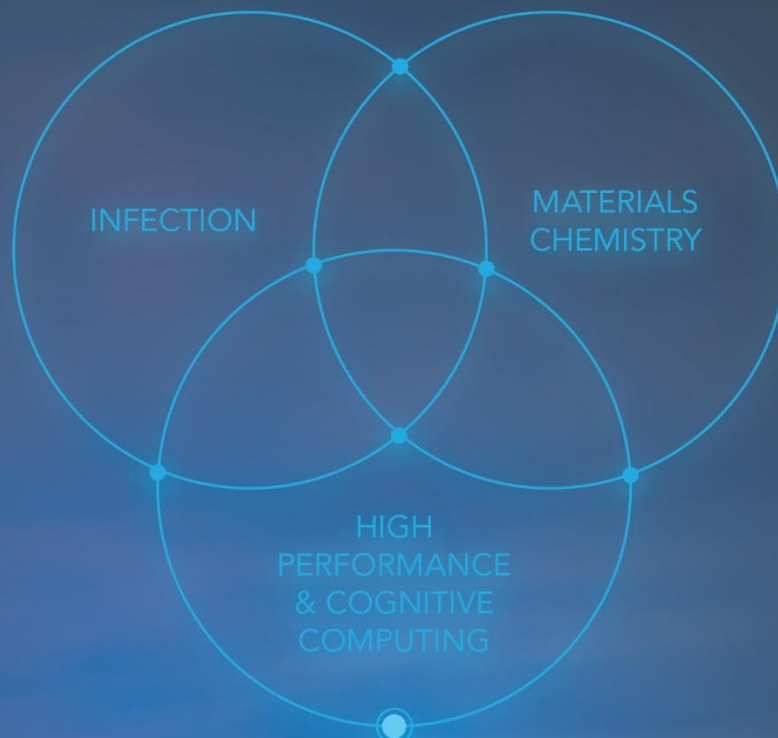


LIVERPOOL CITY REGION + A SCIENCE & INNOVATION AUDIT SUMMARY REPORT

SPONSORED BY THE DEPARTMENT FOR BUSINESS, ENERGY & INDUSTRIAL STRATEGY
SEPTEMBER 2017



Department for
Business, Energy
& Industrial Strategy



LIVERPOOL
CITY REGION
COMBINED AUTHORITY



Liverpool City Region
Local Enterprise Partnership



LSTM
LIVERPOOL SCHOOL
OF TROPICAL MEDICINE



Science & Technology
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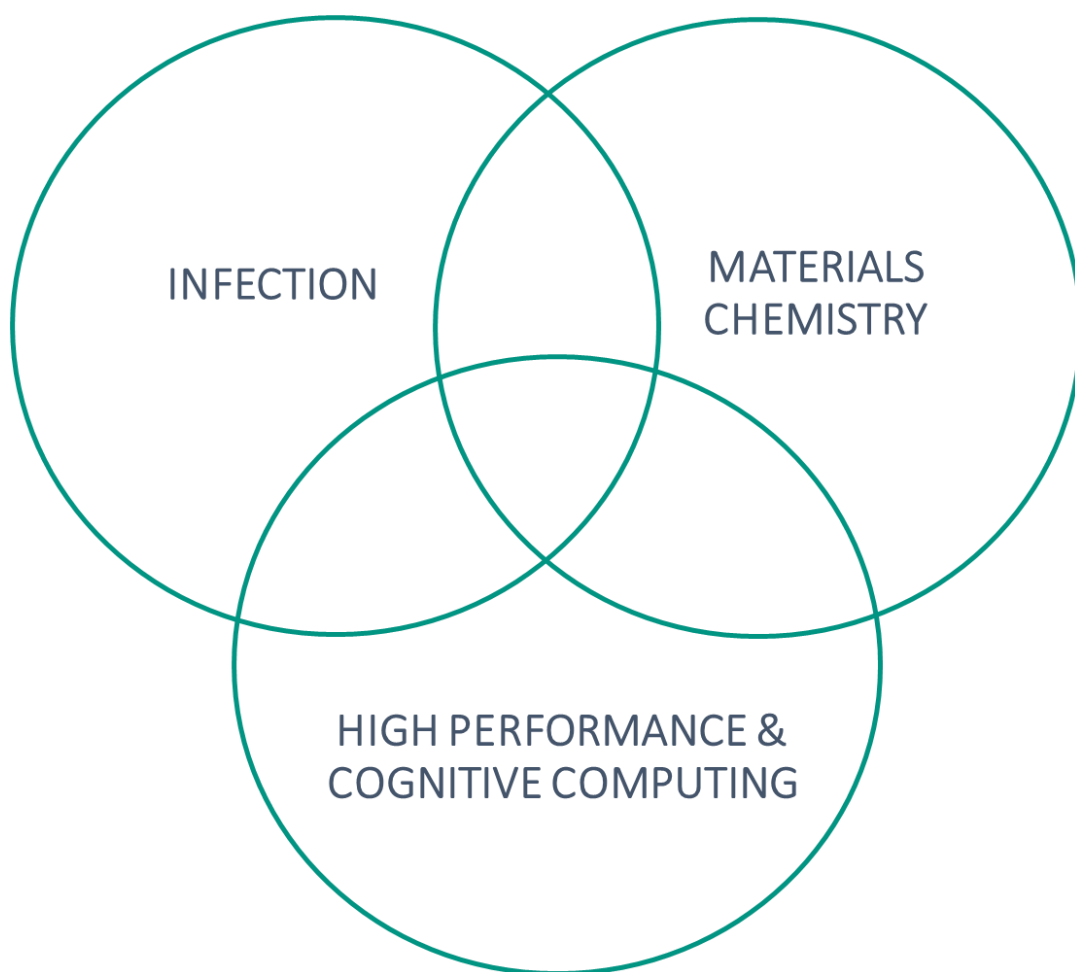
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City Council



OUR FINALISED SCIENCE & INNOVATION AMBITIONS:

Infection To consolidate the LCR's position as an international centre of excellence in tackling infectious diseases, and create a cluster of anchor and high growth companies to take advantage of global market opportunities in infection.

Materials Chemistry To apply the LCR's world class materials chemistry capabilities and commercialisation model to provide transformational opportunities for mature UK sectors, create new high-growth industries, and become a recognised global leader.

HP&CC To harness the LCR's world-leading High Performance and Cognitive Computing¹ capabilities to accelerate cross-sector growth and productivity, public sector transformation, and develop a world-class data-centric and disruptive digital technologies cluster.

Innovation Excellence For the LCR to be a national exemplar of place-based and innovation-driven economic growth that supports the UK Industrial Strategy.

¹ NB. We have chosen to use this term rather than "Artificial Intelligence", while acknowledging that the two are closely related.

1 Introduction & Context

- 1.1 These are exciting times for Liverpool City Region, and we are at a pivotal moment in our place's history. Faced with major economic, technological, environmental and political changes, the old



certainties are passing, and new ways of thinking about and approaching inclusive economic growth are needed. The grand challenges we face cannot be dismissed and are also major opportunities – shifting trade patterns, increased automation as the Fourth Industrial Revolution, driven by data, computing and artificial intelligence, becomes pervasive, and new demographic and health concerns, including anti-microbial resistance present fundamental changes for us. We need to be able to respond to these, both locally for our businesses and our people, and as part of UK rebalancing efforts through, for example, the prospective

Industrial Strategy.

- 1.2 Liverpool City Region is well equipped to respond. We bring:

- A high global profile and an international outlook and connections, which builds on our maritime, trade and industrial heritage;
- Connectivity, with strong connections into our immediate hinterland, including West Lancashire, Warrington, Cheshire, Greater Manchester and North East Wales, as well as global networks developed by our universities, centres of excellence, and businesses;
- Scale and critical mass, based on a functional economic geography employing 612,000 workers, 86% of whom live in the City Region, and generating around £30bn GVA per annum;²
- Economic capabilities aligned with those of the wider Northern Powerhouse, namely, Advanced Manufacturing and Materials, Health Innovation, Digital, and Energy;
- An agreed growth plan, *Building Our Future*, to tackle challenges and exploit future opportunities;³
- A well-mapped and coordinated innovation ecosystem, with a dedicated Innovation Board and excellent industry links via our other business-led Sector Boards;
- Integrated local governance and resources focussed on Smart Specialisation principles to drive place-based innovation and commercialisation for productivity-based growth; and
- A leading role in the development and prospective delivery of the UK's devolution agenda.

- 1.3 We have the scale, assets, governance arrangements, capabilities, pipeline of investable propositions, and the appetite to play a leading role in the delivery of the UK Industrial Strategy.

² Parkinson, Evans, Meegan &, Karecha, 2016, *The State of Liverpool City Region Report: Making the most of Devolution*. University of Liverpool and Liverpool John Moores University. www.liverpoollep.org/wp-content/uploads/2016/01/SOLCR.pdf-Jan-15.pdf

³ Liverpool City Region Local Economic Partnership and Combined Authority 2016, *Building Our Future; Liverpool City Region Growth Strategy*. <https://www.liverpoollep.org/growth-strategy/>

2 Vision

The What ...?

- 2.1 Liverpool City Region's growth plan, *Building Our Future*, sets the broader context for our Science and Innovation Audit. By 2040, and relative to 2016, we are committed to achieving:
- 100,000 additional jobs;
 - A net increase of 20,000 businesses;
 - An additional 50,000 people living in the City Region, and
 - An increase in the City Region's economy to around £50bn.

... and the How?

- 2.2 We are committed to developing our innovation ecosystem to maximise its contribution to the promotion of economic growth. To do this we aim to embed open innovation across the LCR's innovation ecosystem. Our approach to open innovation to date has been based on a close coupling of science and innovation excellence and collaboration between industry and academia. Our approach to developing open innovation in the future will build on this by emphasising the importance of knowledge-sharing supported by state-of-the art computational capability. We will also prioritise co-location of complementary organisations, a process that is already well-established in the Liverpool Knowledge Quarter and at Sci-Tech Daresbury.
- 2.3 Over £2billion⁴ of recent and ongoing innovation infrastructure investments in the LCR provide an exceptional platform for innovation-led growth and underlines the deliverability of our ambitions.
- 2.4 In May 2017, our residents elected the first Liverpool City Region Mayor who will control devolved budgets across Transport, Skills, Infrastructure, Planning, Housing, and Business Support (including Innovation). Significantly, the Mayor has taken personal responsibility for the Innovation Portfolio. Devolution gives us more freedom to shape and deliver the economic future of our place; government has defined the role, we will assume responsibility for delivery.

⁴ Including the £1billion Paddington Village development (1.8m sq. ft, including RCP North); £335million new Royal Liverpool Hospital (opening 2018); £279million new Alder Hey Children's Hospital; £124million Clatterbridge Cancer Centre in the KQL (opening 2018); £64million Materials Innovation Factory (MIF Nexus opening 2017); £25million Life Sciences Accelerator; £20million Bio Innovation Hub; Unilever's £24million Advanced Manufacturing Centre (opening 2017); £15million Sensor City incubator (opening 2017), the £8million "LCR 4.0" manufacturing digitisation project; and the ongoing £35million Sci-Tech Daresbury expansion which builds upon the £113million UK funding for the STFC Hartree Centre and IBM Watson's £200million investment.

3 Key Strengths

- 3.1 Enthusiasm and assertion can only get you so far in life. In economic development, substantive strength is what carries places and their businesses and people forward. In the Liverpool City Region, we have an established history of building and exploiting complementary strengths in industry and academia – and over 20 years’ experience in strategic partnerships driving growth; these strengths reflect the region’s long history of vibrant industrial and research communities linked to a port of global significance.
- 3.2 Our City Region’s excellence in science and research is coupled closely with innovation excellence and industrial strengths:
- In the manufacture of basic pharmaceutical products and preparations, we have three times the UK average employment, and twice the UK average in local businesses; and
 - In the manufacture of chemicals and related products we have well-over twice the UK average employment, and twice the UK average in local businesses – reflecting the City Region’s role as part of a leading national cluster.
- 3.3 The findings of the 2014 Research Excellence Framework (REF) highlight our research excellence in Chemistry, General Engineering, Electrical and Electronic Engineering, and Physics, all of which had over 90% of their research outputs classed as world-leading or internationally excellent. Whilst Clinical Medicine as a whole had 71% of its output classed in this top tier, there is world-class research in Infectious Diseases in the LCR; for example, data on literature citations (SciVAL) between 2011 and 2016 shows LCR research in Infectious Diseases is cited more than 2.3 times the global average. Materials Chemistry research is cited nearly 2.5 times the global average. High Performance and Cognitive Computing research in our City Region is cited at over twice the global average rate.
- 3.4 These standout strengths are enhanced by access to high-performance computing via the Science and Technology Facilities Council (STFC) Hartree Centre and the only UK deployment of IBM’s Watson cognitive computing platform. This provides a unique and international-class capability to innovate faster, cheaper and at a scale and scope that has not been possible in the past. As we move towards the third decade of the 21st century, innovation in industry, the public sector, and the public good objectives of improved global health will all rest on the ability to use advanced computation and automation in the discovery, testing, application and market introduction of new products and processes.
- 3.5 More widely, our innovation ecosystem is built on co-funded and co-located research and open innovation facilities and asset clusters – most notably concentrated within the Liverpool Knowledge Quarter and at Sci-Tech Daresbury - via which industry and academia work together to exchange know-how, and commercialise research and innovation. This is characterised as the “Liverpool Model”, delivering the “Liverpool Advantage”, and is best exemplified by the Materials Innovation Factory (MIF Nexus).

4 Growth Opportunities

- 4.1 Our three SIA themes – Infection, Materials Chemistry, and High Performance & Cognitive Computing – all relate to significant global markets, which are forecast to experience major growth over the next 20 years. Researchers, entrepreneurs, and businesses in our City Region, working with international partners, are well-placed to exploit these opportunities.

Infection Theme

- 4.2 The Infection market falls into three broad categories – Diagnosis, Therapeutics, and Prevention. North America and Europe tend to be the biggest markets, with growth coming from Asia-Pacific, Latin America, the Middle-East, and donor-driven demand in Africa. One of the most significant challenges to be faced in relation to prevention is anti-microbial resistance (AMR)⁵. Antimicrobial coatings and the application of surface science, e.g. on medical devices, are likely to see significant market growth. Global Market Insights research (2016) estimates that the market could potentially treble over the next 20 years to approximately USD\$7bn. LCR is well-placed to address this challenge.

Materials Chemistry Theme

- 4.3 The chemicals industry makes vital contributions to UK exports, employment and GVA. The Chemistry Growth Strategy Group estimate the industry value to be £200 billion and highlight the strong potential for a further £100 billion contribution to the UK economy, of which one-third will come through innovation. A specific example of a potential growth area is sensors, an area underpinned by materials chemistry. The market for sensor systems is estimated to be £310 billion globally and is growing at over 10% per annum. The UK sensor industry (impacted on by materials chemistry) is a £13 billion per annum sector supporting 70,000 jobs and producing £6 billion in exports. Around 1.4 million people in the UK are employed in the sensor aligned professions, of which 159,000 are in the North West and 27,000 are in Liverpool City Region (supported by the new Sensor City University Enterprise Zone incubator in the Knowledge Quarter).

High Performance & Cognitive Computing Theme

- 4.4 The markets for High Performance & Cognitive Computing (HP&CC), including those related to Artificial Intelligence (AI), are already large, and set to grow massively over the coming years. Data from American technology specialists IDC Research Inc (2016) indicates that the HPC market will be worth circa \$31 billion by 2019, with an expected compound annual growth rate of eight per cent. Similarly, the global CC market's size is expected to reach \$50 billion by 2025, (Grand View Research Inc, 2016). In order to make the most of these opportunities, we require constant re-investment with upgrades every four years.

⁵ Jim O'Neill et al, *Tackling Drug-resistant infections globally* Final Report and Recommendations, May 2016 and Annual Report of the Chief Medical Officer, Volume Two, *Infections and the rise of antimicrobial resistance*, 2011

5 Gap Analysis

R&D Spending

- 5.1 In 2014, gross expenditure in R&D in the North West in all sectors was £2,557 million (8.3% of R&D expenditure in the UK). The breakdown of R&D expenditure by sector in the North West is in line with UK norms, except for the case of government sector R&D, which is estimated at 1.55% of total R&D expenditure. This is below the Wave 2 SIA average (6.28%) and the UK (at 7.26%).⁶ Thus, the North West is under-represented in government sector R&D. We have a strong pipeline of investable proposals offering strong returns.

Infection

- 5.2 Our SIA confirms that our City Region has:
- World-leading assets and expertise, with the largest concentration of translational-focused public sector RD&I infectious diseases expertise in the UK, and leading international science and innovation networks;
 - A century-long track record of academic-industry collaboration, and
 - An excellent current track record of accessing research funding from national and international sources, including the World Health Organisation and the Bill and Melinda Gates Foundation.

It has highlighted that the City Region must:

- Develop a targeted inward investment strategy that leverages its excellence in research into infectious diseases, and the combination of world-leading facilities and expertise offered by the three Themes – by building on the achievements of and, lessons learned from, the Knowledge Quarter development, in particular the importance of colocation and cluster development;
- Continue to invest in its research assets to maintain its world-leading status;
- Re-double its efforts to attract, develop, and retain the skills and talent required to grow the supply chain in the City Region, and
- Ensure that relevant support regimes, especially access to finance, business support services, and inward investment expertise – are in place, if the growth of a locally based cluster of firms active in the Infection RD&I space is to be realised.

Materials Chemistry

- 5.3 Our SIA work confirms that our City Region has:
- World-leading expertise in Materials Chemistry, and Fast Moving Consumer Goods (FMCG);
 - A track record of accessing research funding from national and international sources, and

⁶ See Appendix 5 of the main report for more detail.

- A unique model for university-industry collaboration - the 'Liverpool Model', which has been developed in partnership with multinationals and their supply chains in several phases over the past 15 years.

5.4 It has highlighted that the City Region:

- Has a significant opportunity to become a globally significant player in both FMCG and other high-value chemical industries and their supply chains, underpinned by academic excellence;
- Should move to exploit the unique and distinctive contribution that the Liverpool Model can make to the LCR+ area by transferring knowledge into other parts of the City Region's Innovation Ecosystem, and
- Must ensure that new open innovation facilities plus relevant support mechanisms, such as access to finance, business support services, and inward investment expertise, are in place to foster opportunities for new Materials Chemistry-related ventures to thrive.

High Performance & Cognitive Computing

5.5 Our SIA confirmed that the City Region has:

- An emerging cluster of HP&CC capability and capacity, which is already of national class and, in terms of computing power, is international class;
- Achieved a major 'result' in attracting IBM to locate its UK R&D Centre alongside The Hartree Centre, and
- An opportunity for HP&CC in the LCR to be developed both as a 'sector' in its own right, and as a key 'enabling service' for the Infection and Materials Chemistry themes, and the wider economy.

5.6 It has highlighted that the City Region must:

- Broaden its HP&CC activities to include both industry and service sector user bases (in both private and public sectors), and reflect the multi-partner grouping that LCR's HP&CC actors comprise;
- Continue to work to ensure that the different components of its HP&CC offer are integrated effectively;
- Increase HP&CC activity at the business core of the City Region; proposals for a Hartree presence in Liverpool itself, and the proposed Digital Innovation Factory, will be essential for this to happen;
- Ensure strong and vibrant links with centres of excellence elsewhere in the UK and internationally remain a priority, and
- Retain, enhance and maximise the LCR presence of IBM's R&D Centre and Atos, by packing around these prime assets a resilient supply chain of local HP&CC providers and partners.

6 Key Ambitions & Proposals

Key Ambitions

- 6.1 Our work was informed by an over-arching framework of analysis (Figure 1) and an initial set of hypotheses and ambitions, which we tested and revised.

Figure 1 Our City Region's Science & Innovation Audit at a glance

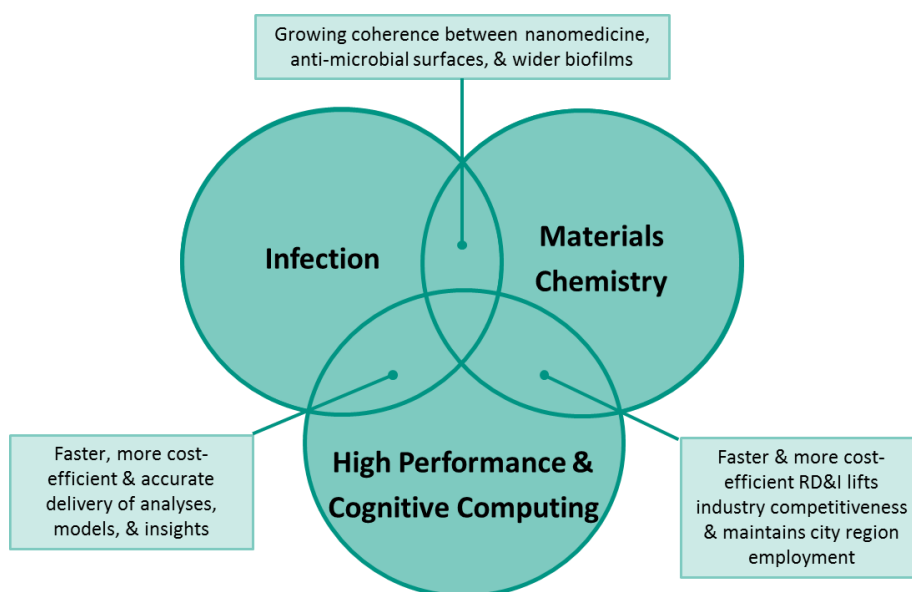


Table 1 Our Revised Ambitions

- To consolidate the LCR's position as an international centre of excellence in tackling infectious diseases, and create a cluster of anchor and high growth companies to take advantage of global market opportunities in infection;
- To apply the LCR's world class materials chemistry capabilities and commercialisation model to provide transformational opportunities for mature UK sectors, create new high-growth industries, and become a recognised global leader;
- To harness the LCR's world-leading High Performance and Cognitive Computing capabilities to accelerate cross-sector growth and productivity, public sector transformation, and develop a world-class data-centric and disruptive digital technologies cluster;
- And, overall, for the LCR to be a national exemplar of place-based and innovation-driven economic growth that supports the UK Industrial Strategy.

Proposals

- 6.2 Our SIA process has initiated and facilitated many large-scale and bi-lateral discussions among institutions and businesses both within the City Region and further afield. These generated ideas and helped to shape existing proposals from partners, and are continuing actively to do

so. The tables below summarise the theme-specific proposals. The cross-theme proposals are discussed in Section 7, as examples of how the SIA process added value to existing arrangements and networks.

Infection Theme	
Project Title	Centre of Excellence for Infectious Diseases Research+ (CEIDR +)
Leads	Liverpool School of Tropical Medicine, and University of Liverpool
Partner Organisations	<p>Core Partners: Royal Liverpool and Broadgreen University Hospital; Alder Hey Children's Hospital Trust; Liverpool Clinical Laboratories; The Innovation Agency. Affiliate partners: Liverpool Health Partners; Liverpool Knowledge Quarter.</p> <p>Business: Collaborative programmes with large pharmaceutical companies with operations within and outside the LCR; locally based companies include Seqirus, AZ/Medimmune and Elanco; plus SMEs including MAST Diagnostics, Perfectus Biomed, Arcis Biotechnology, Biofortuna, Pro-lab Diagnostics and Global Biodiagnostics, Gencoa, Vodus Medical and other digital health companies.</p>
Project Description	<p>CEIDR's first phase (2017-2020) will build a portfolio of projects with collaborating companies. This will catalyse the second phase (post 2020) where we anticipate a new bespoke facility stimulated by increased SME spinouts and demand from collaborating companies for co-location. Three of the exemplar projects are: Discovery and Development of Next Generation Anti-infective Drugs; Discovery and development of vaccines; Consumer products for prevention of emerging arboviral diseases (ZIKA+). Based on the size and scope of Liverpool's Infection capacity, CEIDR is forecast to create 252 gross direct and indirect jobs (138 net additional) and £42 million in cumulative net additional GVA in the region over 10 years.</p>
Materials Chemistry Theme	
Project Title	MIF (Materials Innovation Factory) Nexus
Leads	Co-leaders University of Liverpool, and Unilever
Partner Organisations	<p>Core Partners: University of Liverpool, Unilever and NSG Pilkington.</p> <p>Affiliate partners (initial): Croda; Bristol Myers Squibb; ACAL energy; C Tech Innovation; Chemistry Growth Partnership; Ceres Power; Gencoa / Pegasuss; ITM Power; Johnson Matthey; Liverpool Chirochem; Morgan/Ceramtec; National Nuclear Laboratory.</p>
Project Description	<p>The proposed project was developed directly from the SIA process. MIF Nexus will support major companies through access to shared robotic testing, scale-up and proof-of-concept facilities; SMEs through access to synthesis and characterisation services and facilities they would not otherwise afford; start-ups and spin-outs through access to expertise and pump-priming support. It will comprise a Materials Design Engine focussed on academic research of industrial relevance and several Materials Applications Engines specific to industry sectors. The integrated facility will help to de-risk investment in new materials for a wide variety of applications, most importantly in a manner that will facilitate investment in major transformational and potentially disruptive technologies of global significance. This will be achieved by decreasing the levels of investment faced for these high-reward opportunities in a manner unique to this facility. As such, MIF Nexus will create a virtuous circle of cumulative economic impacts based on attracting risk capital able to exploit this unique 'investment ready' translational facility. The facility business model is based on accelerating the development of new advanced materials, creating a commercial capability in materials design that will attract investment, encouraging corporate re-location and, itself, will generate revenue from services provided and funds for re-investment to develop the facility's capabilities over the long-term.</p>

High Performance & Cognitive Computing Theme	
Project Title	'Deep Change'
Lead	Science & Technology Facilities Council (STFC) Hartree Centre
Partner Organisations	The wider HP&CC cluster in the LCR - STFC's Scientific Computing Department (SCD), the Virtual Engineering Centre (VEC), Departments/Schools of Computing at Liverpool and Liverpool John Moores Universities, IBM, and Atos
Project Description	<p>Deep Change is a path-finding three-stage programme designed to embed a pervasive understanding of HP&CC technologies and methods across all parts of the Liverpool City Region economy, and eventually to develop a model for national application. Building on existing HP&CC activity and linked to the LCR Activate project, it will be delivered using the hardware platform expertise of Hartree, the fundamental science capabilities of the Scientific Computing Department, the applied project experience of the Virtual Engineering Centre, the international understanding of HP&CC technologies and the proposed Digital Innovation Factory in University of Liverpool, and the inclusive outreach expertise of Liverpool John Moores University. Deep Change will have three phases; (i) <i>Discovery</i>, a broad-based outreach component, designed over a five-year period to benefit 12,500 firms, organisations, and/or individuals, focused on developing understanding of HP&CC technologies and their benefits; (ii) <i>Accelerator</i>, identifying from the pool of <i>Discovery</i> beneficiaries some 200 organisations (both private and public sector) with potential to engage with HP&CC major vendors (e.g. in Liverpool, IBM UK and Atos in particular) to co-address HP&CC challenges and opportunities; and (iii) <i>Rising Stars</i> which, from within the <i>Accelerator</i> cohort, will identify and develop 50 organisations with real HP&CC capacities and capabilities to offer expertise, services, and/or products at an international level. The Rising Stars will have the potential to create very significant volumes of higher value-added jobs, contributing directly to our economic well-being. The project will be focused on the City Region but will operate with strong links to another part of the UK and internationally, especially in terms of where other major HPCC vendors are located.</p>

- 6.3 In addition to these theme-specific proposals and the cross-cutting proposals discussed in the next section, our SIA work has additionally shown that we need to:
- Ensure relevant business support regimes, especially access to finance, business support services, and inward investment expertise are in place in order to facilitate inward investment, business start-ups and supply-chain and cluster development;
 - Develop and retain strong and vibrant links with centres of excellence elsewhere in the UK and internationally, in order to maintain and enhance world-leading positions in our theme areas, and
 - Build on the global reputation of LSTM for supporting the public good by generating new diagnostics, therapeutics and preventative products.

7 Networking & Collaboration

Networking & Collaboration Process

- 7.1 Science and innovation partners in the City Region are well networked with leading Northern and national industry, academic, and research leaders, not least via the LCR Innovation Board, under whose auspices our work has been conducted. This foundation, with a particular emphasis on business engagement, enabled us to effectively engage partners in the SIA. A major stakeholder event, attended by over 80 people, was held in Liverpool on 7th March, at which attendees discussed overarching issues related to science and innovation in the City Region along with theme-specific matters, and cross-cutting synergies.

Proposals arising from the SIA process

- 7.2 Two cross-thematic proposals – building on existing activity – have been developed.

Case Study 1: Development of a 'Biofilms Innovation and Knowledge Centre'

This proposal builds on the work of the Open Innovation Hub for Antimicrobial Surfaces (OPIHAS), which is already translating internationally leading expertise from University of Liverpool's UK Interdisciplinary Research Centre in Surface Science. OPIHAS partners with global companies such as Akzo Nobel, Ansell, Croda, dePuy Synthes, Smith & Nephew, Scapa, Unilever and Walgreens Boots and many innovative SMEs. It combines physical, biological and clinical sciences to develop next generation anti-infective surfaces and materials that are key in infection prevention and control. OPIHAS already has a demonstrable commercialisation pathway – four patents are filed, and clinical trials are underway for one, and will take place in 2018 for two others. While led by the Infection theme, the new proposal involves cross-theme working with Materials Chemistry and HP&CC, where multiscale modelling will help drive knowledge-based innovation.

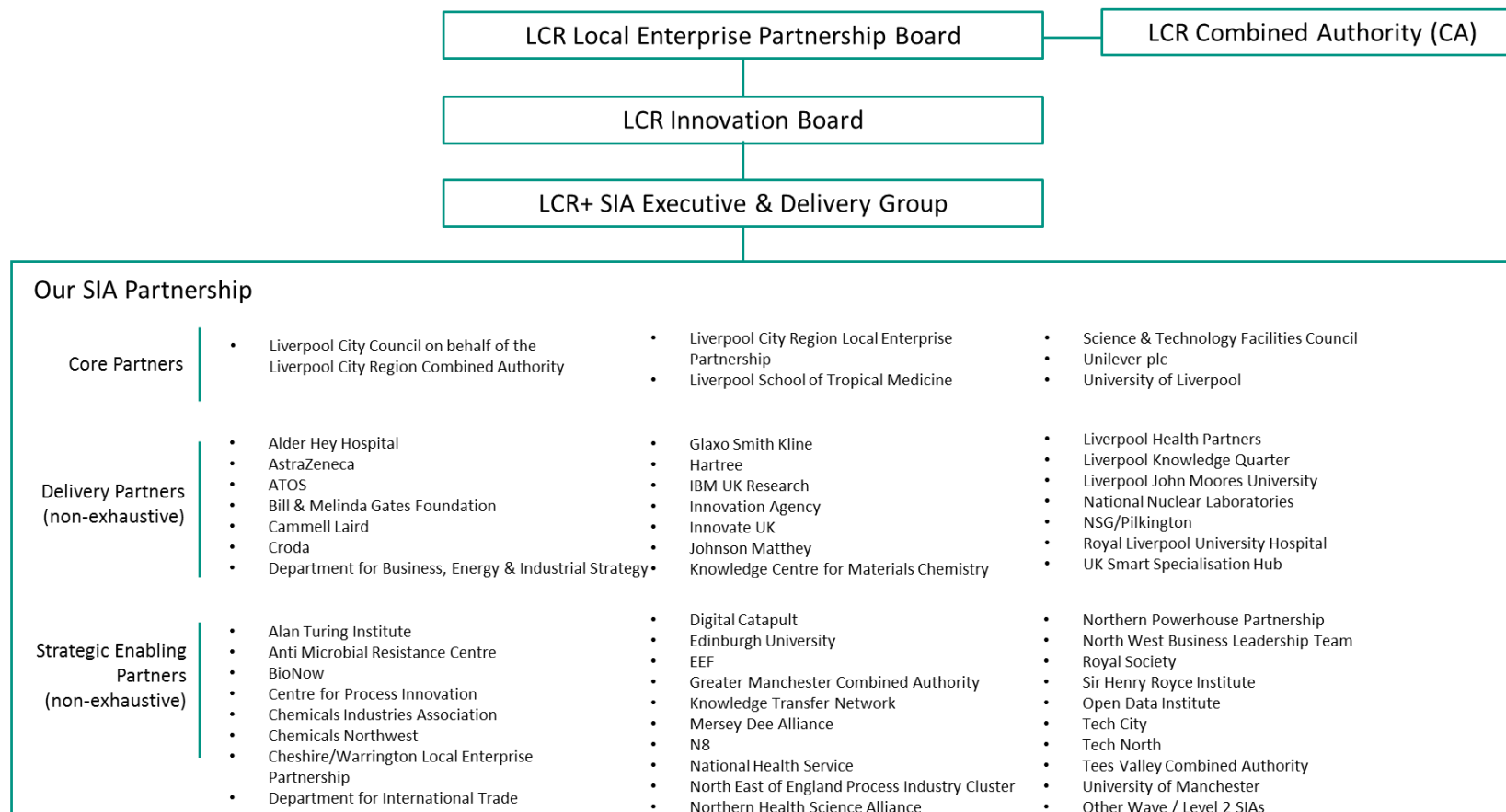
Case Study 2: Improving product design and efficacy through optimising placement

Products designed to prevent infectious disease transmission are often tested in artificial systems, or designed to be placed at the point where 'expert' opinion suggests they will have the greatest traction. Products in the development phase or early operational testing often look very promising only to fail when they are deployed in real-life situations. The technology is now available to track the movement of microbes, parasites or viruses over time in three dimensions, alongside tracking human and secondary vector movements. Hence, for example, we can start to track how resistant bacteria enter a hospital environment, how they move around the building and how they are carried by patients, staff and visitors. The data generated from 24hrs of tracking requires several weeks of detailed analysis using traditional technology. We aim to develop an Open Innovation Hub for 3D monitoring linking with the high-speed computing abilities at Daresbury/Hartree, to speed up this process.

Conclusions

- 7.3 Our SIA process has been a rewarding journey. We have collectively built upon existing smart specialisation activity to forensically prioritise the truly world-leading elements of our science and innovation offer and identified a clear and ambitious plan for future development. We have immeasurably strengthened existing relationships, established new external connections, and developed major new ideas. We are excited by what can do for our place, and for the wider UK.
- 7.4 Our audit has taken place within the context of over £2 billion investment in LCR's innovation infrastructure; it coincided with the launch of the UK Industrial Strategy Green Paper and Challenge Fund, and the election of our new Metro Mayor and the establishment of a devolved Single Investment Fund. Taken together, this presents an unprecedented opportunity for the LCR to deliver transformational growth, which we fully intend to grasp with both hands.

LCR+ SIA governance arrangements and key stakeholders



- You can contact us via lcisia@liverpoollep.org
- The full SIA report, appendices and further information can be accessed via our website www.liverpoollep.org/lcisia

