economic impact of BT and EE in the East of England,* A report prepared by Regeneris for BT Group)

[184] Consultation conducted with businesses and stakeholders as part of the East of England SIA ICT evidence gathering process, March 2017

Box 6-9: BT, Adastral Park and Innovation Martlesham

Adastral Park is home to **BT's Global Research and Development Headquarters** and is recognised internationally as a centre of excellence in telecommunications research.

BT itself is a major player within the region's ICT sector and, nationally, BT is the 3rd largest investor in corporate R&D. Specifically at Adastral Park, it accounts for around 3,000 direct jobs of which over 2,000 are focused on R&D. In addition, Adastral Park hosts BT's national broadband operations centre and also BT's network test & integration facility, which is the largest facility of its kind in Europe.

BT's research priorities include: faster, cheaper and more reliable broadband services (covering ultra-fast broadband, fibre broadband and 5G mobile networks), improving data and network security using advanced analytics, automating service operations through big data and machine learning techniques, and developing smart solutions through the use of IoT.

BT's approach is one of open, collaborative innovation and has an extensive range of local, national and international partnerships with universities, start-ups, suppliers and customers. Its achievements have shaped both the UK's digital economy and the telecommunications industry including: single-mode optical fibre, which underpins the entire global telecoms network; G.FAST which enables ultra-fast broadband of 300Mbps+ over copper networks; the world's fastest speeds over fibre optics; and the world's first "real-world" demonstrations of quantum-encryption for secure data transmission.

Since the late 1990s, BT has encouraged suppliers to co-locate at Adastral Park. This collaborative environment and BT's policy of 'open innovation' has led to a cluster of like-minded companies at Adastral Park. **Innovation Martlesham (IM)** – the name of this cluster of high-tech ICT companies – officially launched in 2011. It is now over 90 companies strong. These include global ICT vendors – such as **Cisco, Huawei, Nokia** and **Intel** – as well as scale up businesses such as **Coderus** and **Silicon:Safe**.

In 2011, all the companies based at the park became members of the cluster. The cluster has subsequently grown at over 10% per annum with four buildings at Adastral Park now dedicated to it. The initial offering of serviced offices, a business Incubator, networking events and the ability to promote throughout the East of England, struck a chord with existing ICT companies and entrepreneurs in the region. The Incubator that hosts early stage companies developing products and services for sectors such as medical, logistics and utilities, is enhanced by the IM Mentor Group (senior partners or founders in specific knowledge areas such as legal, technology, chartered accountancy, patent law, etc.). IM Business Club was launched in 2012. This offers a hot desk in one of the IM buildings, access to the well-respected mentor group as well as the on-site facilities such as restaurants and coffee lounges.

By 2014, the cluster started to attract small and medium sized companies which were not focused on BT, but wanted to co-locate with other tech companies and share knowledge and experience. The eco-system was further enriched by the injection of non-tech, but ICT aware, companies in areas such as recruitment, marketing, ISO standards and exports. In 2016, IM launched IM Accelerator to support the start-ups which were slightly further forward with delivering against their initial business plan.

One of the key advantages for the cluster, is being co-located with BT at Adastral Park. Innovation Martlesham enables BT to engage with a diverse community of high-tech companies. BT's scouting function looks globally for technology that might be of interest to BT to support its commercial goals. It sees the IM Cluster as a potential source of new innovation. IM companies are able to attend events run by BT and use Adastral Park's facilities.

Alongside the development of IM, another recent – and important – development at Adastral Park has been the opening of the **Tommy Flowers Institute** (in late 2016). This is a new Higher Education ICT training institute which is focusing on bringing ICT-sector organisations together with academic researchers to solve some of the challenges facing UK businesses, exploring areas such as cyber-security, 'Big Data', autonomics and converged networks.

Source: Based on information provided to the East of England Science and Innovation Audit

National and international engagement

6.20 The ICT sector in the East of England – both within the recognisable clusters and more generally – is highly networked at many spatial scales. There is a long and growing list of networking/cluster groups which include, *inter alia,* Agile Peterborough, BioCoders Cambridge, Cambridge Game Creators, Cambridge Spark, Reactor Meetup, DevOps Cambridge, Digital people in Peterborough, Essex Programmer Meetup, Essex User Experience Meetup, Hot Source, Norfolk Developers, PhP Essex, Software East Cambridge, SouthendTechMeet, Suffolk Developers, SyncDevelopHer, SyncIpswich, and SyncNorwich. In

addition, bodies like TechEast have been set up to drive the sector as a whole forward, and the although based in Cambridge, CW (Cambridge Wireless), draws together ICT companies from across the UK.

6.21 But to understand the true nature of national and international engagement, it is necessary to look harder within the core of the ICT ecosystem. Two processes – which are inter-related – stand out.

6.22 First, **there are high and rising levels of international ownership**. The acquisition of ARM Holdings by Japanese-owned SoftBank for £24.3bn in 2016 generated much comment[185], but there are many other examples. Huawei – which is Chinese-owned and the largest telecommunications equipment manufacturer in the world – acquired the Centre for Integrated Photonics (on Adastral Park) and then Cambridge-based Neul to establish its R&D presence in the UK (see Box 6-10). VocallQ – a spin-out from the University of Cambridge's Dialgoue Systems Group which had received seed funding from Amadeus Capital Partners – was acquired by Apple in 2015. Amazon acquired Cambridge-based Evi Technologies in October 2012.

6.23 As the narrative in Box 6-2 demonstrated, at one level, this process is not new. The judgement as to whether it is "good or bad" is a complicated one, and views differ radically. However the fact is that the East of England's ICT ecosystem – and the Cambridge cluster in particular – is defined in relation to global capital and global knowledge it needs to be understood and nurtured from this premise: it is not isolated or insular but intrinsically interconnected and part of the global mainstream. Its technologies and competitive potentials must be appraised from this perspective: it has to be globally excellent to survive and – as demonstrated in Table 6-2, it is clearly growing.

Box 6-10: Case Study of Neul, Huawei and the globalisation of a Cambridge-based "Internet of Things" business

Neul was set up in Cambridge in 2010. Its founders previously worked for Cambridge Silicon Radio. Neul initially looked to exploit radio frequencies that were freed up when the analogue TV signal was switched off. However regulatory uncertainties led to a change in focus and the company sought to consider how its innovations could be deployed on the existing mobile network.

As an Internet of Things (IoT) innovator, Neul sought to roll out networks of connected devices over existing mobile networks, connecting (for example) street lights, electricity metres and pet tracking devices, providing remote access for consumers and allowing the devices to "talk" to each other. It trialled its emerging technology with Huawei and Vodafone.

In 2014, Neul was acquired by Huawei, reportedly for US$25m. This was its second acquisition in the UK following the acquisition of CIP on Adastral Park, where Huawei already had a presence being a key partner for BT.

Subsequently, Huawei provided the investment that Neul needed to grow. Moreover Huawei – as the world's largest telecoms equipment manufacturer – brought a global footprint, and provided channels to customers. Commenting at the time of the acquisition, the Chairman of Neul noted that *"this outcome is just brilliant for Cambridge. Just think – Cambridge has another multinational company in the cluster. And not just any multinational. Huawei has the financial power, the desire, the technical knowhow and the global telecoms contacts to build Cambridge into a world-leading centre for IoT"*[186].

In February 2016, Neul's technology was still a proprietary solution demonstrated at Mobile World Congress in Barcelona. Within 12 months, the Neul technology transmorphed into a new global technology standard NB-IoT, published by 3GPP and supported by the telecoms industry.

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[185] *SoftBank to acquire UK's Arm Holdings for £24.3bn*, Financial Times, 18th July 2016
[186] http://www.businessweekly.co.uk/news/hi-tech/17554-huawei-hiring-big-build-cambridge-iot-powerhouse

Huawei has invested hugely in this new technology. Henk Koopmans, CEO of Neul, commented that "*The investment overall is huge and it was a gamble – we needed to establish credibility, but with networks being rolled out in countries around the globe I believe we have the momentum now*".

Currently, Neul employs 50 people in Cambridge and 50 people in Shanghai. The Cambridge based staff include 15 different nationalities. Koopmans believes that there are so many opportunities in Cambridge that people are willing to take a chance on working on high risk, unproven technologies. However, whilst Cambridge attracts outstanding research and technology development skills, broader business skills (such as customer support, maintenance and production) are more difficult to find locally. The tie up with Huawei has been important in this context.

In today's market, companies need to be able to roll out new technologies quickly. Alongside Huawei, the presence of companies such as Qualcomm, Apple and Philips is starting to give Cambridge this multinational capability and global market outreach.

Looking ahead, Koopmans makes a plea that sectors should collaborate more: "*I have often said that the next Bill Gates will be found in the crossover between different disciplines. It is really interesting in the case of Huawei. To date it has been focussed on being the world's largest network equipment provider but it now also wants to become a technology leader. It has set up research institutes around the world that are not focused on traditional telecom areas, such as in maths, materials and design. Huawei is realising new innovations will come from doing something across these disciplines*."

Source: Based on discussions with Neul and other evidence submitted to the East of England Science and Innovation Audit

6.24 Second, **to grow, even the smallest companies appear to need to seek out global investment, suggesting fundamental "international engagement" from the outset**. Provision of finance within the East of England is good in UK terms, but it is not "*the best in the world*". As one of the business stakeholders interviewed during the Audit explained,

> *"I have raised no private investment here. All of the money we have raised has come from abroad. Our company has raised money in South Korea, in the USA and through high net worth individuals on the Isle of Man. That is where there are people who will take risks in our part of the tech industry…. In the UK, as soon as you say "risk", everybody ignores you. That is why we have gone abroad"*[187]

Developments in the wider funding landscape

6.25 As intimated in paragraph 6.5, the East of England has consistently been successful in securing research funding in the ICT sphere from both UK Government and through Horizon 2020. In relation to innovation, regional participants secured grants totalling £4.1m in "*digital*" and £2.5m in "*information communications and technology*" from Innovate UK between 2010 and 2015. These were 5.8% and 6.6% of the UK totals respectively – suggesting that the East of England had actually underperformed on this measure (certainly as compared to its share of research funding).

6.26 However the funding landscape needs to be understood much more broadly. From the evidence gathered through the Audit, three points stand out. One – discussed above – is that **despite the relative abundance of early stage investors in the region (particularly Cambridge), many digital firms are looking abroad for early stage investment** where attitudes towards risk appear to be more forgiving.

6.27 A second observation is that **novel approaches to financing growth are developing quickly**. In particular, crowdfunding is increasingly commonplace, although it is not without

[187] Consultation conducted with businesses and stakeholders as part of the East of England SIA ICT evidence gathering process, March 2017

its own challenges. It appears to be particularly effective in sectors like gaming; Frontier Developments, for example, recently raised well over £1m through the Kickstarter crowdfunding platform for its "*Elite: Dangerous*" product.

6.28 A third key finding came from the stakeholder consultations conducted as part of the Audit. It surrounds the importance of **R&D tax credits** as a mechanism for incentivising investment and hence funding growth. In the context of the ICT sector, two schemes aimed to encourage investment in small businesses – **Enterprise Investment Scheme (EIS)** and **Seed Enterprise Investment Scheme (SEIS)** – were highlighted. Although there was a suggestion that SEIS in particular was, on occasion, misused, other consultees were more positive:

> *"Those two tax incentives are really important and really key, particularly for a high risk technology start up. If you fit into that window of the first two years, it can make a huge difference between getting an investment and not. It is risky, we know it is, but if you have that tax break, it is really a big influence"*[188].

Conclusions – and future potential

> *"Artificial intelligence has enormous potential. Building on the already-strong base of AI at University of Cambridge, UEA and University of Essex is a natural. From strength in AI follows strong data science, and also automation and virtualisation"*[189]

6.29 For the most part, the evidence that has been gathered through the Science and Innovation Audit supports the ICT Theme hypothesis set out in paragraph 6.3. Demonstrably, the ICT sector has seen rapid growth within the region and it is underpinned by foremost scientific assets. It is also evolving very quickly. Parts of it are already world-leading (in terms of the research underpinning it, the businesses commercialising it and the people working within it); other elements are developing.

6.30 Through the Audit, two main gaps/opportunities have been identified. The first relates to the **availability of local talent.** As set out in paragraphs 6.14 to 6.16, there are acute challenges in relation to digital skills and there is a specific requirement for more programmers with a "deep" understanding of computer science. Within the region, localised responses are being developed. For example:

- BT has an established programme with the University of Suffolk for network engineering and software engineering.
- The Tommy Flowers Institute – focused on ICT training – was opened in 2016. This is focusing on bringing ICT-organisations together with academic researchers to address challenges facing UK business. The intention is that by 2020, the Tommy

[188] Consultation conducted with businesses and stakeholders as part of the East of England SIA ICT evidence gathering process, March 2017
[189] Consultation conducted with businesses and stakeholders as part of the East of England SIA ICT evidence gathering process, March 2017

Flowers Institute should be recognised as the "*major national centre for supporting the development of future leaders in ICT research*"[190].

- It was announced in April 2017 that the School of Computer Science and Electronic Engineering at the University of Essex had formed a partnership with ARM to develop a degree apprenticeship programme. The first degree apprenticeships will be offered from autumn 2017[191].

- In collaboration with major ICT companies and others in the region, UEA School of Computing Sciences is developing a Level 7(MSc) in Data Science which leverages existing research strengths in Machine Learning, AI, Data Analytics to create a programme relevant to the telecommunications, supply-chain fintech, health and manufacturing sectors.

- New Anglia LEP's *Digital Skills Plan* is seeking to increase collaboration between skills providers and employers; stimulate effective career choice through schools (including alternative pathways for graduate-level talent); and support continuous professional development for ICT and digital skills.

- *Accelerate EAST* is looking to define progression pathways more effectively.

6.31 Despite the range of initiatives, there is much more to do and all parts of the supply side – from schools through to universities – have a role to play, as indeed does central government. ICT businesses must also engage much more consistently if the shortages are to be addressed effectively.

6.32 The second opportunity relates to **possibilities for greater collaboration.** The East of England covers a very large geography and its assets are scattered. Individual clusters can and should follow their own development paths, but the ecosystem as a whole could function more effectively if stronger – but targeted – collaborations were forged. From the Audit, three specific examples were highlighted:

- **Big Data Analytics and Machine Learning**: There are world class competencies in this field in several academic institutions and in emerging organisations (such as the Earlham Institute on NRP). Currently access to this asset base is *ad hoc*, yet it appears to be a regional priority. It is important in its own right and long term, it will also be significant for all three other Themes (Life Sciences, Agri-tech and AM&M).

- **High Performance Computing:** The region has significant assets in this sphere and more investment is planned (see Box 6-2). These are expensive resources and access is important. It will be used for large scale simulations; benchmarking and testing; complex computations, etc. This links to "deeptech" – which is prevalent within the region. Again, these applications are likely to be relevant for all Themes.

- **Scalable Network Test-bed:** At Adastral Park there is a substantial test-bed asset based on future digital network infrastructure that can be used by researchers and research departments to assess and evaluate software/hardware proof of concept

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[190] See http://atadastral.co.uk/about/tommy-flowers-institute/
[191] "*ARM and Essex University launch degree apprenticeship programme*" Business Weekly, 6th April 2017

designs in a real-world setting which connected to a global telecommunications network reference architecture rather than a simulated one. As with high-performance computing this asset is not easily replicated. Providing access requires ICT infrastructure that is reliable, secure and fast.

6.33 The specific priority interventions that have been identified in response to these gaps/opportunities are set out in Chapter 7.

7. Conclusions

Chapter Summary

- All four Themes examined through the Audit have real research strengths and innovation capabilities. These are especially apparent in Life Sciences and ICT; Agri-tech is growing quickly and draws on both; AM&M has more mixed prospects, but it is an essential underpinning of the innovation ecosystem as a whole and it is contributing to (and benefiting from) growing regional credentials in relation to cleantech.
- Drawing on the findings from the Science and Innovation Audit, four overarching "gaps" are identified across the East of England's innovation ecosystem. These "gaps" are apparent across all four Themes.
- The "gaps" relate to: unlocking investment in the process of convergence; providing skills, particularly relating to data; enabling co-location and clustering; and increasing connectivity.
- To help address the "gaps", eight interventions are identified and described. There is, in addition, a need for an overarching (probably national) response to the challenges relating to middle- and higher-level skills in computer and data science.
- These interventions will need to be advanced as part of a wide-ranging and long term commitment to the East of England's innovation ecosystem from both regional partners and UK Government.

"I believe the active investors here – who are coming from all over the world – are investing in artificial intelligence, big data software, machine learning and then into the life sciences, bioinformatics and medical technology, and bringing it all together"

"The focus here, in the universities and in the business communities, on artificial intelligence, machine learning and robotics, combined with genetics and genomics, presents huge possibilities. Connecting that up in a small place like this could be dramatic"

East of England SIA stakeholder consultations, March/April 2017

Gap analysis

7.1 The East of England has some of the **world's foremost scientific assets**. It also has strong and distinctive **innovation capabilities**. Together these constitute a genuinely world class resource.

7.2 The calibre of the resource is apparent across the four Themes that have provided the focus for the Audit. In both **Life Sciences** and **ICT,** there is evidence of world-leading research – in the region's universities, research institutes and major businesses – driving an innovation ecosystem that has created some of the most exciting knowledge-based businesses anywhere in the world; ARM Holdings, HP Autonomy, MedImmune, Abcam, Heptares and Kymab are all products of it. The power of that same innovation ecosystem is attracting in substantial inward investment from global corporates (such as Huawei, Apple, AstraZeneca, Pfizer and Microsoft) as well as early stage investment in "*the next generation*" (noting, for example, that on one estimate over £500m has been invested in life sciences companies based on the Babraham Research Campus alone over the last two years). **Agri-tech** is emerging quickly and it has strong synergistic links to both Life Sciences and ICT; the existing strength of, and planned investment in, the asset base on Norwich Research Park is outstanding in these terms. The prospects for **Advanced Materials and Manufacturing (AM&M)** are more mixed and as a sector, it is much more diffuse but it is an essential underpinning of the innovation

ecosystem as a whole and looking ahead, it has an important role to play. Locally, there are pockets of excellence in, for example, offshore renewable energy, composites and building technologies; and much of this is underpinned by a growing regional competence in activities relating to cleantech.

7.3 At the start of the Audit **two overarching challenges** were identified – one related to **commercialisation**, the second focused on **collaboration**. Through the Audit, these have been examined rigorously. Four Theme-specific hypotheses have been tested using both primary research and secondary evidence, and in all four cases, the hypotheses have been supported. Addressing the challenges is therefore now crucial in terms of achieving the region's overarching aspiration for science and innovation over the next decade – namely, **to enable translation through convergence in a manner which is precise, smart, connected and world-leading – to deliver sustained economic growth and to achieve wider impacts**.

7.4 **This aspiration relates to all four Themes. But, crucially, it is bigger than any one of them.** To continue to be world-leading, the challenges must be addressed at the level of the East of England innovation ecosystem as a whole. **Translation and convergence are – by definition – statements of "process"**. They are on-going, relentless and demanding, and the bar is set high and rising. The East of England is competing with the most effective ecosystems in the world – some of which are reasonably well known and understood (Silicon Valley, Boston (Massachusetts)) but many of which (particularly those emerging quickly in the Far East) are not. Against this backdrop, there is no room for complacency – or for local politics within the region, or for resourcing squabbles with UK Government. **The East of England innovation ecosystem is world-leading, but it needs to continue to evolve rapidly – and it must be empowered and resourced so to do**.

7.5 In accelerating translation and convergence, **four main "gaps"** – all of which relate to collaboration and commercialisation – have been identified through this Audit. All four are of equal importance. **The "gaps" are defined with a view to the ecosystem's future evolution, not simply its current form**.

Unlocking investment in the process of convergence

7.6 The investment process is integral to the commercialisation journey and it is, by definition, risky. The innovation ecosystem in the East of England is better than most in terms of early stage investment; Cambridge, in particular, benefits from a vibrant local investor community, and it attracts the interest of investors world-wide. But the challenges are not "solved" and indeed, some are becoming more acute as the process of convergence accelerates.

7.7 The issues were noted particularly within the Life Sciences Theme – although they were also observed elsewhere. Open sourcing – and the use of big data – is a major driver of innovation across all four Themes and it is underpinning and accelerating processes of convergence. There are major opportunities relating, for example, to the convergence of clinical patient data, deep/machine learning, communication technology and connected medical and wellness devices, and the region has huge assets and capabilities in this sphere. However the process of convergence may not generate intellectual property in a form that can be easily protected through patents. For investors – who tend to be sector specialists with limited

knowledge of convergence interfaces – this may create further uncertainty and risk. Solutions need to be found.

Providing skills – particularly relating to data

7.8 Across all four Themes, there are major – and similar – skills shortages. The extent and nature of the challenge was summed up by one business consultee from within the AM&M Theme (in this case an automotive business):

> *"I would look beyond automotive. What are the most valuable skills going forward? Software skills, data management skills, automation skills, robotics, artificial intelligence, machine learning. Bringing users to new services through a smart compelling interface… There is a really hard set of computational skills to bring…"*[192]

7.9 The same issues were raised in relation to Life Sciences and Agri-tech. For ICT itself, the refrain was also relentless; to quote another consultee "*we need to make sure enough people are educated in real computer science, not just downloading software*".

7.10 Digital technologies are pervasive. Their application is the essential underpinning of the innovation ecosystem. But without sufficient people who are "*educated in real computer science"*, innovation will falter and business growth will stall. The issues are acute already. Moreover, given the global nature of the higher-level skills pool, the risks linked to Brexit are obvious and immediate – and they were aired consistently through the Audit.

Enabling co-location and clustering

7.11 A third finding which was shared across all Themes surrounded the value – and innovation capacity – that is generated through co-location and clustering. Particularly in Life Sciences, there is much to be gained through physical proximity: silos need to be broken down and scientists from different disciplines need to work alongside clinicians, entrepreneurs, investors and patients on a daily basis. Tacit knowledge needs to be generated and shared, particularly against a backdrop of open sourcing. Serendipity needs to be engineered.

7.12 These observations need, of course, to be contextualised – and they run up against various constraints. First, whilst much value can be generated through physical clustering, considerations relating to Green Belt are also important. Second – and related – even if land can be found, not everything can or should happen in the same physical space. Wider approaches to collaboration across the ecosystem, some of them virtual, need to be developed.

7.13 Nevertheless, insofar as the strength of the East of England's innovation ecosystem rests with localised clusters in which proximity is central to translational processes, those clusters need to be equipped to grow appropriately. Equally, where there is *potential* for clustering around knowledge-rich assets, appropriate physical provision should be made to unlock a future growth dynamic. The relationship between the innovation ecosystem and "place" is intrinsic and critical. It needs to be recognised fully in these terms such that the ecosystem as a whole can evolve optimally.

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[192] Stakeholder consultation, March/April 2017

Increasing connectivity

7.14 Finally, it is imperative that the importance of connectivity is properly acknowledged. Across a relatively large geographical region, the innovation ecosystem is unlikely to function well if connectivity (both within and beyond it) is poor.

7.15 This observation bites at various levels. At the most mundane, it is very important that broadband connectivity is consistently good. Currently 91% of the East of England (GOR) has access to superfast broadband (>30 mbps)[193], but it will be important that this figure continues to improve.

7.16 Anticipating emerging gaps in relation to the medium-term evolution of the innovation ecosystem, the issue of digital connectivity needs also to be considered at a more profound level. Looking ahead, data will be transformational across Life Sciences, Agri-tech and AM&M, and within the ICT sector itself. Huge volumes of data will need to be generated, captured, stored, protected, transmitted and used. The region needs a digital infrastructure that can cope – and, indeed, it needs a digital infrastructure that can help to realise the full transformative potential.

Targeted opportunities

Eight key interventions…

7.17 To start to fill these gaps, **eight key interventions** have been identified through the Science and Innovation Audit. Broadly, these fall into two groups, depending on their intervention focus and their route to impact:

- three interventions are, in principle, **region-wide ventures which are concerned with building hard and soft infrastructures and capacities for sustained innovation, particularly in relation to data**
- five interventions are focused on **specific clusters and/or sectors with the aim of accelerating convergence and/or translation**.

7.18 All eight interventions are grounded in rigorous evidence and endorsed fully by the Science and Innovation Audit Steering Group (and its constituent members) and by GCGP's Science Innovation and Industry Council (which has overseen the whole exercise). High level outline business cases are presented in Annex B. The table below lists the interventions (in no particular order) and provides a very brief description of them. It also shows how they map onto the principal challenges identified through the Science and Innovation Audit.

[193] See http://labs.thinkbroadband.com/local/east-england

Table 7-1: Priority interventions identified through the Science and Innovation Audit

Key "gaps" to be addressed in unlocking the full potential of the East of England's Innovation Ecosystem → / Priority interventions…	Unlocking investment in convergence	Providing skills, particularly in data	Enabling co-location and clustering	Increasing connectivity	Brief description....
A: Building hard and soft infrastructures and capacities for innovation across the East of England					
Building Innovation Capacity	✓	✓			Cross-cutting venture to build innovative capacity, particularly among SMEs in the ecosystem
East of England Innovation	✓	✓		✓	Initiative to encourage technology transfer, particularly for SMEs outside the main clusters
Smart Enabling Technologies Testbed	✓			✓✓✓	Infrastructure project to achieve high speed and high capacity connectivity
B: Cluster and/or sector-specific ventures to encourage convergence and/or translation					
Centre for AgriFood automation	✓	✓		✓	Venture to provide a regional resource in automation, at Holbeach
MedTech Hubs	✓		✓✓✓		Project to accelerate the development of emerging Hubs and to build synergies
Microbiome Hub	✓		✓✓✓		Innovation Centre anticipating the opening of the new Quadram Institute, on Norwich Research Park
Precision medicine cancer ecosystem	✓		✓✓✓		Radical new approach to precision medicine, building on foremost science
Cell & Gene Therapy R&D Centre	✓		✓✓✓		Provision adjacent to the Cell and Gene Therapy Manufacturing Centre, at Stevenage Bioscience Catalyst

7.19 The eight interventions vary in terms of delivery timescales – some can be delivered quickly, others are long term projects. Equally, they vary in terms of resourcing requirements. All will attract investment from the private sector, but there will also be a need for a mix of capital and revenue funding to see them implemented in full. In return, all will be of at least national significance in terms of their impact; and for some, the scale of the impact should be greater again.

…plus a wider response in relation to crucial skills issues

7.20 Alongside the eight interventions, there is an overarching requirement to address **major issues relating to skills – particularly those relating to data science and computer science**. The Audit found shortages across all four Themes – and the scale of the problem is such that unless addressed, it will stymie business growth across the East of England.

7.21 Partners within the East of England are already seeking to address the surrounding issues (see, for example, the discussion at paragraph 6.30). But whilst local initiatives and a series

of bilateral arrangements between individual businesses and HEIs/FECs are important, they are unlikely to be sufficient, particularly given the systemic nature of the challenges. At this stage, partners within the East of England do not have a fully developed "solution" (and hence there is no specific intervention/business case), but they are committed to working towards one, preferably in dialogue with government.

…within an overarching commitment to the East of England's innovation ecosystem

7.22 The eight interventions – and the more systemic skills project – will all need to be delivered as part of a wide-ranging and long term commitment to the East of England's innovation ecosystem, both from within the region and from UK Government. Regional partners are fully committed to seeing this through – including through a steering group that will convert the findings of this Science and Innovation Audit into a regional action plan and then spearhead its delivery. All four LEPs have also committed to using the SIA within forthcoming refreshes of their strategic economic plans.

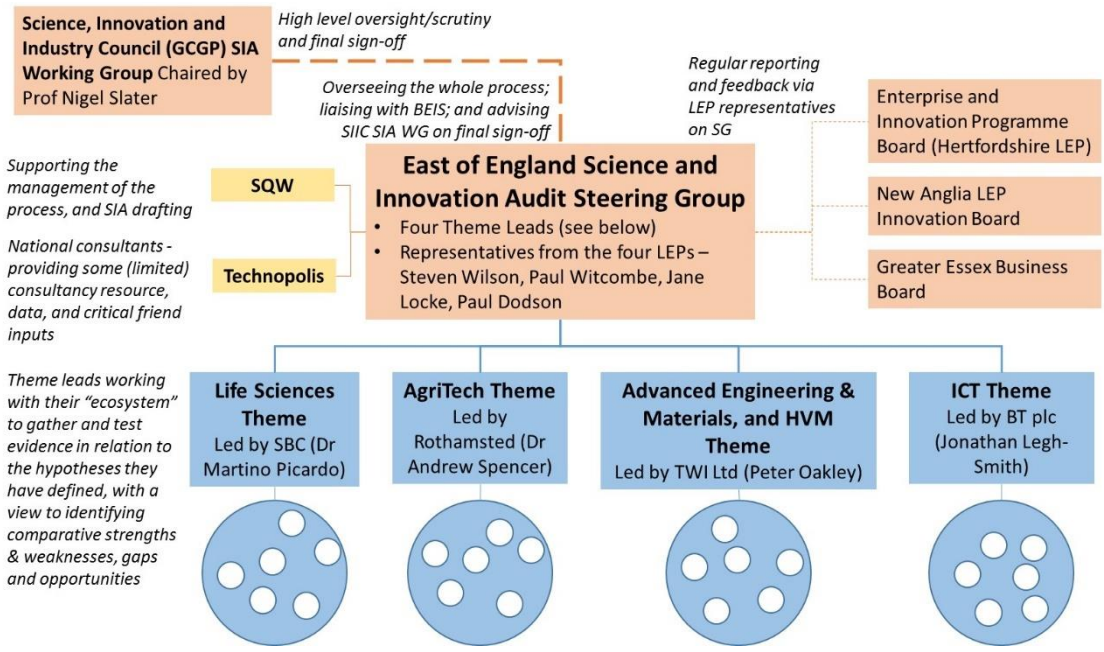
7.23 It is important, also, that a partnership is formed with UK Government to drive the wider venture forward. Delivering the eight interventions set out above is the starting point. In addition – and to use the terminology of the Industrial Strategy Green Paper – there needs to be a sustained, meaningful and effective dialogue between, particularly, Pillars 1 and 2 (*Investing in science, research and innovation;* and *Developing skills*) and Pillars 9 and 10 (*Driving growth across the whole country;* and *Creating the right institutions to bring together sectors and places).* Across the East of England's world class innovation ecosystem, much will be achieved as a result.

Annex A: How the East of England's Science and Innovation Audit was developed

Governance and management

A.1 The overall governance and management structure for developing the East of England Science and Innovation Audit is summarised in Figure A-1 below.

Figure A-1: East of England Science and Innovation Audit: Governance and Management



Source: SQW

A.2 The process was substantially led by **four sector specialists (Theme Leads)**, working with the **East of England Science and Innovation Audit Steering Group.** The Steering Group consisted of the four Theme Leads plus representatives from each of **four Local Enterprise Partnerships**. Support to the Steering Group was provided by SQW. The members of the East of England SIA Steering Group are listed in the table below.

Table A-1: East of England Science and Innovation Audit Steering Group

Name	Organisation	Role in the SIA
Dr Martino Picardo	Stevenage Bioscience Catalyst	Life Sciences Theme Lead / Steering Group member
Dr Andrew Spencer	Rothamsted Research	Agri-tech Theme Lead / Steering Group member
Peter Oakley	TWI Ltd	AM&M Theme Lead / Steering Group member
Jonathan Legh-Smith	BT Technology, Service and Operations	ICT Theme Lead / Steering Group member
Steven Wilson	Greater Cambridge Greater Peterborough Enterprise Partnership	Steering Group Chair

Name	Organisation	Role in the SIA
Paul Witcombe	Hertfordshire Local Enterprise Partnership	Steering Group member
Jane Locke	Norfolk County Council – on behalf of New Anglia Local Enterprise Partnership	Steering Group member
Paul Dodson	Essex County Council – on behalf of South East Local Enterprise Partnership	Steering Group member

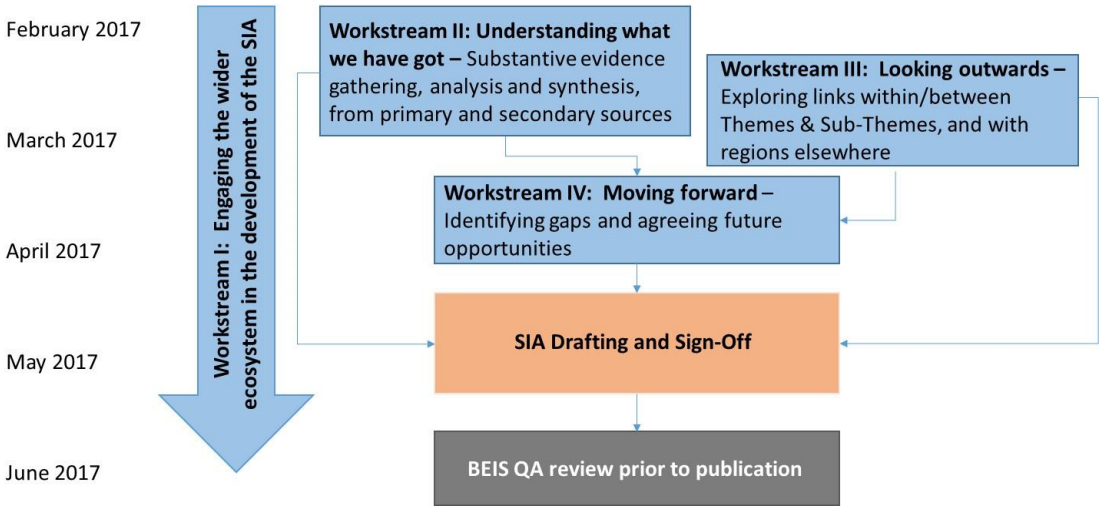
A.3 During the completion of the Audit, the Steering Group met five times (3rd February 2017; 6th March 2017; 10th April 2017; 11th May 2017; and 24th May 2017). There was a further meeting – which also included Sub-Theme Leads – on 17th March 2017.

A.4 In addition, the **Science and Innovation Industry Council** – from Greater Cambridge Greater Peterborough LEP – retained high level oversight. It had final sign-off in relation to the output from the Audit process.

Developing the Theme-level inputs

A.5 The overall timescale and process for developing the Audit was common to all four Themes. It is summarised below.

Figure A-2: Developing the SIA



Source: SQW

A.6 To facilitate what was a highly devolved approach, SQW developed a **Toolkit** in January 2017. This was discussed and agreed with the Steering Group.

A.7 The intention was that this central resource would be used by each of the Themes to ensure some consistency, but also that the Toolkit should be deployed flexibly, allowing each Theme's methodology to reflect the specific characteristics of its own ecosystem.

A.8 A summary of the four Theme-level processes is provided below.

Table A-2: Approach to developing the Life Sciences inputs into the overall SIA

Management and Governance at Theme Level	**Theme Lead**: Dr Martino Picardo (Stevenage Bioscience Catalyst), supported by Emma Palmer Foster (consultant to SBC) **Sub-Theme Lead**: Dr Sally Ann Forsyth (Norwich Research Park; food, health & microbiome Sub-Theme)
Research hypothesis (in its final form)	*"The East of England's life sciences cluster is already world class, with a strong record in terms of the quality of scientific research and the commercialisation of it. In the future, it will retain its pre-eminence through greater collaborative links within and between personalised medicine; regenerative medicine; genomics; food, health and microbiome; and medtech"*
Primary evidence gathering and stakeholder engagement	This included: • **Theme-specific engagement session** at the Innovate UK conference which was held at TWI (Cambridge) on 21st February 2017 • **Working meeting with Sub-Theme Lead** on 6th March 2017 Six **round-table discussions/workshops** which were attended by over 100 high-level stakeholders from within the Life Sciences ecosystem. Each workshop had a different focus, but they were structured around the same research questions to allow comparison (i.e. Is the East of England world class in the area under discussion? If so how, why - what's the evidence?; what would it take to be world class - or to continue building on it?; what projects and/or opportunities are there in the region to partner and collaborate on specific themes, intra–region and beyond?): ➢ **Cambridge big data/healthcare IT/digital health** – 14th March 2017 (held at Wellcome Genome Campus) ➢ **Cambridge cluster, CEOs of start-ups and scale-ups** – 14th March 2017 (held at the Babraham Institute) ➢ **Precision medicine** – 21st March 2017 (held at Precision Medicine Catapult) ➢ **Food, health & microbiome** – 22nd March 2017 (held at Norwich Research Park) ➢ **Genomics and bio-data** – 24th March 2017 (held at Wellcome Genome Campus) ➢ **Cell and gene therapy** – 12th April 2017 (held at Stevenage Bioscience Catalyst) • **E-survey** of Life Sciences businesses which examined the nature and extent of collaboration, and growth expectations • **Engagement** across LinkedIn, Twitter and SBC newsletter • **Engagement** via e mail with personal contacts and East of England life sciences groups such as One Nucleus
Bespoke input from Technopolis	• **Analysis of three main subthemes (cell & gene therapy, precision medicine and food, health & microbiome) including research activity and case studies** – Plasticell, Integrated Medicines and the Quadram Institute respectively • **Medtech heat map** • **Analysis of drug discovery activity in the East of England**

Table A-3: Approach to developing the Agri-tech inputs into the overall SIA

Management and Governance at Theme Level	**Theme Lead**: Dr Andrew Spencer (Rothamsted Research) **Major contributors:** Lydia Smith, NIAB; Jonathan Clarke, JIC; Martin Collison, Collison Associates; Simon Pearson, University of Lincoln; Liliya Serazetdinova, KTN
Research hypothesis (in its final form)	*"The region has world-renowned research strengths in Agri-tech, and increasing expertise and experience in the process of commercialisation. Further strengthening of the mechanisms for commercialisation will bring major economic benefits to the region and to the national economy"*
Primary evidence gathering and stakeholder engagement	This included: • **Theme-specific engagement session** at the Innovate UK conference which was held at TWI (Cambridge) on 21st February 2017 • **Working meeting with Sub-Theme Leads** on 6th March 2017 • **E-survey** of Agri-tech stakeholders (including businesses) which asked for perspectives on the region's main assets and potentials in the ambit of Agri-tech • **Call for evidence from key contributors** – including case studies and business cases
Bespoke input from Technopolis	• **Business:** review of top 100 agri-tech businesses in the East of England • **Research**: analysis of research active Agri-tech organisations in the East of England

Table A-4: Approach to developing the AM&M inputs into the overall SIA

Management and Governance at Theme Level	**Theme Lead**: Peter Oakley (TWI), supported by Steve Jones (TWI) **Sub-Theme Leads**: Advanced materials – Prof Andy Neely (IfM); Advanced manufacturing – Simon Coward (Hethel Engineering Centre); Aerospace and defence – Jo Cox (Cranfield University); Built environment – Dr Deborah Pullen (BRE); Offshore renewable energy (Johnathan Reynolds – Orbis Energy)
Research hypothesis (in its final form)	*"The East of England's strengths in AM&M have grown organically – some map onto the research base but others have emerged within their sectoral context. AM&M is therefore very fragmented. Better planning, networking and co-ordination would create coherence and identity, and it would help achieve critical mass. This in turn would enable market expansion, both nationally and internationally*"
Primary evidence gathering and stakeholder engagement	This included: • **Theme-specific engagement session** at the Innovate UK conference which was held at TWI (Cambridge) on 21st February 2017 • **Working meeting with Sub-Theme Leads** on 6th March 2017 • **Meetings/telephone discussions** with Sub-Theme Leads • **Call for evidence** from the Sub-Theme Leads and wider stakeholders (including asset mapping, science and innovation strengths and prospects, profile of engagement with industry) • **Literature review**, covering published and unpublished literature/data sources on the region's science and innovation assets, their status and potential, and the future needs and growth of the Sub-Themes • **E-survey** of small AM&M businesses which gathered evidence on the nature and extent of current collaboration with the regional science and innovation infrastructure, growth expectations, etc.
Bespoke input from Technopolis	• **Analysis of data:** FP7 and H2020

Table A-5: Approach to developing the ICT inputs into the overall SIA

Management and Governance at Theme Level	**Theme Lead**: Jonathan Legh-Smith (BT Technology, Service and Operations) **Theme Steering Group**: Dr Jan Storgards (Anglia Ruskin University), Dr Rob Singh (University of Essex), Professor Vania Sena (University of Essex), Professor Gerard Parr (University of East Anglia), Tim Robinson (TechEast).
Research hypothesis (in its final form)	*"The ICT sector has seen rapid growth in the East of England, and it benefits from a very strong scientific asset base with a number of recognised ICT clusters. The market is evolving quickly and the demand for digital innovation is relentless. To capitalise, there ought to be greater collaboration across the region to accelerate academic and industry research and innovation activities. As part of this, a high-performance ICT infrastructure interconnecting the key universities and science parks-would provide the foundation for pan-region ICT research and innovation that would enable the East of England to consolidate and strengthen its world-class position"*
Primary evidence gathering and stakeholder engagement	This included: • **Theme-specific engagement session** at the Innovate UK conference which was held at TWI (Cambridge) on 21st February 2017 • **Working meeting with ICT Theme Steering Group** on 6th March 2017 • **Weekly progress calls with ICT Theme Steering Group** • **Call for evidence** from wider stakeholders • **40 in-depth bilateral consultations** with businesses and stakeholders from across the ICT ecosystem; written transcripts of these interviews were prepared for use at the Hot House • **E-survey** of wider stakeholders asking for evidence and insight in relation to the region's ICT assets • **Hot House** which was held over two days at Adastral Park, attended by 25 stakeholders, and which sought to use the assembled evidence to test the hypothesis**.**
Bespoke input from Technopolis	• None

Engaging with other SIAs

A.9 In developing the East of England's SIA, the Steering Group has sought to work closely with other SIA consortia within the constraints provided by a tight overall timescale. This has included, *inter alia:*

- engaging on a regular basis with the Oxfordshire Wave 2 SIA (including reciprocal arrangements for steering group attendance)
- participating in events led by BEIS involving all Wave 2 SIAs – notably a briefing session in December 2016 and a working meeting which was linked to the Industrial Strategy Green Paper in April 2017
- inviting the lead partners from the Midlands Engine Wave 1 SIA and from the Leeds City-Region Wave 2 SIA to act as peer reviewers.

A.10 In addition, more informal engagement with other SIAs has been facilitated by:

- Cranfield University's significant contribution to the East of England SIA, particularly through the AM&M Theme – even though its main campus is in Central Bedfordshire and it formally was included within the Midlands Engine Wave 1 SIA process

- South East LEP's direct interest in two Wave 2 SIAs: whilst the area to the north of the Thames has been included in the East of England SIA, the area to the south is part of the Innovation South Wave 2 Audit.

Engaging with BEIS

A.11 Finally, although the East of England's SIA has been developed locally, it has benefited from a constructive dialogue with BEIS throughout. This has included a series of conference calls which have been scheduled to coincide with meetings of the East of England SIA Steering Group.

A.12 The East of England SIA has also benefited from advice – and tangible inputs – from BEIS's national contractor, Technopolis.

Annex B: High level business cases for priority interventions

B.1 In the course of the Science and Innovation Audit, partners in the East of England have identified a series of strategic interventions which will either help major opportunities to be realised or address key gaps which have been uncovered through the process of the Audit. Summary outline business cases are presented below (noting that the business cases are, in most cases, still "work in progress"). No significance should be attached to the order in which the interventions are presented.

A: Building hard and soft infrastructures and capacities for innovation across the East of England

Building Innovation Capacity

Project name	**Developing and building innovation capacity for the East of England**
Brief description of the main elements of the project What is the project? Who will be the key partners in relation to it?	The project aims to improve the ability of the region to produce and commercialise a flow of innovative technology, products and services over the long term ("create-develop-grow-sustain") to strengthen the regional platform that supports innovation. The SIA has identified the need for a systematic approach to translation across all Themes in the region. Such an approach should also improve our ability to translate the new approaches and technologies that come out of convergence (cross-theme) research. The project will be based on a model which has been developed by Susan Windham-Bannister (former-President of the Mass Life Science Centre, Boston US). She has expressed an interest in working with us (following a Tele-conference with her, Martino Picardo (SBC) and Harriet Fear (CEO One Nucleus) in April 2017). We see this as a cross sector opportunity to benchmark against one of the most successful clusters (Boston, MA - Life Sciences) across ICT, AM&M, Life Sciences and Agri-tech. The project will focus on: • translational scientific research (including improving technology transfer) • workforce development and growth (from entrepreneurs to manufacturing) • building a thriving ecosystem based on networks, entrepreneurial culture and capital (building scalable consistent mentoring programs that can be monitored and evaluated for value) It will be overseen by a project co-ordinator. The activities supported will include: • training and skills development • mentoring • small "seed fund" for exemplar projects • workshops • developing investment capacity There are several key players who can deliver the programme by working together, bringing together the common activities already in place in the region and identifying where gaps exist (e.g. across skills, training and mentoring). These include One Nucleus and centres like the Babraham Research Campus, Stevenage Bisocience Catalyst and Norwich Research Park. The region's established Centres of Excellence and Innovation Centres will support the delivery of activities that will focus on building Innovation Capacity.
Outline Business Cases – In Summary	
1: Strategic Case	Based on feedback received, particularly from colleagues in Boston, **the East of England is regarded as world leading in science but not in translation and commercialisation**. There are therefore fundamental building blocks that need to be developed if we are to improve our Innovation capacity.

Project name	Developing and building innovation capacity for the East of England
What is the case for change (i.e. the rationale)? What are the aims and objectives of the intervention?	The need to build innovation capacity has been a recurrent theme from the SIA, notably at the round-tables and workshops in Life Sciences, but also from activities in other Themes. The view is that we are world class in science but not as good as we could be in translation. This project aims to address this deficiency in the region, starting in Life Sciences but rolling out across the other Themes in due course. The aims are to build and grow a thriving cross-sector ecosystem where innovation can be monitored and measured, as can the outcomes and key targets of jobs, sales and investment. A thriving cross-sector innovation ecosystem of this nature will be unique across the region and the UK. This will benefit the whole region and assist greatly in deprived areas. The process will be based on the Massachusetts model and is both measurable and quantifiable in terms of success and key deliverables. We would aim to work closely with Susan Windham-Bannister, in order to facilitate activity The Life Science Theme will take the lead initially, with a view to sharing best practise across all the Themes.
2: Economic Case Will it deliver value for money? Does it represent a good balance between cost, benefits and risk? Has a range of options been considered?	Although we are doing better than most at translating our world class science, we can do better. Any and every quantifiable improvement that we can make in the process will result in better commercial opportunities, that are investable and will create jobs. The return on investment will therefore be easily measured in the region and beyond. The wider economic case for this project is currently under development. It will take full account of the need to complement and enhance existing initiatives.
3: Commercial Case Is there a supplier who can deliver it? Is it viable?	A Steering Group (cross-sector) will be put together, building on the outcomes from the SIA process. More generally, suppliers already exist and can be encouraged to work with each other.
4: Financial Case Is it affordable? Is the required funding available?	Although some funding is available through already existing activities, there would be a need for further resource (summing to £10m over a 3 year project time-frame) in order to really enhance and improve current innovation capacity. This would be used to fund a project co-ordinator; a small “seed fund”; and then workshops, training and mentoring support.
5: Management Case Is it achievable? Can we deliver it? Is there management capacity and capability?	There is Management Capacity across the key partners within the East of England. For example, Stevenage Bioscience Catalyst successfully led on a BIS mentoring scheme across the North and South of the UK in Life Sciences (2013-14). A Steering Group will be required and funding streams will need to be identified, as well as cross-sector stakeholder buy-in. The SIA partners would be seen to have made a significant recommendation that is strategic for the region and that could be actioned quickly. It may require a feasibility phase first, followed by a full funding and resourced phase. However it will add additional weight to the findings of the SIA process.

East of England Innovation

Project name	East of England Innovation
Brief description of the main elements of the project What is the project? Who will be the key partners in relation to it?	This project will combine the resources of the East of England’s leading AM&M centres to link their cross-cutting information resources of Materials, Manufacturing Processes, Management Methods, Structural Integrity, Environmental Impact and Commercial Viability. It will address issues such as data commonality and interchangeability, to provide an on-line digital suite of pre-competitive innovation support for companies responding to the Challenge Fund as outlined in the Industrial Strategy Green Paper. The support will be particularly relevant to companies wishing to use advanced materials and processes in sectors including aerospace, automotive, offshore renewable energy production and storage, medical devices, and building and construction. The core partners in this activity will be University of Cambridge, BRE, TWI, and Granta Design, who between them have world-class information resources and expertise across the AM&M field. Partners will include other regional science and innovation assets with appropriate knowledge, and regional companies (large and small) as test bed beneficiaries. Linkage of their capabilities into a digital format, supported by expert

Project name	**East of England Innovation**
	consultation will give the East a resource that will be vital locally as an enabler of AM&M innovation. It will also be nationally and internationally significant, cementing the East of England's position as an innovation hub for AM&M information and techniques in a digital age. The first stage of the project involves designing the overall system architecture and means of linking existing resources. This is within the scope and in line with the commercial objectives of the core group. Sector-specific guidance will be given by sector lead companies including Marshalls (aerospace), Johnson Matthey (energy storage), MBDA Systems Ltd (space), Orbis Energy (off-shore renewable energy), etc. This activity will work in concert with, and make use of, the parallel high speed ICT activity involving BT Martlesham and other regional centres, providing that initiative with an AM&M node. It will also act as an important resource for use in the technology transfer programme proposed in the SIA.
Outline Business Cases – In Summary	
1: Strategic Case What is the case for change (i.e. the rationale)? What are the aims and objectives of the intervention?	Digital information access and management will be the central feature of future commercial activity in AM&M, providing a crucial differentiator between conventional and future advanced approaches to manufacture. As AM&M moves into an increasingly digital world, there is a vital need for improved information resources for use by humans and machines. The quality, accessibility and usability of the information on which decisions and controls are based will determine the viability and commercial success of future manufacturing systems. At the moment, many of the relevant information resources are fragmented, difficult to access, "un-standardised" and require interpretation. This project will help overcome existing barriers and enable a more seamless and eventually automatic access to the range of data that underlie product design/specification and production decisions.
2: Economic Case Will it deliver value for money? Does it represent a good balance between cost, benefits and risk? Has a range of options been considered?	The full economic case is under development currently. The core partners in this activity are all world leaders in their respective fields. There will be a significant benefit from jointly working in this important area and co-ordinating knowledge, skills, resources and efforts. While the challenges of linking the various information sets involved are significant, the expertise available and the potential benefits are substantial. For this reason, the project, with appropriate sector-specific guidance, is believed to offer acceptable risk and potentially high return.
3: Commercial Case Is there a supplier who can deliver it? Is it viable?	The first stage of the project is within the scope and in line with the mission and/or the commercial objectives of the core group. Presence of the sector focus industrial partners will give the project commercially valid focus, guidance and verification.
4: Financial Case Is it affordable? Is the required funding available?	While the data resources are available within the project group. Financial support is required for three activities: 1. design of the overall information architecture and data standards and alignment with sector priorities 2. conversion of information resources to meet the requirements of the architecture 3. testing the system with sector-specific cases.
5: Management Case Is it achievable? Can we deliver it? Is there management capacity and capability?	The core partners have the capability to both manage and execute the project. All have been involved and run successful strategic projects in partnership with each other, although this partnership will be the first time all core partners have worked together in one project. The combined knowledge, skills and resources will ensure the project is technically sound.

Smart Enabling Technologies Testbed (with initial application in NHS data and Agri-tech)

Project name	**Smart Enabling Technologies Testbed**
Brief description of the main elements of the project What is the project? Who will be the key partners in relation to it?	The growing importance of data science in all areas of science and innovation cannot be overestimated, and is particularly true for this region. Whether it's combining genomics, field-phenomics, climate and soil data to improve crop productivity, or the large-scale analysis of medical images and patient data, or the automation of manufacturing, it is vital that we have the capacity to manage big-data if the region is to maintain its competitive edge. The SET Testbed will position the East of England as the UK's foremost large-scale test environment for a new generation of data-intensive research and smart technology trials linked to health sciences, advanced manufacturing and agri-tech. The Testbed will be a multi-node research facility, unique to the UK, providing a secure, high-speed and high-capacity ICT infrastructure connecting the region's universities, research institutes and key research parks. With its operations centre hosted at BT's global R&D headquarters at Adastral Park, the Testbed will have nodes across the region including: University of East Anglia/Norwich Research Park, University of Essex, Rothamsted Research/Agrimetrics, Granta Park and Cambridge Science Park. In addition, combining with the Tommy Flowers Institute will position the East of England as the primary location for early-career researchers and PhD students. The intention is that the Smart Enabling Technology Testbed should be delivered in phases, each of which can deliver value in its own right. Each phase will support identifiable sector opportunities which will minimise the risk of a large, up-front investment. *Phase 1:* • establish an operations & networks test facility at Adastral Park, including localised smart technology for data management and sharing that can be used in areas such as agri-tech, logistics, healthcare and AM&M • establish high-speed interconnection between nodes to support medical imaging, informatics and data analysis *Phase 2:* • expand connectivity & operational support for regional trials in agri-tech assisted living and AM&M *Phase 3:* • complete high-speed interconnection of regional research & innovation centres, supporting: advanced manufacturing; environmental and logistics; and design and consultancies • skills development for ICT professionals and service user communities.
Outline Business Cases – In Summary	
1: Strategic Case What is the case for change (i.e. the rationale)? What are the aims and objectives of the intervention?	The East of England benefits from world-class centres of excellence in strategically important sectors such as life sciences, agri-tech, energy, AM&M and ICT. However strategic collaboration is hampered by poor connectivity between the main centres. The SET Testbed will enable direct collaboration between academic and industrial centres across the region. The Testbed will create opportunities to test new products and services at scale, in real world network conditions, through: • connectivity for data-intensive research collaborations e.g. medical image processing • operational support for large-scale smart technology trials across the region e.g. agri-tech, health & social care, aerospace manufacture, energy storage • test & integration of technologies for the UK's next generation digital infrastructure • enabling the sharing, management, curation and interrogation of large data sets to drive value creation. As a result, it will provide the foundation for a pan-region Smart Enabling Technology Institute that will enable the East of England to consolidate and strengthen its world-class position in Agri-tech, Life Sciences, AM&M and ICT.

Project name	Smart Enabling Technologies Testbed
2: Economic Case Will it deliver value for money? Does it represent a good balance between cost, benefits and risk? Has a range of options been considered?	The economic case for the SET Testbed is under development. However, the importance of data in science and innovation is growing rapidly. In healthcare research, for example, medical imaging and the increased use of large patient data-sets will require significantly more data handling capacity. In Agri-tech, the drive for sustainable intensification is in turn driving a huge increase in data driven smart, precision agriculture. All manufacturing industries, ranging from aerospace and electronics to energy systems and healthcare devices are dependent on ICT to improve productivity, functionality and operational safety. The Testbed will build on existing knowledge and expertise in data science held by centres like Agrimetrics, EBI, and the region's universities. As set out above, there would be a phased approach to project delivery which would help to manage both cost and risk
3: Commercial Case Is there a supplier who can deliver it? Is it viable?	The commercial case for the SET Testbed is under development. BT – with its global R&D facility at Adastral Park – is a major partner in the venture and it would be central to the scheme's delivery.
4: Financial Case Is it affordable? Is the required funding available?	The financial case for the SET Testbed is under development
5: Management Case Is it achievable? Can we deliver it? Is there management capacity and capability?	The management case for the SET Testbed is under development. However the group of partners that have developed the concept is likely to be central to its on-going delivery.

B: Cluster and/or sector-specific ventures to encourage convergence and/or translation

Centre for AgriFood Automation

Project name	Centre for AgriFood Automation
Brief description of the main elements of the project What is the project? Who will be the key partners in relation to it?	Holbeach Centre for AgriFood automation (on the Holbeach Food Enterprise Zone), will build on the Lincoln Institute for AgriFood Technology and National Centre for Food Manufacturing to develop a national centre for food chain automation focused on promoting enhanced labour productivity through automation and robotics. The Centre will work with key partners in industry and academia to bring together key skills and expertise, and will dovetail with the Agritech Centres of Excellence, Agrimetrics and Agri-EPI.
Outline Business Cases – In Summary	
1: Strategic Case What is the case for change (i.e. the rationale)? What are the aims and objectives of the intervention?	The scheme builds on existing regional strengths in the food chain and capabilities from the ICT, engineering and digital industries in which the region has world class expertise. It also responds directly to the large growth in global demand for sensors and engineering which together account for nearly 50% of the global Agri-tech market, estimated at £142 billion in 2012[194]. The Centre will engage with partners in the region including companies, Universities and research institutes to support the development and implementation of its technologies. For example, the region has considerable strength in agricultural informatics through Agrimetrics and its partner organisations, and the Holbeach Centre will add to this growing centre of gravity in smart, precision agriculture. The Centre will engage closely with the Agri-EPI Centre. The two Centres will complement each other with Agri-EPI

[194] UKTI (2013), *AgriTechnology Sector: Market Trends and Opportunities Report* Note that UKTI was replaced by Department for International Trade (DIT) in July 2016

Project name	Centre for AgriFood Automation
	focussed primarily on pre-farm gate innovation and this Centre crossing into innovations in the food supply chain. The UK is facing an estimated £7-10 billion per annum wage cost increase due to the introduction of the National Living Wage at the same time as the availability of labour is potentially restricted due to Brexit. The development of the centre builds on a big increase in demand for the services of LIAT and NCFM due to these industrial pressures which has now created a problem in servicing the industry needs in terms of both human and physical resources.
2: Economic Case Will it deliver value for money? Does it represent a good balance between cost, benefits and risk? Has a range of options been considered?	Elements of the economic case are still under development. A range of options have been considered and the preferred option is to base the centre on the Holbeach Food Enterprise Zone (FEZ) in the heart of the UK's food sector, with the University of Lincoln's NCFM and LIAT as the anchor tenant for a cluster of technology businesses working in food chain efficiency. South Lincolnshire has over 1 million vehicle movements per annum connected to the food chain and is estimated to handle about 35% of all UK food movements.
3: Commercial Case Is there a supplier who can deliver it? Is it viable?	The Centre will build on the University of Lincoln's presence on the Holbeach FEZ. The site is being developed in conjunction with South Holland District Council who are leading the development of the FEZ and Lincolnshire County Council (landlords for phase 1). The demand for support in this technology area has been doubling each year and this trajectory is accelerating meaning that investment is viable and justified by industrial demand. Building on the established expertise at NCFM and LIAT will support successful delivery.
4: Financial Case Is it affordable? Is the required funding available?	The first phase of development to install the core infrastructure for the Holbeach FEZ and to establish the University of Lincoln in a new building on the site as anchor tenant is fully funded. However, further significant investment is needed to develop phase 2 which would relocate and expand the demonstration food factory and business units onto the site and facilitate further expansion of the staff team. Phase 2 needs supporting with investment in additional human resources and technical equipment to develop a centre of the scale needed to meet industry demand. A full business case and funding model has been developed and discussions with potential funders and industry supporters are ongoing. The development has the support of national and international commercial companies including food processors, agrifood companies, technology suppliers and supermarkets as well as sector trade bodies.
5: Management Case Is it achievable? Can we deliver it? Is there management capacity and capability?	The centre will build on existing expertise and experience, and complement existing resources held by Agri-EPI and Agrimetrics. The University of Lincoln has already developed new applied research and teaching centres with industry, such as a new Engineering School co-funded by Siemens in two phases. The University has expertise in the food chain, engineering, robotics and in collaborative centres linked to industry and with its industry, LEP and Council partners has the expertise and management capacity to deliver a major new national centre. The new centre will link with organisations in the wider region involved with priority interventions in ICT and AM&M to ensure that it makes use of their expertise and resources.

MedTech Hubs – within a wider regional ecosystem and supply chain

Project name	MedTech Hubs – within a wider regional ecosystem and supply chain
Brief description of the main elements of the project What is the project? Who will be the key partners in relation to it?	This project will accelerate the growth of MedTech Hubs across the East of England. It will also unlock stronger synergies between different local Hubs in order to enhance an innovation ecosystem that will include a wider supply chain (and the wherewithal for production as well as research and innovation). It will build on the region's existing strengths – evidenced throughout this Audit – to reinforce the position of the East of England as world-leading in this fast-growing field. The project will have two main elements: **1: Developing the Hubs** Initially, two groups of Hubs (in Cambridge and Essex) will provide the focus – although in time, the intention is to develop the network, with additional Hubs in Hertfordshire (probably Stevenage) and Norfolk (King's Lynn and Norwich).

Project name	MedTech Hubs – within a wider regional ecosystem and supply chain
	(a): Cambridge Biomedical Campus (CBC) MedTech Hub The formalisation and development of the CBC MedTech Hub will be linked to the next 28 acres of development land at CBC. In delivering the project, early priorities will be to: • attract two anchor tenants from amongst the larger firms in technology/medical technology • support an arrangement whereby smaller SMEs can take accommodation with the bigger firms, thereby reflecting the structure of the industry. The hub is a key part of the Biomedical Campus' Later Stage Translation Platform. This is assembling the campus strengths in health services research, quality improvement science, later phase clinical trials and device development. The latter involves: • bringing the technology sector (both Tech (e.g. ARM, BT, Microsoft) and Med Tech) into the later stage translation stage as a partner with health service clinicians • creating time and space for clinicians to partner with technology developers • negotiating the regulatory and compliance requirements for health service usage • ensuring the technology embeds effectively in clinical processes • ensuring dissemination and diffusion into mainstream NHS provision through the AHSN function and the Accelerated Access Partnership • linking to the NHS' Sustainability and Transformation Programmes to support effective clinical service change and the use of technology for patient self-management. • responding to the pull from the existing convergence of science and industry on the Cambridge Biomedical Campus • responding to the push from the industry's leadership body, the ABHI, for a Med Tech Hub alongside world leading science and clinical excellence. *(b) MedTech Hubs in Chelmsford, Harlow and Southend* There are three emerging Hubs across Essex, all of which have further potential for accelerating growth. These complement the CBC proposal by providing: a network of science parks focused on medical and advanced engineering companies (together with innovation centres that help to support businesses to access academic expertise); expertise from within the local public service commissioning organisations through the Anglia Ruskin Health Partnership; and connections with industrial primes to support roll-out at scale of innovations. Building on the strong track record of teaching and research at ARU and by enabling access to talent and facilities, ARU is delivering a dynamic environment for collaborative and applied research engaging with the very partners seeking medical technology innovation impact. The three Hubs are: 1: In **Chelmsford**, the MedBIC Innovation Centre, which was established in 2014 by Anglia Ruskin University (ARU) with support from Essex County Council and Chelmsford City Council, was fully occupied by medical and advanced engineering businesses within a year of opening. The imperative now is to enable Phase II of MedBIC Chelmsford to be delivered, adding capacity to the existing facility and enabling more innovations to be developed that support regional and national healthcare systems. 2: A MedBIC Innovation Centre will also be delivered in **Harlow**, which is being advanced by ARU working with Essex County Council, Harlow Council and Harlow Enterprise Zone. The MedBic Innovation Centre will deliver the 15,000 sq ft, facility. It ought to see its first occupants moving in by September 2018. This in turn should help to catalyse the delivery of the wider 51 hectare Enterprise Zone site, creating an environment to support open innovation in conjunction with large companies and Public Health England. Public Health England will be relocating its facilities to the former GSK site, creating further opportunities for growth in Harlow and the wider West Essex area. 3: In **Southend**, a site has been identified (Southend Airport Business Park) and this has secured £19.89m from Local Growth Fund. The intention is that this should provide business innovation space, larger commercial space and access to specialist facilities to support the prototyping, development and testing of new products, including via the Anglia Ruskin Clinical Trials Unit and research facilities (e.g. Gait Analysis Lab and Simulation Suites).

Project name	**MedTech Hubs – within a wider regional ecosystem and supply chain**
	2: Building the ecosystem (between Hubs in the East of England and beyond) The physical Hubs differ from each other in scale and focus – and over time, more will be developed (particularly in Hertfordshire and Norfolk). In part because of the Audit process, regional stakeholders are recognising the nature and scale of potential synergies, both within the region and beyond (e.g. to medical devices and technologies expertise that is found in, for example, Manchester, Leeds and Oxford). The second part of the project is therefore concerned with forging links between existing and future Hubs with a view to creating scale and critical mass across a range of MedTech applications. Some of these are close to fundamental science whilst others are concerned with downstream production. The intention is to build on existing ventures and alliances, including: • the existing **MedTech Innovation Partnership** which has been established in Essex and the wider south east to bring together public, private and academic sectors. It connects the demands for innovation from within the health and social care system from partnerships such as the Anglia Ruskin Health Partnership with innovators in the field of MedTech. • **Eastern Academic Health Science Network's MedTech Accelerator Programme** and "NHS readiness" training for start-ups • the growing engagement by the **Wellcome Genome Campus (e.g. Sanger Institute and EBI)** with Medtech opportunities and other clusters in the region. **Key partners in taking the project forward** This is a big and ambitious project with many different elements. Some aspects will need to be advanced locally – and CUHP (plus Cambridge City Council, South Cambridgeshire District Council, Cambridgeshire County Council and GCGP Enterprise Partnership) and ARU (plus Essex County Council, Chelmsford City Council, Harlow Council, Southend on Sea Borough Council, and SELEP) will have crucial early roles. The wider ambitions will be advanced by a broader partnership. Key members will include One Nucleus, Health Enterprise East, Anglia Ruskin Health Partnership and the Eastern Academic Health Science Network, as well as all four LEPs.
Outline Business Cases – In Summary	
1: Strategic Case What is the case for change (i.e. the rationale)? What are the aims and objectives of the intervention?	**Rationale** The strategic case for this project needs to be understood in terms of the trends and drivers which are defining MedTech globally; the specific opportunities at local site/cluster level; and the opportunities linked to greater regional collaboration. *A: Global trends and drivers* Global trends and drivers have been considered in detail through the Audit process (particularly in Chapters 3 and 6). In essence, MedTech is a fast-growing sector and one in which the imperative for convergence is increasing. This relates both to technologies (e.g. data science and advanced materials) but also to the need for far closer links between clinicians, research scientists, investors, entrepreneurs and patients. These developments are global, but the region has outstanding assets and opportunities and is uniquely well-placed to bring the different elements together. Through this project, a robust platform for scaleable growth over the next 20 years will be generated, delivering economic benefits of national significance and healthcare benefits that will be globally important. *B: Local opportunities and challenges* Locally, the overwhelming rationale relates to the need to encourage – and plan for – physical clustering such that convergence in the MedTech sphere is supported and encouraged. This takes different forms in different Hubs, but is apparent throughout. *(i) Cambridge Biomedical Campus* Cambridge Biomedical Campus currently has 70 acres of land in use or under construction for a range of secondary, tertiary and quaternary health services, research and education facilities of the University of Cambridge, research facilities of the MRC Laboratory of Molecular Biology, Cancer Research UK, the Wellcome MRC Stem Cell Institute, and the commercial research facilities of Astrazeneca/MedImmune and GSK. It is a sophisticated multi-partner environment and a leading contributor to the advancement of health science. The focus so far has been on discovery science and early stage translational research. However, as translation has progressed, the opportunity for the development of medical technology has become clear. In cancer research, for instance a range of medical

Project name	MedTech Hubs – within a wider regional ecosystem and supply chain
	devices has been developed through the Cambridge Cancer Centre's Oncology Innovation Unit in conjunction with AZ and GSK. Elsewhere, the development of the artificial Pancreas has emerged from the Institute of Metabolic Science. The rationale for the development of medical technology sectors on CBC is three-fold, recognising that the next generation of Medtech opportunities will involve the integration of both clinical data with hardware for detection and analysis: • the availability of both bioscience and real world patient data – and the Campus assets are world class in these terms • access to the range of world-class science and resources (e.g. The Cambridge Centre for Computational Biology, Alan Turing Institute, the EPSRC Centre for Mathematics in Imaging, the Institute for Manufacturing) across all relevant research areas, such as biology, computer science, engineering, maths, physics – on a single campus, enabling rapid convergence • access to very high quality clinicians and clinical environment, from which time will need to be funded and deployed to enable the right translation partnership. This combination is attracting significant international business interest and – although early days – it is generating momentum, including from the vantage point of national policy-makers and "influencers". The potential within it is substantial and it presents a key opportunity with high levels of additionality; there are no direct "competitor locations" elsewhere in the UK (i.e. other MedTech hubs are qualitatively different and CBC is really competing with international locations). The requirement now is for modest intervention to help convert clearly expressed interest with clear momentum into tangible investment which will have substantial impacts. In addition, it is important to note that land at Cambridge Biomedical Campus is literally "ready to go", with no major planning- or site-related issues to navigate. *(ii) MedTech Hubs in Chelmsford, Harlow and Southend* The Hubs in Greater Essex are different, but these too have been designed both to draw on well-established local specialisms and to encourage processes of convergence, particularly in relation to expertise from the AM&M sphere. The intention also is that they create production capacity – which will not be a primary focus for the CBC Hub – and so the two ventures ought to be complementary and connected through value chains. For example, the Kao Park Development (with the Data Centre, Raytheon and Arrow Electronics) alongside Harlow Science Park and the wider Enterprise Zone will be a catalyst for links between MedTech businesses and leading electronics companies. Moreover, the relocation of Public Health England (to Harlow) is providing a unique opportunity and catalyst. If the different strands are brought together – and appropriate physical provision is made – the MedTech sector ought to be able to advance rapidly. *C: The rationale for developing the wider ecosystem (at regional scale and beyond)* MedTech is a very exciting sphere and one in which advances are happening quickly. Across the East of England, there are world class assets currently and from these, there is potential to build a world class ecosystem, including most elements of the wider supply chain. Outstanding science is a feature of CBC and through the project, it is proposed that some prototype production will occur on site, but this will not be production at scale. However, that could easily happen at some of the Essex Hubs, which are nearby but with different – and highly complementary – strengths and opportunities. One of the major challenges for the region is how the outstanding scientific assets in the Cambridge area might deliver wider impacts region-wide. The MedTech venture is one in which the synergies are very clear and the market potential is huge; it could be genuinely transformational, at a regional scale. In addition, the intention will be to forge links with other centres across the UK. There are likely to be immediate opportunities with the Leeds City-Region, but also with Manchester and Oxford. Partners in the East of England are keen to nurture links of this type where they add value and impact. **Aims** Consistent with the rationale outlined above, the aims of this project may be summarised as follows: • to develop a series of MedTech Hubs in the East of England – starting with Cambridge Biomedical Campus and three Hubs in Greater Essex, but then establishing Hubs in Hertfordshire and Norfolk – that enable and encourage processes of convergence within the MedTech sphere

Project name	MedTech Hubs – within a wider regional ecosystem and supply chain
	• to build appropriate links between these local Hubs such that patterns of growth are genuinely synergistic within an overall ecosystem that encompasses the wider supply chain • to deliver substantial economic impact and health benefits on a scale that achieves national and international recognition.
2: Economic Case Will it deliver value for money? Does it represent a good balance between cost, benefits and risk? Has a range of options been considered?	The economic case is being progressed. Some of it is confidential at this stage – but the situation is expected to evolve quickly. The level of private sector interest in the CBC element of the project is sufficient to suggest that it is relatively low risk: a modest public sector investment should unlock an investment process involving both global corporates and smaller, newer firms.
3: Commercial Case Is there a supplier who can deliver it? Is it viable?	The commercial case is under development. The existing research and clinical ecosystem combined with a growing MedTech sector will create a powerful driver for the development of new health products. The combination of "hardware and data" will be very significant. Nowhere else in the UK has the same scale of assets in these terms.
4: Financial Case Is it affordable? Is the required funding available?	The financial case is under development. It is important to note that the element of the scheme which is focused on CBC is being developed in a way that "designs in" SME involvement from the outset. The intention is that corporates should be "anchor tenants" and smaller businesses will cluster around them.
5: Management Case Is it achievable? Can we deliver it? Is there management capacity and capability?	The management case is under development.

Microbiome Hub

Project name	Microbiome Hub
Brief description of the main elements of the project What is the project? Who will be the key partners in relation to it?	The project will establish an **Innovation and Commercialisation Hub based at Norwich Research Park. It will support the coordination and commercialisation of UK innovation related to the emerging microbiome market**. The UK has excellent work in the microbiome field but currently it is fragmented. In addition to this, greater emphasis is required on early stage translation and commercialisation of this innovation to meet the interest in this technology by both investors and a range of commercial companies. Specifically, it will: • bring together developments in human and animal gut microbiome, skin microbiome and soil/plant microbiome across the UK • map UK strengths in these fields • connect academics, funders and industry to speed routes to market for this technology • develop the value chain from research to revenue and share best practice • support the translation and formation of start-ups and their rapid growth • attract inward investment • generate jobs and economic growth Overall, the aim is to bring together the key elements required to translate leading UK research in the microbiome into innovative products for the global market. Nested within the wider Norwich Research Park, **the Microbiome Hub will have two main elements:**

Project name	**Microbiome Hub**
	• **the provision of incubator facilities and grow-on space in a highly supportive added value environment with access to leading organisations in the field** • **the provision of advice and support both for tenants of the Hub and for organisations from around the UK with a distinctive focus on the Microbiome** The Quadram Institute (QI) based at Norwich Research Park, will be at the forefront of a new interface between food science, gut biology and health, developing solutions to worldwide challenges in food-related diseases. It brings together academics and clinicians in a purpose build facility treating 40,000 patients p.a. The initial partnerships between academics and industry are likely to be driven around the science interactions so will mostly be with QI at the early stage. These will then drive connections with the Microbiome Hub. The Microbiome Hub would therefore be highly complementary to this activity, building on this initial stage of translation and driving further commercial interaction both with QI and the microbiome community within the UK. This wider remit will help to amplify the benefits of QI and help to coordinate currently fragmented microbiome activities across the UK. Together they will make an international centre of excellence for research and commercialisation in the UK and be an attractor for inward investment globally. **Lead organisation:** Norwich Research Partners LLP (NRP LLP) will lead this project. NRP LLP's member organisations comprise four research institutes (i.e. John Innes Centre, Quadram Institute Biosciences (QIB), Earlham Institute and The Sainsbury Laboratory) plus the Norfolk and Norwich University Hospital Trust (NNUH) and the University of East Anglia (UEA). The BBSRC and John Innes Foundation are also Members. **Key Partners –** the Hub will provide a focus for: • **Industry**: interested parties from the foods, consumer goods, pharmaceutical and agricultural industries including those that have already expressed an interest such as Nestle, Unilever, AB Agri. and many others. • **Investors**: Seventure (which has a $176m fund dedicated to the microbiome), Arix Ventures, Illumina Ventures, Quatris Fund, Rock Springs Capital, etc. • **Start-ups**: given the research strength of the UK and the commercial interest there is an opportunity to support more start-ups in the microbiome across the UK. • **Academic organisations**: The NRP Member institutions have close links with academic organisations within the UK and internationally, and these will be built on further. • **Biofilm Innovation Knowledge Centre** - close links will be encouraged to leverage any synergies in microbial technical knowhow, translation, commercialisation and funding. More generally, whilst the Hub will be industry-led, the project will also build on existing links with other research institutes across the East of England – notably, University of Cambridge, the Sanger Institute, the European Bioinformatics Institute and Rothamsted Research. There are also substantial synergies with other strengths in the region including Agri-tech (soil/plant microbiome), Personalised medicine (human gut and skin microbiome), Genomics (sequencing data) and ICT (transfer and analysis of complex data). ***Note on definitions:*** • *Biofilms are any group of microorganisms adhering to each other within a matrix on or at a surface.* • *The microbiome is the collection of microbes or microorganisms that inhabit an environment, creating a "mini-ecosystem".* *Whilst there is some overlap between the two fields they are different, particularly in health-related applications. A further paper can be submitted to provide a precis of the distinctions between biofilms and the microbiome.*
Outline Business Cases – In Summary	
1: Strategic Case What is the case for change (i.e. the rationale)?	Research, investment and commercial organisations with an interest in the field of the microbiome already exist. What is lacking is a single touch point both to support (and accommodate) SMEs in the field **and** to enable sign posting and connectivity between researchers, corporates and SMEs (both those that are also tenants, and those based elsewhere in the UK). The rationale for the Microbiome Hub at NRP is defined from three perspectives:

Project name	**Microbiome Hub**
What are the aims and objectives of the intervention?	• First, the **microbiome** field brings together expertise in food, health and agri-tech. There is a **global challenge** related to diet related diseases. Interventions in this field have a very large economic impact. Food related illnesses cause over 350 million deaths each year. Gut microbes are becoming a significant area of medicine and health. There are other widespread applications for this technology in personal care (e.g. deodorants), animal health (e.g. reduced antibiotic use) and agri-tech plant and soil health. However whilst there is research expertise and interest from industry in the sector, the gap lies in establishing new start-ups and grow-on companies in the field. • Secondly, international competition is substantial. The activities within the UK are currently world leading but fragmented. They therefore need to be brought together through a coordinating body such as a Microbiome Hub to create critical mass to ensure the UK is not left behind. At NRP, there is a **cluster of research institutions** and a **major medical hub**; this is synergistic with pharmaceutical-focused activities in Cambridge and Hertfordshire and there is nothing like it elsewhere in the UK. It is therefore well-placed in relation to international competitors • Third – and more generally – the UK is known as **world leading in science** but not in translation and commercialisation. There are therefore fundamental building blocks that we need to improve if we are to increase our innovation capacity. The **Microbiome Hub** will be part of a national response in an important area of disruptive technology. **The aim of the intervention is therefore to provide support for translation of UK research in the microbiome field through a Microbiome Hub.** In practice this means providing specialist advice for the sector; and supporting the growth of SMEs. In turn the venture will create critical mass in the UK; attract inward investment; and generate economic benefit for the UK. The intervention also specifically addresses some of the major findings of the Audit. It expressly aims to unlock the process of convergence between the East of England's research strengths as work on the microbiome has multiple applications in human, animal, plant and soil science. Equally it promotes clustering at the NRP and potentially elsewhere.
2: Economic Case Will it deliver value for money? Does it represent a good balance between cost, benefits and risk? Has a range of options been considered?	There is an outstanding market opportunity through the wide range of commercial applications of this technology. There is also scope to achieve improvements in public health leading to societal benefit and substantial reductions in NHS costs. There are also a number of routes to market which may provide a shorter timeline to commercialisation than the traditional pharmaceutical route e.g. personal/skin care consumer goods and agri-tech applications. The creation of the Hub should be cost effective since the Hub will leverage existing assets such as the Quadram Institute (QI) which opens at NRP in 2018. The QI will bring together in one building researchers and clinicians from the NNUH, UEA and Institute of Food Research to build understanding of how food and the gut microbes interact providing a key national centre of research excellence where current provision is dispersed and poorly coordinated. This new development will house the largest gastroenterology unit in Europe. The Institute of Food Research will leave behind a large (77,500 sq. ft.) lab and office building when it moves to the Quadram Institute that could be re-purposed as a base for the proposed Microbiome Hub and related innovative companies creating a cluster in this field. Given the scale of potential demand and the depth of research-based expertise already on NRP, the Microbiome Hub ought to be occupied quickly, delivering early economic impacts and achieving good value for money. Further work is needed to develop the Economic Case in detail, and to explore alternative options relating to the scheme's delivery.
3: Commercial Case Is there a supplier who can deliver it? Is it viable?	The full Commercial Case is currently under development. **The intention is that the establishment of the Microbiome team would be supported by Norwich Research Partners LLP.** The project is seen to be relatively low cost for potentially very high benefit for the UK. NRP has been identified as a national asset providing an academic base combined with a supportive environment for innovation, translation and commercialisation. The proposal re-uses existing facilities and the location benefits from Enterprise Zone status. There has also been substantial interest from industry in the Microbiome field. A recent Microbiome seminar at NRP attracted speakers from multinationals (Unilever, Nestle, Ag.Agri), investors (Seventure, Arix) and a range of start-ups from across the UK. The event was highly oversubscribed and highlighted the great interest from industry in this

Project name	Microbiome Hub
	field. The next stage will be to capitalise on this interest by working with industry to establish an investors platform for innovation and translation within the microbiome field. Other investment into NRP includes £26m investment from UK Government and BBRSC to help deliver the NRP Science and Enterprise Vision; £75m funding for the Quadram Institute (from BBSRC, IFR, NNUH NHS Foundation Trust and UEA); and contributions in cash and kind from Member landowners, the John Innes Foundation, UEA and the BBSRC. Approaches to procurement and issues relating to viability will be explored in due course.
4: Financial Case Is it affordable? Is the required funding available?	At this stage, it is estimated that the costs of the project over the first three years will be as follows: • **Revenue:** £1.5m over 3 years to assist with establishment of knowledge transfer, coordination and promotional activities, and to develop an appropriate commercialisation strategy to deliver significant economic benefit across the UK. The potential Microbiome team could comprise a Director (senior Industry expertise), Deputy (scientific expertise) plus 2 Relationship Managers and travel/events budget. • **Capital**: There is an opportunity to repurpose existing lab and office space owned by the BBSRC which will be vacated by the Institute of Food Research in 2018 when it moves to the new Quadram Building. If made available, this building could be refurbished in whole or in part to provide a facility for the new Microbiome Hub plus accommodation for start-ups and inward investments. The total cost of refurbishment of this building is estimated at £5m (77,500 sq. ft.) but initially may be possible to refurbish a portion of the building at an estimated cost of £1-2m. The funding package for the Microbiome Hub is under development and would also crucially include investment by lead industry players. However, it will require additional external funding support but this should be seem in the context of wider plans for Norwich Research Park. These plans are levering in substantial private and public sector investment.
5: Management Case Is it achievable? Can we deliver it? Is there management capacity and capability?	**The project will be delivered with the support of Norwich Research Park LLP**. NRP LLP has an experienced management team and a **track record of success** within the UK. From its establishment in 2012, the Park has grown from 16 to 75 companies and around 78% of these organisations have a close association with the academic base. NRP's stakeholders (including Member organisations and local authorities) are fully supportive of the Microbiome Hub proposal. With the opening of the Quadram Institute and increasing interest in the microbiome, the timing is right to capitalise on this opportunity and establish a specialist Microbiome Hub based at the Park. The relationships already exist with the key players in the industry but what is lacking is the dedicated resource to manage this. A Steering Group to provide input and guidance to the Microbiome team will be formed representing relevant commercial, academic and public sector stakeholders from across the East of England Science and Innovation Audit area, working with the NRP LLP lead contact.

Precision medicine cancer ecosystem

Project name	Precision medicine cancer ecosystem
Brief description of the main elements of the project What is the project? Who will be the key partners in relation to it?	This project is intended to advance cancer medicine, moving from a reactive system that waits for cancer to present in patients, to a proactive personalised strategy for all patients that continually detects cancer in its earliest form, intervenes precisely, and closely monitors the disease course with non-invasive technologies. The project is underpinned by world class science but with an immediate focus on translation, particularly early detection. Specifically, the intention is to: • detect cancer earlier – by understanding and detecting the pre-malignant state • invent new treatments – by partnering with biopharma and bringing new therapies to patients • treat precisely – by tracking tumour response and resistance. This approach will reduce mortality and morbidity for all patients and also deliver economic benefits. The latter will be achieved through the commercialisation of new devices and treatments and in the massive reduction in treating end-stage cancer.

Project name	**Precision medicine cancer ecosystem**
	The project itself has two main elements – one focused on Cambridge Biomedical Campus and a second which will develop wider regional opportunities. **1: Cambridge Precision Cancer Medicine Hospital** The proposed Cambridge Precision Cancer Medicine Hospital represents a new concept in hospital operation and design. In recognition of the imperatives and opportunities linked to convergence, physics, chemistry and engineering laboratories will be positioned next to clinical facilities. Teams of scientists who are inventing and perfecting the next generation of cancer early detection devices, diagnostics and treatments will work alongside patients, physicians, surgeons and nursing staff. This convergence of a range of science and industry partnerships in the heart of an NHS cancer hospital will propel both clinical improvements and economic growth. Facilities for early detection and diagnosis will form a key part. Space has been identified to develop the Hospital as part of the wider development of the Cambridge Biomedical Campus. It will be linked to the Forum development (in which education, training and conference facilities will be built). The Precision Cancer Medicine Hospital overall is supported by Astra Zeneca and other partners linked to the Cambridge Biomedical Campus (e.g. GSK, Cancer Research UK, MRC, Wellcome and the University of Cambridge). But it would be available to a range of industry and science partnerships working together. **2: The wider ecosystem** There is a real opportunity for the region-wide collaboration to enhance the prospects for a world class ecosystem in precision cancer treatment. Engagement with the Sanger Institute will be crucial. More broadly, the intention is to work with other hospitals – notably Norwich and Norfolk University Hospital (NNUH) and the Lister Hospital (in Stevenage). NNUH is located on Norwich Research Park which – as set out elsewhere in this Audit – has world class expertise in relation to microbiome. NNUH is actively involved in related research including, for example, an on-going investigation into the benefits of dietary interventions in the development and course of prostate cancer by researchers in the Trust, the Institute of Food Research (now Quadram Institute Bioscience) and UEA, funded by the Prostate Cancer Charity. The imperative will be to draw insights and expertise of this nature into precision cancer treatment region-wide. In taking this forward, there will be an important co-ordinating role for the Eastern Academic Health Science Network. **Key partners** In advancing this project, key partners will include Cambridge University Health Partners (CUHP), CRUK Cambridge Institute and Cambridge University Hospitals NHS Trust. Other NHS Trusts will also be involved and the Eastern Academic Health Science Network will play a key co-ordinating role, particularly in relation to wider ecosystem developments.
Outline Business Cases – In Summary	
1: Strategic Case What is the case for change (i.e. the rationale)? What are the aims and objectives of the intervention?	**Rationale** The CRUK Cambridge Institute is an international leader at the heart of a cancer ecosystem, and it is a major national centre. It is actively developing world-leading precision cancer medicine (e.g. it is the first Cancer Centre in the world to introduce whole genome DNA and RNA sequencing as the standard investigation for managing patients with breast cancer in real time). This work interfaces directly with major commercial partners including Illumina and with Cambridge University Hospital's EPIC electronic health record system (the first example of a data lake covering both bioscience and real world patient data on which Cambridge can lead nationally). This has allowed patients to be genotyped into different disease types, allowing the identification of actionable mutations for clinical trials. This ability to stratify patients according to their cancer genotype will in turn result in increased cure rates and decreased side effects. Through the Precision Cancer Medicine Hospital, the intention is to roll out this approach across 12 programmes. This will converge a range of key sciences – biology, computer science, chemistry, engineering, medicine, physics, surgery – with the drug development work of the key biopharma companies, and the patients flowing through the hospital. Besides the disease specific programmes there will be four discipline-focused programmes in Advanced Imaging, Cell and Molecular Biology, Early Cancer Detection and Onco-Innovation. The main purpose of these programmes is to translate fundamental discoveries in cancer biology made across the Centre into novel biomarkers, clinical devices and treatments for patients.

Project name	Precision medicine cancer ecosystem
	Aims The aims of the intervention are to: • advance the development of personalised medicine, focused on cancer treatments through a new Precision Cancer Medicine Hospital • build links between the Precision Cancer Medicine Hospital in Cambridge and other regional centres (particularly Norwich and Stevenage) to ensure that learning (in both directions) is quickly disseminated and mainstreamed within cancer treatments • deliver substantial health benefits, cost savings and wider economic impacts.
2: Economic Case Will it deliver value for money? Does it represent a good balance between cost, benefits and risk? Has a range of options been considered?	The full economic case is under development, including the exploration of different options. While the Cambridge Biomedical Campus is already a leading hub for health services and life sciences, it is recognised that revolutionising the cancer ecosystem represents the next stage of scientific development and patient service. The project will draw upon skills and expertise from the region and beyond and will be a benchmark globally, should it prove to be successful. The potential for investment and job creation are huge.
3: Commercial Case Is there a supplier who can deliver it? Is it viable?	The commercial case is under development. However, it is important to note that very few other centres in the UK have the complete integration of pharma (through AZ and GSK and potentially others), biotech and medtech, academia and clinical engagement. This project presents a unique commercial opportunity.
4: Financial Case Is it affordable? Is the required funding available?	The detailed financial case is under development. However, it is important to note that besides partner support and contributions, there is already growing support for the Precision Cancer Medicine Hospital from a range of funding sources. This leaves a "funding gap" of £25m which is where we place the focus on early detection and diagnosis. This could be sought from Government as part of the Life Science Sector Growth Plan and/or the Industry Challenge Fund. This would signal Government's intention to invest in the industry and stimulate further support from industry partners in Cambridge.
5: Management Case Is it achievable? Can we deliver it? Is there management capacity and capability?	The management case is under development

Cell & Gene Therapy R&D Centre

Project name	Cell & Gene Therapy R&D Centre
Brief description of the main elements of the project What is the project? Who will be the key partners in relation to it?	After opening its doors five years ago, the Stevenage Bioscience Catalyst (SBC) is today seen as a benchmark for Science Parks across Europe and beyond. Its Incubator+ model has supported over 60 different companies, which have raised over £220m of investment and have a 95% survival rate. It has attracted inward investment from biotech startups (Tokyo Electron, Auspherix and Tusk Therapeutics) and multinationals (J&J Innovations, GE Healthcare, Lilly and Sanofi). MRC Technologies has relocated all its drug discovery operations from London to SBC and in 2015 it was selected by the UK Cell & Gene Therapy Catapult as the site for its £55m state-of-the-art Cell & Gene Therapy Manufacturing Centre. SBC is now ready to expand its vision to establish a full-service, cutting edge Cell & Gene Therapy R&D Centre on its campus, directly adjacent to the UK Catapult's Cell & Gene Therapy Manufacturing Centre. Companies located in the Cell & Gene Therapy R&D Centre will work on products and technologies that can subsequently be manufactured within the Manufacturing Centre. The translational pathway should attract new and established companies from the UK and internationally. In addition, there will be mentoring activity between the R&D Centre and the Manufacturing Centre (and GSK). GSK is active in cell and gene therapy, making the Stevenage Campus a world-leading hub. In addition, the aim is to promote, innovation, networking and knowledge transfer more generally.

Project name	**Cell & Gene Therapy R&D Centre**
	This will provide a flow of collaborative and commercial opportunities in the Cell and Gene therapy field from concept to clinical product, expediting clinical trials and supporting a next generation of treatments for patients. It will also provide over 300 new direct jobs and up to 450 supporting roles with an additional 200 jobs involved during the construction phase. Importantly, it will provide a single hub for the UK's future position as the World Leader in Cell & Gene Therapy – a rapidly growing field that promises to transform the way we treat human disease. The Cell & Gene Therapy R&D Centre will create approximately 50-60,000 sq. ft. of net lettable space over three floors, plus interactive space. The building will contain up to 80% laboratory space and 20% office space, plus convivial areas intended to spark discussions and collaboration. This single, multifunctional facility will be designed to support a variety of technologies including dry and wet labs and clean rooms, as well as additional incubator space. The requirements for the building infrastructure have been drawn up in consultation with internal tenants and external parties. SBC is in discussion with potential anchor tenants and will work with these on the spatial and functional requirements. Flexibility is key as there is a need to provide maximum opportunities for collaboration and interactions between tenants, as well as optimising engagement with external partners and the community. SBC's stakeholders (GSK and Wellcome) are fully supportive of SBC maintaining its significant momentum and are prepared to invest again.
Outline Business Cases – In Summary	
1: Strategic Case What is the case for change (i.e. the rationale)? What are the aims and objectives of the intervention?	SBC is already home to one of the UK's leading Cell & Gene Therapy communities, alongside the imminent UK Catapult Cell & Gene Therapy Manufacturing Centre. GSK is building a Cell & Gene Therapy R&D platform on the site to underpin the development of novel therapies in oncology and rare diseases – two of its core research areas. This reflects the company's belief in Cell & Gene Therapy's potential as an important treatment approach for tackling the underlying cause of serious disease. Indeed, in March 2016, regulators gave GSK approval to sell a new gene therapy, Strimvelis; this was the first approval for a genetic therapy granted to a large multinational drug company. GSK's Strimvelis marks an important milestone for the company in developing gene therapies. It has research programmes underway for three relatively rare diseases and several programmes aimed at using gene therapy to treat cancers. SBC's plans for campus expansion build on an ethos of open innovation, strong science, commerciality and healthcare benefit. It does not believe that there is another facility planned elsewhere in the UK that is driven like this, and based on the outcomes of Phase 1, SBC believes it has excellent prospects for success. The new Cell & Gene Therapy R&D Centre will deliver: • long-term security for the UK's position as the World Leader in Cell & Gene Therapies; • accelerated translation of cutting edge academic research into pioneering next generation Cell & Gene Therapy medicines; • 300 new direct jobs and up to 450 supporting roles with an additional 200 jobs involved during the construction phase; • step change growth, productivity and investment in current and new tenant companies; • critical in-demand incubation and grow on space for IP-driven, Cell & Gene Therapy companies in the greater south east.
2: Economic Case Will it deliver value for money? Does it represent a good balance between cost, benefits and risk? Has a range of options been considered?	There is a wide range of benefits associated with the expansion of the campus including positive impacts on the performance of businesses, convergence of technologies, entrepreneurship, company formation and new business models (including spin-out processes), inward investment, innovation performance, skills development and other indicators of economic progress. It is now seeking £15m in government support to round out capital funding for the facility that will break ground at the end of 2017 and will be completed by the end of 2019.
3: Commercial Case	SBC has established a reputation for successfully translating excellent science and technology into sound business opportunities through developing partnerships. As part of the UK Science Base, the Stevenage Campus contributes to the wealth creation, quality of life and public understanding of science objectives of Government. SBC has

Project name	**Cell & Gene Therapy R&D Centre**
Is there a supplier who can deliver it? Is it viable?	created the opportunity for commercial science to stimulate curiosity-driven research to the benefit of the site's and other user communities. This is a significant opportunity for Government to underpin the UK's status as a World Leader in Cell & Gene Therapy by investing in the renowned SBC Campus. The site infrastructure, operating model, stakeholders and team are already in place to deliver this plan for the advancement of UK life sciences and ultimately for the health and wellbeing of patients in the UK and beyond.
4: Financial Case Is it affordable? Is the required funding available?	Stevenage Bioscience Catalyst has already secured offers of £20m funding for this new £50m facility from its founding members (GSK and Wellcome Trust) and has agreed further infrastructure support from Hertfordshire Local Enterprise Partnership. SBC is in advanced discussions with recently funded spin-outs to become anchor tenants and provide significant fit-out contributions. It is now seeking £15m in government support to round out capital funding for the facility that will break ground at the end of 2017 and will be completed by the end of 2019. Alternative sources of finance have been considered but viewed as inappropriate for Phase 2. These included commercial property developers (which are perceived to be potentially detrimental to campus ethos at this stage of development, with other drawbacks such as onerous lease requirements). Commercial funding is however expected to form part of the development of Phase 3, and success of Phase 2 is expected to help to facilitate this.
5: Management Case Is it achievable? Can we deliver it? Is there management capacity and capability?	SBC has rapidly established itself as a thriving asset critical to the ambitions of Hertfordshire and the Cambridge life sciences corridor, providing a model for other UK incubators which are increasingly emulating its practices. Recognised as a leader, its unique "part infrastructure/part virtual model" promotes pan-UK innovation. The management team is one of the UK's and Europe's leading bioincubator development teams and is keen to repeat its success. With the expansion of the campus, it could quickly: • create a world class campus which will grow its national and international reputation, based on the high quality of its tenants, campus and staff • enhance financial sustainability • continue to support translational efforts that emphasize patient benefit • continue to increase quality of campus life for tenants and allow them to grow on that very campus, retaining deep resources of expertise and innovation for the benefit of all • 'institutionalise' a culture which practises entrepreneurship and open innovation, embraces new technologies and the 'bumper car' model where proximity promotes engagement • be nationally recognised for having a unique specialist model, focusing its innovation in core areas of excellence and catalysing cross-UK innovation.

Annex C: LEPs' commitment to science and innovation in their SEPs

C.1 The tables below summarise the content of the four Local Enterprise Partnerships' existing Strategic Economic Plans (SEPs) as of April 2017. Note that all four are in the process of being refreshed. Hertfordshire LEP is leading the way and its refreshed draft SEP went through a public consultation process which ended early in 2017. New Anglia LEP and Greater Cambridge Greater Peterborough Enterprise Partnership are both refreshing their SEPs currently. South East LEP is about to embark on this process.

Theme	Summary
Greater Cambridge – Greater Peterborough Economic Partnership – SEP, 2014	
Commitment to Science and Innovation	The SEP encourages: 'Specific technology sectors where we can build or increase our internationally competitive lead' and 'Research and innovation to fuel our technology pipe line.'
Priority sectors identified	N/A
Immediate/ongoing actions	• Alconbury Weald Enterprise Campus • Respond to existing pressure for the growth and retention of businesses by facilitating the provision of additional commercial space • Deliver a Growth Hub to support business growth
Future priorities	• Support projects that deliver innovation and incubator space across the LEP area. • Create a fund mechanism that will allow greater flexibilities on the use of this funding to support innovation and incubator space • Target research, innovation and follow-on space • Encourage the expansion beyond Cambridge of technology businesses • Translation of innovation from start-up to commercialisation
Hertfordshire – Refreshed SEP, consultation draft, 2017	
Commitment to Science and Innovation	Priority 1 from the SEP is concerned with "maintaining global excellence in science and technology"
Priority sectors identified	• Life Sciences • Advanced Engineering/Manufacturing • Agri-science and Agri-Tech • Sustainable construction • Creative industries
Immediate/ongoing actions	• Investment in Stevenage Bioscience Catalyst • Development of the Envirotech Enterprise Zone (involving Rothamsted Research and BRE) • Investment in STEM skills working with Airbus
Future priorities	• Develop long-term ecosystem plans for each sector • Sustain dialogue with major science and tech-based companies, as well as neighbouring LEP areas. • Engagement with national bodies to secure investment • Continue STEM agenda prioritisation • Keep a "watching brief" especially regarding loss of employment land, particularly that crucial to science and tech-sectors

New Anglia – SEP, 2014	
Commitment to Science and Innovation	Encouraging enterprise and innovation is listed as one of the key factors in achieving New Anglia's broader economic growth ambitions
Priority sectors identified	• Advanced Manufacturing and Engineering • Agri-tech • Energy • ICT/Digital culture • Life Sciences
Immediate/ongoing actions	• 'Innovation Voucher Scheme', which provides specialist support from the university of East Anglia, University Campus Suffolk and Norwich University for the Arts • Establish OrbisEnergy as one of the major delivery partners for the new national Catapult Centre for Offshore Renewable Energy. • Support the developing relationship between BT at Adastral Park and the Catapult Centres for the 'Connected Digital Environment', 'Satellite Applications', and 'Future Cities' • Link up Hethel Engineering Centre with the work of the High Value Manufacturing Catapult Centre • Exploit links between the Norwich Research Park and the national Agri-tech Strategy
Longer term priorities	Covered above
South East – SEP, 2014	
Commitment to Science and Innovation	'The drive for innovation must come from businesses themselves and reflect their needs. Across the SE LEP area, partners can ensure expertise is accessible, promote business to business collaboration, and facilitate effective university and college partnerships with businesses.'
Priority sectors identified	• Advanced Manufacturing • Transport and Logistics • Life Sciences and Healthcare • Environmental Technologies and Energy • Creative, Cultural and Media • Visitor Economy
Immediate/ongoing actions	• Enterprise zones are in place which have scientific research and development at their core, such as Harlow Enterprise Zone and Discovery Park in Kent. • Support for the Knowledge Gateway at the University of Essex. • World leading agri-tech research and development facility at East Malling Research
Longer term priorities	• Increased access to finance: 'we know that many innovative businesses in, for example, the life sciences and healthcare and low carbon sectors, require equity investment rather than loan funding.' • Growth plans and programmes for innovation in rural economy, targeting rural priorities. • Continue to enhance agri-tech sector for which SE is ideally placed. • Maintain strength of SE LEP's HEIs. • Programmes of investment for coastal economies.

Annex D: List of Stakeholders who have contributed to the Audit

D.1 The individuals listed below have all contributed to the Audit – through attendance at workshops, the submission of written evidence and/or participation in surveys and other primary research. Note that a number of other people have also contributed but expressed a preference not to be named. The East of England Science and Innovation Audit Steering Group would like to acknowledge the time that has been devoted to this process by stakeholders, partners and businesses from across the region and beyond.

Table D-1: List of stakeholders, partners and businesses that have contributed to the East of England Science and Innovation Audit

Name	Organisation	Name	Organisation
Shahid Hanif	ABPI	Deborah Pullen	BRE
Andrew Pacey	Advotek Medical Devices	Allison Nicholl	BRE
Claire Thompson	Agility Health	Kevin Woollard	BT
David Horna	Aglaris	Jonathan Legh-Smith	BT
Miquel Costa	Aglaris	Sarah Mackenzie	BT
Belinda Clarke	Agri-Tech East	Sally Bromham	Business Stortford
David Miles	AKL R&D	Peter Cowley	Cambridge Angels
Jan Storgards	Anglia Ruskin University	Jeanette Walker	Cambridge Biomedical Campus
William Davies	Anglia Ruskin University	Martin Garratt	Cambridge Cleantech
Jemma Little	Anglia Ruskin University	Nick Taptiklis	Cambridge Cognition
Andy Salmon	Anglia Ruskin University	Andrew Barrett	Cambridge Consultants
Vittoria Danino	Anglian Water	Edward Brunner	Cambridge Consultants
Stephen Pattison	ARM	Christine Martin	Cambridge Enterprise
Kevin A. Auton Ph.D	Aseptika	Martyn Postle	Cambridge Healthcare & Biotech
Harren Jhoti	Astex Therapeutics	Michael Anstey	Cambridge Innovation Capital
David Andrews	AstraZeneca	Robert Tansley	Cambridge Innovation Capital
Ruth March	AstraZeneca	Alan Barrell	Cambridge Judge Business School
Duncan Judd	Awridian	Phil O'Donovan	Cambridge Judge Business School
Derek Jones	Babraham	Jack Jachmann	Cambridge Medtech
Bill Poll	BBSRC	Jonathan Brech	Cambridge Network
Steve Bates	BIA	Hans Hagen	Cambridge University Health Partners
Kevin Lee	Bicycle Therapeutics	Malcolm Lowe-Lauri	Cambridge University Health Partners
Miranda Weston-Smith	Biobeat	Abhi Naha	Cambridge Wireless
Joe Panetta	Biocom (US)	Bob Driver	Cambridge Wireless
Susan Windham-Bannister	Biomedical Growth Strategies LLC (US)	Maxim Rossmann	Camonx
Bill Sprigings	Bionet	Uday Phadke	Cartezia
Anon	BioPmed (Italy)	Taslimarif Saiyed	C-CAMP (India)

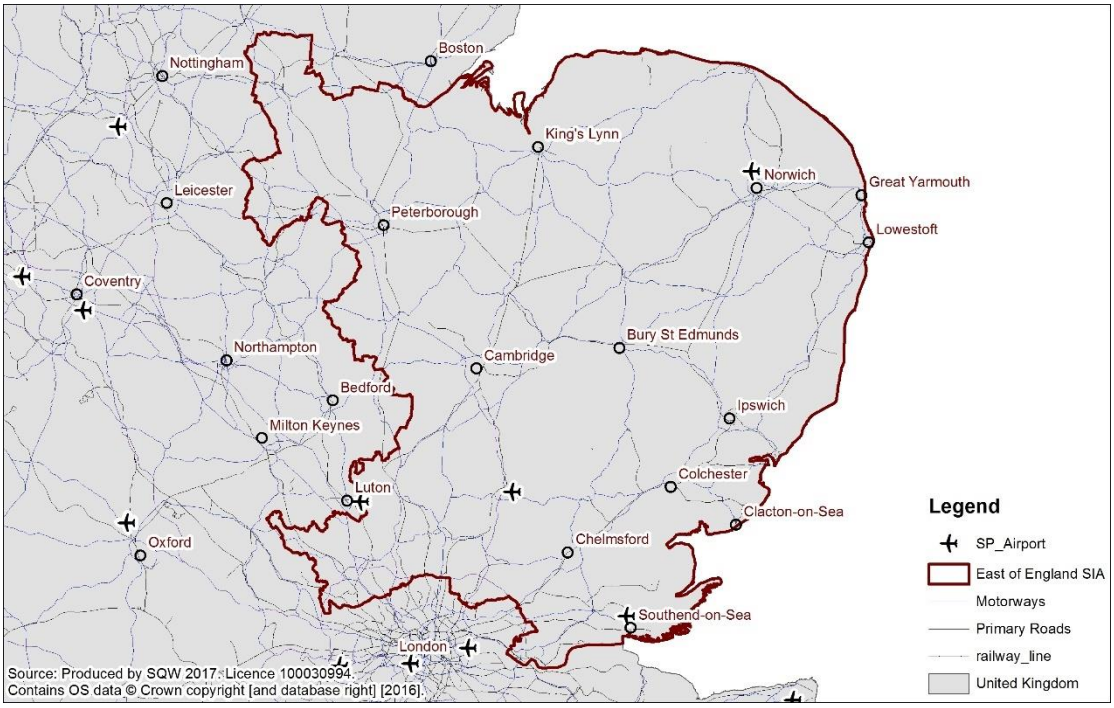
Name	Organisation	Name	Organisation
Sharon Brownlow	Cell & Gene Therapy Catapult	Steven Howe	GSK
Matthew Durdy	Cell & Gene Therapy Catapult	Ian Pitfield	Gyroscope
Nigel Brooks	Cellcentric	Julie Houston	Harlow Council
John Royle	Chronicle Digital Storytelling	Anita Thornberry	Haven Gateway Partnership
Teresa Hogsbjerg	Colchester Borough Council	Anne Blackwood	HEE
Martin Collison	Collison and Associates	Malcolm Weir	Heptares
Simon Poulter	Collusion	Robert Gurney	Hertfordshire Constabulary
Tom Weaver	Congenica	Paul Witcombe	Hertfordshire LEP
Jo Cox	Cranfield University	Jeeta Aulak	Hertfordshire Police
Peter Pack	Crescendo	Aaron Hunter	Hethel Innovation
Trevor Perrior	Domainex	Simon Coward	Hethel Innovation
Phillip Smith	E&N Hertfordshire NHS Trust	Philip Mickleborough	Hethel Innovation
Anthony Finbow	Eagle Genomics	Michael Hill-King	Huawei
William Spooner	Eagle Genomics	Andy Blackwell	Ieso Digital Health
Abel Ureta-Vidal	Eagle Genomics	Jim Marshall	IF Recruitment
Steven Feast	EAHSN	Andy Richards	Independent
Karen Livingstone	EAHSN	Howard Partridge	Innovate UK
Mark Otto Smith	EAHSN	Marek Tyl	Innovation Forum
Wilfried Haerty	Earlham Institute	Nicky Daniels	Innovation Martlesham
Tamas Korcsmaros	Earlham Institute	Jim Milne	Innovation Martlesham
Federica di Palma	Earlham Institute	Christian Roghi	Institute of Food Research
Mary Barlow	EMBL-EBI	Eddie Blair	Integrated Medicines
Ewan Birley	EMBL-EBI	Richard Bailey	Invest Essex
Chuck Cook	EMBL-EBI	Simon Papworth	Invest Essex
Lindsey Crosswell	EMBL-EBI	David Russell-Graham	Invest Essex
Paul Flicek	EMBL-EBI	Linda DiMario	Irvine Chamber of Commerce (US)
Alex Mitchell	EMBL-EBI	Adam Collier	Isogenica
Jessica Vamathevan	EMBL-EBI	Linda Jenkins	Jenkins & Jenkins
Paul Dodson	Essex County Council	Anne Osborne	John Innes Centre
Joe Brennan	Evonetix	Jonathan Clarke	John Innes Centre
Nick Pittom	Fire Panda	Davide Danovi	Kings College London
Simon Ellison	Fisher Bioservices	Sue Dunkerton	KTN
David Skipp	Ford	Alex Henzing	KTN
David Walsh	Frontier Developments	Terry O'Neill	KTN
John Haurum	F-star	Liliya Serazetdinova	KTN
Steve Goode	GaitSmart	Allan Bradley	Kymab
Craig Warrington	Gemalto	David Chiswell	Kymab
Mischa Kapuchesk	GeneStack	Alex Blyth	Lift Biosciences
Gary Stafford	Global Invacom	Jane Reed	Linguamatics
Greer Deal	Global Regulatory Services	John McGill	London Stansted Cambridge Corridor
Steven Wilson	Greater Cambridge Greater Peterborough LEP	Tom Sommer	MassMedic (US)
Dave Allen	GSK	Sinead Kearns	MedCity
Philipe Sanseau	GSK	David Grainger	Medicxi

Name	Organisation	Name	Organisation
Matthew Woodwark	MedImmune/AZ	Emma Palmer Foster	SBC
Mike Romanos	Microbiota	Martino Picardo	SBC
Anker Lundermose	Mission Therapeutics	Iain Wilcox	Seventure
Paul Wallace	Mission Therapeutics	Steven Huckle	Shark Infested Custard
Michael Adeogun	National Physical Laboratory	Daniel Clark	Smart Cambridge
Scott Parkinson	Nestle	Andrew Basu-McGowan	Smart Specialisation Hub
Madeline Coupe	New Anglia LEP	Julian Munson	South Norfolk Council
Laura Mitchell	NG:Safe	Murray Foster	Southend Business Partnership
Lydia Smith	NIAB	Chris Burr	Southend-on-Sea Council
CD Nigel Toseland	Nigel Toseland Consultancy	David Gill	St John's Innovation Centre
Bo Olofsson	Nokia Bell Labs	Kirsten Masson	St John's Innovation Centre
Kate de Vries	Norfolk County Council	Daniel Coole	Surgical Holdings
Jane Locke	Norfolk County Council	John Fagan	SyncNorwich
Sally Ann Forsyth	Norwich Research Park	Pauline Lukey	Target to Treatment Consulting
Sarah Steed	Norwich University of the Arts	Tim Robinson	TechEast
Bill Carpou	Octane Orange County (US)	Allan Marchington	Touchstone Innovations
Harriet Fear	One Nucleus	Steve Jones	TWI Consultant
Tony Jones	One Nucleus	Barry Murphy	Unilever
Johnathan Reynolds	Orbis Energy	Andrew White	Unilever
Sarah Wren	PA Consulting	Andy Hopper	University of Cambridge
Richard Owen	PlaqueTec	Pat Langdon	University of Cambridge
Yen Choo	Plasticell	Alexandra Bolton	University of Cambridge
Rob Ollett	PlayFusion	Lynda Drumright	University of Cambridge
Joanne Hackett	Precision Medicine Catapult	Alexi Lapkin	University of Cambridge
Mark Bechter	Precision Medicine Catapult	Peter McNaughton	University of Cambridge
Iwan Roberts	Puridify	Tom Monie	University of Cambridge
Ian Charles	Quadram Institute	Mariana Fazenda	University of Cambridge
Eddy Littler	ReViral	Kate Parsley	University of Cambridge
Mitch Da Silva	RS Components	Andy Neely	University of Cambridge (IfM)
David Aanensen	Sanger	Peter Templeton	University of Cambridge (IfM)
Matt Garnett	Sanger	Tim Minshall	University of Cambridge (IfM)
Adrian Ibrahim	Sanger	Richard Harvey	University of East Anglia
Ross Rounsevell	Sanger	Joost Noppen	University of East Anglia
Manj Sandu	Sanger	Gerard Parr	University of East Anglia
Julia Wilson	Sanger	Chris Blincoe	University of East Anglia
Trevor Lawley	Sanger	Jon Carter	University of East Anglia
Matt Hurles	Sanger and Congenica	Dylan Edwards	University of East Anglia
Jeff Barrett	Sanger and Open Targets	Fiona Lettice	University of East Anglia
Nuno Alves	SBC	Ruth Welters	University of East Anglia
Amanda Keightley-Pugh	SBC	Andrew Whilding	University of East Anglia
Miranda Knaggs	SBC	Simon Lucas	University of Essex

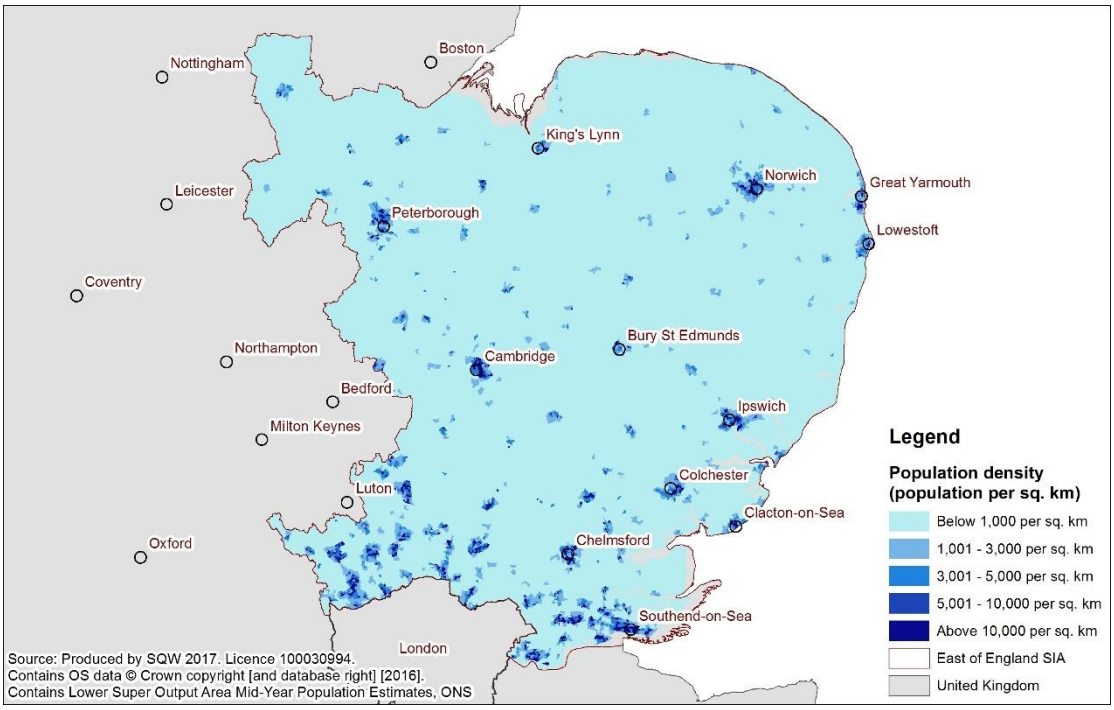
Name	Organisation	Name	Organisation
Vania Sena	University of Essex	Philip Fiddaman	University of Hertfordshire
Rob Singh	University of Essex	Rodney Day	University of Hertfordshire
Richard Lui	University of Essex	Simon Pearson	University of Lincoln
Kirstie Cochrane	University of Essex	Stephanie Thorne	University of Suffolk
John Senior	University of Hertfordshire	Rod Richards	VHsquared
Volker Steuber	University of Hertfordshire	Joanna Gould	VisusNano
Paul Findlay	University of Hertfordshire	Martin Dougherty	Wellcome Genome Campus
Darragh Murnane	University of Hertfordshire	Wendy Arntsen	Wellcome Genome Campus
		Tim Cutts	Wellcome Trust Sanger Institute

Annex E: Maps from Chapter 1

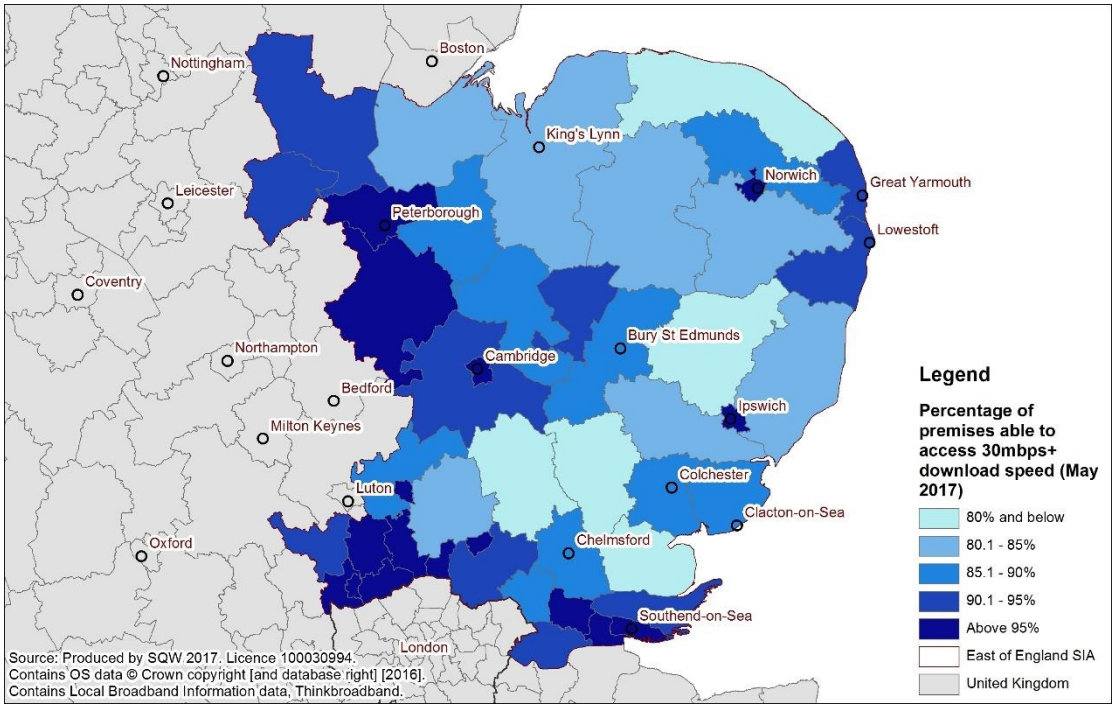
The geography of the East of England Science and Innovation Audit Area (Figure 1-1)



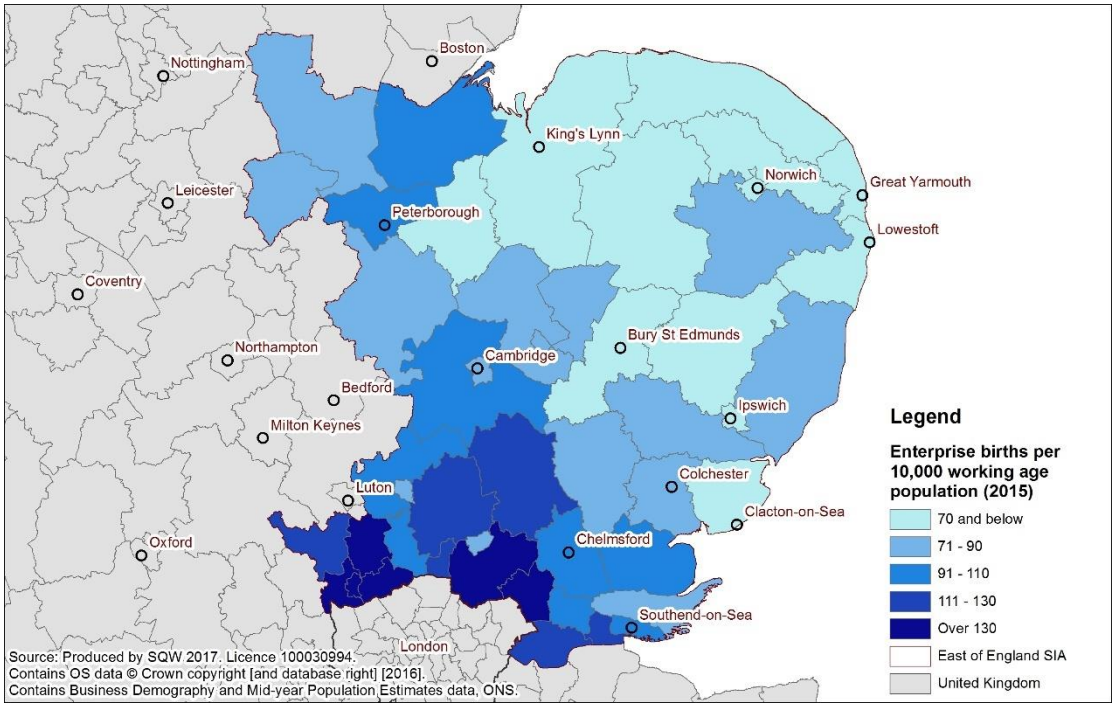
Population density, 2015 (Figure 1-2, Map A)



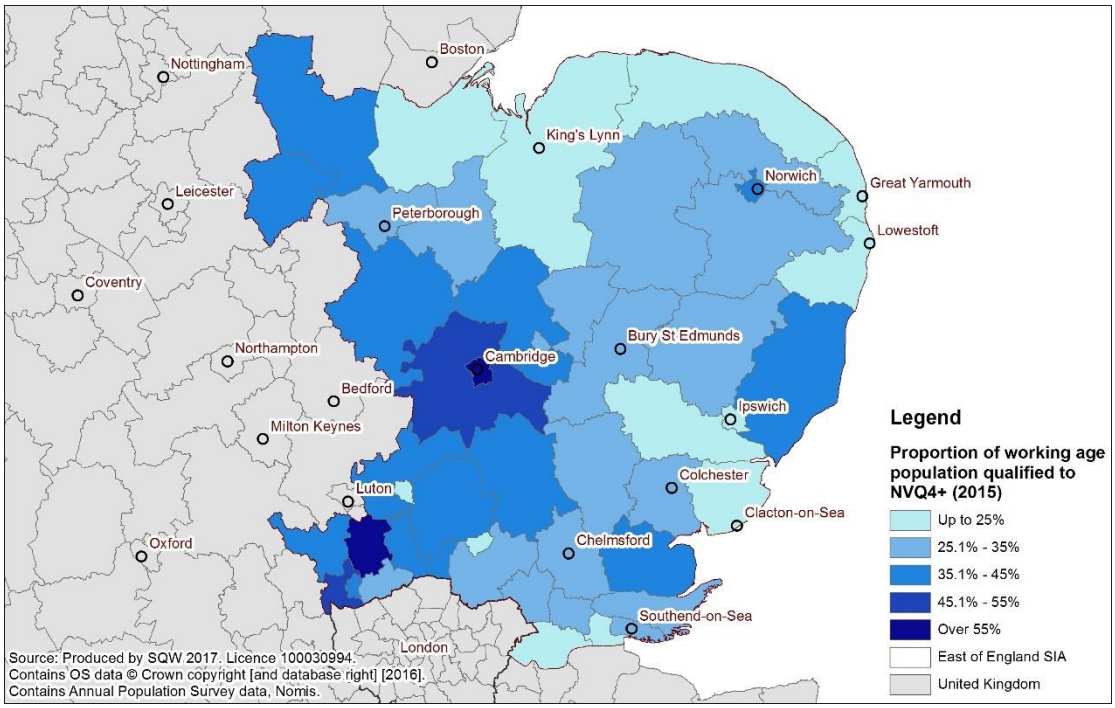
Access to >30mbps download speeds, 2017 (Figure 1-2, Map B)



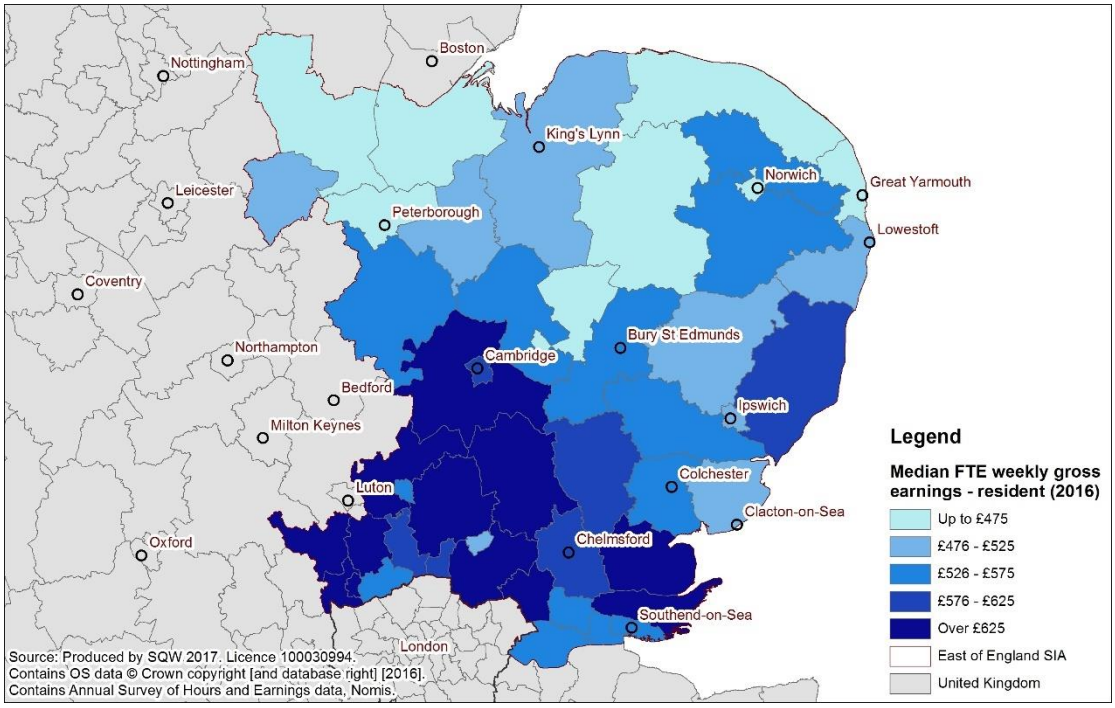
Enterprise births per 10,000 working age population, 2015 (Figure 1-2, Map C)



Proportion of working age population qualified to NVQ4+, 2015 (Figure 1-2, Map D)



Median residence-based FTE employee earnings, 2016 (Figure 1-2, Map E)



Median workplace-based FTE employee earnings, 2016 (Figure 1-2, Map F)