Department for
Business, Energy
& Industrial Strategy

South West England and South East Wales Science and Innovation Audit

Annexes A–F

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

A–F

Annex A: Consortium membership, governance and consultation

Consortium Membership

The following organisations were members of the South West England and South East Wales Science and Innovation Audit consortium, and were consulted during the development of the Expression of Interest, and subsequently during the SIA process.

Business	
Aardman	General Dynamics UK
AgustaWestland / Finmeccanica	Gooch & Housego
Airbus in the UK	Goonhilly Earth Station Ltd.
Airbus Defence & Space (formerly Cassidian)	HiETA Technologies Ltd.
Airbus Group Innovations UK	Huawei
Airbus Group Endeavr Wales Ltd	IBM Global Business Services
Andromeda Capital	IQE plc
BAE Systems	Johnson Matthey plc
BBC	Oracle
Boeing Defence UK Ltd.	Ortho Clinical Diagnostics
Bristol is Open Ltd.	Renishaw
Broadcom UK	Rolls Royce
Centre For Modelling and Simulation	South West Water
ClusterHQ	Toshiba Research
Cray	Watershed
EDF Energy R&D UK Centre	Wavehub
First Group plc	
LEPs	
Cornwall and Isles of Scilly LEP	Swindon and Wiltshire LEP
GFirst (Gloucestershire) LEP	West of England LEP
Heart of the South West LEP	
Universities	
Cardiff University	University of Bristol
Falmouth University	University of Exeter
Plymouth University	University of Gloucestershire
Royal Agricultural University	University of St Mark and St John
University of Bath	University of West of England
Local Authorities	
Bath and North East Somerset Council	Gloucestershire County Council
Bristol City Council	North Somerset Council

City of Cardiff Council	Plymouth City Council
Cornwall Council	Somerset County Council
Council of the Isles of Scilly	South Gloucestershire Council
Devon County Council	Swindon Council
Exeter City Council	Torbay Council
	Wiltshire Council
Research Organisations	
DSTL	Plymouth Marine Laboratory (PML)
Marine Biological Association of the UK	Rothamsted Research
Met Office	Sir Alister Hardy Foundation for Ocean Science (SOHFOS)
National Nuclear Laboratory (NNL)	
Catapults	
Compound Semiconductor Catapult	Future Cities Catapult
National Composites Centre – part of the High Value Manufacturing Catapult	Precision Medicine Catapult – when Cardiff node formed
SW Centre of Excellence in Satellite Applications – part of the Satellite Applications Catapult	
Other organisations, networks and intermediaries	
Bristol and Bath Science Park	RegenSW
Bristol Health Partners	SEW Academic Health Science Partnership
Business West	SW Peninsula AHSN
Exeter Science Park	West of England Aerospace Forum
MediWales	West of England AHSN
NHS Innovations South West Ltd.	WoE LEP High Tech Sector Group
NIHR Clinical Research Network South West Peninsula	WoE LEP Low Carbon Sector Group

Table A1 Consortium Membership

Governance

To ensure local participation and ownership, the Audit was governed by a senior level steering group made up of industry representatives and research organisations within each theme, University Pro-Vice-Chancellors for Research and Innovation and LEPs. This Group supported the development of the expression of interest, and steered the SIA throughout. Initial consultation was undertaken with key private sector organisations to incorporate their views into our approach. An industry representative from the Steering Group chaired each theme review panel.

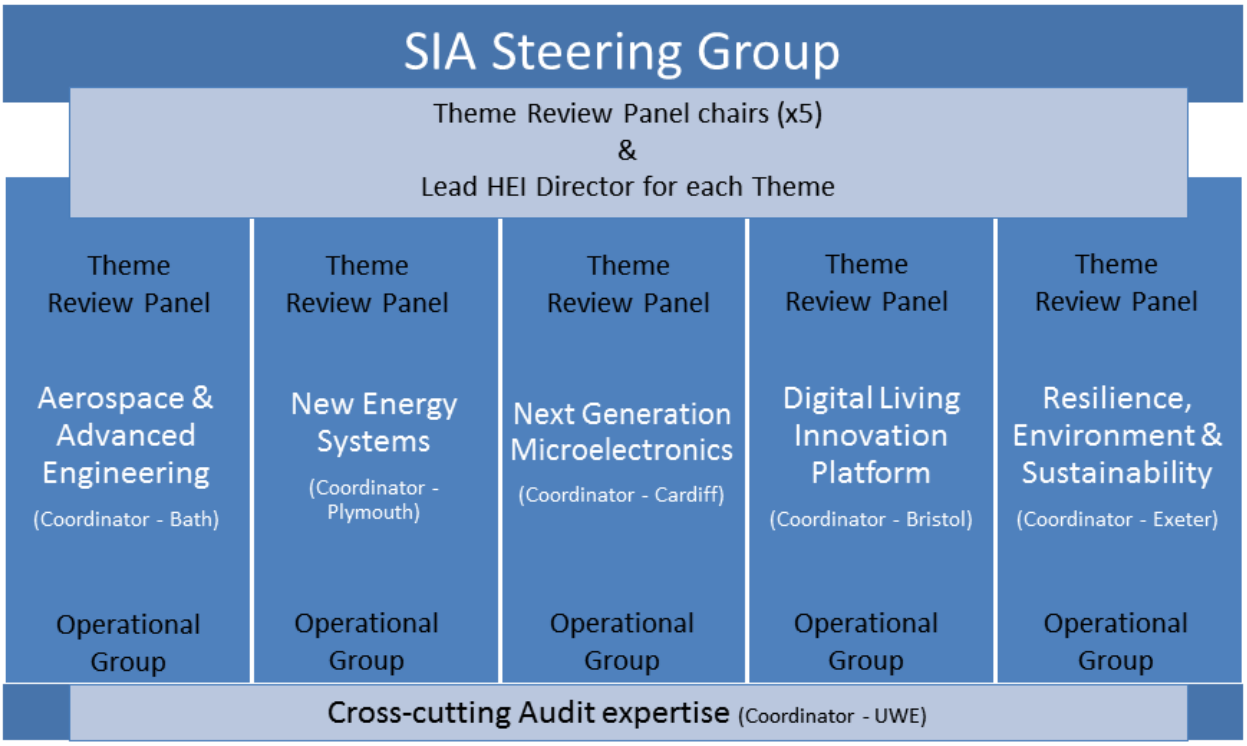


Figure A1 SIA Governance

Steering Group Membership

The Steering Group, chaired by Professor Nick Talbot, University of Exeter, met on four occasions: 19 January, 18 April, 13 June and 14 September 2016. The membership was:

Name		Organisation
Nick	Crew	Airbus Defence and Space Limited
Mark	Howard	Airbus Operations Limited
Matt	Griffith	Business West
Rob	Rolley	General Dynamics
Ian	Chatting	GKN
Mike	Adams	Hieta
Michael	Hill-King	Huawei
Wyn	Meredith	IQE plc
Jack	Frost	Johnson Matthey
Vicky	Pope	Met Office
Graham	Harrison	NCC
Phil	Bates	Oracle
Icarus	Allen	Plymouth Marine Labs
Dean	Jones	Rolls-Royce plc
Jon	Siddall	SWAHSN
Joe	McGeehan	Toshiba Research
Hywel	Thomas	Cardiff University
Elizabeth	Treasure	Cardiff University
Dave	Bembo	Cardiff University

Dafydd	Moore	Plymouth University
Adrian	Dawson	Plymouth University
Jon	Knight	University of Bath
Jon	Freeman	University of Bath (to July 2016)
Jon	Hunt	University of Bath (from July 2016)
Nishan	Canagarajah	University of Bristol
Neil	Bradshaw	University of Bristol
Nick	Talbot	University of Exeter (Chair)
Sean	Fielding	University of Exeter
Martin	Boddy	University of West of England
Helen	Davies	Cardiff City Region
Sandra	Rothwell	Cornwall and Isles of Scilly LEP
David	Owen	Gloucestershire LEP
Paul	Taylor	Heart of the SW LEP (to July 2016)
Eifion	Jones	Heart of the SW LEP (from July 2016)
Duncan	Kerr	Swindon and Wiltshire LEP
Alastair	Davies	Welsh Government
Barbara	Davies	West of England LEP (to July 2016)
Antony	Corfield	West of England LEP
Deborah	Watson	Consultant

Table A2 Steering Group Membership

Theme Review Panel Membership

Oversight of each Theme was provided by a Theme Review Panel – a strategic group made up of industry and academic experts. Each Panel was chaired by a member of the Steering Group from business and supported by a Director and Business Development Manager from within Higher Education. The Panel's role included:

- To review the scope of the theme(s) and identify known niche areas of expertise within the theme, and areas of overlap / gaps between themes.
- To receive initial data on their theme and to flag any omissions, errors and ideas for further research in terms of capabilities, market needs and innovation pathways.
- To identify potential national / international comparator geographies

Aerospace and Advanced Engineering

	Name	Role	Organisation
Industry chair	Ian Chatting	Vice President Technology	GKN
Industry Expert	Mike Adams	Director	HiETA Technologies Ltd
Industry Expert	Graham Harrison	Head of Government Affairs and Strategic Partnerships	National Composites Centre
Industry Expert	Dean Jones	Partnership Manager	Rolls Royce
Industry Expert	Adrian Harding	Supply Chain Business Development	West of England Aerospace Forum
Academic expert	Chris Brace	Professor of Automotive Propulsion and Deputy	University of Bath

		Director Powertrain Vehicle Research Centre	
Academic expert	Richard Butler	Professor of Aerospace Composites	University of Bath
Academic expert	Ian Bond	Head of Queen's School of Engineering (Aerospace, Civil & Mechanical)	University of Bristol
Academic expert	Chris Smith	Associate Prof in Functional Materials	University of Exeter

Digital Living Innovation

	Name	Role	Organisation
Industry chair	Phil Bates	Architect Oracle Cloud	Oracle Corporation
Industry expert	Paul Appleby	Director	VID Communications
Industry expert	Rick Chapman	Consultant	West of England High Tech Group
Industry expert	Paul Massey	Director	Bluefruit software
Industry expert	Nick Crew	Manager: Endeavr Wales project	Cassidian
Industry expert	Liz O'Driscoll	Head of Innovation	Exeter City Futures
Industry expert	Lars Sundstrom	Director of Enterprise and Translation	AHSN
Academic & Industry expert	Ian Craddock	Toshiba R&D lab director / Bristol academic	Toshiba / University of Bristol
Industry expert	Michael Hill-King	Collaboration Director, UK R&D Centre	Huawei
Academic expert	Nathan Clarke	Professor in Cyber Security and Digital Forensics	Plymouth University
Academic expert	Darren Cosker	Reader in Computer Science	University of Bath
Academic expert	Dave Cliff	Head of Merchant Venturers School of Engineering	University of Bristol
Academic expert	Richard Everson	Head of Computer Science, Prof of Machine Learning, Exeter University	University of Exeter

Resilience, Environment & Sustainability

	Name	Role	Organisation
Industry chair	Vicky Pope	Head of Integration and Growth	Met Office
Industry expert	Simon Power	Director, Renewables and Environment, South West consulting business lead	Arup (Bristol office)
Industry expert	Andrew Garrad	Founder of Garrad-Hassan	Founder of Garrad-

		(now DNV-GL), former Chair of Bristol 2015	Hassan (now DNV-GL), former Chair of Bristol 2015
Industry expert	Jon Bentley	Partner, Innovation, Energy & Environment	IBM
Industry expert	Icarus Allen	Head of Science	PML
Industry expert	Lewis Jones	R&D Manager	South West Water
Academic expert	Terry Marsden	Professor of Environmental Policy and Planning	Cardiff University
Academic expert	Iain Stewart	Director of Sustainable Earth Institute	Plymouth University
Academic expert	Matt Davidson	Director of the Centre for Sustainable Chemical Technologies	University of Bath
Academic expert	Richard Pancost	Director of the Cabot Institute	University of Bristol
Academic expert	Tim Lenton	Chair in Climate Change/Earth System Science	University of Exeter

New Energy Systems

	Name	Role	Organisation
Industry chair	Jonathan Frost	Technology Strategy Director	Johnson Matthey
Industry expert	Jonathan Adey	Smart Cities Energy Group	Hitachi
Industry expert	Matt Burley	Head of Strategic Development UK	Atkins Nuclear & Nuclear South West
Industry expert	Gareth Davies	Specialist Nuclear Management consultancy	DNA Ltd.
Industry expert	Keith Hounsell	Managing Director	Green Acorn Energy Solutions
Industry expert	Claire Gibson	Managing Director	WaveHub Ltd
Industry expert	Merlin Hyman	CEO	RegenSW
Academic expert	Marcelle McManus	Senior Lecturer in Renewable Energy Technology	University of Bath
Academic expert	Tom Scott	Director, SW Nuclear Hub	University of Bristol
Academic expert	Deborah Greaves	Professor of Ocean Engineering; Director of COAST	Plymouth University
Academic expert	Phil Jones	Professor; Chair of the Wales Low Carbon Research Institute	Cardiff University

Next Generation Microelectronics

	Name	Role	Organisation
Industry chair	Wyn Meredith	Commercial Director, Compound Semiconductors	IQE plc
Industry expert	Rick Chapman	Consultant	West of England High Tech Group
Industry expert	Andy Sellars	Lead Technologist	Innovate UK
Industry expert	Daniel Newman	Senior Economic Development Officer	Torbay Development Agency
Academic expert	Phil Buckle	School of Physics	Cardiff University
Academic expert	Peter Wilson	Department of Electronic and Electrical Engineering	University of Bath
Academic expert	David May	Department of Computer Science	University of Bristol
Academic expert	Geoffrey Nash	College of Engineering, Mathematics and Physical Sciences	University of Exeter

Table A3 Theme Review Panel membership

Stakeholder workshops and follow-up activities

Each theme held a workshop during June 2016 to consult with stakeholders, and the following people registered for further information, or attended the event; and have also been consulted on this report during its' production.

Resilience, Environment and Sustainability - Exeter Science Park, Exeter

Adrian Dawson, Plymouth University
Andrew Staphnill, Cardiff University
Andy Williams, Avanti Communications / ApTec
Ben Rhodes, Devon & Cornwall Business Council
Colin Brownlee, Marine Biological Association of the UK
David Johns, Sir Alister Hardy Foundation (SAHFOS)
Dawn Scott, University of Exeter
Deborah Watson, Deborah Watson Consultancy
Iain Stewart, Plymouth University
Icarus Allen, Plymouth Marine Laboratory
James Lynch, ARTIS
Jenny Camaradou, jennycamaradou.com
Jon Hunt, University of Bath
Kathryn Edwards, SWMAS Ltd.
Laurence Oakes-Ash, Oxygen House
Lewis Jones, South West Water Ltd.
Louisa Evans, University of Exeter
Matthew Davidson, University of Bath
Martin Redfern, Sustainable Exeter
Matthew Davidson, University of Bath
Melanie Roberts, Somerset County Council
Michael Moseley, KTN Ltd
Mike Harris, University of Bristol
Nigel Ward, UK Hydrographic Office
Peter Cox, University of Exeter
Rich Pancost, University of Bristol Cabot Institute
Richard Soffe, Rural Business School

Sal Lampkin, University of Exeter
Sean Fielding, University of Exeter
Shaun Jordan, University of the West of England
Simon Jones, Dashboard
Stephen Bird, South West Water Ltd
Susannah Carlson, UK Hydrographic Office
Tim Daley, Plymouth University
Vicky Pope, Met Office
William Wakeham, Exeter Science Park
Willie Wilson, SAHFOS

RES Stakeholder survey

- 37 interviews were undertaken with a range of companies.
- 35 of these companies either had their HQ or other sites/branches in the South West England and South East Wales, the other 2 identified key collaborators in the region.

Digital Living Innovation - Merchant Venturers' Building, Bristol

Andrew Calway, University of Bristol
Ben Rhodes, Devon & Cornwall Business Council
Ben Shorrock, TechSPARK
Ben Trewhella, Opposable Group
Carolin Villforth, University of Bath
David Relph, Bristol Health Partners
Deborah Watson, Deborah Watson Consultancy
Dick Penny, Watershed
Doug Laughlen, Taxonomics
Duncan Allsopp, University of Bath
Gavin Jones, Elixel
Hywel Edwards, Cardiff University
Ian Craddock, University of Bristol & Toshiba
Jean Vogel-Gourgand, University of Bristol
Jenny Camaradou, jennycamaradou.com
John Bradford, High Tech Bristol & Bath
John-James McChesney, TBC
Josh Costar, Aquarian Products
Julian Head, Wiltshire Council / SWLEP
Kevin O'Malley, Bristol City Council
Kurt De Freitas, South West Academic Health Science Network
Lisa Wheatley, Bristol Health Partners/Elizabeth Blackwell Institute
Liz O'Driscoll, Exeter City Futures
Maria Korea, University of Bristol
Mary Page, National Composites Centre
Matthew Asher, University of Bristol
Mike McMillan, NISW
Nathan Clarke, Plymouth University
Navein Madhavan, National Composites Centre
Ni Zhu, Universtiy of Bristol
Neil Bradshaw, University of Bristol
Ni Zhu, University of Bristol
Paul Appleby, VID / Bristol Media
Paula Underhill, NIHR CRN: South West Peninsula
Peter Madden, Future Cities Catapult
Philippa Shelton, University of the West of England
Rachel Baker, Cardiff University
Sarah Jones, University of Bath
Steven Puetz, CFMS Ltd.
Walterio Mayol-Cuevas, University of Bristol

New Energy Systems - Somerset College, Taunton

Adrian Dawson, Plymouth University
Ben Rhodes, Devon & Cornwall Business Council
Clare Jackson, Ecuity Consulting
Corinne Matthews, Heart of the SW LEP
David Bembo, Cardiff University
Deborah Greaves, Plymouth University
Deborah Watson, Deborah Watson Consultancy
Graham Butler, IBM United Kingdom Ltd.
Iain Bearh, Renewable Power Limited
Ian Craddock, University of Bristol & Toshiba
Jamie Townes, University of Bristol
Jeremy Bartosiak-Jentys, University of Bath
Jerry Trevarthen, Pliosaur Energy Ltd
Jessica Vallentine, Nuclear South West
Jim Grant, University of Exeter
Jonathan Adey, Hitachi
Jonathan Frost, Johnson Matthey
Jun Zang, University of Bath
Keith Hounsell, Green Acorn Energy Solutions Ltd
Kevin Fothergill, Johnson Matthey Fuel Cells Ltd
Kim Howat, KH Technology Broking
Kinga Grabarczyk, Sedgemoor Council
Laurence Oakes-Ash, Oxygen House
Matthew Burley, Atkins Nuclear
Mustafa Rampuri, University of Bristol
Neil Phillips, University of the West of England
Olly Frankland, RegenSW
Phil Jones, Cardiff University
Philippa Venables, Swindon Borough Council
Samantha Seddon, Somerset County Council
Sarah Pryor, Cardiff University
Sheldon Ryan, Plymouth City Council
Simon Cheeseman, Offshore Renewable Energy Catapult
Sonya Bedford, Stephens Scown LLP
St. John Hughes, Avenir Energy

Next Generation Microelectronics - Clayton Hotel, Cardiff

Ailsa Davies, University of the West of England
Andy Sellers, Innovate UK
Avril Lewis, ESTnet Ltd
Bob Musk, Entroptix Ltd
Chris Young, Welsh Government
Clayton Jones, University of South Wales
Colette Mallon, Swindon and Wiltshire LEP
Daniel Newman, TDA
David Bembo, Cardiff University
Deborah Watson, Deborah Watson Consultancy
Graham Fisher, University of Bath
Graham Marshall, University of Bristol
Huw Davies, Trameto
Hywel Edwards, Cardiff University
Johannes Benedikt, Cardiff University
Jude Bown, Cardiff University
Laurent Kling, Centre for Quantum Photonics
Martin McHugh, Microsemi
Matthew Smith, University of South Wales
Michael Hill-King, Huawei Technologies Co Ltd
Mustafa Rampuri, University of Bristol
Neil Bradshaw, University of Bristol
Nigel Rix, Knowledge Transfer Network
Paul James, Infineon (IR Newport)
Paul Tasker, Cardiff University
Peter Clayton, ContinuumBridge Ltd
Peter Mosley, University of Bath
Phil Buckle, Cardiff University
Rick Chapman, Microelectronics iNet
Sam Evans, Infineon Newport
Wyn Meredith, CSC

Aerospace and Advanced Engineering - National Composites Centre, Bristol

Aaron Bowsher, Cross Manufacturing Co.
Adrian Harding, WEAF
Alun Reece, Loop Technology
Andrew Hawthorn, Altran UK
Benjamin Woods, University of Bristol
Bill Colquhoun, TMB Patterns Limited
Caroline Godwin, Trizo Ltd
Chris Brace, University of Bath
Chris Jones, iAero
Chris Smith, University of Exeter
Chris Mahn, Ed Fagan Europe Ltd
Chris Wands, scorpion tooling uk ltd
Claire Harvey, Cardiff University
Craig Brown, Stride Treglown
David Ashford, Bristol Spaceplanes
Dean Jones, Rolls-Royce
Deborah Watson, Deborah Watson Consultancy
Duncan Kerr, Swindon Borough Council
Ed Barrett, Generative Parametrics
Ellen Rodger, SC Innovation
Hamish McAlpine, University of Bristol
Ian Bond, University of Bristol
Ian Chatting, GKN Aerospace
Ian Lane, Airbus
Ian Stone, QuEST Global Engineering Ltd
Isabel Gonzalez, University of Exeter
Jacques Bouton, JPH Services (SW) LTD
Jane Galsworthy, Oxford Innovation
Jeremy Bartosiak-Jentys, University of Bath
Jon Hunt, University of Bath
Jonathan Taylor, Assystem UK Ltd
Karl Friedrich, Hoare LEa
Katie Gough, University of the West of England
Keri Montague, Yeovil College
Khanor Runzi, AKKA Aeroconseil UK Ltd
Kim Davies, University of Bath
Mark Mathieson, McLaren Automotive Limited
Mark Saunders, Renishaw plc
Paul Hickson, Somerset County Council
Paul Perera, Assystem UK Ltd
Raj Nangia, Nangia Aero
Richard Trask, University of Bath
Simon Jones, HiETA Technologies
Stephen Hallett, University of Bristol
Stephen Suddell, National Composite Centre
Steven Puetz, CFMS Ltd
Timothy Yates, BP Castrol

Aerospace meeting – 23 August 2016, National Composites Centre, Bristol.

Adrian Harding, WEAF
Richard Butler, University of Bath
Dean Jones, Rolls-Royce
Deborah Watson, Deborah Watson Consultancy
Nick Lieven & Hamish McAlpine, University of Bristol
James Godman, GKN Aerospace
Mark Howard, Airbus
Jon Hunt & Jeremy Bartosiak-Jentys, University of Bath
Alison Starr, Graham Harrison & Miroslav Stojkovic, National Composite Centre
Paul Shakespeare, HVMC
Tom Egan, Leonardo (formerly Agusta Westland)

Annex B: Universities, Colleges & Research Organisations

The consortium area has 14 research institutions and 15 higher education institutions and 27 Further Education Colleges:

LEP / SEW	Institute name	HEI / FEC	Campus
Cornwall and Isles of Scilly	Cornwall College	FE	Entire institution
	Falmouth University	HE	Entire institution
	Truro and Penwith College	FE	Entire institution
	University of Exeter	HE	Cornwall campus
Gloucestershire	Cirencester College	FE	Entire institution
	Gloucestershire College	FE	Entire institution
	Hartpury College	FE	Entire institution
	The Royal Agricultural University	HE	Entire institution
	University of Gloucestershire	HE	Main campus
Heart of the South West	Bridgwater College	FE	Entire institution
	City College Plymouth	FE	Entire institution
	Exeter College	FE	Entire institution
	Petroc	FE	Entire institution
	Plymouth College of Art	HE	Entire institution
	Richard Huish College	FE	Entire institution
	Somerset College	FE	Entire institution
	South Devon College	FE	Entire institution
	Strode College	FE	Entire institution
	University of Exeter	HE	Main campus
	University of Plymouth	HE	Entire institution
	University of St Mark & St John	HE	Entire institution
	Yeovil College	FE	Entire institution
Swindon and Wiltshire	New College Swindon	FE	Entire institution
	Swindon College	FE	Entire institution
	Wiltshire College	FE	Entire institution
West of England	Bath College	FE	Entire institution
	Bath Spa University	HE	Entire institution

	City of Bristol College	FE	Entire institution
	South Gloucestershire and Stroud College	FE	Entire institution
	The Conservatoire for Dance and Drama	Conservatoire / HE	Bristol Old Vic Theatre School
	The University of Bath	HE	Entire institution
	University of Bristol	HE	Entire institution
	University of the West of England, Bristol	HE	Entire institution
	Weston College of Further and Higher Education	FE	Entire institution
South East Wales	Cardiff University	HE	Entire institution
	Cardiff Metropolitan University	HE	Entire institution
	University of South Wales (incl. Royal Welsh College of Music and Drama)	HE	Entire institution
	Coleg Gwent	FE	Entire institution
	St David's Catholic College	FE	Entire institution
	Cardiff and Vale College	FE	Entire institution
	Coleg y Cymoedd	FE	Entire institution
	The College Merthyr Tydfil	FE	Entire institution
	Bridgend College	FE	Entire institution

Table B1 HE Institutions and FE Colleges in SIA geography[1]

Our consortia universities have a combined income of £2.6 billion (2014-15). They generate an estimated further £3.5 billion in downstream income through the expenditure of their suppliers and staff across the UK. Their direct contribution to GVA is £1.7 billion with a further downstream contribution of £1.7bn across the UK, representing around 0.2% of UK GVA.

They employ 35,700 staff in total, of which 17,000 are academic staff. More than half (55%) of staff aligned to a subject-related cost code are in STEM-related fields.

1 Underlying data for local growth 2013-14. Higher education and local growth. HEFCE (2015). Available at: http://www.hefce.ac.uk/analysis/maps/; HEFCW and Colegaucymru

Research Organisations

1. Campden BRI, Chipping Campden, Gloucestershire (www.campdenbri.co.uk)
   Campden BRI is the UK's largest independent membership-based organisation providing the food and drink industry with the practical scientific, technical and advisory services needed to ensure product safety and quality, process efficiency and product and process innovation. The Campden BRI Group operates from three sites in the UK and a fourth in Hungary. The site in Chipping Campden employs 300 full or part-time staff. A further 50 staff are employed at the site at Nutfield, Surrey and 20 staff are employed at our site in Budapest, Hungary. We also have a Consumer Test Centre in Leamington Spa
2. DSTL, Porton Down, Wiltshire (www.gov.uk/government/organisations/defence-science-and-technology-laboratory)
   DSTL ensures that innovative science and technology contribute to the defence and security of the UK. It is an executive agency, sponsored by the Ministry of Defence. It brings together the defence and security S&T community, including industry, academia, wider government and international partners, to provide sensitive and specialist S&T services to the Ministry of Defence and wider government.
3. Environment Agency (https://www.gov.uk/government/organisations/environment-agency)
   HQ in Bristol, and employing over 10,000 staff. Other regional offices can be found in Cornwall, Somerset and Gloucestershire, with specialist facilities in Bath with their geomatics group, and near Exeter, with its National Laboratory Service, a leading provider of high quality environmental testing and analysis.
4. GCHQ, Cheltenham, Gloucestershire & Bude, Cornwall (www.gchq.gov.uk)
   GCHQ is part of the team which protects the UK, along with law enforcement and the other intelligence agencies. Working with HMG and industry, GCHQ defends Government systems from cyber threat, provides support to the Armed Forces and strive to keep the public safe, in real life and online. It employs over 6,000 people. It's headquarters are based in Cheltenham.
5. Marine Biological Association of the UK, Plymouth (www.mba.ac.uk)
   Founded in 1884, the Marine Biological Association was granted a Royal Charter in 2013. The charitable aims of the MBA are to promote scientific research into all aspects of life in the sea, including the environment on which it depends, and to disseminate to the public the knowledge gained.
6. Met Office, Exeter (www.metoffice.gov.uk)
   The Met Office is the UK's National Meteorological Service. It is a Trading Fund of the Department for Business, Energy and Industrial Strategy (BEIS).
7. National Composites Centre, Bristol (www.nccuk.com)
   The NCC brings together dynamic companies and enterprising academics to develop new technologies for the design and rapid manufacture of high-quality composite products. The combination of academic and business strengths will speed progress from laboratory to design to factory and into products. A wholly owned subsidiary of the University of Bristol, the NCC is part of the High Value Manufacturing Catapult.
8. Natural Resources Wales

HQ in Cardiff, the largest Welsh Government body, employing 1,900 staff across Wales. With the overarching objective to sustainably manage the air, land and water in Wales.

9. Office of National Statistics, Newport (www.ons.gov.uk)
   The UK's largest independent producer of official statistics and the recognised national statistical institute of the UK. Responsible for collecting and publishing statistics related to the economy, population and society at national, regional and local levels. We also conduct the census in England and Wales every 10 years.
10. Plymouth Marine Laboratory, Plymouth (www.pml.ac.uk)
    PML is an independent company limited by guarantee with charitable status. It develops and applies world-leading, integrated marine science towards the sustainable future of the ocean. It has 157 members of staff, hosts 21 PhDs, and has 500 worldwide partners in over 60 countries.
11. Rothamsted Research (North Wyke Farm Platform), Devon (www.rothamsted.ac.uk/farmplatform)
    Rothamsted Research Limited is an independent charitable company, limited by guarantee. North Wyke is integrated with Rothamsted Research and brings together BBSRC research on grassland and arable systems.
12. Satellite Applications Catapult – SW Centre of Excellence, Cornwall (www.sacatapultcoe.org/centre/south-west/)
    The South West Satellite Applications Centre of Excellence will be based at Goonhilly Earth Station with the University of Exeter as the lead delivery partner. The centre partnership includes GES Ltd, the Met Office, Plymouth University, Falmouth University, PML, and Rothamsted Research, and has extensive commercial partner backing.
13. Sir Alister Hardy Foundation for Ocean Science (SOHFOS), Plymouth (www.sahfos.ac.uk)
    An international charity that operates the Continuous Plankton Recorder (CPR) Survey. SOHFOS has been collecting data from the North Atlantic and the North Sea on biogeography and ecology of plankton since 1931. More recently, as the Foundation has become more involved in international projects, work has expanded to include other regions around the globe.
14. UK Hydrographic Office, Taunton (www.ukho.gov.uk)
    The United Kingdom Hydrographic Office (UKHO) collects and supplies hydrographic and geospatial data for the Royal Navy and merchant shipping, to protect lives at sea. Working with other national hydrographic offices, we set and raise global standards of hydrography, cartography and navigation. UKHO is an executive agency, sponsored by the Ministry of Defence.

The UK's Research Councils (AHRC, BBSRC, EPSRC, ESRC, NERC, STFC) and Innovate UK are based in Swindon, and HEFCE, OFFA, HE Statistics Agency (HESA), UCAS, and HEFCW are also based in the area.

Annex C: LEPs and Local Authorities within SIA area

LEP / Cardiff Capital Region	LAU	NUTS3	ONS_CODE
Cornwall and Isles of Scilly	Cornwall		E06000052
Cornwall and Isles of Scilly	Isles of Scilly		E06000053
Gloucestershire	Cheltenham		E07000078
Gloucestershire	Cotswold		E07000079
Gloucestershire	Forest of Dean		E07000080
Gloucestershire	Gloucester		E07000081
Gloucestershire	Stroud		E07000082
Gloucestershire	Tewkesbury		E07000083
Heart of the South West	Torridge		E07000046
Heart of the South West	West Devon		E07000047
Heart of the South West	South Hams		E07000044
Heart of the South West	Teignbridge		E07000045
Heart of the South West	Exeter		E07000041
Heart of the South West	East Devon		E07000040
Heart of the South West	Mid Devon		E07000042
Heart of the South West	North Devon		E07000043
Heart of the South West	Plymouth		E06000026
Heart of the South West	West Somerset		E07000191
Heart of the South West	Taunton Deane		E07000190
Heart of the South West	Sedgemoor		E07000188
Heart of the South West	Mendip		E07000187
Heart of the South West	South Somerset		E07000189
Heart of the South West	Torbay		E06000027
Swindon and Wiltshire	Swindon		E06000030
Swindon and Wiltshire	Wiltshire		E06000054
West of England	South Gloucestershire		E06000025
West of England	Bristol, City of		E06000023
West of England	Bath and North East		E06000022

LEP / Cardiff Capital Region	LAU	NUTS3	ONS_CODE
	Somerset		
West of England	North Somerset		E06000024
Cardiff Capital Region	Bridgend	Central Valleys	W06000013
Cardiff Capital Region	Vale of Glamorgan	Central Valleys	W06000014
Cardiff Capital Region	Cardiff	Gwent Valleys	W06000015
Cardiff Capital Region	Rhondda Cynon Taf	Gwent Valleys	W06000016
Cardiff Capital Region	Caerphilly	Gwent Valleys	W06000018
Cardiff Capital Region	Blaenau Gwent	Bridgend and Neath Port Talbot	W06000019
Cardiff Capital Region	Torfaen	Monmouthshire and Newport	W06000020
Cardiff Capital Region	Monmouthshire	Monmouthshire and Newport	W06000021
Cardiff Capital Region	Newport	Cardiff and Vale of Glamorgan	W06000022
Cardiff Capital Region	Merthyr Tydfil	Cardiff and Vale of Glamorgan	W06000024

Table C1 Local Authorities within SIA geography

Annex D: Science Parks and Innovation Centres

The SIA area is home to over 35 science parks and innovation centres, including:

South West England

1.	Bristol and Bath Science Park	www.bbsp.co.uk
2.	Exeter Science Park	www.exetersciencepark.co.uk
3.	Plymouth Science Park	www.plymouthsciencepark.com
4.	Gloucestershire Science and Technology Park at Berkeley	Buildings come on stream 2016-2018
5.	Bath Guildhall	http://www.theguildhub.co.uk
6.	Porton Science Park, Wiltshire	
7.	Bishops Place, Paignton; Cockington Court; Lymington Road, Torquay; SW Energy Centre, Paignton; Vaughan Parade, Torquay	http://www.swinnovationcentres.co.uk/
8.	Bristol Enterprise Research and Innovation Centre	http://www1.uwe.ac.uk/bl/research/beric.aspx
9.	Bristol Games Hub	https://bristolgameshub.com/
10.	Cheltenham Cyber Business Park	Proposed in Growth Deal 3
11.	Dartington Social Enterprise Hub	https://www.dartington.org/our-work/our-projects-initiatives/the-social-enterprise-hub/
12.	Emmaus incubator	http://www.emmausbristol.org.uk/business-incubator/
13.	Engine Shed, Bristol	http://www.engine-shed.co.uk/
14.	Entrepreneurial-Spark, Bristol	http://www.entrepreneurial-spark.com/tag/bristol/
15.	Exeter Innovation Centre	www.spaceforsuccess.co.uk
16.	Formation Zone, Plymouth	www.formationzone.co.uk
17.	Future Works, the West of England University Enterprise Zone, Bristol	http://uwe.oxin-centres.co.uk/uez-launch/
18.	Gloucestershire Growth Hub, Gloucester	http://www.thegrowthhub.biz
19.	Health & Wellbeing Innovation Centre, Truro, Cornwall	http://www.cornwallinnovation.co.uk/health-wellbeing-centre
20.	Mendip Hub, Wells, Somerset	http://www.mendiphub.co.uk/
21.	Pervasive Media Studio, Bristol	www.pmstudio.co.uk
22.	Pool Innovation Centre, Redruth, Cornwall	http://www.cornwallinnovation.co.uk/pool-innovation-centre
23.	Rural Innovation Centre, Cirencester, Gloucestershire -	https://www.rau.ac.uk/about/farms/rural-innovation-centre
24.	SETsquared in Bath, Bristol and Exeter	www.setsquared.co.uk
25.	Spike Design, Bristol	http://www.spikeisland.org.uk/spike-design/

26.	Tetricus Science Park, Porton Down, Salisbury, Wiltshire	www.tetricus.co.uk
27.	The Hive, Weston Super Mare	http://thehiveweston.org.uk/
28.	Torbay Electronics & Photonics Innovation Centre, Paignton	http://www.torbaydevelopmentagency.co.uk/projects/regeneration/epic
29.	Tremough Innovation Centre, Penryn, Cornwall	http://www.cornwallinnovation.co.uk/tremough-innovation-centre
30.	University of Bath Innovation Centre, Bath	www.ubic.org.uk
31.	University of Exeter Innovation Centre, Exeter	www.spaceforsuccess.co.uk
32.	Various centres in Somerset	http://www.somerset-enterprise-centres.co.uk/
33.	Yeovil Innovation Centre, Yeovil, Somerset	www.yeovilinnovationcentre.co.uk

South East Wales

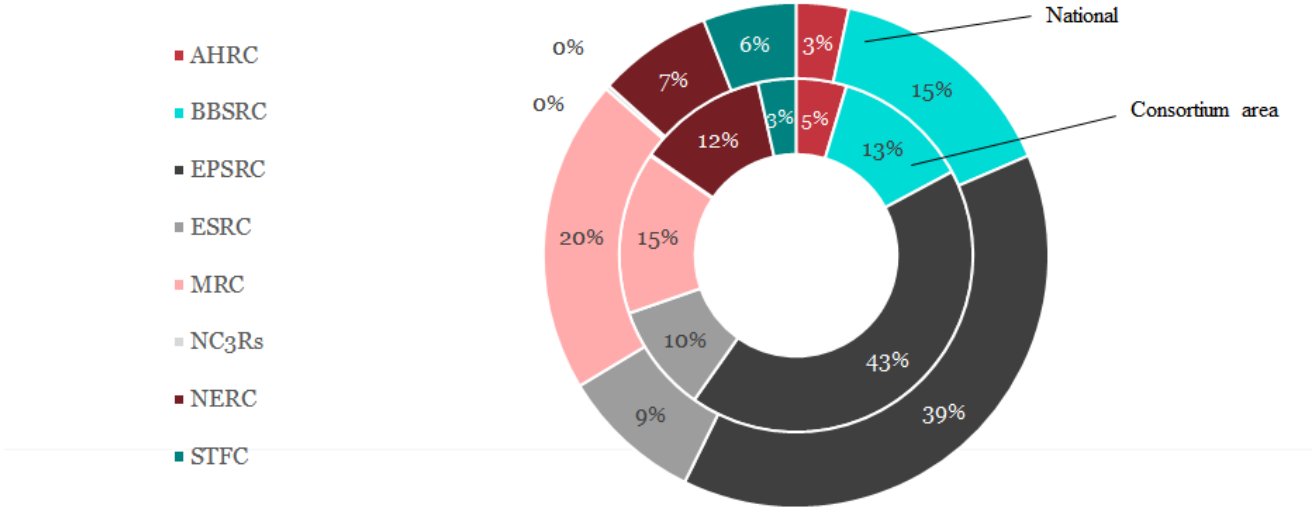
34.	Cardiff Business Technology Centre	www.cbtc.co.uk
35.	Cardiff Innovation Centre	http://www.cardiff.ac.uk/innovation/campus-investment/innovation-central/innovation-centre
36.	Cardiff Medicentre	www.cardiffmedicentre.co.uk
37.	Cardiff University Innovation Campus	www.cardiff.ac.uk/innovation/campus-investment
38.	Orbit Business Incubator, Merthyr Tydfil	www.merthyr.gov.uk

Table D1 Science Parks and Innovation Centres

Annex E: Theme Rationale

Strength and competitiveness in research and innovation funding

Of the Research Council funding received over the period 2010 – 2015 (Total: £ million), the majority was from the EPSRC (43%, £443.1m). By comparing the consortium area's funding proportions to the national proportions, we can see that the consortium area is significantly more competitive in drawing down funding from the EPSRC and NERC, and slightly more competitive in drawing down funding from the AHRC and ESRC.



Source: Gateway to Research (GtR). Research Councils UK (RCUK) (2016).

Figure E1 Research Council funding 2010-2015

The consortium area accounts for 7% of the UK's domestic REF income and 6% of the UK's total international REF income. Within the consortium, analysis of those areas that make up a higher percentage than the overall UK proportion reveals higher performing or more competitive areas. These areas are highlighted below.

Table E1 shows nine areas of interest to the consortium that perform relatively better than the consortium area's overall proportion. In particular, Biological Sciences, Clinical Medicine and General Engineering all perform well in both domestic and international funding, as compared to the consortium area's shares of overall declared funding.

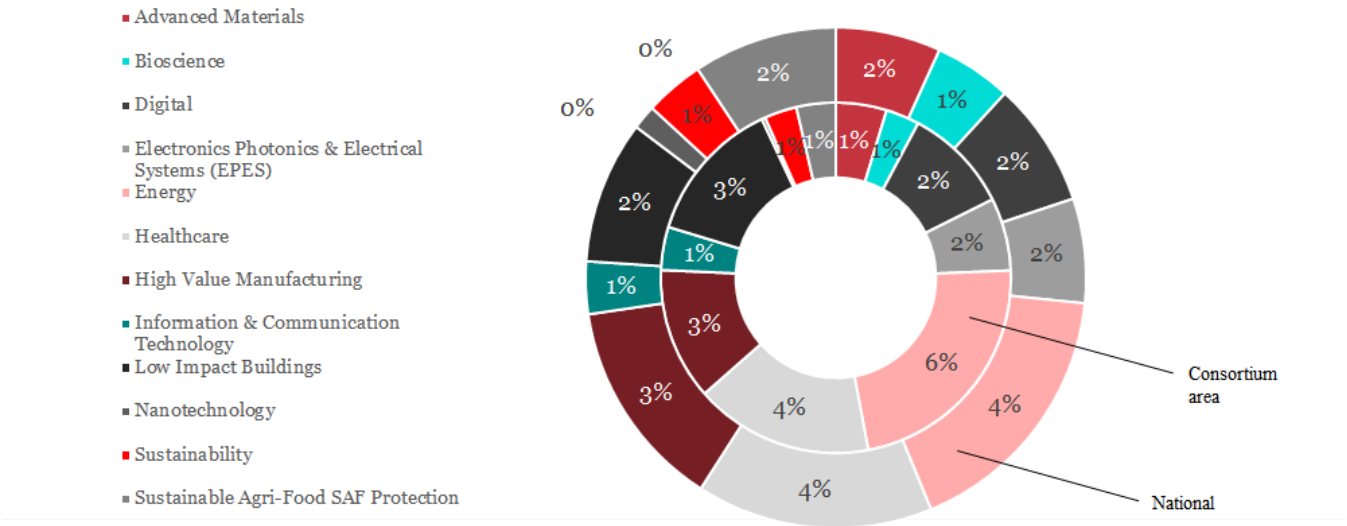
Area of interest	Unit of Assessment	% of domestic income (REF)	% of international income (REF)
Health	Allied Health Professions, Dentistry, Nursing and Pharmacy	6%	6%
Bio economy	Biological Sciences	10%	13%
Health	Clinical Medicine	13%	7%
Digital	Computer Science and Informatics	2%	7%
Bio economy	Earth Systems and Environmental Sciences	3%	9%

Advanced manufacturing	General Engineering	9%	17%
Energy / Advanced Manufacturing	Physics	9%	5%
Health	Psychology, Psychiatry and Neuroscience	7%	4%
Health	Public Health, Health Services and Primary Care	11%	2%
	% of all UK REF funding	*7%*	*6%*

Source: Research Excellence Framework (REF) Results, Higher Education Funding Council for England (HEFCE) (2015)

Table E1 REF funding - national and international

The largest proportion of Innovate UK awards received for an area of interest within the consortium area was Energy (6%, £12.3m). The second highest level of funding received for an area of interest was awarded to healthcare (4%, £8.9m). The consortium area slightly outperformed the national average in Energy and Low Impact Buildings.

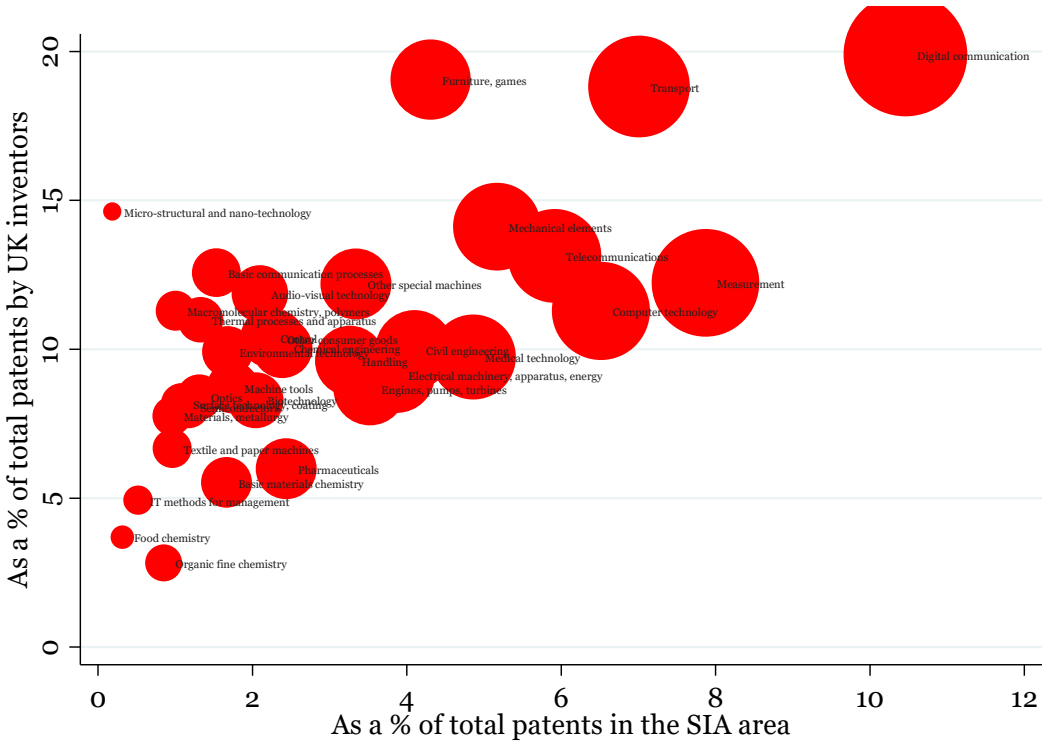


NB: In order to focus on the areas of interest to the consortium, this chart does not represent 100% of the Innovate UK funding received in the consortium area over the period.

Source: Transparency data. Innovate UK funded projects since 2004. Innovate UK (2016).

Figure E21 Innovate UK award breakdown

Patent data reveal strengths in several areas which show a relative high share of the total patents submitted by UK inventors (overall share: 10.2%) and represent a relative high proportion within the patent portfolio of the consortium. These areas include: Digital communication, Transport, measurement, Computer Technology and Telecommunications.



Source: EPO PATSTAT, 2004-2013

Figure E3 EPO Patent Data

Analysis of the 8th European Commission Framework Programme (H2020) shows the consortium's participation in European competitive funding. There are three areas where drawdown is high and participation is relative high in comparison with the overall participation of the consortium in H2020 (9%): Energy, Food and Environment.

	Relatively high participation (based on EC Contribution)	Top 5 (based on EC contribution)
Access to risk finance	0%	
Advanced manufacturing and processing	8%	3.04
Advanced materials	7%	1.59
Biotechnology	1%	0.05
Climate action, environment, resource efficiency	20%	16.63
Europe in a changing world	9%	3.21
Food security, sustainable agriculture	16%	11.15
Health, demographic change and wellbeing	4%	8.73
Industrial Leadership - Cross-theme	3%	0.45
Information and Communication Technologies	7%	15.66
Innovation in SMEs	13%	0.48
Nanotechnologies, Advanced Materials	16%	5.52
Secure societies - Protecting freedom	5%	3.26

Secure, clean and efficient energy	13%	21.41
Smart, green and integrated transport	5%	4.52
Societal Challenges - Cross-theme	0%	
Space	25%	6.96
	Total EC Contribution	102.66
	Relative overall participation	9%

Table E2 8th European Commission Framework Programme (H2020)

Industry capacity and capability

The last UK R&D Scoreboard (2010)[1] clearly identifies the largest business investment in R&D in SW England and SE Wales comes from the Aerospace and Advanced Engineering sector, with Airbus, Cobham, GE Aviation Systems, Dyson, Renishaw and Messier-Dowty in the top 10 positions for R&D investment. Intel, Cisco Sytems, IR Newport, IQE, RWE Npower, MessageLabs and picoChip Designs are amongst other multi-million pound investors in R&D.

The more recent 2013 EU industrial R&D Investment Scoreboard[2] identifies Rolls-Royce, GKN, BAE Systems, Johnson Matthey, Cobham, Spirent, Renishaw, Ultraelectronics and Gooch & Housego in the EU top 1000 by R&D spend, and all have R&D activities in the SIA area.

This demonstrates significant industrial R&D capacity in Aerospace and Advanced Engineering and Microelectronics within the SIA area.

With a few notable exceptions, the lack of a significant bio / medical / health industry (except related to Digital Health) led to the exclusion of this area of research strength from being an SIA Theme.

Summary

To summarise, the SIA consortium has:

- above UK average RCUK funding drawdown in the research areas covered by EPSRC and NERC: Engineering, Physical Sciences, and Natural Environment
- significant funding in terms of UK proportion of national and/or international REF income in General Engineering, Computer Science and Informatics, Earth Systems and Environmental Sciences, and Physics
- IUK awards in Energy that outperform the national average

1 http://webarchive.nationalarchives.gov.uk/20101208170217/http://www.innovation.gov.uk/rd_scoreboard/?p=31

2 http://iri.jrc.ec.europa.eu/scoreboard.html

- Patent data that reveals strengths in Digital communication, Transport, Measurement, Computer Technology and Telecommunications
- H2020 drawdown of funding and participation that are high in Climate action, environment, resource efficiency; Food security, sustainable agriculture; and Secure, clean and efficient energy
- significant industrial R&D capacity in Aerospace and Advanced Engineering and Microelectronics within the SIA area
- an opportunity to capitalise on strengths aligned to the UK's first new build Nuclear Power station at Hinkley C
- the potential to capitalise on the Met Office's position in the region and it's alignment with significant other research expertise in digital / data analytics

There is clearly significant research excellence, numerous significant regional assets and industrial capacity to provide the rationale to further investigate:

- Aerospace and Advanced Engineering
- New Energy Systems
- Next Generation Microelectronics

The strength of the research capability and underpinning technology building blocks within industry clearly identifies the possibility for creating significant future potential in:

- Digital Living Innovation

The strength of the research capability clearly identifies the possibility for emerging potential in:

- Resilience, Environment & Sustainability

Annex F: LEP / Welsh Government Strategic Alignment

The themes in the Audit are consistent with those identified by the LEPs and Welsh Government as evidenced from analysis of their strategies detailed below and summarised in Table F1 LEP / Welsh Government Strategic alignment with them.

The five LEPs in the consortium submitted plans to Growth Deal 3 in July 2016. These are summarised below in Table F21 Summary of LEP Growth Deal 3 submissions by SIA Theme (July 2016).

Aerospace and Advanced Engineering

Aerospace and Advanced Engineering is identified in the LEP strategies for Cornwall & Isles of Scilly, GFirst, Heart of the SW, Swindon & Wiltshire and West of England LEPs, and as a Grand Challenge area for Innovation Wales. It is core to the economic development priorities in the Somerset Growth Plan and Newquay Enterprise Zone in Cornwall.

The theme aligns with the UK Government's Industrial Strategies "eight great technologies" of robotics & autonomous systems; advanced materials & nanotechnology; and, energy & its storage.

New Energy Systems

Nuclear energy is in the Heart of the SW, GFirst and West of England LEP strategies, and in the economic development priorities in the Somerset growth plan, Enterprise Zone at Huntspill Energy Park and the new Somerset Innovation Centre.

Marine renewables is in Cornwall & Isles of Scilly and Heart of the SW LEP strategies, with Low Carbon in the West of England LEP strategy and renewables in the Gfirst LEP one. Local Authorities on both sides of the Bristol Channel / Severn Estuary are working together on the strategic and sustainable development of our vast offshore resources. The Cornwall & Isles of Scilly Marine Renewable Roadmap was launched in 2015. We have a Marine Enterprise Zone in South Yard, Plymouth.

The theme aligns with the UK Government's Industrial Strategies "Eight great technologies" of robotics & autonomous systems; and energy & its storage.

Next Generation Microelectronics

Next Generation Microelectronics is identified in the West of England LEP (under High Tech and Creative and Digital media) and in Torbay strategic development plans. Key enablers, photonics and cyber security, are Grand Challenge areas for Innovation Wales. Welsh Government strategy supports the UK National Centre for Compound Semiconductors to create Europe's fifth semiconductor cluster.

The theme aligns with the UK Government's Industrial Strategies "Eight great technologies" of advanced materials & nanotechnology.

Digital Living Innovation

Digital Living is identified in Heart of the SW LEP's strategic priorities: ICT – 'Big Data', and Health and Social Care; and in Cornwall & Isles of Scilly LEP's under digital economy and e-health and e-wellbeing. S&W LEP have digital 'information economy' as a theme. West of England LEP identify this priority under High Tech and Creative and Digital media. Precision Engineering and medical instruments are key for GFirst LEP. ICT and digital economy, life sciences & health are Grand Challenges for Innovation Wales

The theme aligns with the UK Government's Industrial Strategies "Eight great technologies" of big data & energy-efficient computing; robotics & autonomous systems; synthetic biology; and regenerative medicine.

Resilience, Environment & Sustainability

Agri-tech and data analytics are Cornwall & Isles of Scilly LEP smart specialisation areas; Agri-food, Environmental Futures and Marine Environment are in the Heart of the SW LEP strategy; and Swindon & Wiltshire LEP priorities are Environmental Tech (sustainable energy).

The theme aligns with the UK Government's Industrial Strategies "Eight great technologies" of big data & energy-efficient computing; and agri-science.

Theme / LEP	Aerospace & Advanced Engineering	New Energy Systems	Next Generation Micro-electronics	Digital Living Innovation	Resilience, Environment and Sustainability
Cornwall & Isles of Scilly LEP	Aerospace and Advanced Engineering; Newquay Enterprise Zone in Cornwall.	Marine renewables; Cornwall & Isles of Scilly Marine Renewable Roadmap (2015)		Digital economy, e-health and e-wellbeing	Agri-tech and data analytics
Heart of the South West LEP	Aerospace and Advanced Engineering; Somerset Growth Plan	Marine renewables; Marine Enterprise Zone in South Yard, Plymouth; Nuclear energy; Somerset growth plan, Enterprise Zone at Huntspill Energy Park; Somerset Innovation Centre.	Photonics cluster within Torbay strategic development plans	Big Data; Health & Social Care	Agri-food, Environmental Futures and Marine Environment
GFirst LEP	Aerospace and Advanced Engineering	Nuclear energy	Precision Engineering and medical instruments	Precision Engineering and medical instruments	
South East Wales	Aerospace and Advanced Engineering		Welsh Government strategy supports the UK National Centre for Compound Semiconductors	ICT and digital economy, life sciences & health are Grand Challenges	

			to create Europe's fifth semiconductor cluster		
Swindon & Wiltshire LEP	Aerospace and Advanced Engineering	Renewables		Digital 'information economy'	Environmental Technology (sustainable energy).
West of England LEP	Aerospace and Advanced Engineering	Low Carbon; Nuclear energy	High Tech and Creative and Digital media	High Tech and Creative and Digital media	

Table F1 LEP / Welsh Government Strategic alignment with themes

Theme / LEP	Aerospace & Advanced Engineering	New Energy Systems	Next Generation Microelectronics	Digital Living Innovation	Resilience, Environment and Sustainability	Cross-cutting / Other
Cornwall & Isles of Scilly	Cornwall Airport Newquay EZ. National Centre of Excellence for Future Flight Technologies with iAero. - Unmanned Aerial Systems - Future Aerostructures and Aircraft - Propulsion of the Future - Engine and rocket testing.	Low Carbon Enterprise Zone - Marine Hub			Cornwall Airport Newquay and Goonhilly Earth Station which together form our AEROHUB+7 EZ	Cornwall College – Institute of Technology: to extend coverage in STE(A)M based learning to all parts of LEP area

	Aerospace Skills Centre	Smart Islands - smart grid infrastructure		Smart Islands - smart grid infrastructure	Goonhilly Antenna Upgrades: creates a Space Comms Gateway	STEM skills centre at Callywith College, Truro and Penwith's new Bodmin campus.
	Space for Knowledge Exchange: SpoKE will provide space and a supportive environment				Goonhilly Science Outreach Centre	
Heart of the South West	New aerospace innovation and collaboration space, Yeovil - iAero (South)	Roundswell Business Park (phase 3) to open up employment space, as well as a marine innovation centre	Hi-Tech Centre, South Devon College - strong focus on advanced manufacturing, links to Torbay electronics /photonics cluster	LEP-wide ICT training - Hub and spoke training for Cyber-security, Big Data and Social Media.	Centre for Innovation Excellence in Livestock, Bicton - new facility to enable data analysis & research	Royal Bath and West Food Enterprise Zone
		Oceansgate, South Yard EZ, phase2. South Coast Marine Cluster			Infrastructure improvement links to the Environmental Futures	Yeovil College – Health and Care Career College
		Infrastructure to unlock Huntspill Energy Park EZ				Health and Social Care Campus, Torbay Hospital
		Further phase of Somerset Energy Innovation Centre				
		Building on the forthcoming SW England and SE Wales Science & Innovation audit to transform this potential into reality, supporting development of our 'golden opportunities' with a nuclear research hub, development of the Smart Sound opportunity in marine and developing the environmental futures cluster.				

Gfirst LEP	Eco Park - focused on knowledge-based industries and advanced technology businesses; transport improvements	Cheltenham Cyber Park - unlock site next to GCHQ, creating 'honeypot' for cyber security & high tech supply chain next to national cyber innovation centre	The Cirencester Enterprise Quarter - links with RAU Agri-tech investments;	Gloucestershire College Forest of Dean Campus - extend the provision of STEM Centres built within the County
				Gloucestershire Engineering Training: Centre of Excellence for Food & Drink
Swindon & Wiltshire LEP			Swindon College Centre of Excellence in Sustainable Technologies - skills development in sustainable construction and advanced engineering	Swindon and Wiltshire HE Centre - HE provision in digital technologies, life sciences and financial and professional business services
				Wiltshire College Lackham - land-based university centre 'The Wiltshire Regional Centre of Land-based Excellence'
				Wiltshire College Salisbury - construction,

				engineering and life sciences centre and a HE centre
West of England LEP	New aerospace innovation and collaboration space, Filton Enterprise Area - iAero (North)	NUCLEATE Nuclear Futures Open Innovation & Technology Centre	Quantum Innovation Factory	Bristol & Bath Science Park Grow On Centre (GO2)
	Institute for Advanced Automotive Propulsion Systems (IAPPS)			FoodworksSW - SW Food & Drink Centre @Food EZ, Weston

Table F21 Summary of LEP Growth Deal 3 submissions by SIA Theme (July 2016)

Department for
Business, Energy
& Industrial Strategy

South West England and South East Wales Science and Innovation Audit

Annex G: Aerospace and Advanced Engineering Theme Report

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

G

Annex G Aerospace & Advanced Engineering Theme Report

1. Introduction

Aerospace & Advanced Engineering has been identified as a strength of the Audit region. This strength has been built over decades and has resulted in the rich landscape of Industrial Primes; Systems / Structural Suppliers; Research Centres and renowned Academic Institutes, all with related skills. This community has a long history of collaboration both within and outside of the region.

This truly world class and world leading capability has delivered iconic products that the UK has taken great pride in being associated with, such as the Westland Sea King Helicopter, Dyson cyclone vacuum cleaner and Bristol Proteus gas turbine engine which powered the Bluebird CN7 land speed record car.

Whilst these foundations are strong, much more remains to be done. Our international competitors are advancing and UK national momentum must be maintained. The overriding impression gained from conducting this audit is the strength of opportunity that the region can deliver, backed by evidence of achievement but mollified by the concern created by the risks and challenges faced related to loss of long established capability which threatens the Government's Industrial Strategy.

A lot of emphasis has been placed on developing high value manufacturing capability; this audit considers that a broader strategy to protect and enhance capabilities elsewhere in the Industrial Value Chain is essential. Specifically, **High Value Engineering Design** and **System Integration Skills** (e.g. whole structure, sub-structure and propulsion) are core to the region and core to the protection of longer term manufacturing, recognised by the AGP; ATI; APC and the CEO of the HVM Catapults. Additionally, opportunities exist in developing **Composite Capabilities** and addressing life-long learning to manage the transition into the 4th Industrial Revolution – Industry 4.0.

Proposals to protect and reinforce the regional capabilities can be categorised as **High Value Design & Systems Integration** and **Composite Materials & Manufacturing:**

High Value Design and Systems Integration:

1) A **High Value Design Institute** - a Catapult centre focused on Design Integration capabilities, initially focused on Aerospace. This could be translated to other sectors and regions.

2) Institute for Advanced Automotive Propulsion Systems **IAAPS** – delivering future generations of low carbon vehicles through efficient powertrain **design and integration**, which is also applicable to Aerospace and other sectors.

Composite Excellence:

1) National Composites Materials Centre **NCMC** - re-shoring the **Composites Materials Value Chain** by building on the existing capability at the NCC. Applicability across multiple sectors, all of which are forecast to grow.

Core to this outcome is the coordinated support that these developments will bring, along with projects addressing skills and training such as the South West Institute for Technology & Skills **SWIFTS** (which is aligned to the National College for Advanced Manufacturing agenda), to deliver the National agenda for industrial development.

The current Aerospace & Advanced Engineering activity in the South West of England and South East Wales is built on over 150 years of engineering pedigree. Advanced engineering strengths in the region fall into three broad sectors, aerospace, automotive and marine, each of which can be divided into defence and civil applications. The steel industry is also a further sector of national importance (AAE6).

Aerospace – companies are located throughout the Audit area from Cornwall to Gloucestershire, with the region being home to 14 of the 15 largest aerospace companies in the world. In particular, the West of England has been a cradle of aviation innovation since the British Empire and Colonial Aeroplane Company opened in Filton (near Bristol) in 1910. There has been over 100 years of continuous development, design and manufacture, which includes global companies such as Airbus, BAE Systems, GKN Aerospace, Leonardo Helicopters, MBDA and Rolls-Royce resulting in the largest aerospace cluster in the UK, and the second in Europe, with 20% of the UK aerospace workforce, many of whom are involved in advanced design and systems integration within prime contractors and major Tier 1 suppliers.

Automotive – industry is concentrated at locations along the M4, Swindon: Honda UK Manufacturing, South East Wales: Ford Engine Plant, as well as high-end manufacturers in Somerset: Ariel Motor Company and West of England: Bristol Cars. The region is also a home to a spoke of the Advanced Propulsion Centre UK with the internal combustion engine system efficiency (ICE-SE) centre based at the University of Bath which conducts technology development with automotive companies from across the UK and around the globe, such as Ford, JLR and McLaren, and their supply chains.

Marine –Strengths lie in marine engineering, historically through the Royal Navy and more recently firms such as Babcock, MSubs and Princess Yachts. Indeed, Plymouth has the highest proportion of its employment in manufacturing of any city in Southern England. Ship building is found in Falmouth (A&P is UK's largest ship-repair complex) and North Devon, (Appledore). Marine defence organisations are also located further east in the region e.g., BMT Defence Services, Bath.

The audit area's strengths in AAE have grown up alongside the **steel** industry in South Wales, which has historically served as a source of raw materials for many of the region's industries. Additionally, there is significant cross over between the Marine Engineering sector in the Aerospace & Advanced Engineering and Marine Renewables within the New Energy theme as well as Industry 4.0 in Digital Living Platforms and Sensors discussed in the Next Generation Microelectronics theme; with many AAE firms supported by common supply chains in these related areas.

The Aerospace & Advanced Engineering (AAE) audit references publically available as well as novel datasets and publications and has been informed by canvassing the views of academia, industry and local government connected to the Aerospace & Advanced Engineering sector. A workshop was held which attracted 48 delegates representing the

majority of academic institutions in the region as well as a cross section of Blue Sky start-up companies, SMEs and OEMs. The outputs from the workshop as well as further consultation with stakeholders throughout the audit process were used to add context to the data collected centrally. Further review of the outputs was carried out by a theme review panel representing a cross-section of stakeholders.

2. Regional science and innovation assets

Our region's physical and intellectual assets in AAE have breadth and depth, reflecting a rich heritage of innovation in aerospace, automotive and marine engineering. The region's AAE strengths are supported by numerous multi-million pound infrastructural investments that support key sector clusters. The Universities of Bath, Bristol, Cardiff, Exeter, Plymouth, West of England, South Wales and Gloucestershire are involved in research directly related to the theme with many of the region's major AAE assets are associated with these Higher Education Institutions.

R&D Assets (Appendix AAE1) – Facilities of note include The National Composites Centre (NCC)[1], owned by The University of Bristol, is part of the High Value Manufacturing Catapult and is based at the Bristol & Bath Science Park. Opened in 2011, the NCC is a key part of the Government's composites strategy and brings together dynamic companies and enterprising academics to develop new technologies for the design and rapid manufacture of high-quality composite products. The University of Exeter's Centre for Additive Layer Manufacturing (CALM)[2] was developed in partnership with Airbus Group Innovations. Funded by the European Regional Development Fund (ERDF) it has supported more than 200 companies and has created regional growth of £20m. The Morgan-Botti Lightning Laboratory[3] at Cardiff University was established in 2011 as a collaboration between the Welsh Government, Cardiff University and Airbus Group Innovations (formerly EADS). It undertakes research including measuring the direct-effects of lightning strikes on structures and samples and investigating lightning protection mechanisms for the aerospace industry. The Electron Microscopy Centre (EMC)[4] at Plymouth University has 30 years' experience working with AAE industries, supporting them through analysis of defects and quality control.

Capabilities in the automotive sector lie at the Powertrain & Vehicle Research Centre (PVRC)[5] which builds on 50 years of research excellence focused on improving the systems efficiency of the whole vehicle powertrain (engine, transmission and control), which recently has been aimed at reducing CO_2 emissions of both diesel and petrol engines, and improving real world driving conditions. It partners with local companies, Ashwoods (Exeter) and HiETA Technologies (Bristol), and nationally Ford UK, Jaguar Land Rover, Lotus Engineering, TATA and McLaren Automotive, Ricardo, Honeywell, Shell, BP, and many more.

[1] National Composites Centre - http://nccuk.com/
[2] Centre for ALM - http://emps.exeter.ac.uk/engineering/research/calm/
[3] Morgan Botti Laboratory - http://lightning.engineering.cf.ac.uk/
[4] Electron Microscopy Centre - www.plymouth.ac.uk/your-university/about-us/university-structure/faculties/science-engineering/electron-microscopy-centre
[5] University of Bath PVRC - http://www.bath.ac.uk/mech-eng/research/pvrc/

Further assets lie outside HEIs. Aerohub[6] at Cornwall Airport Newquay is a designated enterprise zone that offers planning-free development and 100% business rate relief. Funded with £2.3m from the Homes and Communities Agency (HCA) and £3.9m from the European Regional Development Fund Convergence programme, with Cornwall Council providing the land, Aerohub is home to Advanced Engineering companies such as CIS UK Ltd and Apple Aviation as well as Bloodhound Supersonic Car which is attempting the UK's latest land speed record. Aerohub / Cornwall Airport Newquay is well placed to be the UK's first spaceport.[7] With one of the UK's longest runways, available development land, uncongested clear airspace and access to segregated airspace. The Aerohub Enterprise Zone also incorporates Goonhilly Earth Station, a major satellite communications hub and location for a proposed Space Science Centre. This complementary expertise is covered in the Resilience, Environment and Sustainability Theme as Goonhilly is part of the Satellite Applications Catapult Centre of Excellence.

The marine technology focused Enterprise Zone at the 35 hectare Plymouth Devonport site (now named Oceansgate[8]) will provide further impetus to marine sector growth and the partnership between BMT and MSubs to develop a test range, located off the Plymouth coast for testing UxV technologies. The facility features sensors within fixed buoys, environmental sensors, GPS, Wi-Fi (for tracking, communications and navigation) and will help developers test their technology in real conditions.

Skills & Training - In September 2009 Flybe announced its successful bid for Training Academy project at Exeter Airport. Funding included £4.3m from Learning and Skills Council's (LSC) new Capital Specialisation Fund (CSF) and £2.8m South West Regional Development Agency. The Flybe Training Academy[9] offers a wide range of Pilot, Technical, Cabin Crew and Customer Service courses to airlines across the world, as well as a range of non-aviation training to other individuals and organisations in the South West.

Teaching related to the region's AAE strengths is also evidenced in the further education landscape with City of Bristol College offering courses in Aeronautical engineering and Aerospace engineering manufacturing[10]. Exeter College offers in partnership with Flybe at Exeter International Airport an Aircraft Engineering higher education foundation degree[11]. Yeovil College provides post GCSE students with an opportunity to gain qualifications in Composites engineering (Level 3) as well as vehicle maintenance & repair[12]. Cornwall College's Falmouth Marine School offers a range of qualifications in boat building and repair and marine engineering[13]. In the higher education space, a significant number of Centres for Doctoral Training (CDT) / Doctoral Training Entities (DTEs) are housed in the

[6] Aerohub at Cornwall Airport Newquay - http://www.aerohub.co.uk/
[7] http://www.cioslep.com/assets/uploads/documents/1463644707_AH_spaceport_v3.pdf
[8] Oceansgate - http://www.oceansgateplymouth.com/
[9] Flybe Academy - http://www.flybetraining.com/
[10] City of Bristol College - http://www.cityofbristol.ac.uk/courses/aeronautical-engineering/
[11] Exeter College - http://www.exe-coll.ac.uk/Course/engineering-flybe-diploma/
[12] Yeovil College - http://www.yeovil.ac.uk/Apprenticeships/Engineering/AdvancedCompositeEngineering.html
[13] Cornwall College - https://www.cornwall.ac.uk/boat-building

region's universities including those in Advanced Composites for Innovation & Science[14] and Composite Manufacture[15] (Bristol), Catalysis[16] (Bristol, Bath and Cardiff), Autonomous & Robotic Systems[17] (Bristol and UWE), Metamaterials[18] (Exeter) and Sustainable Materials and Manufacturing[19] (Exeter).

3. Excellence in science and research

Research Excellence Framework 2014 (REF)

Approximately 250 academic staff based at the region's Universities are involved in AAE research (Appendix AAE3). Since 2008 the AAE academic community have trained over 750 PhD students with 90% of the research activity was classified as world-leading or internationally excellent (4 & 3*, respectively).* Researchers are drawn from 10 Units of Assessment (UoA) as defined by the REF, with the majority associated in UoAs 12 Aeronautical, Mechanical, Chemical and Manufacturing Engineering and 15 General Engineering.

21 REF Impact Case Stories are directly associated with academics from this theme, pointing to excellence in:

- Design and manufacture processes: e.g. composite wing structures, light-weighting and performance enhancement of aerospace structures, and improving car production processes
- Decarbonisation through improvements in engine fuel efficiency
- Modelling, simulation and testing of new materials (composites, steel & alloys, concrete) and structures applicable across AAE

An audit of research income associated with AAE shows that in the period 2008-2015 the total research income across the consortium was over £210m, with 2014/15 representing the academic year with the highest research income. This is reinforced by the region's Universities being awarded eight further recent AAE projects worth over £1m each and all involving at least one commercial partner.

Publication data

SciVal analysis of publication data for the period 2011-15 shows the combined publishing output of the Universities in the audit region out-performs the UK, Europe and the World in Aerospace and Automotive Engineering. 23% of the University of Bristol's papers on this topic are highly cited (compared to 20% UK, 17% Europe, 10% World) and 84% of the University of Bath's articles are found in high impact journals (76% UK, 73% Europe, 53% World). The region's universities also outperform the UK, European and World averages for publication citations and impact in the area of Automotive Engineering with 63% of the

[14] Advanced Composites for Innovation & Science - www.bristol.ac.uk/composites
[15] Composites Manufacture - www.epsrc.ac.uk/skills/students/centres/profiles/compositesmanufacture/
[16] EPSRC CDT in Catalysis - http://www.catalysis-cdt.ac.uk/
[17] EPSRC CDT in Future Autonomous & Robotic Systems - http://farscope.bris.ac.uk/
[18] EPSRC CDT in Metamaterials - http://emps.exeter.ac.uk/metamaterials/
[19] Sustainable Materials & Man. - www.exeter.ac.uk/doctoralcollege/fundedcentres/materialsmanufacturing/

University of Bristol's output being in highly cited papers, compared to 21% for the UK, 16% Europe and 12% World.

Further analysis of these data on topics central to AAE indicates that universities in the audit region out-perform the Russell Group (which includes Universities of Bristol, Cardiff and Exeter) and the UK as a whole on citation impact, publishing in high impact journals and co-publishing with industry in the subject area of composites. The University of Bath's publications on wing aerodynamics and The University of Bristol's publications on laminates and composite materials are more than twice as likely to be highly cited and 1.5 times more likely to be published in high impact journals than other articles in this topic area. In the areas of Composite Materials, Laminates and Delamination, Buckling, Fibres and Textiles, the University of Bristol is world-leading in terms of number of publications, overall citations and field- weighted citation index.

Cardiff University is the leading UK institution for publishing on supply chains and is among the top 10 most active universities worldwide for this topic. University of Bath, University of Exeter, University of Plymouth, University of Bristol and University of the West of England are also significant contributors to publishing in this area[20].

Patents

Based on named inventors, over the period 2004-2013 companies in the consortium area and associated with AAE filed over 1,500 patents. Across South West England & South East Wales eight of the ten most active companies in terms of protecting their intellectual property are associated with the theme. This includes firms such as Dyson, Airbus, Rolls-Royce, Renishaw, BAE Systems, Vecto Gray Controls and Edwards. Furthermore, The Universities of Bath, Bristol and Cardiff all appear in the top 40 organisations in terms of number of patent filings[21].

4. Innovation strengths and growth points

In 2015, across the consortium area there were 7,775 enterprises operating within Aerospace & Advanced Engineering. This represents an increase of 29% over the past 5 years, with much of this growth occurring after 2012. This is more than twice the average rate of growth in number of enterprises across industries in the Audit region (13%)[22]. Approximately 475 companies are associated with the aerospace sector with a value to the economy of £3.2bn and Gross Value Added (GVA) of £2.3bn[23], 190 are within the automotive sector, 150 with the marine sector and 140 with steel. Furthermore, 14 of the 15 largest aerospace companies in the world have a presence in the South West and sector exports from the region are estimated to account for between 50 – 65% of sales[24]. 1015, 1385, and 3805 companies were classified under Engineering Design for Production & Process, Technical Consulting in Engineering and Other Engineering codes, respectively. However, over 90% of these companies employed fewer than 10 people.

[20] SciVal Analysis at University of Bath Library July 2016 - www.scival.com
[21] Technopolis patent data - World Intellectual Property Organization 2004-2013
[22] Business Register and Employment Survey 2014, NOMIS Official Labour Market Statistics
[23] ADS Group UK Aerospace Outlook 2011
[24] South West & Wales, Spotlight, Autumn 2015 - http://sites.southglos.gov.uk/wp-content/uploads/sites/241/2015/09/2015-bristol-spotlight-autumn.pdf

Between October 2013 and May 2016 the region's SMEs population had the highest uptake of NATEP projects (35) and highest predicted growth in jobs. Moreover, a significant number of these projects undertaken in the region were in Innovative materials for aerostructures and components, particularly composites. This links directly to the ATI pillars and themes and support the national AGP strategy[25].

When expressed as location quotients (LQ), the consortium area has particularly high concentrations of enterprises in the Aerospace sector (LQ - 2.62). Indeed the Audit region boasts largest aerospace cluster in the UK, and the second in Europe, with 20% of the UK aerospace workforce. Further analysis indicates that companies engaged in these activities are clustered in the South East Wales and West of England Local Enterprise Partnership (LEP). South East Wales also has high LQ scores, 2.75, for Manufacture of basic iron and steel and of ferro-alloys. Similarly concentrations of companies involved in the building of watercraft and structures are found in Cornwall & the Isles of Scilly LEP (LQ - 5.15) and Heart of the South West (LQ - 2.75). Swindon & Wiltshire LEP area has particularly high location quotients (4.23) for the manufacture of transport equipment and associated equipment for motor vehicles (LQ - 2.64)[26].

Jobs

According to the Business Register and Employment Survey (BRES) 98,100 people are employed in AAE in the region, representing over 12% of all those in employed in this sector in Great Britain (812,600). Employment in AAE has been rising locally and in 2014, was 9,800 (10.9%) higher than it was in 2009. This is a much larger percentage increase than employment across all industries in the Audit region (0.6%) and is higher than the industry average across Great Britain (6.6%)[5].

Jobs in AAE are high value. Productivity throughout the aerospace sector is estimated at £54,000 per FTE, rising to £73,000 amongst the major aerospace companies, and as compared to a regional productivity average of £43,000 per FTE. More than 30% of UK aerospace employees are educated to degree level or above, compared to a national average of 21% for the total working age population[27]. Despite a projected decrease in the total number of people employed in AAE in the region between 2010 and 2020, the replacement demand, will be roughly twice the scale of the employment decline; a net requirement for 2,500 additional employees in advanced engineering over the next ten years[28].

These sectors are underpinned by technical engineering services, materials and component supply chains and research and experimental development in the region, with over 42,000 jobs classified under general engineering activities, engineering design activities for industrial process as well as engineering related scientific and technical

[25] NATEP Analysis and Statistics May 2016- issue 005
[26] Business Register and Employment Survey 2014, Nomis Official Labour Market Statistics
[27] Aerospace & Advanced Engineering Sectors - South West Region's Inward Investment Strategy
[28] West of England Strategic Economic Plan 2015-2030

consulting activities[5]. Approximately 65% of workers engaged in these industries are qualified to at least NVQ Level 3 or above[6].

Strengths by Local Enterprise Partnership

West of England[7]

Advanced Engineering is recognized as being vital to the economy of the West of England as it makes intensive use of capital or knowledge; has high levels of R&D and technology expenditure; requires strong specialist skills particularly in science and technology; and is likely to compete nationally or internationally. Aerospace is the single most powerful sector in the West of England, with one of the largest concentrations of aerospace activities in Europe. The cluster acts as a magnet for further inward investment but the LEP also recognizes the accretion of strength and resilience in the local economy by virtue of having a broad spectrum of advanced engineering companies that include, robotics, automotive, white good manufacturing, general advanced engineering.

Manufacturing in the LEP contributes to a GVA of £58,800 per full-time equivalent employee, with output in the West of England approximately 20% higher than it is nationally, and 30% above the West of England economy as a whole. These high productivity levels are largely driven by the aerospace cluster comprising Airbus, GKN Aerospace, Rolls-Royce, BAE Systems, Honeywell, Claverham, MBDA and associated supply chain, as well as luxury car maker Bristol Cars.

Gloucestershire[29]

The composition of the AAE sector in Gloucestershire comprises precision engineering sub-sector (50% of employees) and an even split between the Automotive (26%) and Aerospace (24%) sub-sectors. The picture differs in South West Gloucestershire with the Aerospace sub-sector accounting for 56% of employees. The strong advanced engineering cluster in Gloucestershire means that the proportion of employees engaged in the sector stands 50% higher than the national average.

Significant AAE employers in Gloucestershire include Spirax Sarco, Safran Landing Systems UK, Messier-Bugatti-Dowty, Renishaw, Kohler Mira, Bond Aviation Group, Oberthur Technologies, L-3 TRL Technology, Avon Metals, Glatfelter Lydney, Moog Controls, Corin Group and Relyon. The manufacturing sector accounts for a greater than average proportion of both employment and GVA; accounting for 11.9% of total employment (8.8% nationally) and contributing £1.88bn to the local economy or around 16.2% of total GVA (11.6% nationally). The percentage of young people attempting ‘Triple Science’ in Gloucestershire is increasing which has been shown to lead to a greater uptake of STEM subjects at A-level and University. DoE data indicates that pupils in Gloucestershire achieve better than average maths and science results.

Heart of the South West[30]

Advanced Engineering, with its principal sub-sector Aerospace and other important components, Automotive, Advanced Electronics/Photonics, Defence and Marine, employs over 23,000 people across the LEP and contributes over £1bn to the economy. Many leading AAE companies are situated in Somerset and Devon, including Leonardo

[29] Strategic Economic Plan for growing Gloucestershire
[30] Heart of South West Strategic Economic Plan 2014-2030

Helicopters - Britain's only helicopter manufacturer that retains a complete indigenous design, development, production, manufacturing and support capability, Honeywell Aerospace, BAE International, SC Group (former Supacat), Centrax, MB Aerospace, Alcoa Howmet, Helitune, Beran Instruments, Ashwoods Automotive, Hymec, Aero Stanrew, Anglo-Krempel, Babcock, Thales, Aerosystems International, Ariel Motor Company, and Numatic International as well as links to major Ministry of Defence sites at Yeovilton and Abbey Wood. Interestingly, Somerset company, Ascenta, was acquired by Facebook to develop solar powered drones to supply wireless broadband to the developing world. Furthermore, Brecknell Willis has its UK centre for manufacturing and its global innovation centre in railway electrification systems located in Chard.

Such a robust and varied industry cluster generates a highly skilled, experienced and eminently "transferable" workforce with many supply chain companies being dual or multi-sector oriented. Indeed over 1/3 of the population in Devon are educated to degree standard or above. This makes for a highly diverse AAE base which the LEP is keen to secure and to grow both in size and scope.

Swindon & Wiltshire[31]
The LEP is home to some of the best known Advanced Engineering companies in the world including Dyson's global HQ in Malmesbury as well as Johnson Matthey Fuel Cells, Herman Miller, Torin, Knorr-Bremse, Tamura Europe, Honda and Wavin Plastics. Siemens Rail Automation formed after the acquisition of the control, command and communications divisions of Westinghouse Brakes & Signals, has its UK centre for manufacturing and its global centre for R&D in Chippenham. Swindon & Wiltshire is an internationally recognised centre of innovation in Automotive, Mechanical, Electrical and Process Engineering and has a growing Manufacturing cluster with the sector employing 11.8% of the county's workforce.

Wiltshire has a tradition of defence-related research and manufacturing with QinetiQ and Defence Science and Technology Laboratory (DSTL) at the Porton Down facility and Chemring Countermeasures. The automotive and rail systems sectors are also well represented in the LEP with Invensys Rail, BMW Group and an extensive automotive supply-chain network, including DTR VMS. Honda UK's fully integrated manufacturing facility currently produces the Civic, CR-V and Jazz range. Acknowledging the diverse Advanced Engineering capability as pivotal to the success of the local economy, the LEP is keen to foster cross-sector collaboration between Automotive and Aerospace.

Cornwall & Isles of Scilly[32]
C&IoS has very low levels of business investment in R&D. In 2012 R&D spend was 0.22% of GDP, the lowest of any LEP area, compared to a national figure of 1.63% and an EU average of 2.09%. In the period 2010-2013 only 20 companies in C&IoS (out of 5,464 nationally) successfully applied for Innovate UK funding - with only £4 million of grants being secured out of £922 million nationally.

[31] Swindon & Wiltshire Strategic Economic Plan – Aligning local innovation with Government ambition
[32] Cornwall and Isles of Scilly Research, Development and Innovation Framework

The LEP has identified agri-tech, digital economy, e-health and e-wellbeing, marine technology, and, space and aerospace as markets where C&IoS has an existing asset base and where there is potential for global growth and development in that market. The LEP contains AAE companies including Lockheed Martin UK, Leonardo Helicopters, British International Helicopters, Western Aviation, A&P, Babcock and Princess Yachts. Consequently, investment will focus on these areas with for example €20-25M of ERDF funding earmarked for the space[33] & aerospace sector with marine technologies supported through schemes such as the Devonport Dockyard development under the Plymouth and South West Peninsula City Deal**.**

South East Wales
The region is centre of excellence for aircraft Maintenance, Repair and Overhaul (MRO) with British Airways Maintenance Cardiff, the world's only licensed dual bay facility capable of maintaining and overhauling Boeing 747, 767 and 777 aircraft[34]. Furthermore the audit region is part of the wider steel industry cluster in South Wales (including Tata, Port Talbot) and contains companies such as Celsa Steelworks UK, Liberty Steel and Tata Steel Service Centre. The automotive industry is also represented by the Ford Bridgend Engine Plant which produces 750,000 engines per annum including the Ford SI6 engine for Volvo and Jaguar Land Rover and the Ford 1.6 L I4 EcoBoost. In March 2015 it was announced the "Dragon" designed petrol engines would be built at Bridgend following a £15m investment grant by the Welsh Government[35].

5. National and international engagement
Industry Bodies & Networks - *As well as being connected nationally and internationally, organisations in the Audit region can boast strong local networks involving industry, academia and government*. Aerospace Wales, provides a membership trade service for AAE companies in their geography[36]. Similarly, the West of England Aerospace Forum (WEAF)[37] is a regional membership trade organisation representing the aerospace and defence sectors from SMEs to global corporations. As one of the largest aerospace and defence associations in Europe, WEAF provides a strong voice, representation and access to prominent regional, national and international decision makers in industry and government. It also serves as the regional coordinator for National Aerospace Technology Exploitation Programme (NATEP) activities.

The Exeter Initiative for Science and Technology (ExIST)[38] is a subgroup of Exeter Chamber of Commerce and Industry. Founded in 2011 by a group of business leaders in Exeter and the surrounding area, the initiative aims to optimise interaction between science, technology, engineering, mathematics and medicine (STEMM) businesses

[33] http://www.cioslep.com/assets/uploads/documents/1463644707_AH_spaceport_v3.pdf

[34] British Airways Engineering - http://www.britishairways.com/baemro/assets/download/BA_Engineering.pdf
[35] Brdigend Council - https://democratic.bridgend.gov.uk/documents/s7098/151007%20Council.pdf
[36] Aerospace Wales - http://www.aerospacewalesforum.com
[37] West of England Aerospace Forum - http://www.weaf.co.uk/
[38] Exeter Initiative for Science & Technology - http://www.existexeter.co.uk/

trading in the area. Further South West the Torbay Hi-tech forum[39] is a membership group dedicated to industry-led development, collaboration and promotion across the tech and advanced manufacturing sector. The Growth Acceleration and Investment Network (GAIN)[40] was founded by Plymouth University, Plymouth City Council and Tamar Science Park to accelerate the creation, growth and investment in high quality businesses, creating wealth and jobs in the South West

The Audit region has national Advanced Engineering links through bodies such as the Advanced Propulsion Centre (APC) UK[41]. The APC was established by the Automotive Council as the delivery hub for a joint industry / Government strategy to help the UK accelerate its leadership and excellence in advanced low carbon propulsion development and production. It will channel £1bn into the UK automotive industry over the next decade. The Centre's hub and spoke model, with the "internal combustion engine system efficiency" spoke based at the University of Bath, provides access to the UK's leading expertise and facilities in key strategic technologies for the automotive industry.

Collaborative Projects - The Audit area Universities all undertake significant collaborative research in AAE (Appendix AAE2) with companies of various sizes (SME to OEM / Multinational) and universities across the UK, Europe and further afield. Highlights include the £26m Advanced Combustion Turbocharge Inline Variable Valve-train Engine (ACTIVE)[42] project with Ford, Continental, Schaeffler, Unipart Eberspacher Exhaust Systems, BP, Cambustion, AP Raicam and the Universities of Bath, Bradford, Loughborough and Nottingham. Its objective is to further improve the already class leading 1L Ford EcoBoost car engine.

Significant aerospace collaborations include Agile Wing Integration (AWI)[43] lead by Airbus with Marshalls, AGI and The Universities of Bristol, Cranfield and Loughborough. The £16m project will develop rapid, world-beating, wing design and integration capabilities for use during the early phases of an aircraft product development cycle with the aim of cutting aircraft carbon emissions. Aeroelastic Gust Modelling (AEROGUST)[44], is a €4.3m EU Horizon 2020 Research and Innovation programme. The project seeks to drive the competitiveness of European Aviation through cost efficiency and innovation, maintaining and extending industrial leadership. Led by The University of Bristol with The Universities of Liverpool and Cape Town, Airbus, Dassault Aviation, DLR, INRIA, NLR, NUMECA, Optimad, Piaggio Aerospace, VALEOL it will also transfer technology to the wind turbine industry.

Connectivity in the composites area is exemplified by projects such as High Performance Ductile Composite Technologies (HiPerDUCT)[45]. The £6.4m project involving University of

[39] Invest in Torbay - http://www.investintorbay.com/our-networks/hi-tech-forum/
[40] Growth Acceleration and Investment Network - https://gaininbusiness.com/
[41] Advanced Propulsion Centre UK - http://www.apcuk.co.uk/
[42] Advanced Propulsion Centre UK - http://www.apcuk.co.uk/wpcontent/uploads/2014/10/APC1-Ford-ACTIVE-Overview.pdf
[43] Research Councils UK - http://gtr.rcuk.ac.uk/projects?ref=113041
[44] European Commission Horizon 2020 - http://www.aerogust.eu/
[45] Research Councils UK - http://gtr.rcuk.ac.uk/project/94A87C82-2284-4E27-A6DA-5BA06996E2C6

Bristol, Imperial College London, BAE Systems, DSTL Porton Down, Halliburton Energy Services, Hexcel Composites, Mouchel, Rolls-Royce, Vestas, aims to design, manufacture and evaluate a range of composite systems with a ductile or pseudo-ductile response, while maintaining the strength and stiffness for which composites are so highly prized. The two-year, £4m ENABLES project supported by BEIS, ATI and Innovate UK assisted Rolls Royce in establishing a Composite Technology Hub in Bristol. The partnership between Rolls Royce, the NCC, University of Bristol and Advanced Manufacturing Research Centre in Rotherham, and the Manufacturing Technology Centre, Coventry, as well as the SME bf1systems, who brought experience from the automotive and motorsports sector, developed composites for fan housings with the new Hub central to the development of the next generation CTi (carbon/titanium) fan blades.

The highly innovative £1.9m Language of Collaborative Manufacturing (LoCM)[46] project in the areas of digital manufacturing and Industry 4.0 involves The University of Bristol, University of Bath. Airbus Operations, CIMPA S.A.S., Delcam International, Dyson Appliance, FBM Babcock Marine, Jaguar Land Rover, National Centre for Text Mining NaCTeM, Ove Arup and Partners, Shapespace, and Volvo.

Collaborative Publishing - *Collaboration between industry and academia is further evidenced through publications data (Appendix AAE4) with the percentage of highly cited articles by universities' in the Audit region that are co-authored with industry partners being over twice that of similar publications from the Russell Group and the UK as a whole*.

This is exemplified by University of Bristol being Airbus's top UK academic publishing partner. University of Bath, University of Exeter & Cardiff University are also in Airbus's top 10 UK academic publishing partners. University of Bath is a major publishing partner for Lotus Engineering being Lotus's second most frequent academic publishing partner and joint publications between University of Bath and Lotus have a strong citation impact, receiving over twice as many citations as would be expected for publications of their age and subject field. University of Bath and University of Bristol are significant academic publishing partners for Jaguar Land Rover and Rolls Royce UK. Bath and Bristol are both in Jaguar's top 10 most frequent academic publishing partners. Bristol is Rolls Royce's 7th most frequent UK academic publishing partner and Bath is in Rolls Royce's top 20 UK academic publishing partners, achieving a strong citation impact for co-published works[47].

The data also indicates the desire for companies outside the region to participate in the world class research being carried out by academics at universities in South West England and South East Wales.

6. Developments in science and technology – international markets and opportunities

National & International Comparators - To build on the region's strengths in AAE by retaining and attracting future research intensive and innovative companies which provide high skilled jobs, the activities, infrastructure and initiatives across the UK, Europe and around the globe should be considered for context and comparison (Appendix AAE7).

[46] Language of Collaborative Manufacturing - http://locm.org.uk
[47] SciVal Analysis at University of Bath Library July 2016 - www.scival.com

UK - Along with WEAF and Aerospace Wales, other regional aerospace alliances (RAAs) represent clusters in different parts of the UK. This includes Farnborough Aerospace Consortium (FAC)[48], Midlands Aerospace Alliance (MAA)[49] and North West Aerospace Alliance (NWAA)[50]. These RAAs work closely with the national aerospace sector body, ADS, and are recognised as the Federation.

Automotive research facilities include the National Automotive Innovation Centre (NAIC)[51], a £150m investment between Jaguar Land Rover, Tata Motors European Technical Centre, Warwick Manufacturing Group (WMG) and the University of Warwick. Ford's Dunton Technical Centre[52] in Essex houses one of the largest automotive technical centres in the UK, employing approximately 5000 staff.

Marine clusters within the UK including Belfast Harbour[53] a trustee port covering an estate of over 2,000 acres which has invested over £60m to create new facilities to support the deployment and assembly of offshore wind farms, Lowestoft/East of England and the Southampton / Portsmouth region, which is supported by the £115m Portsmouth Southampton City Deal[54].

In March 2015, the £14.5m UK Research Partnership Investment Fund (UKRPIF) funded Advanced Steel Research Centre (ASRC)[55], housed in the Advanced Manufacturing and Materials Centre, was announced. Developments in skills training include the Airbus Defence and Space £2.5m science, technology, engineering and maths (STEM) centre[56] at its Exomars Rover facility in Stevenage. The centre hopes to attract more than 5,000 students a year.

Europe - Toulouse Aerospace Valley (TAV)[57], created in 2005 has 859 members from industry and academia. It employs 124,000 staff and 8,500 researchers representing ⅓ of the French aerospace workforce. To 2015 its 450 R&D projects had a value of €1.1bn. By 2025 TAV aims to create 35-40,000 new jobs. The model has been replicated across Europe, if on a smaller scale at locations such as Andalucia Aeropolis[58], Italian Aerospace Research Centre (CIRCA)[59] and Poland's Aviation Valley[60].

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[48] Farnborough Aerospace Consortium - http://www.fac.org.uk/
[49] Midlands Aerospace Alliance - www.midlandsaerospace.org.uk
[50] North West Aerospace Alliance - www.aerospace.co.uk
[51] National Automotive Innovation Centre - http://www2.warwick.ac.uk/fac/sci/wmg/research/naic/
[52] Dunton Technical Centre - https://en.wikipedia.org/wiki/Dunton_Technical_Centre
[53] Belfast Harbour - https://www.belfast-harbour.co.uk/
[54] Southampton / Portsmouth City Deal - http://solentlep.org.uk/strategic_priorities/strategic_sectors
[55] Advanced Steel Research Centre - http://www2.warwick.ac.uk/fac/sci/wmg/research/steel_processing/asrc/
[56] Airbus Defence & Space Centre for STEM - https://airbusdefenceandspace.com/newsroom/news-and-features/airbus-defence-and-space-to-build-stem-centre-at-its-uk-exomars-rover-test-facility-in-stevenage/
[57] Toulouse Aerospace Valley - http://www.aerospace-valley.com/en
[58] Andalucia Aeropolis - http://aeropolis.es/en/
[59] Italian Aerospace Research Centre - http://www.cira.it/en?set_language=en

Advanced automotive research centres are located in Germany including The BMW Group Research and Innovation Centre[61]. Home to 9,200 staff working across the Group this unique setup reduces development time and is regarded as a pacesetter in the car industry. The International Centre for Turbomachinery Manufacturing (ICTM)[62], established in 2015, constitutes the Fraunhofer Institute and RWTH Aachen University. Working together with industry partners the Institute aims to speed up innovation and provide specialist training related to turbomachinery.

Brest commercial port is located on the northern coast of France in the Brittany region and is an important gateway to France and continental Europe. The port is managed by the chamber of commerce and industry of Brest and is owned by the Regional Council of Brittany. The Port of Brest is the leading French port for military fleet maintenance and for civil naval repair[63].

Global – Aerospace, automotive and marine clusters are spread globally in traditional manufacturing locations such as Detroit, Centre for Automotive Research (CAR)[64] and San Diego[65] but with the emergence of new activity particularly in Asia. Examples include Asia Aerospace City[66], Korea Aerospace Research Institute (KARI)[67] as well as, China Automotive Technology and Research Centre (CATARC)[68], Pan Asia Technical Automotive Centre (PATAC)[69].

Market trends - *AAE companies face a crossroads of immense importance over the coming years. The extended design, build, test, implement cycles in advanced engineering industries require technologies to meet future policy demands to be developed today. This necessitates careful analysis of the policy and technology landscape in order to ensure the direction of travel remains relevant and opportunities aren't missed.*

Policy & Socio-Economic Drivers

Legislation – One of the most important issues currently shaping the aerospace, automotive and advanced engineering industries globally is fuel economies and emissions standards required under Government legislation. The Climate Change Act (2008) set a long-term legally binding framework for greenhouse gas (GHG) reduction in the UK[70]. The Act requires Government to reduce GHG emissions by at least 34% by 2020 and 80% by

[60] Poland Aviation Valley - http://www.dolinalotnicza.pl/en/
[61] BMW Group Research and Innovation Centre www.bmwgroup.com/forschung_entwicklung/
[62] International Centre for Turbomachinery Manufacturing - http://www.ictm-aachen.com/
[63] RegenSW - Plymouth Marine Industries Demand Study
[64] Centre for Automotive Research - www.cargroup.org/
[65] San Diego Maritime Cluster - http://www.sandiegobusiness.org/industry/maritime
[66] Asia Aerospace City - http://www.asiaaerospacecity.com/
[67] Korea Aerospace Research Institute - http://www.kari.re.kr/eng.do
[68] China Automotive Technology and Research Centre - www.catarc.ac.cn/ac_en/
[69] Pan Asia Technical Automotive Centre - http://www.patac.com.cn/
[70] The Climate Change Act 2008 (c 27)

2050 from 1990 UK levels. In 2013, domestic and international transport accounted for 26% of all UK GHG emissions[71].

Skills - The Royal Academy of Engineering calculates that the UK needs an annual minimum of 100,000 graduates in STEM just to maintain the status quo in UK industry. It says more would be needed if the sector were to expand and help grow the economy. Currently only 90,000 STEM graduates are produced each year – around ¼ of whom go on to work in non-scientific careers[72]. Larger companies appear not to suffer from serious skill shortages. Their size and resources make it possible for them to either attract the very best staff and graduates, or to develop dedicated training schools to up skill their workforces. However, SMEs highlight the need for upskilling of the current "technical" workforce. Additional concern centres on an ageing workforce[73].

Devolution - Devolution of regional infrastructure budgets is current Government policy with deals so far agreed across the country including Cornwall in the audit region. Further devolution deals in are planned, including The West of England. The agreement negotiated would see the creation of a West of England Single Investment Fund distributing £30 million per annum over 30 years to boost growth and support infrastructure (roads and superfast broadband), skills (19+ adult education budget from 2018/19) & business (increased support for key growth sectors and the Bristol & Bath Science Park)[74].

Sector Analysis

Aerospace - The UK aerospace sector is expected to grow at a rate (CAGR) of 5% over the coming years[75]. To 2031 there is an estimated global requirement for over 27,000 new passenger aircraft worth circa $3.7Tn. Over the same time period, the global market demand for new commercial helicopters is expected to be in excess of 40,000 units, worth circa $165bn[76]. The MRO market is growing rapidly and represents a significant opportunity for the future[77].

Intriguingly, the commercial space market is forecast to be worth a trillion dollars globally by 2020 and the global market for Unmanned Air Vehicles (UAVs) was worth ~$5bn in 2010 and is projected to increase to more than $11.5bn per annum over the next decade[78]. Aerohub Enterprise Zone / Cornwall Airport Newquay has the potential to be the UK's first space port.[79]

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[71] Department for Energy & Climate Change - 2013 UK Greenhouse Gas Emissions, Final Figures
[72] Royal Academy of Engineering - Jobs and Growth: the Importance of Engineering Skills to the UK Economy
[73] WEAF Members' Skills Survey
[74] West of England Devolution Agreement
[75] ADS UK Aerospace Outlook 2015
[76] Lifting Off – Implementing the Strategic Vision for UK Aerospace
[77] Commercial Aircraft Maintenance, Repair & Overhaul (MRO) Market Forecast 2015-2025
[78] Aerospace & Advanced Engineering Sectors - South West Region's Inward Investment Strategy
[79] http://www.cioslep.com/assets/uploads/documents/1463644707_AH_spaceport_v3.pdf

Automotive - Britain is the fourth largest vehicle producer in Europe, making 1.6 million vehicles in 2014. Every 20 seconds a car, van, bus or truck rolls off a UK production line. Approximately 4 in 5 cars produced in the UK (78%) are exported to more than 100 countries. It is expected that the global light vehicle sales will hit 100m units by 2017 and 111m by 2020[80].

Furthermore, The Government has launched a consultation to explore factors around implementation of autonomous vehicles. Automated vehicle technologies will have a profound impact on the UK transport system and deliver major benefits: fewer crashes, greater freedom to travel, more efficient transport networks and new high value jobs in the technology and automotive sectors[81].

Marine - The global marine market is estimated at £3Tn, especially with high value opportunities across emerging economies. As well as offshore renewables manufacturing (Cross Ref – New Energy Systems), naval export of high tech systems and class leading capability in leisure craft can capture the rapid growth of middle classes in other countries, building on the UK's reputation for quality[82].

Steel - In 2014 the contribution of the UK steel industry to the economy totalled £2.2bn, 0.1% of the total output and 1% of manufacturing output, a decline of 24% since 1990. By way of contrast, world steel production increased 96% between 2000 and 2014, mostly driven by Chinese steel production. China produced 779m tonnes of steel in 2013, 48% of the world total. The UK produced 12m tonnes[83].

Technology Developments

High Value Engineering Design – "High Value Design" is the intellectually-intensive activity associated with the architectural definition of a complex product, its major components and its systems. Studies such as that by The Ford Motor Company[84] have shown that "product design" has the greatest influence on productivity improvement and downstream costs. Correcting the effects of "poor design" can be prohibitively expensive and have tangible impact on market share and/or business performance. Global excellence in "high value design" capability will ensure that the UK is able to deliver world-leading technologies and product solutions, delivering maximum competitiveness to customers. Leadership in design quality and productivity will ensure that the UK is an attractive supplier for product solutions and analysis/validation services.

Composite Materials - The global market for composite products in 2013 was worth $68.1bn and is expected to grow at around 6.5% CAGR over the next 7 years to about $105.8bn in 2020. The Composites Leadership Forum (CLF) estimates the size of the UK composites industry to be worth £1bn in terms of finished parts. Consultation with the UK composites supply chain has shown that the UK has the opportunity to grow its current £2.3bn composite product market to £12bn by 2030[85]. If fibre and materials manufacturing

[80] Statista - Worldwide light vehicle sales - outlook 2011-2020
[81] Centre for Connected & Autonomous Vehicles - Pathway to Driverless Cars
[82] UK Marine Industry Alliance: A strategy for growth for the UK Marine Industries
[83] UK steel industry: statistics and policy Briefing Paper Number 07317, 11 July 2016
[84] Sandy Monro (Ford Motor Company) – Lean Design Philosophy, 1988:
[85] Composites Leadership Forum, UK Composites Strategy 2016

is successful on-shored it would bring ~£2bn of additional exports from the UK, and save up to £5/£7bn of imports by 2030.

The strong growth in the short to medium term will be driven by the production of composite components for the new civil and military aircraft and adoption of composites in the automotive and marine sectors with a major driving being the need to reduce weight for fuel efficiency. Aerospace, Automotive, Construction, Oil & Gas and Renewables all have a potential market size of over £1bn each by 2030[86].

Figure AAE1 Opportunities in composite materials by market

Automation, Smart Factories & Industry 4.0 - A report by McKinsey estimated that the application of advanced robotics could generate a potential economic impact of $1.9Tn to $6.4Tn per year by 2025[87]. This would result in new products and transformation in the way in which products are built and services are delivered. Robotics and Autonomous Systems (RAS) was identified by the UK Government in 2012 as one of the Eight Great Technologies that support the UK Industrial Strategy[88].

Industry 4.0 is a current trend that represents the application of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Internet of things and cloud computing to create a "smart factory". Here cyber-physical systems monitor physical processes, create a virtual copy of the physical world and make

[86] Aerospace & Advanced Engineering Sectors - South West Region's Inward Investment Strategy
[87] McKinsey & Co: Disruptive technologies: Advances that will transform life, business, and the global economy
[88] RAS 2020 Robotics and Autonomous Systems: A national strategy to capture value in a cross-sector UK RAS innovation pipeline through co-ordinated development of assets, challenges, clusters and skills

decentralized decisions. Over the Internet of Things, cyber-physical systems communicate and cooperate with each other and humans in real time, allowing services to be offered and used by participants of the value chain[89].

Propulsion - Despite the promise of new, cleaner technologies, the automotive sector still believes downsizing the traditional internal combustion engine is likely to yield the best results in the short-to-medium-term. Furthermore, when it comes to alternatives, fuel cells have moved ahead of battery electric systems to become the number two priority for investments until 2020[90]. As shown in the Automotive Council's technology roadmap[91], whilst electrification of the powertrain remains a goal for national governments, a mixtures of technologies, including internal combustion, will remain for decades to come.

The increasing divergence in requirements combined with the large array of possible technologies creates new challenges for the vehicle industry with the future holding uncertainty around preferred powertrain platform technologies and more specialized powertrain platform(s) to meet competition. The challenge for the UK economy is therefore to be ahead of any market preferences, across sectors and technologies, in order to secure the long-term future of propulsion in this country.

Additive Layer Manufacturing (ALM) - ALM involves the production of three-dimensional parts directly from computer aided design data (3D-printing). Objects are constructed from deposition of material (resin of metal) in layers as little as 0.05mm thick. The benefits include: lower manufacturing costs; shorter time to market; greater flexibility and the potential to create innovative and complex components that previously could not be manufactured. ALM is likely to have wide-ranging uses across advanced engineering.

Exeter's Centre for Additive Layer Manufacturing has identified around 1,000 components used by Airbus that could be built using ALM, saving 3,000 tonnes across Airbus' forecast of 25,000 new aircraft and resulting in end users saving to the tune of $300bn over the next 20 years[92].

Testing, Certification and Metrology - Industrial metrology is integral part of advanced engineering manufacturing processes, with the use of laser tracker systems and coordinate measurement machines used for inspection, tooling, part mating and reverse engineering tasks, achieving single-micron accuracies. Innovative manufacturing processes and materials must also be amenable to this rigorous inspection with their suitability established at the earliest possible TRL. To achieve this the testing and characterisation of materials in silico as well as at component and sub-structure level is essential. Moreover, evolving existing and developing new testing regimes that mirror real world operation, for example in light of the vehicle emissions testing scandal, will be crucial to development of new technologies.

[89] McKinsey & Co: Manufacturing's next act
[90] Warwick Economics & Development Report – University of Bath IAAPS
[91] Technology Roadmap - http://www.automotivecouncil.co.uk/wp-content/uploads/2013/09/Automotive-Council-Roadmaps.pdf
[92] Centre for ALM - http://emps.exeter.ac.uk/engineering/research/calm/

7. Conclusions

Capital investments already in place or currently being developed are competing to provide companies and countries with market and economic advantage in all these areas. Globalisation is moving at such a pace that it is becoming irrelevant where the supply base sits and many 'Primes' (first tier manufacturers) are moving their manufacturing nearer to emerging customers - especially the Far East and China. Furthermore, UK manufacturers often require the majority of materials to be sourced from outside UK, increasing risk especially in times of economic turbulence. This can be compounded by, increased cost, poor availability and variable quality and consistency from manufacturers and suppliers. For UK supply chains to compete in this global market it is important to stem the trend to offshore. The region's advanced engineering sectors: aerospace, automotive, steel & marine, display synergies which can be underpinned by common, sector agnostic, technology developments. With appropriate investment the region's competitive advantage, over the clusters in the UK, Europe and globally, in AAE can be secured and developed.

Stakeholder Workshop – The workshop helped identify a number of actions that would help the region to realise these opportunities, or that without action have the potential to inhibit success:

- Programmes or structures to enable cross-sector participation in knowledge-exchange, mediated by Universities; particularly to enable SMEs to work collaboratively with each other, Universities and, crucially, OEMs /major suppliers
- Coordinated incubator facilities with lab/experimental/test space and in-house innovation support
- Establishment of a "Digital Factory" or "Catapult" for Advanced Engineering
- Long-term investment for teaching of STEM subjects in schools and beyond
- Increased and innovative "quick and easy" funding mechanisms: Increase in NATEP-type funding, an "Innovation Fund" i.e. offering tax incentives, management education, and start-up capital. Fund offering financial incentives to implement sustainable/circular manufacturing.

In addition, several specific capital investments have been identified which help support the workshop outputs and will enable the region to capture and maximise market share in growth areas. These projects (Appendix AAE7) are at various stages of development.

The £37m **Airbus Wing Integration Facility** has been funded by the joint industry and government aerospace R&D funding programme. Scheduled to open in 2017, and located at Airbus' existing Filton site but with an "open door" policy where external organisations can make use of the equipment and laboratory space, it will be delivered as a partnership between the Department for Business, Innovation & Skills (BIS), the Aerospace Technology Institute and Innovate UK. The advanced testing centre for large structural components will enable Airbus and its partners to develop new and cutting edge ideas in wing design & manufacture, an area in which the region is world leading academically and in industry.

In the Marine sector, the **Marine Industries Production Campus (MIPC)** at the ex-MoD site at Davenport will see Princess Yachts expand their superyacht manufacturing facility to include a £35m investment in new production hangers and office accommodation. The

rest of the site will see phased development between April 2015 and April 2017. Successful delivery of this strategy has the potential to deliver 1800 jobs and £85m of investment.

The Bristol & Bath Science Park already hosts the NCC, The Centre for Modelling and Simulation (CFMS)[93] and HiETA Technologies (leaders in additive manufacturing for aerospace and automotive propulsion). Its central location, proximity to many of the major advanced engineering companies in the region and the GW4 Universities, coupled with its excellent transport links, make it an ideal focal point for further investments to realise, together with the Airbus Wing Integration Facility, MIPC and existing assets, many of the opportunities identified in this submission. Moreover, the West of England devolution deal includes additional investment for the Bristol & Bath Science Park with the concept of an **Advanced Engineering Campus (AEC)** supported by South Gloucestershire Council and Bath & North East Somerset Council. Serving as the regional hub *The **AEC** constituents will deliver world leading **High Value Engineering Design** and **Systems Integration** capabilities, **Composite Materials** technologies, as well as the teaching, CDTs and life-long learning to position the UK as a global leader as we transition into the Industry 4.0 revolution.*

Projects that would deliver this regional advanced engineering competitive advantage include the ***High Value Design Institute**. Initially focussing on the Aerospace sector and built on the Catapult model, the Institute will develop and demonstrate high value engineering skills as well as securing **a** "corporate memory" for UK aerospace*. The extended period between new aircraft development programmes, combined with retirement of experienced Engineers, is leading to a growing "capability gap". The aerospace industry's continued success depends on retaining excellence in design and competitiveness in the face of growing international competition. Supported by partners including Airbus, Rolls-Royce, Leonardo Helicopters, GKN, Dowty Propellers, together with West of England Aerospace Forum, regional universities and the National Composites Centre, the HVDI will collaborate closely with the existing and planned assets at the Bristol & Bath Science Park and will provide a collaborative workspace creating a magnet for Advanced Design Capability. It will bridge the key gap between academia and industry offering a safe environment to demonstrate new technologies – whole aircraft modelling; digital manufacturing; materials applications; propulsion / systems integration; sub-structure concepts. As a mechanism to assist in delivering iAero, the Institute would develop High Value Design capability outside the OEMs and would enable the supply chain to better understand the whole value chain and move up it by developing integrated solutions.

The learning from Aerospace challenges would be applicable across advanced engineering sectors where "system of systems" focus and integration challenges are paramount as well as being the prototype for a UK High Value Design network. Crucially, overseas investment in HVD capability is increasing in response to recognition of the need for action, threatening the competitiveness of the UK. Without immediate action, there is a real danger that vital HVD capabilities will be lost making it difficult, if not impossible, for the UK to bid for future high value opportunities. The HVDI seeks to address some of the fundamental challenges articulated in the AGP Means of Ascent, Industrial Strategy for UK

[93] The Centre for Modelling and Simulation - http://cfms.org.uk/

Aerospace 2016 which states that 'HVD is essential to high value manufacturing'. Current indications are that a HVDI would be an effective means to co-ordinate a programme of capability development and demonstration. Such an environment would give the "next generation" (of Engineers and businesses) a chance to learn from experienced practitioners, but also allow them the opportunity to explore innovative ideas that can form the basis for future products and services relevant to evolving market demands. The UK must also proudly demonstrate its proven capability if it is to influence the investment and procurement decisions of international stakeholders.

The automotive propulsion **systems integration** expertise at the University of Bath's Powertrain & Vehicle Research Centre (PVRC), the internal combustion engine system efficiency spoke of the Advanced Propulsion Centre UK, is sought after by UK and global automotive companies, e.g. CLEVeR project. The Centre boasts 40 years of collaborative industrial research excellence but has outgrown its current location. Costing £50m, **The Institute for Advanced Automotive Propulsion Systems (IAAPS)** will be a 10,000m^2 world-leading facility at the Bristol & Bath Science Park that delivers transformational R&D for low carbon propulsion systems development and integration, enabling UK industry to define the next and future generations of powertrain technologies while helping Government meet its environmental policy commitments. R&D facilities will emulate and exceed those housed in other research facilities in Europe (e.g. ICTM Aachen) and globally, allowing technology options to be researched, developed and brought to market more quickly and at lower cost; benefiting the entire propulsion systems market.

IAAPS is being backed by a cross section of AAE companies who have committed £67m additional R&D to 2025, including the majority of automotive and aerospace SMEs surveyed. The Advanced Propulsion Centre, Local Enterprise Partnerships, Local Authorities, Government Officials, The Department for Business Innovation & Skills, Innovate UK and the GW4 grouping of Universities (Bristol, Cardiff, Exeter & Bath) are also supporters. *IAAPS will generate over £800m additional turnover (NPV) & £221m GVA, respectively and create 1,900 new jobs while protecting 21,000 UK engineering jobs.* Through training increased numbers of PhD, MSc students and Apprentices, IAAPS will help meet the pressing skills need for higher level engineers and will enhance knowledge transfer to improve UK productivity.

The global composite materials market is large and growing rapidly. *The region is in a nationally unique position to take advantage of this growth, with the National Composites Centre, which houses unique facilities for high volume composites manufacturing for the automotive industry, world-leading academic strength in the University of Bristol's ACCIS and a large concentration of companies involved in composite materials manufacture. However, there is no current UK capability to produce the constituent elements of Carbon Fibre based products. The NCC together with the Centre for Process Innovation (CPI), have therefore identified the strong potential for a* ***National Composites Materials Centre (NCMC)*** *to anchor a composite materials supply chain in the UK.* Operating on a Hub and Spoke arrangement and seeking to partner with excellence wherever it is located in the UK, NCMC aims to enhance the investment (via academia, HVM Catapult, industry) and drive the development of new fibres, resins, textiles, and the associated component high volume manufacturing process technologies.

As part of the proposed £115m investment near Avonmouth, Bristol, the NCMC would enhance the NCC's current offering and capabilities by expanding the NCC's influence on the complete value stream of composites systems design and manufacturing, including sustainability. Specific programmes of work would cover activities under its £2m Catapult REACH project engaging with SME's to launch projects such as National Product Verification Programme (NPVP), to improve data driven manufacturing in the regions SME population. This would ready them for High Value Design and Industry 4.0 with a regionally enhanced NATEP programme to assist the regions SME's investigation of new technologies; facilitated by the NCC acting as the gateway to the rest of the HVM Catapult network.

In the wider context of the Government's National Aerospace Strategy "Means of Ascent" to 2026, **Innovation Aero (iAero)** is intended to act as the "SW regional delivery mechanism" of the Aerospace Growth Partnership (AGP) strategy. Supported by OEMs and local LEPs, iAero addresses the future capabilities required to sustain and grow the region's AAE sector through collaborative investments, interventions and developments. Infrastructure enhancements necessary to realise the iAero ambition include the innovation centres in Yeovil and Filton, Bristol. Scheduled for May 2018, the 2,500m^2 "iAero Centre at Yeovil" facility in the Heart of the South West LEP will cost approximately £9.6m with investment sought from the ERDF, LEP Growth Deal 3 and business in the region. The iAero Innovation hub at Filton costing £16m and generating £8m GVA, will provide a 4,000m^2 facility within the Filton Enterprise Area.

A key challenge identified in the National Aerospace Strategy and the AGP and ATI Technology Strategy, is the validation of the performance before final assembly and full integration, i.e. at pre-production TRL4-6. Wing integration is at the core of the region's aerospace manufacturing and design capability, drawing together structures, propulsion and systems integration elements of aircraft design and delivered through an industrial base represented by Airbus, GKN, Rolls-Royce, Cobham, GE and Leonardo Helicopters. The formation of a South West **Aerospace Substructure Wing Integration Centre (ASWIC)** aligns directly with this strength national strategy. Flight test and validation are a certification requirement for aircraft development, however, the process is not only expensive, but also structural changes revealed by flight test late in development are difficult to implement. ASWIC will provide the technical capability to integrate, test and analyse (hardware-in-the-loop) for individual components or assembled sub-structures at a pre-production phase adopting techniques from the partner Universities and components from early stage design to test and validate static and dynamic flight performance before full wing integration, thus mitigating these risks.

Locating ASWIC on at the Bristol & Bath Science, adjacent to the NCC and CFMS develops the synergies at the Advanced Engineering Campus and links it directly with the HVM Catapult and the South West's aerospace industry which is key to knowledge exchange from academia. Furthermore, Initiatives such as the Testbed for Robust Integration of MAterials and STructures (TRI-MAST) and Aerospace Substructure Wing Integration Centre (ASWIC) underpin the work at the Airbus Wing Integration Facility and will, in collaboration with regulatory bodies, expedite the adoption of these new materials (e.g. composites) and manufacturing processes (e.g. ALM) across advanced engineering sectors.

To help address the identified challenges around skills & training, the South West Institute for Technology & Skills **SWIFTS** is a collaborative model for skills development and technological education that seeks to align with regional employment requirements, integrate existing activities and providers, such as the National Colleges for Advanced Manufacturing and build upon the opportunities offered by new developments (devolution of adult education budgets) and projects within the region. The model for SWIFTS is based on the Learning Factory model where a blended industrial and educational environment modernising the learning process by bringing it closer to the industrial practice and allowing training in realistic manufacturing environments. Partners include the regions Universities and Further Education Colleges, employers, regional business networks as well as the LEPs. SWIFTS will embed facilities/capacity within in the existing regional educational network. This will maximize the benefit from any capital/revenue investment by complementing existing investment and avoid duplication.

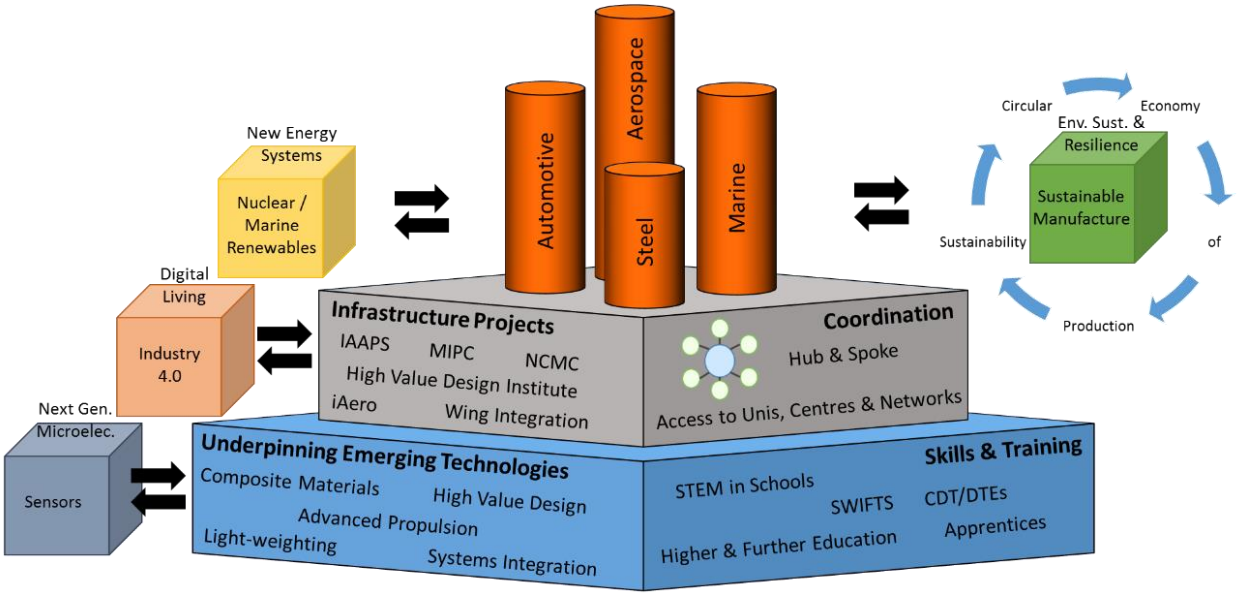


Figure AAE2 Development in the Aerospace & Advanced Engineering sectors (orange cylinders) is underpinned by emerging technologies and areas such as High Value Design, Systems Integration, Composite Materials, Advanced Propulsion and Light-weighting. These must be aligned with appropriate skills and training from school/college to University and beyond e.g SWIFTS (South West Institute for Technology & Skills). The sectors are further strengthened by research centres and infrastructure projects described in the text. Although, these require better coordination and ease of access. The AAE theme interacts with the other Science & Innovation Audit themes either through sector (Nuclear), an underpinning technology (Sensors) or more general process and engineering themes (Circular Economy, Industry 4.0).

The UK incumbent position is at risk from growing international competition and substantial changes in product and manufacturing technologies. However, AAE industry and academia in the South West of England and South East Wales already have a strong base in these markets and are well positioned to take advantage of future growth. The projects identified above and others yet to be conceived are critical to capitalise on the market opportunities outlined in Sections 6 & 7 and deliver the regional and UK growth agenda. Their coordination under an Advanced Engineering umbrella, encompassing the unifying

areas of High Value Engineering Design, Composites technologies and Systems Integration capabilities, will link the present and future assets at the Bristol and Bath Science Park (NCC, CFMS, IAAPS, NCAM) with the nearby Airbus Wing Integration Facility and iAero project at Filton, NCMC at Avonmouth and also The MIPC in Plymouth, iAero in Yeovil and Aerohub in Newquay.

Appendices

Appendix AAE1 List of Assets

Asset	Value	Host/Lead	Descriptor
Flybe Training Academy	24M	Exeter Airport	In September 2009 Flybe announced its successful bid for Training Academy project at Exeter Airport. £4.3m from Learning and Skills Council's (LSC) new Capital Specialisation Fund (CSF) £2.8m South West Regional Development Agency. The Flybe Training Academy offers a wide range of Pilot, Technical, Cabin Crew and Customer Service courses to airlines across the world, as well as a range of non-aviation training to other individuals and organisations in the South West
National Composites Centre (NCC)	55M	University of Bristol	Part of the High Value Manufacturing Catapult, the NCC is based at the Bristol & Bath Science Park. Opened in 2011, the NCC is a key part of the Government's composites strategy and brings together dynamic companies and enterprising academics to develop new technologies for the design and rapid manufacture of high-quality composite products. The founding members of the NCC were GKN Aerospace, Airbus, Leonardo Helicopters, Rolls-Royce, General Electric ans QinetiQ. Current membership extends to 25 companies spanning the complete Advanced Engineering spectrum as well as a further 18 associate member firms
Aerohub	6.2M	Cornwall Airport Newquay	Aerohub is a designated enterprise zone that offers planning-free development and 100% business rate relief. The site has uncongested and unrestricted airspace, one of the UK's longest runways, direct maritime access and superfast broadband. Funded by £2.3m from the Homes and Communities Agency (HCA) and a grant from the ERDF Convergence programme (£3.9m), with Cornwall Council providing the land. Aerohub is home to AAE companies such as CIS UK Ltd and Apple Aviation as well as Bloodhound Supersonic Car which attempts the UK's latest land speed record. Aerohub / Cornwall Airport Newquay is well placed to

			be the UK's first spaceport.[94]
Morgan-Botti Lightning Laboratory	1.6M	Cardiff University	The lightning research facility was established in 2011 as a collaboration between the Welsh Government, Cardiff University and Airbus Group Innovations (formerly EADS). It undertakes research including measuring the direct-effects of lightning strikes on structures and samples and investigating lightning protection mechanisms for the aerospace industry
Centre for Additive Layer Manufacturing	2.6M	University of Exeter	Airbus Group Innovations partnered with Exeter University to develop the Centre for Additive Layer Manufacturing. Funded by European Regional Development Fund (ERDF) it has supported more than 200 companies and has created regional growth of £20m
Centre for Systems, Dynamics and Control		University of Exeter	Research in robust and fault tolerant control laws, validation and verification is undertaken
Cardiff Catalysis Institute	6.1M	Cardiff University	The Cardiff Catalysis Institute (CCI) was created in 2008 with an initial investment from Cardiff University of £2.8m. Its focus lies in the fields of photocatalysis and renewable fuel synthesis, including considerable expertise in the catalytic synthesis and decomposition of hydrogen peroxide, which has applications as a fuel for remote energy generation and in propulsion technologies and exhaust after-treatment. It was upgraded to Institute status in 2012 and granted a further investment from the University of £3.3m.
Centre for Power Transmission and Motion Control (PTMC)		University of Bath	The University of Bath's Centre for Power Transmission and Motion Control (PTMC) was founded as the Fluid Power Centre in 1968. The Centre's scope has grown beyond the original fluid power field, to include electromagnetic and piezoelectric systems and other technologies motivated particularly by challenges in automotive and aerospace engineering
Innovative Design and	10M	University of	The Innovative Design and Manufacturing Research Centre (IdMRC) was established in

[94] http://www.cioslep.com/assets/uploads/documents/1463644707_AH_spaceport_v3.pdf

Manufacturing Research Centre (idMRC)		Bath	2001 and received two major funding awards from EPSRC totalling more than £10m. The IdMRC undertakes world-leading research into the design and manufacture of machines, systems and processes. The Centre is unique in combining a design focus with a strong emphasis on manufacture in a closely integrated group.
Turbomachinery Research Centre		University of Bath	The Gas Turbine Research Unit has secured grants and funding from both the Engineering and Physical Sciences Research Council (EPSRC) and from multinational engineering conglomerate Siemens as well as local firm Cross Manufacturing
Materials & Structures Centre		University of Bath	The Materials and Structures (MAST) Centre is as a multidisciplinary centre that simultaneously develops and designs innovative materials with unique properties, whilst targeting the technological and manufacturing applications in which they will be employed, thereby revolutionising performance and production process.
Gas Turbine Research Centre (GTRC)	10M	Cardiff University	In 2004, Cardiff University took ownership from QinetiQ of their large-scale gas turbine combustion research facility. The GTRC was established with the support of a £3.85m grant from the European Union's Objective 1 Programme and £350k from the Welsh Assembly Government's Knowledge Exploitation Fund. With this funding the equipment was moved from Farnborough and re-instated in Port Talbot at the Welsh Assembly Government's Energy Research Building. The GTRC consists of two major combustion rigs each designed for detailed investigation of combustion and emissions in gas turbines. The rigs are designed for the study of different facets of the combustion process.
Advanced Composites Centre for Innovation and Science (ACCIS)	3.1M	University of Bristol	ACCIS brings together composites activities across the University of Bristol, based in the Faculty of Engineering and linking to the Science and Medical Faculties. Their vision is to be a world leading centre for composites research and education, combining cutting edge fundamental science with strong industrial links for exploitation and technology

			transfer. ACCIS is a focus for collaboration internally, nationally and internationally, with over 100 active researchers and doctoral students under the themes of Multifunctional composites and novel microstructures, design analysis & failure, intelligent structures, and composites processing & characterisation. ACCIS labs have state-of-the-art testing capabilities from single fibres to bridges
Rolls Royce Technology Research Centre (RR-UTC)		University of Bristol	The Composites University Technology Centre (UTC) at the University of Bristol is a research centre supported by Rolls-Royce plc to provide a validated analysis capability for the response of composites that can be used to design and manufacture composite components. It aims to act as a focus for composites research activities, liaising with other universities to provide a coordinated programme to meet the needs of Rolls-Royce. The Composites UTC was established in 2007 and in 2012 entered into a partnership with the Lightweight Structures UTC at TU Dresden to form the Rolls-Royce Composites University Technology Partnership (UTP).
Powertrain & Vehicle Research Centre (PVRC)	5M	University of Bath	The PVRC at the University of Bath encompasses 40 years of research excellence focused on improving the efficiency and emissions of both diesel and petrol engines. The PVRC currently has 17 active research projects, all of which are collaborative in nature, with a total value in excess of £40M. The growing research portfolio supports 60 researchers and over 200 students from undergraduate to PhD level. It partners with local companies, Ashwoods, HiETA Technologies, and Ford UK as well as nationally and internationally with firms such as Jaguar Land Rover, Lotus Engineering, BMW, Tata and McLaren Automotive.
Centre for Low Emission Vehicle Research (CLEVeR)	2M	University of Bath	The newly installed Dynamometer, commonly known as a rolling road aims to bridge the gap between the lab and the real world by allowing vehicles to be analysed in a series of real-world driving conditions, but within a precisely controlled laboratory

			environment.
Centre for Automotive Powertrain and Systems Engineering (CAPSE)	2M	University of South Wales	CAPSE is Wales' only independent research, development, test and certification house which undertakes cutting edge research and knowledge transfer activities within the advanced automotive and power systems engineering sectors, particularly relating to hybrid and electric vehicles. CAPSE has helped develop, supply and test all the batteries for the McLaren P1 sports car, homologated the Smart Electric Car, life tested and improved the 1000hp motor that won Le Mans and works with JLR, Tata, Johnson Matthey and Williams.
South Yard Plymouth		HM Naval Base, Devonport	The Royal Navy Dockyard consists of fourteen dry docks (docks numbered 1 to 15, but there is no 13 Dock),[2] four miles (6 km) of waterfront, twenty-five tidal berths, five basins and an area of 650 acres (2.6 km²)
Boscombe Down			QinetiQ, whose airfield at Boscombe Down in south Wiltshire benefits from the 2nd longest landing strip in the UK, is essential to sovereign capability having a long term partnering agreement under which it provides the UK MOD with innovative and realistic test and evaluation of military and civilian platforms, systems, weapons and components.
ACMC Advanced Composites Manufacturing Centre		University of Plymouth	Founded in 1987, ACMC is a leading composites R&D facility at the University of Plymouth. Based in the School of Marine Science and Engineering (SMSE), ACMC is active in a wide range of projects, and aims to bridge the traditional gap between academic R&D and the needs of industry
Electron Microscopy Centre	Recent upgrade 1.3M	University of Plymouth	EMC houses light microscopes, electron microscopes, imaging processing and analysis software providing support to a range of disciplines within Plymouth University, external research organisations and industry clients. Recent upgrades to capability funded by ERDF, JEOL (UK) Ltd and Plymouth University.
Wales Space Academic Partnership (WASP)		Welsh Government, Cardiff University and pan-	WASP is pan-Wales, and SE Wales has strengths represented by both major blue chip companies such as Airbus and specialised SMEs such as QMC Instruments Ltd. which designs, develops and

	Wales	manufactures instrumentation. Cardiff University's School of Physics and Astronomy develops astronomical instrumentation, especially at millimetre and sub-millimetre wavelengths, supporting ground and space-based observatories and studies of the Cosmic Microwave Background. The School played a major role in the first recorded observation of gravitational waves early in 2016 and also led the team which built the camera for Europe's Herschel Space Observatory.
Astrophysics Research and Electronics & Electrical Engineering	University of Bath	Focus on real-time, autonomous and robotic systems; the exploitation of ESA and NASA space-based data; and the exploitation of Global Navigation Satellite Systems (GNSS) and Earth Observation satellite data for specification of the space-weather conditions (ionosphere), for atmospheric measurements (dynamics) and for satellite-to-ground and ground-to-satellite communications.
Centre for Device Thermography and Reliability; and other related research centres	University of Bristol	Development of new technologies (*e.g.* robotics, deployable structures, low-power electronics), but also fields that rely on satellite-derived data (*e.g.* navigation, earth observation and geosciences), as well as fundamental physics (*e.g.* astrophysics, planetary science). CDTR aims to understand and improve the reliability and thermal performance of semiconductor devices such as GaN and other power electronic devices used in satellites, switches and radars, and to develop new materials such as borides for neutron detectors.
Satellite Applications Catapult Centre of Excellence	Goonhilly, Met Office Universities of Exeter, Falmouth, Plymouth and other partners	Detailed in the Resilience, Environment and Sustainability Theme, but with clear linkages to AAE (e.g. space) and Digital Living (e.g. satellite communications) themes

Appendix AAE2 Collaborative Projects

Project	Value (£)	Lead (Partners)	Descriptor
Advanced Combustion Turbocharge Inline Variable Valve-train Engine (ACTIVE)	26M	University of Bath (Uni of Bradford, Loughborough, Nottingham, Ford, Continental, Schaeffler, Unipart Eberspacher Exhaust Systems (UEES), BP, Cambustion, AP Raicam)	The ACTIVE project is supported by the Advanced Propulsion Centre (APC). Its objective is to further improve the already class - leading 1L EcoBoost car engine
Future Fast Aeroelastic Simulation Technologies (FFAST)	€3.7M	University of Bristol (Institut National de Recherche en Informatique et en Automatique, Council for Scientific and Industrial Research, Delft University of Technology, Deutsches Zentrum für Luft- und Raumfahrt, International Research Institute for Advanced Systems, The University of Liverpool, Politecnico di Milano, Numeca International, Optimad engineering, Airbus UK, EADS Deutschland. Military Air Systems DE, Institute for Information Transmission Problems)	The project aims to improve the speed and accuracy of unsteady load calculations which play an important role in the design and development of aircraft components
Agile Wing Integration (AWI)	16M	Airbus (Marshalls, AGI and The Universities of Bristol, Cranfield and Loughborough)	The project will develop rapid, world-beating, wing design and integration capabilities for use during the early phases of an aircraft product development cycle with the aim of cutting aircraft carbon emissions
Aeroelastic Gust Modelling (AEROGUST)	€4.3M	University of Bristol (Unis of Liverpool, Cape Town, Airbus Defence & Space, Dassault Aviation, DLR, INRIA, NLR, NUMECA, Optimad Engineering, Piaggio Aerospace, VALEOL	Funded by the European Union's Horizon 2020 Research and Innovation programme. The project seeks to drive the competitiveness of European Aviation through cost efficiency and innovation and has taken inspiration from FlightPath 2050 whose goals include

			maintaining and extending industrial leadership. Further transfer of technology to the wind turbine industry will increase the renewable energy sector.
Aircraft Loads Prediction using Enhanced Simulation (ALPES)	€1.3M	University of Bristol (LMS International, Airbus)	EC FP7 Marie Curie European Industrial Doctorate Training Network. The aim of the network is to improve the prediction accuracy and efficiency of the loads experienced by an aircraft in-flight and on the ground. The ALPES network involves five PhDs combining a novel research programme with industry focused training, including placements at Airbus in the UK and/or France
Centre for Innovative Manufacturing in Composites (CIMComp) and the Future Manufacturing Hub	5.2M	University of Nottingham (Unis of Bristol, Cranfield and Manchester)	Established in 2011, the EPSRC funded CIMComp underpins the development of next-generation composites manufacturing processes based on low cost, short cycle times, efficiency and sustainability. Current activities involve 32 industrial partners and four Technology Centres, with a portfolio of 25 interrelated projects and an Industrial Doctoral Centre, with a total portfolio value of over £16 million; forming a key link in the UK Composites infrastructure strategy
Modelling of Adaptive Wing Structures (MAWS)	€0.2M	University of Liverpool, (University of Bristol, Aircraft Research Association, and Stirling Dynamics)	Adaptive wing tip concepts have the potential to improve fuel efficiency towards achieving the

			Vision 2020 ACARE Agenda, represented by: 80% cut in NOx emissions, halving perceived aircraft noise, 50% cut in CO2 emissions per passenger km. The project, closely aligned with the Control and Alleviation of Loads in Advanced Regional Turbo Fan Configurations (CLAReT)
Experimental TRansonic Investigations On Laminar flow and Load Alleviation (ETRIOLLA)	€4.2M	IBK-Innovation, (University of Bristol, Revoind Industriale and Totalforsvarets Forskningsinstitut)	Wind-Tunnel-Model capable of assessing the extent of laminarity on the wing and evaluating the performance of load control and alleviation (LC&A) systems in the trailing edge of the wing, thus reducing development costs and associated energy usage for operation of wind tunnels
Experimental Subsonic Investigation of a Complete Aircraft Propulsion system Installation and Architecture power plant optimization (ESICAPIA)	€2.6M	IBK-Innovation, (University of Bristol, Revoind Industriale and RUAG Schweiz)	ESICAPIA focused on the experimental optimization of a regional aircraft configuration and a subsequent optimization of take-off/ landing configuration.
Gust Load Alleviation techniques assessment on wind tUnnel MOdel of advanced Regional aircraft (GLAMOUR)	€2.6M	Politecnico di Milano (TECHNION - Israel Institute of Technology, IBK-Innovation, University of Bristol and Revoind Industriale)	The aim of the project is a technological optimisation and experimental validation through an aero-servo-elastic innovative wind tunnel model of gust load alleviation control systems for advanced Green Regional Aircraft through increases in

			weight saving.
High Performance Ductile Composite Technologies (HiPerDUCT)	6.4M	University of Bristol (Imperial College London, BAE Systems, DSTL Porton Down, Halliburton Energy Services, Hexcel Composites, Mouchel, Rolls-Royce, Vestas)	The aims of HiPerDuCT are to design, manufacture and evaluate a range of composite systems with a ductile or pseudo-ductile response, while maintaining the strength and stiffness for which composites are so highly prized
Language of Collaborative Manufacturing (LoCM)	1.9M	University of Bristol, University of Bath (Airbus Operations, CIMPA S.A.S., Delcam International, Dyson Appliance, FBM Babcock Marine, Jaguar Land Rover, National Centre for Text Mining NaCTeM, Ove Arup and Partners, Shapespace, Volvo	The vision of this research will be realised through a suite of ICT tools that embody new methods and approaches for capturing and analysing the content and evolution of engineering communication and digital objects, and new methods and approaches for generating, representing, interacting with, and interpreting what are defined as signatures of in communications and digital objects. The term signature is used to represent a meaningful relationship between one or more dimensions of communication and/or digital objects at a point in time or over a period of time.

Appendix AAE3 Research Excellence Framework (REF) 2014 data

The Aerospace & Advanced Engineering theme covers a broad range of academic disciplines from Supply Chain Management to Heavy Engineering. The research of academics associated with the theme was submitted to 10 REF units of Assessment (UoAs), as outlined in the table below:

UoA		Submitted staff associated with theme	No of Institutions	Doctoral awards 2008-16	UoA overall profile (% 3 or 4*)
8.	Chemistry	7	2	8	97%
9.	Physics	7	1	47	90%
10.	Mathematical Sciences	3	3	1	87%
11.	Computer Science and Informatics	8	2	61	72%
12.	Aeronautical, Mechanical, Chemical and Manufacturing Engineering	33.2	1	145	89%
13.	Electrical and Electronic Engineering, Metallurgy and Materials	3	1	11	91%
14.	Civil and Construction Engineering	5	1	-	97%
15.	General Engineering	107.2	4	509	89%
19.	Business and Management Studies	8	2	7	79%
25.	Education	1	1	8	85%

Appendix AAE4 Publication data

An analysis of data pertaining to academic publications related to the AAE theme was undertaken, based on the 250 academic staff identified by consortium institutions that are active in the field. The following three SciVal subject categories were used to profile and benchmark the South West Region's research publishing for the theme: Aerospace Engineering, Automotive Engineering, Ceramics & Composites. Publications (articles, reviews and conference proceedings) for the five year period 2011-15 are reported.

Publication metrics for the SIA Universities' combined publishing:

	Aerospace Engineering	**Automotive Engineering**	**Ceramics & Composites**
Scholarly Output (publications)	431	104	629
Authors	412	149	818
Field-Weighted Citation Impact	1.29	1.87	1.83
Citations	1,526	594	6,397
Citations per publication	3.5	5.7	10.2
Outputs in Top Percentiles % (publications in top 10% most cited worldwide for their year of publication and subject area)	17	21	24
Publications in Top Journal Percentiles (Publications in top 10% journals by SNIP)	40	37	48
Academic-Corporate Collaboration % (Publications with both academic and corporate affiliations)	8	19	6
Citations per publication for Academic-Corporate co-authored publications	3.4	6.8	9.6

Aerospace Engineering

	SIA Universities	World	UK	Russell Group
Scholarly Output	431	100689	4447	2342
Field-Weighted Citation Impact	1.29	0.9	1.57	1.83
Outputs in top 10% of subject area (%)	17	10	16	18
Publications in Top Journal Percentiles (%)	40	27	45	51
Academic-Corporate Collaboration (%)	8	2	6	6
Citations per publication for Academic-Corporate co-authored publications	3.4	3.2	3.9	4.2

Automotive Engineering

	SIA Universities	World	UK	Russell Group
Scholarly Output	104	46,051	2,253	1,041
Field-Weighted Citation Impact	1.87	1.16	1.57	1.85
Outputs in top 10% of subject area (%)	21	14	19	23
Publications in Top Journal Percentiles (%)	37	25	44	53
Academic-Corporate Collaboration (%)	19	4	8	10
Citations per publication for Academic-Corporate co-authored publications	6.8	3.8	3.6	4

Ceramics & Composites

	SIA Universities	World	UK	Russell Group
Scholarly Output	629	95,737	5,129	3,762
Field-Weighted Citation Impact	1.83	1.38	1.68	1.79
Outputs in top 10% of subject area (%)	24	16	20	22
Publications in Top Journal Percentiles (%)	48	30	36	38
Academic-Corporate Collaboration (%)	6	2	5	5
Citations per publication for Academic-Corporate co-authored publications	9.6	8	9.9	10.2

Aerospace Engineering

Aerospace Engineering publications from …	Highly cited (top 10% most cited for year & subject area)	High impact journal (top 25% of journals by SNIP)	% Academic – industry co-authored papers	Average citations for academic-industry papers
University of Bath	21.4	84.3		
University of Bristol	23.1	80.8		
SIA South West Universities	20.9	78.5	8.5	5
United Kingdom	20.4	75.8	6.1	4.8
Europe	17.4	73.3	3.9	5.7
World	10.2	53.4	2.3	4.5

Automotive Engineering

Automotive Engineering publications from …	Highly cited (top 10% most cited for year & subject area)	High impact journal (top 25% of journals by SNIP)	% Academic – industry co-authored papers	Average citations for academic-industry papers
University of Bristol	62.5	81.3		
SIA South West Universities	29.1	78.2	18.2	11.1
United Kingdom	20.7	76.4	7.1	4.8
Europe	16.1	61.9	5.5	7.1
World	12.3	52.2	3.9	6.1

Ceramics & Composites

Ceramics & composites publications from …	Highly cited (top 10% most cited for year & subject area)	High impact journal (top 10% of journals by SNIP)	% Academic – industry co-authored papers	Average citations for academic-industry papers
Cardiff University	32.9	47.1		
University of Exeter	23.9	82.5		
SIA South West Universities	24.6	49.9	5.7	8.8
Russell Group	21.7	39.1	5.4	9.2
United Kingdom	20.3	37.9	5.2	9
Europe	15.9	37	2.9	7.5
World	16	33.5	2	7.5

Wing Aerodynamics

Publications group	# Publications	Highly cited (top 10% most cited for year & subject area)	High impact journal (top 25% of journals by SNIP)
University of Bath's publications in wing aerodynamics (SciVal competency)	30	30	90
All publications in wing aerodynamics (SciVal competency)	637	13.8	56.5

Laminates and composite materials

Publications group	# Publications	Highly cited (top 10% most cited for year & subject area)	High impact journal (top 25% of journals by SNIP)
University of Bristol's publications in laminates & composite materials (SciVal competency)	143	24.5	73.4
All publications in laminates & composite materials (SciVal competency)	1,351	12.6	53.2

Supply chains (publications group defined by keywords**)**
SIA South West universities' publishing on supply chain, 2011-15.

University	# Publications	Field-weighted citation impact
University of Bath	33	2.04
University of Bristol	23	1.48
Cardiff University	99	1.95
University of Exeter	26	5.07
University of Plymouth	22	1.96
University of the West of England	24	0.86

Top 10 universities worldwide most active in publishing on supply chain management

University	Country	# Publications	Field-weighted citation impact
Islamic Azad University	Iran	126	1.61
Hong Kong Polytechnic University	Hong Kong	115	5.04
Michigan State University	United States	63	2.95
Syddansk Universitet	Denmark	56	9.01
University of Arkansas	United States	50	2.12
Arizona State University	United States	48	2.59
Universiti Teknologi Malaysia	Malaysia	47	2.74
Cardiff University	UK	46	2.57
University of Tehran	Iran	43	2.28
The Ohio State University	United States	43	2.74

Number of publications each university has in the broad subject area 'Engineering' for the 5 year period 2011-15 and the number of engineering publications co-authored between each pair of universities over this 5 year period. For example: University of Bath has 1,642 engineering publications, 47 of which were co-authored with University of Bristol.

	Bath	Bristol	Cardiff	Exeter	Plymouth	UWE
Bath	1642	47	4	18	9	12
Bristol		3050	32	40	11	35
Cardiff			1708	7	10	4
Exeter				1068	13	1
Plymouth					687	3
UWE						577

Number of researchers each university has who have published in the broad subject area 'Engineering' in the 5 year period 2011-15 and the number of these authors involved in co-published engineering publications between each pair of universities. For example: 1,081 University of Bath affiliated authors have published engineering papers; 52 of these have been authors on papers co-authored with the University of Bristol, while 53 University of Bristol affiliated authors have been involved with papers co-authored with the University of Bath.

	Bath	Bristol	Cardiff	Exeter	Plymouth	UWE
Bath	1081	52	6	20	10	16
Bristol	53	2030	65	68	16	37
Cardiff	6	49	1229	10	7	4
Exeter	18	40	7	643	15	1
Plymouth	8	10	11	27	464	1
UWE	9	37	6	1	3	350

Corporate collaboration. Number of academic publications co-authored between South West region universities and major industry partners, 2011-15.

	Bath	Bristol	Cardiff	Exeter	Plymouth	UWE
ABB	1	1		1		
Airbus	7	32	7	5		4
BAE Systems	1	10		5		
Boeing	2					
BP	3	1	1	1		
Finmeccanica		1				
Ford	1	1				
GKN Aerospace	1					
Jaguar	16	10	2			
Lockheed Martin				1		
Lotus	4	1				
QinetiQ	3	12	6	4	2	2
Rolls Royce	8	38	5	1	1	1
Thales	1	12	1			

Appendix AAE5 Theme income data

Research Income for AAE based on funder type for period 2008 – 2015

HESA funder type	Total research income as related to theme £(k)							
	Code	**2008/09**	**2009/10**	**2010/11**	**2011/12**	**2012/13**	**2013/14**	**2014/15**
Research Councils	1	9089	8012	8626	8281	9075	10226	11521
UK based charities (Open competitiveness)	2	61	102	157	143	194	255	133
UK based charities (Other)	3	53	99	130	152	138	188	287
UK central government & local authorities	4	3318	3575	3790	2983	9419	10535	14947
UK industry, commerce, public corporations	5	3458	3405	3895	5619	4447	4331	4633
EU Government Bodies	6	2282	2528	3374	4692	4803	5207	5150
EU-based charities (open competitive process)	7	0	2	0	0	3	0	0
EU industry, commerce and public corporations	8	191	610	535	653	358	525	351
EU other	9	0	11	11	19	26	17	75
Non-EU-based charities (open competitive process)	10	0	0	0	0	0	56	34
Non-EU industry, commerce and public corporations	11	862	414	175	661	444	215	93
Non-EU Other (Other overseas)	12	31	77	174	187	244	363	392
Other sources	13	34	78	26	4267	7202	4437	5291

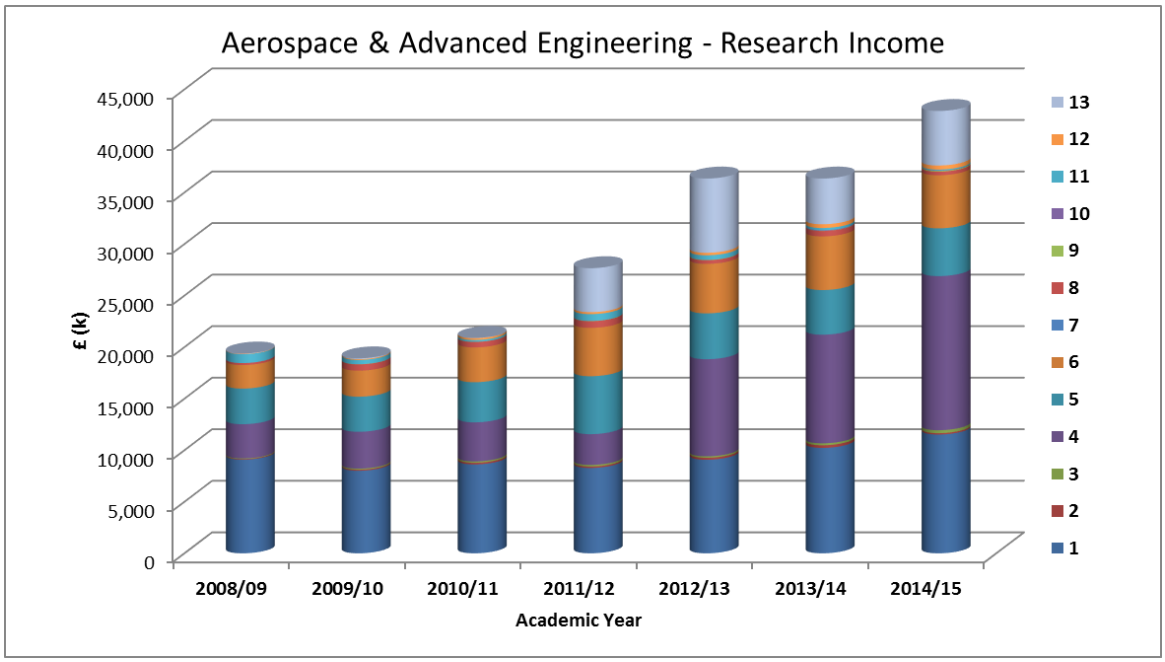


Figure AAE3 New Energy Research Income

Appendix AAE6 Major Clusters, Present and Planned Infrastructure

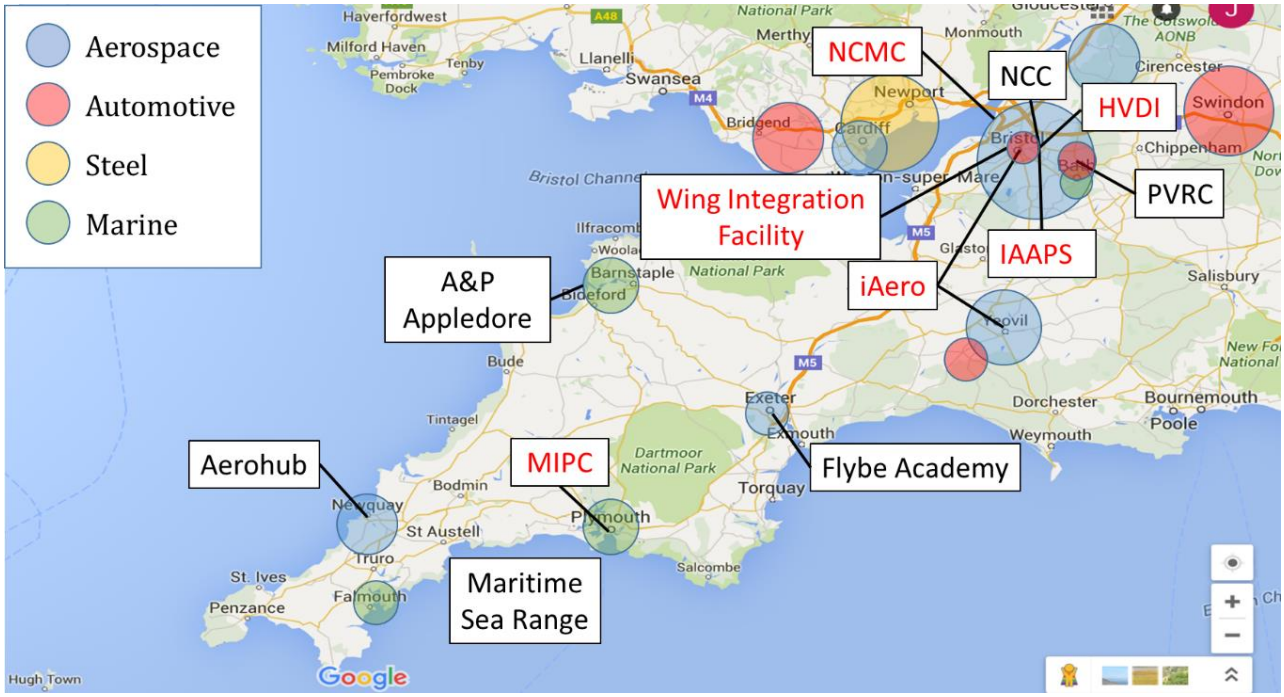


Figure AAE4 Major Clusters, Present and Planned Infrastructure

Aerospace – companies are located throughout the Audit area from Cornwall to Gloucestershire, with the region being home to 14 of the 15 largest aerospace companies in the world with a major cluster around Filton (near Bristol). The 2014 Top aerospace companies report from pwc[95] give the global top 15 as:

Company	Where?	Company	Where?	Company	Where?
1. Boeing	WoE	6. Raytheon	Glos.	11. Honeywell Int.	WoE
2. Airbus	WoE SE Wales	7. General Electric	Glos. SE Wales	12. BAE Systems	WoE
3. Lockheed Martin	C&IoS	8. Leonardo (was Finmeccanica)	HoSW C&IoS	13. L-3 Communications	Glos.
4. United Tech. Group		9. SAFRAN	Glos.	14. General Dynamics	S. Wales
5. Northrop Grumman	Glos.	10. Rolls Royce	WoE	15. Bombardier	HoSW

Automotive – industry is concentrated at locations along the M4, Swindon-South East Wales. The region is also a home to a spoke of the Advanced Propulsion Centre UK with the internal combustion engine system efficiency centre based at the University of Bath (PVRC). **Marine** –is concentrated in Plymouth and Falmouth (A&P is UK's largest ship-repair complex) and North Devon, (Appledore). Marine defence organisations are also located further east in the region. The audit area's strengths in AAE have grown up alongside the **steel** industry in South Wales, which has historically served as a source of raw materials for many of the region's industries.

[95] http://www.pwc.co.uk/industries/aerospace-defence/top-100-aerospace-companies-2014.html

Appendix AAE7 Project Portfolios

The table shows current and proposed initiatives in AAE related areas across the region. This includes funded programmes and those looking to access funding through a variety of routes including Research Councils, Local Growth Fund LEP round 3 submissions, City deals and other Government programmes.

Project/Scheme	Funding Source	Description
Airbus Wing Integration Facility	**Funded** - BIS Aerospace Technology Institute & Innovate UK	The £37m Airbus Wing Integration Facility is scheduled to open in 2017, and located at Airbus' existing Filton site but with an "open door" policy where external organisations can make use of the equipment and laboratory space. The advanced testing centre for large structural components will enable Airbus and its partners to develop new and cutting edge ideas in wing design & manufacture, an area in which the region is world leading academically and in industry.
Marine Industries Production Campus (MIPC)	**Funded -** Plymouth and South West Peninsula City Deal	From April 2015, key areas of South Yard are being transferred from the Ministry of Defence to Plymouth City Council. The site will offer 25,000m^2 of flexible employment space and deep water testing facilities suitable for the marine and advanced manufacturing sector. South Yard has recently been awarded Enterprise Zone status and will benefit from incentives such as reduced business rates, simplified planning rules and super-fast broadband.
iAero (South), Yeovil	**Business Case** - ERDF, LEP Growth Deal 3 & business	Scheduled for May 2018, the 2,500m2 "iAero Centre at Yeovil" facility in the Heart of the South West LEP will cost approximately £9.6m
iAero (North), Filton	**Business Case** -ERDF, LEP Growth Deal 3 & business	The iAero Innovation hub at Filton costing £16m and generating £8m GVA, will provide a 4,000m^2 facility within the Filton Enterprise Area.
Institute for Advanced Automotive Propulsion Systems (IAAPS)	**Full Business Case** -BEIS, LEP Growth Deal 3 & business	Costing £50m, **IAAPS** will be a 10,000m^2 world-leading facility at the Bristol & Bath Science Park that delivers transformational R&D for low carbon propulsion and will enable UK industry to define the next and future generations of powertrain technologies while helping Government meet its environmental policy commitments.
National Composites Material Centre	**Outline Business Case** -	The £115m NCMC will provide open-access facilities to industry to support innovation in the production of all of the constituents of composite materials. Operation

(NCMC)	Treasury, BEIS	will be based on, and expand on, the current HVM Catapult model. The NCC would lead on R&D Hub and Spoke Programme Management, building relationships with OEMs and industrial sponsorships, skills and training, standards development.
Advanced Engineering Campus	**Concept** - West of England Single Investment Fund, Local Growth Fund	Bristol & Bath Science Park is close to many of the major advanced engineering companies in the region and the GW4 Universities. Coupled with its excellent transport links this makes it an ideal focal point for further investments to realise the West of England devolution ambitions in AAE. The devolution deal includes additional investment for the Bristol & Bath Science Park with the concept of an Advanced Engineering Campus and CDT in Industry 4.0 being supported by South Gloucestershire Council and Bath & North East Somerset Council.
Aerospace Substructure Wing Integration Centre (ASWIC)	**Concept**	ASWIC will provide the technical capability to integrate, test and analyse (hardware-in-the-loop) for individual components or assembled sub-structures at a pre-production as well as validating static and dynamic flight performance before full wing integration. Locating ASWIC on at the Bristol & Bath Science, adjacent to the NCC and CFMS develops the synergies at the Advanced Engineering Campus and links it directly with the HVM Catapult and the South West's aerospace industry which is key to knowledge exchange from academia into industry.
Aerohub / Spaceport	LEP Growth Deal 3	Aerohub / Cornwall Airport Newquay is well placed to be the UK's first spaceport.[96] With one of the UK's longest runways, available development land, uncongested clear airspace and access to segregated airspace. The Aerohub Enterprise Zone also incorporates Goonhilly Earth Station, a major satellite communications hub and location for a proposed Space Science Centre.

[96] http://www.cioslep.com/assets/uploads/documents/1463644707_AH_spaceport_v3.pdf

Department for
Business, Energy
& Industrial Strategy

South West England and South East Wales Science and Innovation Audit

Annex H: New Energy Systems Theme Report

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

H

Annex H New Energy Systems Theme Report

1. Introduction

In relation to the New Energy theme, there are a number of clusters of industrial and R&D activity which have specific geographical nuances, and in some cases important synergies with neighbouring regions. In summary these are:

Marine renewables – the South West is the only region with all renewables resources accessible from ports and infrastructure, and with clusters of specialist industrial and academic activity spread across the region, but with significant infrastructure in the far South West (Wave Hub, Fab Test, COASTLab etc). There is an important wider geographical linkage with Southampton (NoC,) which is reflected in the development of the South Coast Marine Cluster. As recognition of the unique set of geographical and industrial assets, the South West was designated as the first Marine Energy Park in 2012, while the Offshore Renewable Energy Catapult also has a dedicated presence in the area.

Hydrogen / fuel cells – a corridor of technical expertise, specialism and capacity along the M4, from the Hydrogen hub at Swindon through to Cardiff, including the research centres at Baglan (University of South Wales) and Bath. This 'corridor' needs to be better co-ordinated and networked to increase its potential for growth.

Nuclear – activity centred on the M5 corridor running from Gloucestershire (EDF Energy Generation at Barnwood, Magnox at Berkeley, and Horizon Nuclear in Gloucester), Bristol and Somerset, with the nuclear skills centre at Bridgwater, EDF's national learning and development centre, not to mention the presence of both Hinkley C and the proposed site at Oldbury.

In addition the audit has revealed an emerging cluster of excellence and good practice in underpinning technologies relating to **distributed energy systems and smart grids**, including the Smart Islands project on the Isles of Scilly, which will have relevance across many new energy technologies.

While this summary paper provides an overview of the strength and depth of this expertise and capacity, it also reveals where the region is ideally placed to develop its science and innovation capacity further, and by so doing drive the development of new technologies where the UK has the potential to achieve competitive advantage.

2. Regional science and innovation assets

The audit area has a wealth of research and innovation assets related to the New Energy theme, with academic research centres, major industrial R&D capacity and focused innovation support and skills infrastructure.

Details of this, specific to each energy technology, can be found in the tables at Appendix NES1. Of particular note are:

- Major research centres and testing facilities relating to marine renewables, with significant synergies across institutions, but particularly Plymouth (the largest marine institute in Europe at Plymouth University, and the home of Plymouth Marine Laboratories - PML), Exeter's Marine Energy Group, and major collaborative projects such as PRIMARE and MARINET. The presence of the unique WaveHub facility off the

Cornish coast has been the catalyst for much of this collaborative effort, while the creation of the Enterprise Zone at South Yard, Plymouth (Now Oceansgate) will be a key driver of innovation led business growth in the future.

- Academic and industrial capabilities in nuclear operation, new build and decommissioning particularly centred on the Bristol-Oxford Nuclear Research Centre, with a strong and complementary industrial R&D capability, as well as significant innovation and skills infrastructure (Somerset Energy Innovation Centre, the approved Enterprise Zone at Huntspill, National College for nuclear at Bridgwater college and the Gloucestershire Science and Technology Park at the old Berkeley nuclear laboratories)
- Significant hydrogen production, storage and fuel cell research with its academic focus at the Sustainable Environment Research Centre (University of South Wales), the Cardiff Catalysis Institute and at Bath, as well as world leading industrial R&D and collaboration including Johnson Matthey Fuel Cells in Swindon
- A number of leading research centres focused on underpinning technologies and energy systems including the Energy Systems Research Institute (Cardiff), the Centre for Integrated Renewable Energy Generation and Supply (National Grid centre) and the Institute for Sustainable Energy and Environment at the University of Bath.

This rich R&D environment, in both research institutions and industry, provides a sound bedrock for further development that will add real value to the UK's innovation capacity.

3. Excellence in science and research

The audit area has an extensive world class research community related to New Energy across a range of academic disciplines, with a track record of attracting research income worth nearly £150m in the past seven years.

Our analysis has shown that **there are 232 academic staff undertaking research related to the New Energy theme, with 164 submitted to the REF**. The New Energy theme covers a broad range of academic disciplines, across 17 REF units of Assessment (UoAs), as outlined in full in the table in Appendix NES2. This table, and an analysis of UoA environment statements and impact case studies, from which a thematic mapping was produced (see Appendix NES3) reveals that the main clusters of academic excellence within the New Energy theme are in the fields of:

UoA		Submitted staff associated with theme	No of Institutions	Doctoral awards 2008-16*	UoA overall profile (% 3 or 4*)
7	Earth Systems and Environmental Sciences	22.75	3	36	91%
Key research themes • Marine renewable energy • Environmental impact • Resource modelling and simulation					
UoA		Submitted staff associated with	No of Institutions	Doctoral awards	UoA overall profile (% 3

		theme		2008-16*	or 4*)
8	Chemistry	23	3	80	97%

Key research themes

- design and synthesis of materials for hydrogen storage, fuel cells and catalysts for the enhanced production of biofuels
- developing a quantitative understanding of structures, mechanisms and interactions in organic chemistry, with applications in energy
- Energy storage

UoA		Submitted staff associated with theme	No of Institutions	Doctoral awards 2008-16*	UoA overall profile (% 3 or 4*)
15	General Engineering	79.8	5	156	81%

Key research themes

- Coastal processes
- Hydrodynamics of marine renewable energy
- Physical and numerical modelling of marine renewable energy
- Autonomous marine vehicles
- Marine composite structures
- Marine systems and interactions on energy generation
- Performance and reliability of advanced structural materials in marine structures, offshore energy devices, and thermal power plant, including nuclear pressure vessels and steam turbine components
- Combined network analysis and smart grids; grid infrastructure; hazard analysis; unconventional fuels; combustion diagnostics and control; emission characterisation; tidal energy
- Integration of renewables, energy networks and infrastructure

Much of this research excellence cuts across a number of New Energy technologies, and indeed is relevant more broadly across the audit themes. These synergies are important as much of the world class R&D being undertaken in the region can be applied across a range of energy (and indeed other technologies). Modelling and simulation is a good example of this, with relevance to a range of engineering and manufacturing sectors.

Research Income

An analysis of research income associated with New Energy shows that in the years 2008-2015 the total research income across the consortium was £149m, with an upward trend over the period. This upward trend has been confirmed in more recent years with major awards totalling £56m in 2014-16.

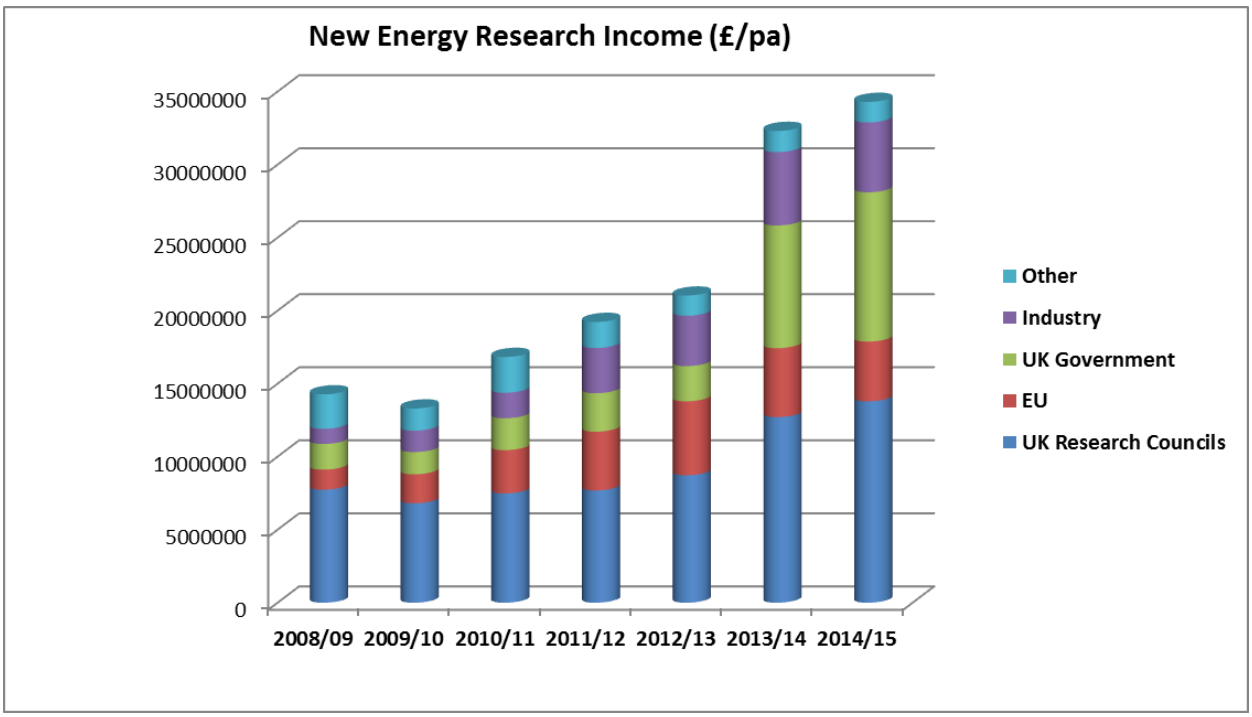


Figure NES1 New Energy Research Income

An analysis of data relating to academic publications related to the New Energy theme has also been undertaken, based on the 230 academic staff identified by consortium institutions that are active in the field, and searching by a comprehensive list of keywords / phrases to focus the search on areas of particular relevance. As the table below shows, there were over 1,400 relevant published articles between 2011 and 2016, and a high level of citation impact. A third of all publications were in publications in the top 10% most cited globally, and over 40% of papers involved international collaboration.

	All Authors (no keywords)	Keyword dataset
Scholarly Output (publications)	7422	1412
Field-Weighted Citation Impact	1.82	2.11
Citations	66,615	11,921
Citations per publication	8.2	8.4
Outputs in Top Percentiles (Publications in top 10% most cited worldwide) %	28.8	33.3
International Collaboration % (Publications co-authored with researchers in other countries)	46.6	43.1
Publications in Top Journal Percentiles (Publications in top 10% journals by SNIP)	37.6	51
Academic-Corporate Collaboration % (Publications with both academic and corporate affiliations)	4.3	3.8

Further analysis can be found in Appendix NES4, including benchmarking comparison of publications by journal filter. This shows particularly high levels of field weighted citation impact for “materials science” (3.26) and “physics” (3.37) publications – both significantly higher than the Russell Group average.

4. Innovation strengths and growth points

Across all New Energy themes the audit area has potential to deliver significant growth and high value jobs, driven by innovative businesses and collaborative R&D, with positive impact across the whole geography

Using standard measures of economic activity related to sector employment and counts of active enterprises is challenging in the energy field, as many enterprises that supply or are connected with energy generation will identify themselves across a range of engineering and service sector industrial classifications. For instance, the marine renewables “sector” includes businesses involved in a range of activities from technical and engineering consultants to specialist engineers. However, through using a suite of proxy SIC codes (see Annex M), we can broadly estimate the scale of the industrial capacity that could support the development and deployment of New Energy technologies.

This analysis[1] reveals that there are 184,100 employees across the consortium area in sectors with a connection to the New Energy theme. The largest sectors are: other engineering activities (24,600), electrical installation (23,200) and other telecommunications activities (15,000).

Taken as whole, this accounts for the same share of employee jobs (7%) as the Great Britain average. More qualitative analysis has been undertaken that has more specificity to the theme – with the work or Regen SW and Nuclear SW particularly useful in understanding these industries. These are summarised below:

Marine renewables

The number of people directly employed in the south west renewables industry overall has grown to 12,800 people, including 4,800 in renewable heat and 7,700 in renewable electricity. Based on current growth rates, it is predicted there will be 16,000 people working in the south west renewable energy sector in 2020[2]. The South West Renewable Energy Manifesto sets out how meeting the 15 percent target in the south west could deliver £10bn of investment and up to 34,000 jobs.

The majority of the employment above, however, is related to onshore wind, PV, and renewable heat. The marine renewables sector currently makes up only a small part of the total. However, in the past seven years the South West has invested over £100m to provide world leading research and demonstration marine renewables facilities including:

- Wave Hub, the largest consented demonstration area for marine energy in the world;

[1] Undertaken by Marchmont Observatory at University of Exeter – report in full is in Annex M to the main audit report

[2] South West Renewable Energy Progress Report, 2015, Regen SW

- the FaB Test nursery site in Falmouth Bay; and
- Plymouth University's COAST laboratory, which includes a deep water wave tank capable of creating complex, scaled current and wave environments.

The new Demonstration Zones off the north coast of Devon and Cornwall (managed by Wave Hub) provide the next development step to these facilities. The PRIMaRE programme has also funded specialist research facilities such as the South West Mooring Test Facility (SWMTF) and Dynamic Marine Component Test facility (DMAC) at the University of Exeter. These facilities complement existing centres for research such as the National Composites Centre. Reflecting these assets and investment, the South West was designated as the first Marine Energy Park in 2012. This latter is particularly important as it reflects the regional perspective of sector development, bringing together research and assets from the Isles of Scilly to the Severn.

Bristol has become a centre for tidal technology development with both technology specialists and consultancy firms based in the city region. Further down the peninsula in Plymouth and Cornwall the research and demonstration facilities have attracted UK and international wave and tidal developers such as Wello, Carnegie, Seabased, Simply Blue, Seatricity, Searaser, OWEL and Tocardo.

It is estimated that the marine energy sector in the South West currently employs over 450 people in high skilled jobs ranging from research and technology development, design engineering, consultancy, offshore operations, component supply and fabrication to training and business support[3].

The region also has an important underpinning and enabling capability in manufacturing for the marine environment including large scale fabrication in steel and concrete as well as manufacturing services in plastics and composites. Born out of the aerospace and yacht building industry, the region has developed significant expertise and capability in the design and manufacture of complex composite structures. The high strength to weight ratio, corrosion resistance and ability to manufacture complex shapes means composite materials are highly suitable for wind and tidal turbine blades in addition to numerous other components subjected to the highly dynamic offshore environment. This wider marine tech capability in both academia and industry is reflected in the establishment of the South Coast Marine Cluster as the UK's leading marine and maritime hub, an initiative that will be central to driving inward investment across the South coast.

The Supply Chain Directory compiled by Regen SW provides a comprehensive insight to the number and breadth of companies associated with the development, deployment and operation of marine renewable technologies, from device developers to consultancy companies. A summary of this can be found at Appendix NES5.

As the marine renewables sector expands it is expected that the number of long term jobs directly associated with the industry in the region will increase, with an ambition to reach over 3000 permanent and long term jobs in the sector by 2030, plus a potential average of 1900 jobs (2018-2030) involved in the construction of major tidal lagoons and offshore

[3] SW Marine Energy Park - Outlook and statement of ambition to 2030, Regen SW, 2015

wind projects. With regard to tidal lagoons, the current Independent Review, led by industry expert Charles Hendry, will be influential and may provide fresh impetus following previous reviews of the Cardiff Western barrage, to capitalise on the tidal range expertise (both academic, developer (Tidal Lagoon Power) and supply chain) that exists in the audit area.

Recent years have seen significant turbulence in the sector (typical of an industry at early stage), with the loss of long term players Pelamis and Aquamarine Power in wave energy, and in tidal energy, the exit of Voith Tidal and Siemens' decision to divest from Marine Current Turbines (MCT).

With the marine renewables sector at a pivotal point in terms of commercialisation, the extent of investment to date in the region, and its growing cluster of dynamic businesses could be among the key drivers of future growth, but continued development and investment is needed to maintain this position.

Hydrogen Storage / Fuel Cells

According to the UK hydrogen and fuel cell association (UKHFCA) there are currently over 100 UK companies, as well as over 35 academic and contract research groups highly active in fuel cells and hydrogen. Within the audit area, and stretching along the M4 corridor is a cluster of businesses with significant R&D activity in the field including Johnson Matthey, Fuel Cell Systems, Cella and Auriga Energy as well as large global players such as Air Products, MMI and BOC / Linde.

The UK fuel cell industry is characterised by a number of world class system developers, active across a range of application areas. Companies such as Ceres Power, Intelligent Energy, Honda and Rolls-Royce Fuel Cell Systems are designing products which will revolutionise transport and stationary power markets. Others are developing and supplying innovative materials and components; these range from established global players such as Johnson Matthey and UCM Advanced Ceramics through to innovative start-ups, such as BAC2 and Acal Energy.

The UK is also internationally recognised for its research and consultancy services, active across many parts of the supply chain and addressing common issues, such as socio-economic aspects, policy and market development etc.

Nuclear new build, operation and decommissioning

While considerable focus has been given to the development of Hinkley Point C as a driver of supply chain development and investment given its potential to create up to 25,000 jobs during its construction phase, there is an existing cluster of R&D activity (particularly around Bristol). For instance cluster maps for existing nuclear-related entities[4] show that the Region has:

- A very strong professional services, engineering and consultancy capability and reputation with structural and civil engineering a particular strength; and

[4] South West Nuclear Cluster Inward Investment Opportunities Evaluation and Initial Engagement Report, DNA Ltd, June 2015

- A large number of high precision manufacturing companies, and some specialist contract service providers (e.g. inspection services).

Consultancy (and University) capabilities cover a range of nuclear activities beyond new build – including life extension of existing reactors, decommissioning of retired Magnox and early research reactors, and effective solutions for management of radioactive waste.

The Berkeley site in South Gloucestershire is a potentially significant asset for the SIA region. Home of the decommissioned nuclear power station, most of the site has been taken over by South Gloucestershire and Stroud College, and is being developed in partnership with the University of Gloucestershire and Gfirst LEP as the Gloucestershire Science and Technology Park. Magnox and Cavendish Nuclear have a presence there, and Growth Deal funding is supporting the development of skills training, business support, and computing/cyber capacity. If Oldbury is confirmed as the site of a new nuclear power station, the Berkeley site will take on additional significance as a centre for training, innovation and support. Further South, around Bridgwater, there is a complementary set of assets including the approved Enterprise Zone at Huntspill, with a specific focus on nuclear, as well as the recently opened Energy Innovation Centre, which will be the centre of a growing cluster of nuclear and other energy related enterprises.

The region also hosts the two key nuclear regulators: the Office for Nuclear Regulation (ONR, Cheltenham) and the Environment Agency (Bristol) and with the headquarters of EDF Energy Existing Generation and NNB Genco, Magnox Ltd, Horizon Nuclear Power there is an emerging centre of excellence for nuclear power station development, licensing, operation and decommissioning in the Region. A map which very clearly demonstrates the cluster of licensed nuclear sites in the consortium area can be found at Appendix NES6.

This mix creates a fertile environment for innovation in the nuclear sector, by bringing together the experience of companies used to working within the sector, the new science and technologies based on cutting edge science at Universities, and the innovation of SMEs and other companies new to the nuclear sector. Crucially, engagement with the regulatory community enables these new ideas to be developed with their deploy-ability at nuclear licensed sites in mind from the outset. The outcomes are improvements to current nuclear technologies, such as safety and affordability, and the application to new technologies such as Small Modular Reactors (SMRs) and Fusion.

Most companies that are established within or associated with the nuclear industry are members of the Nuclear Industry Association. The NIA publish a list of its members by Parliamentary constituency (summarised in Appendix NES7). This shows 103 individual business units within the consortium area, employing 6,600 people. The vast majority of companies are located in close proximity to the major road networks – M4, M5 and A30. Bristol is home to the largest number of companies (34% of all entities), though in many of the categories there is also notable clustering around Bridgwater/Taunton and Gloucester / Cheltenham.

Distributed / smart systems

The UK is uniquely placed to be a market leader in smart systems and energy storage, creating a major new supply chain with opportunities to develop high value jobs, innovation and inward investment. As highlighted in the recent National Infrastructure Commission report on Smart Power, the UK already has an established position as a world leader in data analytics and software development. These capabilities are essential for the active management of the emerging flexible energy system. The sector can be broken down into key categories:

- smart grid infrastructure
- advance meter infrastructure
- smart distributed generation integration
- energy storage
- demand side response
- consultancy services

There are clear linkages with these capabilities and other themes within this audit, particularly around digital living. These categories cover a range of technologies and services that create a more flexible and responsive grid, improving energy efficiency across the network from producer to end-user. Regen SW have produced a national directory for the Smart energy and storage supply chain. This reveals particular clusters of activity in the region around battery and inverter manufacturing, and electric vehicles.

Smart grid and storage technologies have begun to move from R&D to deployment. A key driver for this is the limited capacity on the distribution grid network, illustrated by Western Power Distribution's announcement that there will be many years of delay for any new connection, other than those to the low voltage network. The government has recognised the challenges that grid constraints pose to the growth of the renewables industry and Ofgem published a consultation on how distribution connections could be made quicker and more efficient.

In 2014, Western Power Distribution started to roll out technology to manage the grid network in real time, based on actual energy flows and constraints, rather than modelled figures. This will potentially enable the grid to take much more generation. The first area where Active Network Management connections will be available is within the audit area in Bridgwater, submitted under Regen SW's Renewable Energy Grid Collaboration Service.

Also within the consortium area, the Smart Cornwall programme aims to develop the UK's first fully integrated smart energy network, providing new high value jobs and supporting local businesses to grow into this new market; and providing a test-bed and launch-pad into the European market for multinational companies. Analysis of this opportunity concludes it could deliver over 2,000 jobs and £110m GVA in 2020 and just under 7,000 jobs and £370m in 2030. These jobs would be weighted toward knowledge-based industries with an estimated 59% of businesses working in smart energy in knowledge-based sectors compared to a current average figure of 11 per cent for Cornwall and the Isles of Scilly[5].

The Smart Cornwall ambition is now being realised through the Smart Islands programme which will be a first of its kind project to demonstrate a replicable, scalable model of how

[5] Smart Cornwall Evidence base report, Regen SW 2013

an individual community can both rapidly transition from a carbon intensive to a low carbon community, as well as localise much of the value of energy generated in the locality. Underpinning this will be a smart energy platform utilising the latest Internet of Things (IoT) advances to balance energy supply (through a range of new low carbon sources) and demand (from buildings, water, waste and electric vehicles).

The region also has considerable experience at delivering on shore PV and wind RE in both green space and on buildings. This gives the region a good base load of infrastructure with which to develop the supporting infrastructure in terms of load balancing, storage, alternative business models etc. Research on driving distributed / localised / decentralised energy systems in communities such as Wadebrdge (WREN) and Exeter (Cranbrook and Science Park as well as city wide ongoing developments) has been highly influential on local development policy.

The Energy Systems Catapult runs the Smart Systems and Heat demonstrator programme which has a multitude of projects including three large scale demonstrators, one of which is just outside the audit area in Bridgend, South Wales, using the expertise from South Wales Universities.

5. National and international engagement

Consortium partners have been involved in a number of large-scale national and international research consortia, in particular various SUPERGEN projects, as outlined in the table in Appendix NES1.

Currently there are 7 SUPERGEN consortia (Bioenergy, Energy Storage, HubNet, Hydrogen and Storage, Marine, Solar and Wind. Only one (Wind) does not have a SW partner. These consortia provide expertise, knowledge exchange and facilities which attract business locally and internationally to work with them. Leading and fostering such collaboration is particularly important in some of the more nascent renewables technologies.

A particularly relevant example of world leading collaboration within the region is PRIMARE – the Partnership for Research In Marine Renewable Energy - a consortium of marine renewable energy experts across higher education, research and industry which have joined together to establish a ‘network of excellence’ centred in the south of the UK. The Universities of Plymouth, Exeter, Southampton, Bristol and Bath, along with the Marine Biological Association of the UK and Plymouth Marine Laboratory, work together on research projects across the spectrum of marine renewables. The South West Marine Energy Park (SW MEP) and the Wave Hub facility act as conduits between the research community and industry. It currently focuses on the following research areas:

- Materials
- Fluid Dynamics/ Hydrodynamics
- Survivability and Reliability
- Environmental Resources
- Power Conversion and Control
- Infrastructure and Grid Connection
- Impacts on Environment & Ecosystems
- Marine Operations & Maritime Safety
- Marine Planning and Governance

In recognition of the academic skills, test capability, enabling technology supply chain, and the opportunity for commercial arrays using the demonstration zones, the Offshore Renewable Energy Catapult has invested in having a dedicated and supportive presence in both the South West and in Wales, an important factor in forging collaborations with other parts of the UK, particularly Scotland.

The South Coast Marine Cluster is a key academic/industrial collaboration across the wider marine tech sector, involving four Universities as well as other research organisations such as the National Oceanography Centre and Lloyd's Register's Global Technology Centre.

Nuclear energy offers a further example of how the region is either leading, or well connected to, strategic developments at the national and international level. The South West is home to a number of national-level collaborative initiatives aimed at meeting strategic challenges by bringing together academia, government and industry, such as:

- Nuclear South West
- South West Nuclear Hub (Bristol)
- Bristol-Oxford Nuclear Research Centre
- National College for Nuclear (Bridgwater)
- Somerset Energy and Innovation Centre (Bridgwater).

The majority of these have an international scope of interests and links to companies, government agencies and institutions overseas. This is enabling both the export of nuclear expertise developed in the UK as well as the inward attraction of international experts from around the world.

Wales has an extensive research and development base in renewable energy and smart energy solutions. For instance, SPECIFIC (Wales' national Innovation and Knowledge Centre) and the Low Carbon Research Institute are carrying out world-leading research and can play a central role in informing energy policy development in Wales and the UK. They are both working with industry to develop innovative products that will reduce dependence on carbon rich fuels and increase long-term economic growth and the creation of employment opportunities for Wales such as the SOLCER house.

A further example of significant national and international engagement in smart energy systems is Cardiff University's FLEXIS project. This £24m, five year research programme will be supported by £15m of EU funds and will investigate how flexible energy systems can meet modern-day energy challenges. The programme involves collaborations with industry and research organisations in Wales, Europe and worldwide. As part of the scheme, demonstration sites will be established to act as a test bed for new ideas and to show how new and cost-effective technology and energy solutions are being developed – including a project promoting the use of ground energy from mine water.

With a track record of international, national and regional collaboration, the SIA area is ideally placed to lead further R&D and innovation activity in the New Energy field, ensuring activities complement and enhance efforts elsewhere to maximise return on investment.

6. Developments in science and technology – international markets and opportunities

Analysis shows that the region is ideally placed to both benefit from, and drive, new and rapid developments in marine renewables, nuclear and hydrogen technologies, where the opportunity exists to create global leadership in the UK

The Paris Climate Change Summit in November 2015 has given new impetus to the move towards a lower-carbon and more efficient energy system, but does not alter the picture of rising global needs for energy. Energy use worldwide is set to grow by one-third to 2040[6], driven primarily by India, China, Africa, the Middle East and Southeast Asia. Policy preferences for lower carbon energy options are reinforced by trends in costs, as oil and gas gradually become more expensive to extract while the costs of renewables and of more efficient end-use technologies continue to fall, where technology gains are proceeding apace and there are plentiful suitable sites for deployment.

More specifically, recent and projected developments related to R&D and innovation specific to the thematic focus of this audit are outlined below

Marine renewables

Europe is currently at the forefront of the exploitation and development of Marine Renewable Energy, hosting more than 50% of tidal energy and about 45% of wave energy developers[7]. At present, many of the infrastructures required for the development of MRE are located in Europe, including MRE test centres; demonstration and pilot zones; research laboratories; developers etc. At a European level the UK is the leader in both wave energy (with 29 developers) and tidal energy (with 32% of the global technology developers). Across both wave and tidal energy eleven UK developers have reached an advanced technology readiness level. These technologies are therefore at a crucial stage as the technologies at the forefront are going through the critical “valley of death”, where support is critical to reach full commercialisation.

Wave and tidal are still early stage technologies with tidal slightly ahead (with the first array build commencing in the Pentland Firth). It will be critical for the sector (particularly in the UK) to demonstrate how it can drive down costs to be competitive with other energy types. Key to this is technology innovation and particularly technology transfer from other sectors. Increasing competition is being seen from emerging markets – France and Canada for Tidal, and the US and Australia for Wave. Across both, China is engaged in heavily funded catch up research and development.

Public support is crucial for the growth and development of the MRE sector, and in European countries research and development activities have been mainly funded with governmental support. At national level, there are a wide range of initiatives that different European governments have adopted to support the development of MRE technologies, from subsidies such as feed-in-tariffs and quota systems to investment programs or setting

[6] World Energy Outlook, 2015, International Energy Agency / OECD, 2015

[7] Magagna, D., and Uihlein, A.: ‘Ocean energy development in Europe: Current status and future perspectives’, International Journal of Marine Energy, 2015, 11, pp. 84-104

deployment targets. The main financial support mechanism at European level is the 'NER 300 programme'; a joint initiative of the European Commission, the European Investment Bank and Member States. The programme aims to support demonstration projects within emerging carbon capture and storage (CCS) and innovative renewable energy (RES) technologies. Between its two calls for proposals (December 2012 and July 2014) two wave and another two tidal energy projects have been selected for NER300 funding, three of which were located in the UK and Ireland. The implications of Brexit on future support for UK based device developers are uncertain, but uncertainty is in itself one of the primary barriers to future development.

With its wealth of assets to support marine renewables device development, the region is ideally placed to play a key role in enabling the sector to bridge the "valley of death". The commitment of regional economic stakeholders to this is demonstrated by large scale investments in infrastructure, and creation of marine technology and renewables focused Enterprise Zones (for instance South Yard in Plymouth). It will be important to maximise the value of these new assets enabling them to complete the R&D and innovation jigsaw in the region, and attract inward investment.

Hydrogen / fuel cell

Contrary to common perception, the often-quoted technical obstacles to a hydrogen economy, namely, the storage, safety, cost and distribution of hydrogen have already been sufficiently resolved to support its rapid deployment. The sector is already generating billions of dollars in revenues every year, with annual growth (from a low base) of over 50%[8]. This trend is expected to continue for some time. In Asia, car manufacturers will produce around 3,000 fuel cell cars in 2016 and around 50,000 fuel cell combined heat and power devices. Detailed projections by all OEMs for the Californian Air Resources Board suggest that more than 30,000 cars will be on the roads in California by 2021. Fuel cell technologies are performing reliably to deliver many energy services: some hydrogen buses in London's fleet have operated for nearly 20,000 hours since 2011, while individual stationary fuel cells have generated power for over 80,000 operating hours.

However, most hydrogen and fuel cell technologies are still in the early stages of commercialisation within the UK and currently struggle to compete with alternative technologies, including other low-carbon options, due to high costs and a lack of confidence in the technology. Additional attention will be required before their potential can be fully realised. Government support can help accelerate the development and deployment of hydrogen and fuel cell technologies by ensuring continued research, education, development and demonstration funding for hydrogen generation and conversion technologies, such as electrolysers and fuel cells. This will facilitate early commercialisation of fuel cell electric vehicles and support demonstration projects for integration using hydrogen-based energy storage applications.[9]

The UK has a long and impressive track record in fuel cell research and development. The UK has developed a number of leading, and highly innovative, industry programmes,

[8] E4tech "The Fuel Cell Industry Review 2015" http://www.fuelcellindustryreview.com/

[9] Technology Roadmap - Hydrogen and Fuel Cells, International Energy Agency / OECD, 2015

supported by a strong academic base in both science and engineering[10]. The Research Atlases for both Hydrogen and Fuel cells summarise the UK's capability in particular areas and can be found at Appendix NES8. The UK hydrogen research community has relatively few gaps and an appropriate range of knowledge/skills and activities to address future challenges. However, hydrogen and fuel cells are not currently considered either a short or medium term development priority for the UK government (see, for example, the lack of substantial mention in Planning our electric future: a White Paper for secure, affordable and low carbon electricity, July 2011) and the UK lags badly behind Germany, the United States and Japan with regard to the kind of large scale demonstration projects required to capitalise on the UK knowledge base and develop native commercial expertise. The UK has played a part in HFC support to date, and has developed pockets of excellence, but has had no overarching strategy for the sector. In comparison with countries such as Japan and Germany, support has been less consistent and coordinated, and thus far the benefit to the UK has been more limited. But with an increasing number of hydrogen and fuel cell technologies now close to commercial application, small but coherent and coordinated actions could open pathways to large benefits. The production of the UK's Hydrogen and Fuel cell road map (August 2016) is therefore timely in identifying the UK's role and opportunity, as other countries start to commercialise and adopt this technology.

The value of such support is clear. With 20 public hydrogen refuelling stations, Germany is clearly the trailblazer in Europe in terms of hydrogen infrastructure. The further development of the infrastructure in Germany has now taken shape with the establishment of H2 MOBILITY, a company which will establish and operate the first 100 hydrogen refuelling stations by 2018/2019 unconditionally and irrespective of vehicle numbers Hydrogen could cover up to 40% of the demand for energy in Germany's transport sector by 2050.[11]

Nuclear Energy

The production of nuclear energy around the world is growing as countries look for secure, reliable and affordable energy sources that do not contribute to climate change. In the UK, the nuclear energy sector is undertaking a huge science and engineering effort to extend the lives of its unique fleet of Advanced Gas-Cooled Reactors (AGRs), planning and building a new generation of light-water reactors, decommissioning the legacy of the world's earliest nuclear power programme, while facing a workforce of highly experienced experts rapidly approaching retirement. The scale of the effort to train the scientists and engineers and then to deliver this programme is unprecedented.

The UK government has recognised the opportunity of renewing and growing its nuclear energy capability and skills base, both in terms of energy production domestically and opportunities for UK people and companies to contribute to large science and engineering projects around the world. Nuclear new build in the UK is forecast to generate up to 40,000 jobs in the sector at its peak, but employers are currently reporting skills shortages – particularly in engineering. Tackling the skills gaps will be one of the actions to be taken forward through a focussed Skills Delivery Plan led by the Nuclear Energy Skills Alliance.

[10] UKERC Research Atlas,

[11] H2 MOBILITY Deutschland GmbH & Co.KG marks the first time that a private company has coordinated, planned, built and operated hydrogen stations for an entire country - http://h2-mobility.de/en/h2-stations/

The South West region is recognised as a cluster for nuclear expertise, similar to the cluster around Sellafield in the North West, and is thus well positioned to play a significant role in this renewal.

New technologies such as Small Modular Reactors, which the UK has relevant experience in the design and construction of for naval applications, potentially offer solutions to challenges such as construction costs and adaptability to the unknown future energy landscape. The UK is unique in the world in having operated a fleet of high temperature, gas-cooled nuclear reactors, a design which is highly relevant to next-generation (Gen-IV) reactors, offering leaps forward in areas such as fuel utilisation and waste management. However a strategic intervention may be needed to ensure this knowledge is not lost, as the AGR fleet steadily retires over the coming decades, before such new reactors can be designed and constructed.

Both current and future nuclear energy technologies also have the significant potential to deliver a step change in value by being applied in new ways, such as exploiting the radiation environment for the production of high-value materials, production of hydrogen for the hydrogen economy and the large-scale desalination of sea-water to provide freshwater for human populations around the world.

Importantly, this regional excellence is of truly global relevance. It is not predicated on the construction of any one nuclear power station in the UK, and as such the potential developments at Hinkley and Oldbury are further elements of this expertise, not the central components. However the strategic importance of these major new nuclear developments to the SIA area should not be understated, in terms of their potential to drive high value jobs and supply chain innovation, and to deliver a legacy of economic transformation.

7. Conclusions

The analysis provided in this report shows that in new energy technologies there is both significant opportunity to develop competitive advantage and an existing research base of global quality. However, further investment and development is required to ensure that these opportunities are seized and this research exploited for commercial benefit.

This section summarises projects and initiatives that will further deepen capacity and capability to support new energy science, innovation and commercialisation. These are at various stages of development, with a full “Project Portfolio” table in Appendix NES9.

While such investments in particular technology development and commercialisation are important, consultation with industry representatives in the development of this audit confirmed that **the main barrier to the development and commercialisation of new energy technologies was lack of certainty regarding government energy policy, and therefore market certainty and future support for marine renewables, nuclear and hydrogen fuel cell technologies**. Without clear policy drivers in place the opportunity to maintain momentum and global leadership in some technologies may be lost.

Marine renewables

Marine renewables are at a pivotal point in terms of their development. It will be important for the growth of this industry across the UK that opportunities and capabilities in Scotland (Wave Energy Scotland and opportunities in the Pentland Firth, EMEC) are effectively

linked up with those in the South West. The ORE catapult regional representatives will be key to this. The following developments will complement and add value to the significant investment in research and commercialisation capabilities to date in the audit area, and across the UK.

Offshore renewables – modelling, simulation and testing

As described in this audit, the South West has seen significant investment in testing facilities for marine renewables, particularly wave and tidal energy. However there is an increasing focus on offshore floating wind energy, able to exploit deeper water conditions. The Ocean Wave Basin within the COAST Laboratory at Plymouth University currently allows waves and currents to be generated at any relative orientation and can be run at different water depths. It is accessible and utilised by a range of regional, national and international companies. However adding integrated **wind simulation capability** to the offer would expand its applicability and would be a significant in responding to an anticipated offshore floating wind market in providing test, design and specialist supply chain support. This would also complement other regional activity such as the strategic alliance between the Offshore Renewable Energy Catapult and University of Exeter to support capability expansion of FaBTest which would include testing floating wind at scale

Oceansgate – the marine innovation and production campus

The audit has highlighted the rich network of R&D support across the area, with a complementary and unique set of assets that can support marine renewables device developers to commercialisation. The creation of the Enterprise Zone at South Yard in Plymouth (Oceansgate) is intended to provide development opportunities for the manufacture of marine renewables devices, as well as deep water access for testing, particularly for autonomous vessels. An important strand of Oceansgate is to develop a Marine Technology Centre to enable marine businesses to launch and test prototype devices in waters in and around Plymouth Sound. This represents a significant opportunity to complete the TRL ladder within the South West, and has already led to multi-national interest in investment. However, there is a need for significant enabling works on the waterfront that will provide the catalyst for this investment. A dock in Oceansgate has been earmarked for boats and devices to be moored and launched or for devices to be tested within the confines of the dock. However, a programme of works needs to be undertaken before the dock can become operational again.

The marine autonomy test range

As this audit has highlighted a number of underpinning technologies are crucial to this and other themes. Autonomy is one of these, and an area where there is significant expertise and capacity (both academic and industrial) in the SIA area. The concept of an at sea test range for marine autonomy is one that has the support of key industry players (MSubs and Qinetiq) as well as stakeholders across the breadth of the South Coast marine cluster, complementing existing facilities in Southampton. Accessible from Oceansgate, Plymouth Sound is the ideal location for this, as it is a relatively quiet stretch of water, and has support infrastructure planned on the waterfront (see above). The establishment of the test range would make the region the centre for standards around autonomous vessels, and provide a key enabling facility identified in the UK marine technology roadmap.

North Devon demonstrator

This audit has highlighted the importance of the North Devon / West Somerset demonstration zone as the next development step to R&D facilities in the South West peninsula. In order to exploit this fully, the partners in this project; Wavehub, North Devon Council, Devon County Council, and Exmoor National Park have each contributed a small amount in start-up costs for the project. RegenSW are offering expert advice on the sector and the current commercial opportunities.

To take the project to the next level and make the offer more attractive to the commercial operators interested it will be necessary to invest in the consenting process as the first phase of developing and enabling actions. This work will include:

- Technical Feasibility Study – further consultation with developers, initial design and technical specification, site location and impact assessment
- Legal Study - consenting and permitting considerations scoping
- Business Case – market, case for the project, project delivery vehicle, services, finance
- Economic impact study
- Grid studies – solutions to any capacity constraints (energy storage, smart grid, innovative approaches)
- Environmental Scoping Assessment (not full EIA at this stage)
- Baseline surveys
- Delivery vehicle business plan
- Geophysical surveys (side scan/sonar)
- Developer selection
- Economic Impact Assessment (local, including supply chain)

Industrial Doctoral Centre

EPSRC funding for PhD studentships are targeted through Centres for Doctoral Training (CDTs) and Industrial Doctorate centres (IDCs). The Engineering Doctorate (EngD) is an alternative to the traditional PhD for students who want a career in industry. A four-year programme combines PhD-level research projects with taught courses, and students spend about 75 percent of their time working directly with a company. IDCORE is the Industrial Doctorate Centre for Offshore Renewable Energy and funds EngDs based in Edinburgh University. It trains world-class industrially focussed research engineers who will, with the help of sponsoring companies, accelerate the deployment of offshore wind, wave and tidal-current technologies. Given the intensity of MRE research and development activity utilising the assets outlined in this audit, being able to offer EngDs to industry partners and device developers as a method of interaction with the research expertise and facilities available in the SIA area would be a really positive development.

Advanced manufacturing design, build and test facility to support marine renewables

The co-location of key elements of the engineering design, build, test review journey for marine renewables and marine tech developments would complement activities at South Yard, and elsewhere but would also apply to electronic, robotics and autonomous vehicles / vessels so has application across the audit themes. Such a facility, easily accessible to SMEs and larger companies would incorporate (all underpinned by skilled staff allocated to manage and support businesses)

- Composites construction, computer aided design and build maker suite; dry test rig for 6DOF dynamics and control and hardware-in-the-loop testing
- Prototyping through the use of professional rapid prototyping equipment, light manufacturing CNC equipment and studio space for assembly. Access, through an internal bureau type service, to a toolmaking workshop
- Other specialist laboratories and areas such as composites, heavy structures, thermos-dynamics etc.
- Co-location and augmentation of specialist materials characterisation and testing facilities, including the Electron Microscopy Centre.

Nuclear

The nuclear sector, while building on well-established technology, is similarly at an important moment for renewal and innovation-driven growth.

A proposal for **NUCLEATE – Nuclear Futures Open Innovation and Technology Centre** has been submitted to the West of England LEP for Growth Deal round 3 funding. Located on the Bristol-Bath Science park. The 3500m2 facility will house state-of-the-art nuclear technology laboratories and equipment; an early stage incubator for start-up businesses and open innovation environments for co-location of nuclear primes, SMEs, other nuclear businesses and nuclear regulators. Nucleate will attract new business to emerge that will provide methodologies, software, hardware and services for the development of new affordable and safe and secure nuclear power generation. These businesses would not be able to afford the equipment and facilities by themselves to prove safety and reliability of their new products so will benefit from this investment.

Hydrogen / distributed energy systems

The recently published Hydrogen and fuel cells Roadmap[12] sets out a number of priorities for action in the period to 2025, which will help achieve the greatest benefits from hydrogen and fuel cells to the UK. These are summarised as:

[12] Hydrogen and Fuel Cells: Opportunities for Growth, E4Tech and Element Energy, August 2016

Actor	Priorities
Policymakers	• Strategic decisions around future energy systems options are needed before 2020 • Policies and market frameworks should allow the benefits of HFC technologies to be valued • Commercialisation support is needed in transport and fuel cell CHP • Support for research, feasibility, demonstrations and systems analysis
Industry associations	• Providing reliable and timely information to government to support policymaking • Making links between the HFC sector and end use sectors • Supporting HFC industry cooperation
Hydrogen and FC product developers	• further work is needed to hit technical and commercial targets • articulate and demonstrate the benefits of HFCs and their timescale for commercialisation to consumers and policymakers
Research funders and academics	• academic work should focus on technologies that go over and above the current expectations (lower cost, scaling up etc)
Regional organisations	• Driving HFC activity through policy to meet local objectives • Supporting demonstrations and early deployment

As this shows, early support through demonstration and, at a later date, suitable designed incentives are necessary to move towards a diverse energy system involving hydrogen. A key research challenge where the capacity and expertise within the audit area can contribute is to assess the “whole system” viability of such low carbon energy economies and their socio-economic and environmental costs and benefits.

Building on the capabilities and industrial expertise, as well as the public sector support for such a distributed energy system in the region, the creation of a large scale **New Energy Systems Distributed Demonstrator** would provide a national test bed for technologies, and business models (such as impact accelerators) across diverse geographies from core cities to peripheral rural areas, integrating existing initiatives such as Smart Cornwall and the Growth Deal investment in renewable energies at the Berkeley site to create a distributed project that investigates allowing towns/cities to share renewable energy generation and storage (for instance with high energy use public buildings such as hospitals) to create a network of resources that can work together to be more than the sum of the parts. For example, the energy systems demonstrator would able to model how intermittent sources like renewables (marine, wind, PV) could work alongside low-C base-load sources (i.e. nuclear), including modelling the role of disruptive new storage/transmission technologies like Hydrogen and its production using high-temperature nuclear reactors.

This concept would be developed with the recently established Energy Systems Catapult, complementing other systems demonstrators, and taking a whole systems approach incorporating the three core components:

- Supply and demand;
- Technical enablers
- Market enablers

The expertise and geography of the audit area provides a unique opportunity to test this whole system approach, bringing knowledge, energy sources and end-user products together.

Underpinning technologies

Simulation, modelling and visualisation

Our analysis of the academic and industrial strengths across the sub themes have highlighted a number of underpinning technologies and capabilities where the opportunity to create synergies and research partnerships will have real value. Across all of the sub themes, simulation, modelling and visualisation have been flagged as particular strengths with wide application. To foster collaborative and multi-disciplinary R&D with academic and industrial partners, the development of new energy technologies would be stimulated through the establishment of a network of **simulation and visualisation facilities** with multiple applications, and accessible to industry and academic researchers.

Appendices

Appendix NES1 List of Assets

The following tables summarise the main assets for each sub theme:

Marine			
Asset / initiative	**Location**	**Host / Lead**	**Descriptor**
Marine Institute	Plymouth	University of Plymouth	The first and largest such institute in the UK. Provides the external portal to an extensive pool of world-leading experts and state-of-the-art facilities.
COASTLab	Plymouth	University of Plymouth	Housed in the new Marine Building at Plymouth University, the Coastal, Ocean And Sediment Transport (COAST) laboratory provides physical model testing with combined waves, currents and wind, offered at scales appropriate for device testing, array testing, environmental modelling and coastal engineering.
FaB Test	Falmouth Bay	University of Exeter	Pre-consented, 2.8km2 test area, for up to three devices to be deployed concurrently, for the testing of marine energy technologies, components, moorings and deployment procedures
Wave Hub	Hayle	Wave Hub Ltd	the world's largest and most technologically advanced grid connected site for the testing and development of offshore renewable energy technology
North Devon Demonstration Zones	North Devon coast	Wave Hub Ltd	A new tidal energy site with the potential to support the demonstration of tidal stream arrays with a generating capacity of up to 30MW for each project
Plymouth Marine Laboratory	Plymouth		Development and application of world-leading, integrated marine science
Marine Innovation Centre (MARIC)	Plymouth	University of Plymouth	Aims to make the South West's marine and maritime businesses globally competitive; accelerating growth by creating intelligent connections between organisations, world-class knowledge, technologies, people

			and infrastructure.
Exeter Marine Energy Group	Penryn	University of Exeter	Resource Assessment, Marine Operation and Hydrodynamics, and Offshore Reliability. Actively engaged with wave energy developers and has a number of ongoing collaborative research projects
PRIMARE (Partnership for Research In Marine Renewable Energy)			A network of world-class research institutions based in the west, south, and south west of England who undertake research and development to address challenges facing the marine renewable energy industry at the regional, national and international level.
€17M H2020 CEFOW (Clean Energy from Ocean Waves) project,		Partners include Wave Hub, Mojo Maritime, Plymouth & Exeter Universities	Aims to deploy advanced multiple wave energy converters (WECs) with improved power generation capability and demonstrate that they are able to survive challenging sea conditions
Hydro-environmental Research Centre	Cardiff	Cardiff University	Pursues research into the development, refinement and application of hydro-environmental computational models for predicting flow, water quality, sediment and contaminant transport processes in coastal waters, estuaries and river basins
MARINET - Marine Renewables Infrastructure Network for Emerging Energy Technologies (FP7)			Co-financed by the European Commission specifically to enhance integration and utilisation of European marine renewable energy research infrastructures and expertise. MARINET offers periods of free-of-charge access to world-class R&D facilities & expertise and conducts joint activities in parallel to standardise testing, improve testing capabilities and enhance training & networking.
€1.9M **SOWFIA** (Ocean Wind Farms Impact Assessment) project		University of Plymouth	Sharing and consolidation of pan-European experience of consenting processes and environmental and socio-economic impact assessment (IA) best practices for offshore wave energy conversion developments

EPSRC SUPERGEN Marine 3 UKCMER (2011 – 2019)		Exeter and Plymouth Universities are consortium partners	Conducts world-class fundamental and applied research that assists the marine energy sector in the UK to reliably and dependably accelerate deployment rates and ensure sustained growth in generating capacity to meet the 2020 targets.
EPSRC/ETI £6.5M Industrial Doctoral Centre for Offshore Renewable Energy		Universities of Exeter, Strathclyde & Edinburgh	The IDCORE programme will train world-class industrially focussed research engineers who will, with the help of sponsoring companies, accelerate the deployment of offshore wind, wave and tidal-current technologies in order to meet the UK's ambitious offshore renewable energy targets.
Oceansgate (Enterprise Zone)	Plymouth	Plymouth City Council	Bringing together marine-based businesses to create a world-class hub for marine industries, with opportunities for research, innovation and production in a collaborative environment.
Cornwall Marine Hub	Hayle	Cornwall Council	Marine focused Enterprise Zone
Bolt 2 WaveHub		Fred Olsen	Innovate UK funded wave energy demonstrator project ‘Lifesaver’, in collaboration with University of Exeter
Cornwall Marine Hub	Hayle	Cornwall Council	Marine focused Enterprise Zone
Cornwall Marine Network	Cornwall		An organisation dedicated to supporting the Marine sector in Cornwall via initiatives that improve profitability and encourage growth through quality and innovation
Falmouth Marine School		Cornwall College Group	Specialise in Boatbuilding, Leisure & Watersports, Marine Engineering and Marine Science.
DNV GL	Bristol		through their design verification activities are creating specific standards for wave and tidal
Waveport		OPT, Exeter University	€9M FP7 marine energy demonstration project,
£1.1m Dynamic Loadings on Turbines in a Tidal Array (DyLoTTA)			including Airborne, Ansys UK Limited, Arup Group Ltd, Bosch Rexroth Ltd, EPSRC, LLoyd's Register Energy, National Instruments Corporation UK Ltd,

			Nautricity Ltd, Offshore Renewable Energy Catapult, SKF (UK) Ltd, Tidal Energy Ltd, Universities of Cardiff and Strathclyde

Nuclear			
Asset / initiative	**Location**	**Host / Lead**	**Descriptor**
Bristol-Oxford Nuclear Research Centre	Bristol	University of Bristol / University of Oxford	Providing leading edge and innovative research to support the safe operation of current and future generation nuclear systems.
South West Nuclear Hub	Bristol	University of Bristol	Provides a link between the Higher Education, Nuclear Industry and Government sectors, and creates a single door for the nuclear industry to access and form partnerships in academic research and teaching
Geo-environmental Research Centre	Cardiff	University of Cardiff	Tackling the problems caused by the environmental effects of waste, including high level nuclear waste
Advanced Centre for Composites in Innovation and Science (ACCIS)	Bristol	University of Bristol	World leading centre for composites research and education, combining cutting edge fundamental science with strong industrial links for exploitation and technology transfer.
EDF Generation	Barnwood	EDF GenCo	
EDF New Build	Hinkley Point C	EDF	Potentially the first new nuclear power station in the UK for a generation
EDF NNB Command Development Centre	Bristol	EDF	Will be home to 750 staff, the centre of excellence for nuclear new build in the UK
Magnox nuclear labs	Berkeley	Magnox	
Horizon Nuclear Power	Tewkesbury		UK energy company (wholly owned subsidiary of Hitachi,Ltd) developing a new generation of nuclear power stations at Oldbury and Anglesea
National College for Nuclear	Bridgwater	Bridgwater College	Development of programmes and curricula to target a

			strategic skills gap at the advanced technician level, below traditional degree programmes
EDF national Learning and Development Centre	Cannington	EDF Energy	Forms part of EDF Energy's "Campus" programme for all staff which includes an online hub and courses run across the UK. Develops skills to work on smart metering, customer service, existing power stations, nuclear new build, human resources, finance, digital projects and other aspects of EDF Energy's business.
Somerset Energy Innovation Centre	Bridgwater	Somerset County Council (operated by SWMAS Ltd / Business West / Somerset Chamber)	A hub for ambitious businesses seeking to collaborate and exploit opportunities in the low carbon and nuclear energy sectors.
Nuclear South West		Business West / Davies Nuclear	Not-for-profit business platform focussing on supply chain development, networking and sharing of knowledge.
Gloucestershire Science and Technology Park	Berkeley	South Gloucestershire and Stroud College with University of Gloucestershire	Site of the former Berkeley Nuclear Laboratories; with a continuing presence of Magnox and Cavendish Nuclear; now being comprehensively redeveloped to provide facilities for engineering and construction skills training; business support; advanced computing and cyber facilities; and a University Technical College

Hydrogen / Fuel Cells			
Asset / Initiative	**Location**	**Host / Lead**	**Descriptor**
Sustainable Environment Research Centre	South Wales	University of South Wales	Groundbreaking research centre bringing together leaders from biology, engineering, chemistry, and physics, including a focus on hydrogen energy and vehicles
Cardiff Catalysis Institute (CCI)	Cardiff	Cardiff University	Established to • improve the understanding of catalysis • work with industry to develop new catalytic processes

			• promote the use of catalysis as a sustainable 21st century technology
SUPERGEN • Energy Storage Hub (2014-19) • Sustainable Hydrogen Energy Consortium, (2007-12) • Hydrogen and Fuel Cells Hub • Biological Fuel Cells			Various EPSRC funded consortia - part of the wider SUPERGEN initiative from the Research Council's Energy Programme. The programme is led by EPSRC in partnership with BBSRC, ESRC and NERC. It aims to contribute to the UK's environmental emissions targets through a radical improvement in the sustainability of the UK's power generation and supply.
CymruH2Wales (£6.3m)		University of South Wales	Aims to ensure that Wales can play an active role in establishing new hydrogen technology products, processes and services
£1.24m Royal Society/DFID Consortium on "New materials for a sustainable energy future:		Cardiff University	Consortium with Addis Ababa University, University of Botswana and Kwame Nkrumah University of Science & Technology
£1.7M IUK funded project with ITM Power and Cardiff City Council	Cardiff	Cardiff University	Development of a hydrolysis plant in Cardiff to generate hydrogen for injection to grid with landfill gas, to store for use in vehicles or for putting back through a generator to produce electricity
Swindon Hydrogen Hub	Swindon	Johnson Matthey	LEP supported initiative including Honda, Hyundai, Doosan, Johnson Matthey
Johnson Matthey Fuel Cells	Swindon		R&D activity dating back to 1990s and purpose built state of the art facility for flexible manufacturing methods to produce large volumes of fuel cell components for hydrogen and methanol fuelled systems
Auriga Energy	Bristol		Developed and continues the development of high efficiency fuel cell systems, for the marine, stationary power (including UPS/backup and standalone generators) and materials handling applications.

Other (integration of renewables, energy networks and infrastructure)			
Asset / Initiative	**Location**	**Host / Lead**	**Descriptor**
Energy Systems Research Institute	Cardiff	Cardiff University	Undertakes internationally leading research into the development of sustainable, affordable, socially acceptable and secure energy systems through a multi-disciplinary approach that supports collaboration and innovation
Low Carbon Research Institute	South Wales	Cardiff University	Unites the diverse range of low carbon energy research across Welsh universities at Cardiff, Glyndwr, Bangor, South Wales and Swansea, covering research topics relating to the built environment, solar PV, hydrogen, large scale power generation and marine.
Centre for Integrated Renewable Energy Generation and Supply	Cardiff	Cardiff University	A multidisciplinary engineering group with international expertise in both generation and supply of renewable energy
Advanced High Voltage Engineering Research (National Grid Centre)	Cardiff	Cardiff University	Focuses on systems and phenomena related to very high voltage electricity. establishing collaborative partnerships between university researchers and National Grid engineers
Cabot Institute	Bristol	University of Bristol	Cross-disciplinary research institute, conducting world-leading research with main themes including energy security.
Electrical Energy management Research Group	Bristol	University of Bristol	Undertakes research into low carbon electrical systems that are enabled by advanced, compact and highly efficient electrical machines and power electronic conversion.
FLEXIS	South Wales	Cardiff University	£24m European Structural funds project which sets out to meet the diverse, complex and inter-dependent challenges that arise when new sources of energy are integrated into the grid by suppliers, including establishment of a demonstration test bed.
SPECIFIC	South Wales	Swansea University	£3m European Structural funds project which aims to address the

			challenge of low carbon electricity and heat by enabling buildings to generate, store and release their own energy, in one system, using only the energy from the sun
Advanced Renewable Energy Research Centre	Berkeley	University of Gloucestershire	£4m Growth Deal capital investment in renewable energy capacity as part of the wider development of the Gloucestershire Science and Technology Park. The Centre will deliver STEM skills development, business incubation, strategic and applied research and specialist business and consumer support in relation to secure renewable energy generation, storage and management. The aim of the Centre is to build, develop, test and evaluate sustainable energy technologies in a setting where the skills and research can be shared and then demonstrated to industry, existing and future customers, and schools.
Smart Cornwall Programme	Cornwall		UK's first fully integrated smart energy network
Smart Islands	Isles of Scilly	Council for the Isles of Scilly / Islands Partnership / Duchy of Cornwall & Tresco Estates / Hitachi Europe	Proposed smart grid/smart energy programme to support the Islands objectives: - • 20% reduction in electricity bills by 2020 (40% by 2025) • 40% of the Isles' energy demand met through renewable generation by 2025 • 40% of vehicles being low carbon or electric by 2025 • Internships, cultural exchange and STEM skill delivery for young people • 5. Full programme of energy efficiency measures delivered by 2020
Building Research Establishment Trust Centre for Sustainable Engineering	Cardiff	Cardiff University	Research themes include management of energy in buildings with a view of delivering lifelong sustainable facilities

Appendix NES2 REF 2014 Units of Assessment with staff associated with New Energy

UoA		Submitted staff associated with theme	No of Institutions	Doctoral awards 2008-16*	UoA overall profile (% 3 or 4*)
3.	Allied Health Professions	1	1	1	63%
4.	Psychology, Psychiatry and Neuroscience	3	1	-	92%
5	Biological Sciences	1	1	7	88%
7	Earth Systems and Environmental Sciences	22.75	3	36	91%
8	Chemistry	23	3	80	97%
9	Physics	9	3	34.5	89%
10	Mathematical Sciences	14	2	40	70%
11	Computer Science and Informatics	2	2	18	82%
12	Aeronautical, Mechanical, Chemical and Manufacturing Engineering	15	1	43	89%
13	Electrical and Electronic Engineering, Metallurgy and Materials	5	2	30	78%
14	Civil and Construction Engineering	11	1		76%
15	General Engineering	79.8	5	156	81%
16	Architecture, Built Environment and Planning	5	2	15	83%
17	Geography, Environmental Studies and Archaeology	8.4	3	24	75%
19	Business and Management Studies	3	2	3	68%
21	Politics and International Studies	1	1	.5	84%
23	Sociology	1	1		86%
				500	

*Awarded to students supervised by staff associated with the theme

Appendix NES3 Mapping of academic themes from analysis of UoA environment statement extracts and impact case studies

	Marine renewables	New nuclear	Hydrogen storage / Fuel cells	Other
PLYMOUTH UNIVERSITY	international reputation in research related to marine renewable energy	maximise performance and reliability of advanced structural materials in nuclear pressure vessels and steam turbine components (strong links with the South African Energy Utility, ESKOM)		
	-Wave structure interaction / simulation - **Marine systems** & interactions			
	-Offshore wave farms **impact assessment** **-**Understanding the sediment dynamics and coastal impact of offshore wind farms			
	Advanced research into **materials and structures**			
	the application of Artificial Intelligence (AI) techniques to the navigation, guidance and control of **autonomous marine robotic vehicles**, and has extended this expertise into wave energy devices			
	research on marine **composite structures** for the			

	renewable energy domain			
	optimisation of welding and bonding processes seeks to minimise residual stresses and maximise **performance and reliability of advanced structural materials** in marine structures, offshore energy devices,			
CARDIFF UNIVERSITY	evaluating the environmental and engineering implications of tidal energy recovery schemes	research on the physicochemical behaviour of fine-grained soils and its application to high-level nuclear waste	the design and synthesis of materials for hydrogen storage, fuel cells	developing materials for use in energy applications including membranes for natural gas purification and carbon capture
	-design, testing and **simulation of tidal stream turbine** -simulating marine renewable energy structures (e.g. Severn Barrage) -marine renewable energy and in particular on new numerical strategies for **simulating related hydrodynamic processes**	research on processes of reasoning associated with nuclear fusion as an energy technology	Polymer-based hydrogen storage materials	-catalysts for the enhanced production of biofuels -the Cardiff Catalysis Institute - sustainable fuel-to-energy transformations
	scientific data and modelling predictions		Hydrogen End-use Catalysis of reforming reactions at moderate temperature	research on geo-energy and sustainability, including work on ground source heat, underground coal gasification, carbon sequestration in coal and

				soil, and geoinformatics
				-combined network analysis and smart grids -grid infrastructure and smart-grids -National Grid Centre for research into new materials and systems for power transmission -studies and training on the influence of renewables integration on the electrical grid
				linking the built environment to future energy supply options, combining technologies in energy supply, energy demand reduction and energy storage
UNIVERSITY OF BATH			Hydrogen storage	-New materials -Chemical Analysis & Characterisation
			Hydrogen / fuel cells hub	Solar cells / PV
			development of special carbon structures, porous oxides and structured adsorbents, used for H storage	Gas turbine heat transfer research
			Structural chemistry of hydrogenous materials	Smart grid

UNIVERSITY OF EXETER	the consequences of marine renewable technologies (ecosystems)			synthetic approach to Biofuel generation in bacteria
	mathematical research in the areas of dynamical systems, control theory, computational modelling and statistics (interface with renewable energy)			design and fabrication of novel nanoelectronic and photonic devices
	optimal control techniques for wave energy converters			integrated photovoltaics
	issues of power production in offshore renewable energy devices			
	understanding spatio-temporal variation of waves, coupled dynamic behaviour of ocean energy devices			
UNIVERSITY OF BRISTOL		Structural integrity-Fracture mechanics, residual stress, high temperature materials Measurement and role of residual stresses, role of temperature, irradiation and the environment on material(s) properties		
		Nuclear reactor core materials		
		Thermal modelling		

		Nuclear Materials and modelling - Uranium chemistry, metallurgy, corrosion and surface science		
		Simulation and modelling techniques to understand the properties of solids and surfaces at the atomic level, modelling irradiation effects across length and timescales		
		Nuclear waste and fuel management		
		Software reliability / safety systems modelling		
		Nuclear hazards and risks		
		Monitoring technologies		
		Development of new materials		
UNIVERSITY OF SOUTH WALES			broad portfolio of hydrogen, anaerobic system and fuel cell R&D, spanning fundamental materials research through to industrial research and testing.	
			Advanced Control and Network Technology Research Unit has a focus on fuel cell control and electrical systems	

			development, particularly for automotive applications.	
			Hydrogen Research Centre and Baglan provides a platform for the experimental development of renewable hydrogen production and novel hydrogen energy storage. The centre enables further research and development of hydrogen vehicles, fuel cell applications and overall hydrogen energy systems.	
			CymruH2Wales aims to ensure that Wales can play an active role in establishing new hydrogen technology products, processes and services.	

Appendix NES4 Publication Analysis

Summary of SciVal data from 20/07/16

	All Authors (no keyword)	**With Keywords**	Extended keywords
Scholarly Output (publications)	7422	**1412**	2998
Field-Weighted Citation Impact	1.82	**2.11**	1.9
Citations	66,615	**11,921**	24,318
Citations per publication	8.2	**8.4**	8.1
Outputs in Top Percentiles (Publications in top 10% most cited worldwide) %	28.8	**33.3**	30.8
International Collaboration % (Publications co-authored with researchers in other countries)	46.6	**43.1**	45.6
Publications in Top Journal Percentiles (Publications in top 10% journals by SNIP)	37.6	**51**	43
Academic-Corporate Collaboration % (Publications with both academic and corporate affiliations)	4.3	**3.8**	4.0

Top Academic/industry collaborations (no of publications) based on 'all authors' dataset:

Rolls-Royce United Kingdom	**27**
China Electric Power Research Institute	22
Airbus Group	20
Jaguar Land Rover	19
Johnson Matthey Plc	19
CTTC - Catalan Telecommunications Technology Centre	18
KDDI R&D Laboratories	18
Hydro-Quebec	16
Shell	15
Atomic Weapons Establishment	13
Telefonica	12
ExxonMobil	11
Toshiba	10
Fraunhofer - Heinrich-Hertz-Institut - HHI	8
Thales	8
Alcatel-Lucent	7
Fujitsu	7
Osaka University	7
TriQuint Semiconductor, Inc.	7
QinetiQ	6
Deutsche Telekom	5
ETH Zurich	5
Rutherford Appleton Laboratory	5
Siemens	5
Smith & Nephew	5
BT	4
GlaxoSmithKline	4

Benchmarking: Filtered by 'Energy'

	Keyword Dataset	World	UK	Russell Group
Scholarly Output	**440**	459576	19365	10283
Field-Weighted Citation Impact	**2.1**	1.11	1.57	1.78
Outputs in Top 10% of the World (%)	**48.2**	21.7	27.7	33.3

Benchmarking: Filtered by 'Engineering'

	Key word Dataset	World	UK	Russell Group
Scholarly Output	**685**	2895624	115484	65205
Field-Weighted Citation Impact	**2.04**	0.99	1.54	1.74
Outputs in Top 10% of the World (%)	**23.4**	13.3	18.1	21.2

Benchmarking: Filtered by 'Materials Science'

	Keyword Dataset	World	UK	Russell Group
Scholarly Output	**219**	1396227	56772	37052
Field-Weighted Citation Impact	**3.26**	1.11	1.49	1.65
Outputs in Top 10% of the World (%)	**41.1**	21.8	26.4	30.2

Benchmarking: Filtered by 'Physics'

	Keyword Dataset	World	UK	Russell Group
Scholarly Output	**207**	1635271	97976	68390
Field-Weighted Citation Impact	**3.37**	1.05	1.57	1.71
Outputs in Top 10% of the World (%)	**30.4**	18.8	27.6	30.4

Benchmarking: Filtered by 'Maths'

	Keyword Dataset	World	UK	Russell Group
Scholarly Output	**76**	922410	53606	34030
Field-Weighted Citation Impact	**2.69**	1.02	1.46	1.53
Outputs in Top 10% of the World (%)	**10.5**	11.9	15	15.8

Top 20 academic collaborations (publications):

Institution	**Publications**	**Citations**	**Authors**	**Citations per Publication**	**Field-Weighted Citation Impact**
University of Bristol	305	1598	367	5.2	1.68
University of Bath	249	3693	259	14.8	3.64
Cardiff University	222	1414	248	6.4	1.53
University of Plymouth	182	1353	127	7.4	2.65
University of Exeter	167	998	113	6	1.73
University of Edinburgh	74	241	64	3.3	1.46
University of South Wales	63	625	36	9.9	1.36
Universidad de Santiago de Compostela	54	405	46	7.5	2.86
University of Michigan	44	284	9	6.5	2.7
Heriot-Watt University	34	453	30	13.3	2.58
Virginia Polytechnic Institute and State University	33	278	21	8.4	1.18
Tsinghua University	27	240	39	8.9	1.89
Imperial College London	23	409	68	17.8	7.41
Aristotle University of Thessaloniki	22	43	15	2	0.83
University College London	22	258	25	11.7	2.74
University of Cambridge	22	185	60	8.4	2.53
University of Southampton	22	403	35	18.3	3.13
University of Manchester	21	135	56	6.4	1.34
University of Oxford	20	191	55	9.6	3.28
Loughborough University	18	264	30	14.7	2.3

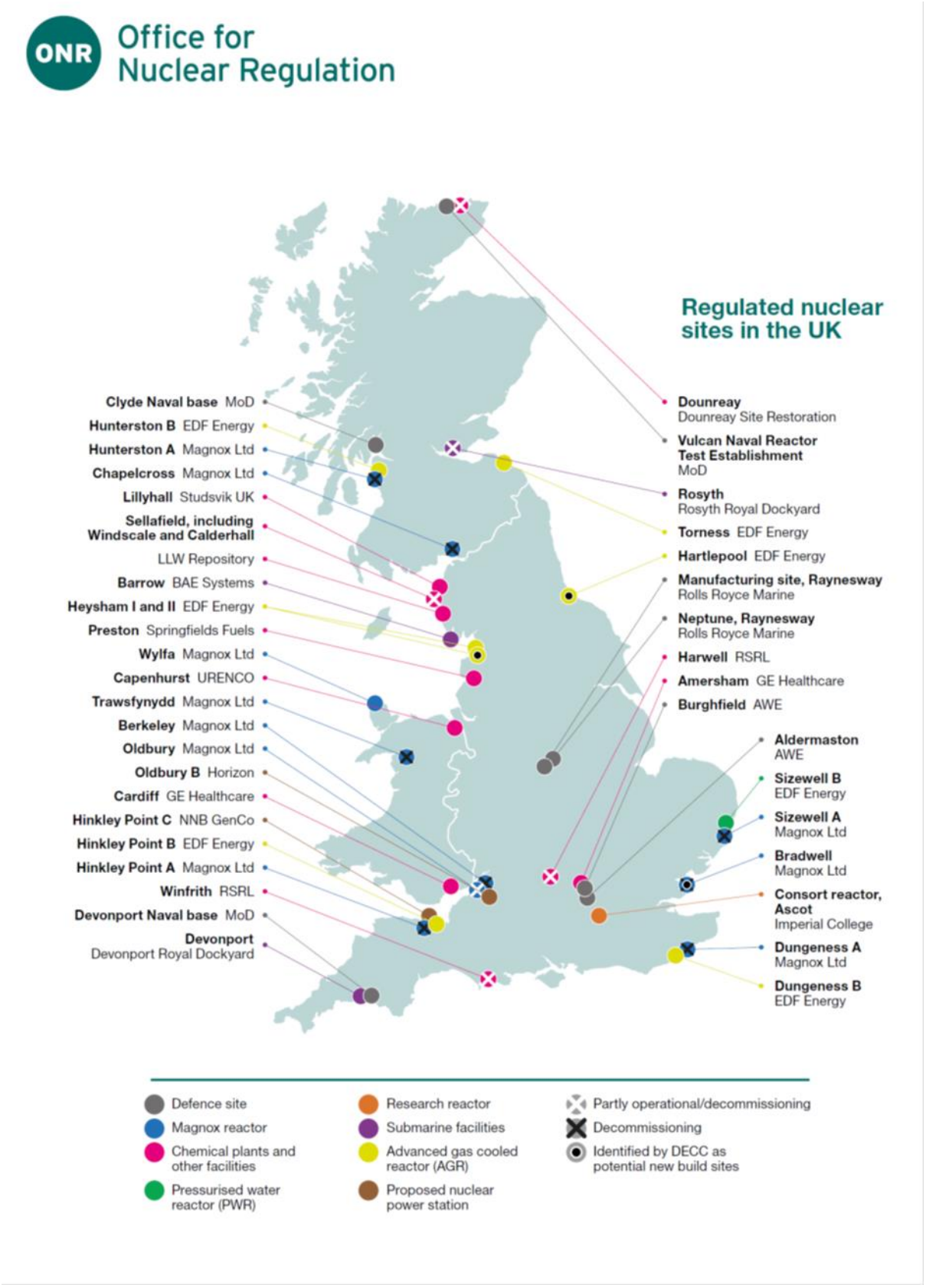
Appendix NES5 marine renewables supply chain

A summary of the marine renewables supply chain, from Regen SW

Tidal Energy Developers	Alstrom	Bristol
	Atlantis Resources Ltd	Bristol
	Longbay Seapower Ltd	Somerset
	Tidal Energy Ltd	Cardiff
	Tidal Lagoon Power Ltd	Cheltenham
	MT Tidal	Exeter
Wave Energy Developers	Carnegie Wave Energy LTd	Cornwall
	Marine Power Systems	Swansea
	Offshore Wave Energy Ltd	Cornwall
	Searaser	Devon
	Seatricity	Cornwall
Renewable Energy Consultants	18 companies	
Technical and engineering consultants	16 companies	
Multi-disciplinary consultants	36 companies	
Environmental consultants and surveyors	21 companies	
Oceanographic consultants and surveyors	9 companies	
Naval architects	9 companies	
Marine engineering	Babcock BMT LICenergy Ocean Fabrication	
Subsea engineering	Sub Marine Services LICEnergy MSubs Viper Subsea	
Specialist engineering	9 companies including Apex Fluid Engineering Thales Underwater Systems Teignbridge propellors	

Appendix NES6 Regulated Nuclear Sites in the UK

Regulated Nuclear Sites in the UK, which shows the cluster within the South West England and South East Wales area.



Appendix NES7 Industrial capacity in the nuclear sector

Nuclear Industry Association members within the audit area.

Constituency	Infrastructure	Business units	Jobs	Significant entities
Bath		2	159	
Bridgwater & West Somerset	Hinkley A (Cavendish Fluor) Hinkley B (EDF) *Hinkley C (EDF NNB)*	23	2,035	BAM – 490 Doosan Babcock – 330 EDF – 718 Magnox - 184
Bristol West		15	301	Frazer-Nash – 144 Small consultancies
Cardiff (x4)		7	55	ARUP - 40
Cheltenham		2	10	
Chippenham		1	110	M&W
East Devon		3	8	
Exeter		2	7	
Filton & Bradley Stoke	Oldbury Power Station (Cavendish Fluor)) *Oldbury Power Station (Horizon)*	9	604	Atkins – 287 Cavendish - 179
Gloucester	Barnwood	6	1471	EDF – 1,332
Newport East				
North Somerset		1	20	
Plymouth (x2)		4	50	
South Swindon		1	33	
Stroud	Berkeley Power Station (Cavendish Fluor)	14	988	Magnox – 494 Fluor - 177
Taunton Deane		2	4	
Tewkesbury		7	325	Horizon Nuclear Power – 233
Thornbury & Yate		4	467	Magnox - 327
		103	**6647**	

Appendix NES8 UK capabilities in Hydrogen and Fuel Cells

UK capabilities in Hydrogen and Fuel Cells from the EPSRC Research Atlases.

UK capability – Fuel Cells	Area	Market Potential
High	FC materials science and engineering	Global market
	Cell and stack engineering	Global market
	Fuel processing	Global market
	System engineering	Global market
	Selected balance of plant components	Global market
	Fuel cell manufacture	Global market
	Techno-economic modelling	Global market
Medium	System demonstration	UK application but a global market
	Control systems	Global market
	Power electronics	UK application but a global market
Low	Product trials	UK application but a global market

UK capability - Hydrogen	Area	Market Potential
High	Hydrogen Production (dark fermentation)	Global (medium/low impact)
	Materials for hydrogen storage	Global (high impact)
	Renewable Energy Systems	Global (high impact)
	Socio-economic analysis	Global (high impact)
Medium	Materials for hydrogen production	Global (high impact)
	Hydrogen production	Global (high impact)
	Hydrogen storage (devices)	Global (medium impact)
	Hydrogen distribution	UK application (low impact)
Low	Hydrogen infrastructure	UK application (high impact)
	Hydrogen systems	Global (high impact)
	Reversible fuel cells	Global (medium impact)

Appendix NES9 Project portfolio

Existing projects/facilities with expansion plans, where local funding is/could be available		
Large scale projects funded already under LEP LGF 1 or 2 (or Catapult, EPSRC etc), full bus case approved but yet to 'open'.		
Advanced Renewable Energy Centre, Berkeley	£4m	Approved under Growth Deal 1, as part of the further development of the Berkeley site, the University of Gloucestershire, in collaboration with South Gloucestershire and Stroud College, is developing the Centre. With a focus on renewable energy, the Centre will work with industry partners to co-deliver skills development, research and development of novel and niche product applications and innovations. It will cover energy management for domestic, community or business use, including retro-fitting of existing plant and purpose-built installations.
Oceansgate (Enterprise Zone) Phase 1 (Growth Deal 1, Heart of the South West)		Plymouth City Council led development to construct new office and industrial space for marine tech industries
Large scale projects put forward by LEPs under LGF3/ Devolution Deals or City Deal or ESIF but not yet funded/approved in full or with full bus cases developed.		
NUCLEATE – Nuclear Futures Innovation Centre (Growth Deal 3, West of England)	£30,000,000	The purpose of NUCLEATE is to provide the Nuclear innovation system access to state of the art facilities, technologies and specialist skills to support the development of a supply chain for an affordable nuclear future.
West of England Centre for Power and Energy	Up to £50,000,000	Discussions are underway with the West of England LEP to secure funding up to £50M
Cornwall Marine RD&I Hub (ERDF Cornwall & Isles of	£8,000,000	Creation of a Marine Technology R&D&I Hub delivering innovation within the marine technology smart

Scilly)		specialisation theme.
Marine Business Technology Centre ERDF Heart of the South West	£4,500,000	Support for marine and supply chain businesses to access and collaborate with all the HotSW knowledge base, (and more widely). It will establish a "Smart Sound" in-sea test facility by co-ordinating and (where market pull exists) filling gaps in the existing marine testing assets around the region
Huntspill Energy Park Enterprise Zone infrastructure Growth Deal 3 – Heart of the South West		A 635 acre brownfield site, to be developed for energy generation and mixed employment uses
Somerset Energy & Innovation Centre Phase 2 Growth Deal 3 – Heart of the South West		Physical space, generic and specialist business support services for high growth businesses wanting to relocate to Somerset in close proximity of Hinkley Point and other regional low carbon initiatives
Oceansgate Phase 2 Growth Deal 3 – Heart of the South West		Unlocking over 800 jobs and continue re-establishing Plymouth as a cutting-edge marine R & D centre
"Shifting Gear" Low Carbon programme (ESIF Bid)		The University of Gloucestershire proposes to build upon ARERC (above) to deliver the project which will: engage businesses in improving energy efficiency through diagnostic audits; deliver a business-to-business mentoring network; provide a development space in which low carbon technology businesses engage with up-to-date research and develop new technologies; and deliver opportunities to test new techniques/technologies.
New Energy Cornwall ESIF – Cornwall & Isles of Scilly stage 2 submitted	£3,000,000	This project aims to combine the best of Cornwall's existing local renewable energy and low carbon environmental good and services (LCEGS) activity and marry it with a more sophisticated 'Big Business' approach to energy supply and the development of local energy markets.

Large scale projects identified through the Audit discussion process		
COASTLab Phase 2		Integration of a unique wind simulation capability integrated with existing wave and current simulation.
Marine advanced manufacturing, testing and innovation Centre		Co-location of key elements of the engineering design, build, test review journey for marine renewables and marine tech developments
Oceansgate Business Technology Centre Dock Enabling		These onshore and offshore facilities will be the first of their kind in the UK and will link to other marine innovation facilities along the south coast. However, a programme of works needs to be undertaken before the dock can become operational again, including new tidal sill and radial gates
New Energy Systems Distributed Demonstrator		A national test bed for technologies, and business models (such as impact accelerators) across diverse geographies from core cities to peripheral rural areas
Simulation and Visualisation Centre		Collaborative and multi-disciplinary R&D facility with academic and industrial partners

Department for
Business, Energy
& Industrial Strategy

South West England and South East Wales Science and Innovation Audit

Annex I: Next Generation Microelectronics Theme Report

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

Annex I Next Generation Microelectronics Theme Report

1. Introduction

Next generation microelectronics are key enabling technologies which underpin multiple industries such as aerospace, automotive and information technology. Their application is so widespread that the European Semiconductor Industry Association has estimated that the impact of micro- and nano-electronics on the whole economy is worth 10% of the worldwide GDP and the European Commission has reported that photonics is essential to keeping >10% of the EU economy competitive[1].

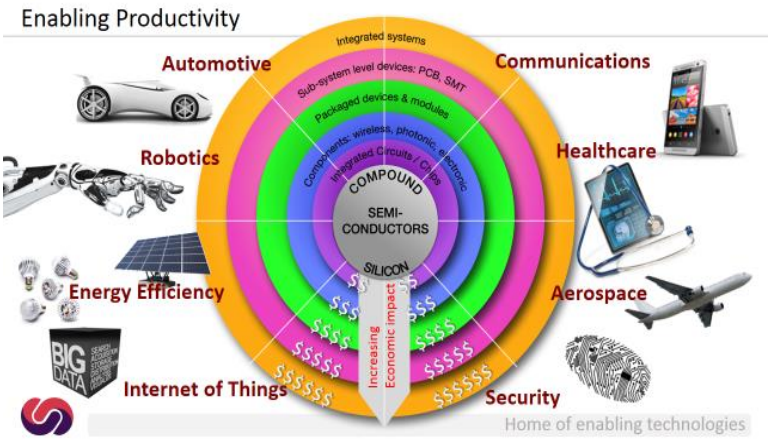


Figure NGM1 Industries underpinned by Next Generation Microelectronics

The South West England and South East Wales region has a long history of microelectronic, photonic and semiconductor companies as well as world-leading system integrators such as GE and BAE systems. The region is home to the largest silicon design cluster outside of the USA[2] and will shortly host the Compound Semiconductor Applications Catapult. The region's universities have a strong track record in relevant cutting edge research and have recently made significant investments in the areas of compound semiconductors and quantum technologies.

The economic importance of the sector is also widely acknowledged and forms a key component of the economic strategy of a number of the LEPs, including the West of England Skills Strategy and the Heart of the South West's Smart Specialisation Strategy. The latter emphasises that the electronics/photonics industry plays an important role both as a standalone sector and in supporting a number of other key sectors including Aerospace, Telecoms and Biomedical. Similarly, the Welsh Government is co-investing heavily in compound semiconductor R&D, supporting both commercial and higher education partners in our Audit region.

[1] The Leverage Effect of Photonics Technologies: The European Perspective, 2011, DG Information Society and Media SMART 2009/0066

[2] Silicon Southwest http://ubic.org.uk/siliconsouthwest/

2. Regional science and innovation assets

People and skills

Numerous studies[3][4] have identified the availability of a highly skilled workforce as being key to the development of the semiconductor industry in the South West England and South East Wales region. The region's involvement in this sector can be traced back to the beginning of the modern electronics industry in 1970s when companies such as Fairchild Semiconductor, Inmos, Nortel and Plessey Semiconductors established offices in Bristol, Swindon and Paignton. These large multinationals attracted highly skilled individuals to the area and created a local workforce with a broad range of technical and commercial skills. Some of these individuals then went on to create a new generation of innovative companies focussing on specialisations within the supply chain. This legacy of a highly trained workforce remains a key driver for attracting new companies such as Intel, Dolby and National Semiconductor to the area.

With the change of emphasis in the Microelectronic and Electronic Design sector away from fabrication towards fab-less design (due to the extreme high cost of building new deep-sub-micron foundries) the UK has become a centre for advanced design of electronic and optical circuits and systems, with the South-West being a particular hot-bed of this type of activity. The legacy of the large companies in the region has led to a significant numbers of smaller, design-oriented companies, with a vibrant and diverse range of applications from microprocessors, ASIC design to photonics, wireless and sensor integrated circuits. There are major opportunities for innovation in novel materials and advanced techniques outside the mainstream CMOS fabrication sector, in particular in wide band gap semiconductor (GaN and SiC) electronics as well as integration of MEMS and photonics with Si or SiGe electronic devices. These new methods are a key enabler of novel applications such as in integrated nano-photonics for the telecoms industry and for quantum technologies. Within the region there are well-developed plans to build a low cost, high throughput, open access compound semiconductor epitaxy foundry pilot line. The ambition is to create the foundations for Europe's 5th Semiconductor Cluster, and the World's first cluster dedicated to compound semiconductors. Simultaneously, multiple specialist manufactures continue to produce world leading products from the region leveraging knowledge intensive skills in fabrication as well as system and component integration for high value markets such as defence, aerospace and health.

Research facilities

The region has a large number of key assets for growing, processing and characterising electronic devices, see Appendix NGM2, including the following highlights:

- University of Bath's David Bullett Nanofabrication Laboratory which hosts the UK's Electron Beam Lithography Service[5].
- Cardiff University's Institute of Compound Semiconductor (£80M capital investment ongoing)
- Quantum Engineering Technology Labs - Bristol University
- University of Exeter's Savchenko Centre for Nanoscience

[3] Microelectronics and Photonics Cluster in the Heart of the South West Region, Harlin ltd, JR Lincoln, 2015

[4] Chips with Everything, NESTA, 2010, https://www.nesta.org.uk/sites/default/files/chips_with_everything.pdf

[5] http://www.bath.ac.uk/facilities/nanofab/electron/index.html

- University of West of England's Institute for Bio-Sensing Technology

Compound Semiconductor Applications Catapult
The UK Government recently announced that it would be investing £50M over 5 years[6] to establish the Compound Semiconductor Applications Catapult in South Wales. The Catapult will provide translational research facilities to accelerate the commercialisation of compound semiconductors in key applications such as: healthcare, the digital economy, energy, transport, defence and security, and space. The location of the Catapult in the region followed a thorough and detailed assessment by Innovate UK and reflects the scientific and innovation strengths within this area. The Catapult will be a cornerstone for establishing the compound semiconductor cluster.

Innovation assets
The region also has a number of key innovation assets:
- The Global #1 university business incubator - SETSquared Business Incubation Network.
- A regionally dispersed network of Science Parks and Innovation Centres - including Bristol and Bath Science Park (Emersons Green), Health & Wellbeing Innovation Centre (Truro), Poole Innovation Centre (Poole), Tremough Innovation Centre (Tremough), Winfrith Technology Centre (Winfrith), Tamar Science Park (Plymouth), Exeter Science Park (Exeter), Mendip Hub (Wells), Plymouth Science Park (Plymouth)
- Development of the £8M Electronics and Photonics Innovation Centre (EPIC) in Torbay[7]
- Compound Semiconductor Centre – a joint venture company between Cardiff University and IQE
- An active angel investors network (including South West Angel and Investor Network and Finance Wales)
- Innovation support for companies, Business West, Medilink SW, Academic Health Science Networks, Heath tech hub and IBST

3. Excellence in science and research
The science and engineering of next generation microelectronics and photonics spans a broad "stack" of activities that include theory, materials science, design and device architectures, manufacturing technologies and systems integration. The term microelectronics is a catch-all for many different approaches for acquiring, harnessing, controlling and manipulating information that is encoded digitally or quantum mechanically, however they all share in common a thread that is the miniaturisation of circuits and components to the micro and nano-scale on a substrate platform and subsequent integration into high value application specific systems – typically Silicon or Silica but increasingly Compound Semiconductor materials such as Gallium Nitride (GaN) and Silicon Carbide (SiC).

The region has science and technological research activities that align with each component of the "stack" but has particular strength in material science, semiconductor growth and fabrication, chip architecture and design, integration and the development of next generation technologies such as quantum computing. Of key importance are the

[6] https://www.gov.uk/government/news/chancellor-pledges-50m-for-ground-breaking-new-innovation-centre-in-wales
[7] http://www.torbaydevelopmentagency.co.uk/projects/regeneration/epic

specialisation toward non-CMOS technologies (in particular III-V materials research from foundations through to application in semiconductor fabrication); photonics (including the light-matter interaction through to fabrication of photonic integrated circuits) and quantum technologies. These hardware research activities are complimented by research into applications such as device verification, validation and high-performance computing architectures, low energy device design and other novel integrated circuit designs for sensors and communications technologies.

Regional Strengths are:

- Photonics – together with the highly innovative Torbay Photonics Cluster[8], which includes Spirent, Gooch & Housego and BB Photonics, the region has research excellence across its academic institutions. Leading researchers at Bath, Bristol and Exeter Universities are opening up the potential for unprecedented broadband speeds via novel Photonic Crystal Fibre, Teraherz Plasmonics, Photonic Integrated Circuits, Metamaterials and Graphene technologies.
- Wireless – The region has pioneered research in wireless communications technologies for over 3 decades, with the underlying protocols for WI-FI being developed at Bristol University, advances in wireless spectrum analysis for the policing of critical national infrastructure at Bath University and the first practical demonstrations of waveform engineering at Cardiff University. These advances have given rise to the LTE communications technologies that are ubiquitous today. This research expertise has been pivotal in attracting Toshiba Research Labs and other communications technology companies to the region[9].
- Sensors – research at Plymouth University have worked on the development of magneto-resistive sensors and a specialist security thread in banknotes which has been adopted by De La Rue, the world's largest commercial currency printer and papermaker, and provided quality assurance for over five billion banknotes worldwide. Another major strength within the region is the development of new sensor technologies for health applications which is underpinned by the Institute of Bio-Sensing Technology (IBST) - a joint collaboration between University of the West of England and Bristol University. The region has one of only two Internet of Things NHS test beds which will be used to evaluate sensor technology in the health sector, in particular the evaluation of glucose sensors and the microelectronic support platforms for the sensors. In this context, we highlight Schneider Electric's base in Plymouth.
- Compound Semiconductors – Cardiff University is making an £80M investment to establish the Institute of Compound Semiconductors as a focal point for research into GaN, III-V on Silicon and other photonic and electronic technologies. Bristol and Bath also have proven and unique expertise, with accompanying high performance facilities for compound semiconductor materials and device research.
- Quantum – The region has world class expertise in the field of Quantum Information and Communications technologies. The Universities of Bath, Bristol and Exeter are partners in the UK Quantum Technologies Hub network and have demonstrated leading approaches in Quantum Computing, Quantum Communications, Quantum Sensing and Measurement as well as the developments in the foundations of Quantum Information Science. This strength has attracted four global businesses (Boeing,

[8] http://tda-business.com/events-and-workshops/hi-tech-forum/
[9] http://techspark.co/cluster-map/

Airbus Group, BAE Systems and Raytheon)[10] to establish Quantum activities in the region as well as catalysing the formation of a number of Quantum Technology start-ups.

- Industrial R&D facilities – The region is also home to a number of industrial R&D centres for companies such as Cambridge Silicon Radio, Huawei and Airbus Innovation Works.

With the increased focused on design and novel materials, companies are increasingly looking towards universities to produce the next generation of highly skilled staff with the necessary technical and entrepreneurial expertise to drive the industry forward. The industry recruits from a wide range of academic disciplines but is particularly interested in graduates and post-graduates with degrees in physics, electrical engineering and computer science backgrounds.[11]

In terms of supply, the region has 4 university Physics departments (Bath, Bristol, Cardiff and Exeter) which submitted a total of 127 academics to the recent REF 2014 exercise (average overall GPA of 3.17). In 2014/15, the region produced 335 physics graduates, 15 postgraduates and 65 PhD students with the University of Bristol hosting three EPSRC Centres for Doctoral Training in Condensed Matter Physics, Functional Nano-Materials and Quantum Engineering; and the University of Exeter hosting the Centre for Doctoral Training in Metamaterials. These physics departments have an annual combined research expenditure of £23M with approximately half of the research being directly relevant to microelectronics theme.

The region has 7 Electronic and Electrical Engineering (E&EE) departments (Bath, Bristol, Cardiff, Plymouth, Exeter, UWE and University of South Wales) which produce 435 graduates, 175 postgraduates and 55 PhD students each year. The University of Bristol also hosts the EPSRC Centre for Doctoral Training in Communications Technologies. These departments submitted 205 staff to REF 2014 (overall GPA of 3.01) and had an annual research expenditure of £18M. Approximately a fifth of this research is of direct relevance to the theme with a particular strong focus on mobile communications, high frequency engineering, new electronic materials like GaN, photonics and photonic integration.

Increasingly, the industry is recruiting more software engineers as much of the new device functionality can be achieved through software innovation[12]. The region is home to 9 computer science departments (Bath, Bristol, Cardiff, Cardiff Metropolitan, Gloucestershire, Plymouth, Exeter, the University of the West of England and University of South Wales) and produces 840 graduate, 300 postgrads and 55 PhD students per year. These departments have an annual combined research expenditure of £12M with approximately half of the academics undertaking research of direct relevance to microelectronics theme.

Overall, the region has 220 academics across the complement of universities whose research interests are directly aligned to the next generation microelectronics theme. A

[10] http://www.airbusgroup.com/int/en/news-media/corporate-magazine/Forum-87/quantum-computing.html

[11] West of England Local Enterprise Partnership Workshop - Workshop F, Sector Skills & Competitiveness Statement Microelectronics

[12] International Technology Roadmap for Semiconductors, Executive Report 2.0, 2015

key-word analysis of the SciVal publication database highlighted 2,029 papers in peer reviewed journals for the period 2011-16 which was directly relevant to the theme. This represented 8-10% of the UK total publications in this area and were of a particularly high quality, with a higher field-weighted citation impact (2.08 vs 1.69) and more citations per publication (10.7 vs 7.9) than the UK average. Of particular note, 591 of the region's publications fell within the top 10% most cited publications worldwide.

The shortage of suitable skills has also been recognised as a regional priority, particularly by the Heart of the South West LEP, which is supporting the development of a £16M Hi-tech Skills Training Centre based in South Devon College[13]. This Centre will provide tailored education and training to meet the needs of hi-tech industries, from design of components through developing firmware and computer coding to testing and verification of components, and the forms a key component of the emerging Torbay Photonics Cluster.

4. Innovation strengths and growth points

Business Environment

There has been considerable consolidation within the microelectronics industry in the past 15 years as volume production has shifted to Asia. This has been driven by the increasingly high cost of building new fabrication plants (e.g. 2015 $23bn estimated cost of Samsung's new plant[14]) and resulted in the development of a 'fabless' business model whereby the actual manufacturing of the chips is subcontracted to a 3rd party. This development has led to a much more fragmented industry and enabled companies and clusters to emerge which focus on a particular specialisation within the value chain such as chip design, device packaging and integration.

The region has a number of next generation microelectronics companies across the entire value chain. The industry is highly international with many regional companies fully integrated into global supply chains with high levels of export. The industry is particularly innovative and under constant pressure to deliver products which are 'smaller, faster and cheaper'. This reduced time to market and increasing pressure to qualify products and processes in advance of full scale manufacture (1st to Production) provides a major challenge for the UK microelectronics industry. The flip side is a major opportunity to extract more value from the supply chain maximising the market advantages realised by exploiting novel component technology within locally clustered system integrators.

The region's expertise can be clustered into three distinct but overlapping sectors.

Cluster	Scope	Key Companies
Microprocessor and Communications Chip Design	Microprocessor and signal processing chips, software, design tools and associated technologies.	Plessey, MIcrosemi, Intel Design Centre (formerly Picochip) Bath, CICO small cell R&D centre Swindon (formerly Ubiquisys), Imagination Technologies, XMOS, Blu Wireless

[13] http://www.southdevon.ac.uk/college-news/3064-college-announces-future-vision
[14] http://www.kitguru.net/components/memory/anton-shilov/samsung-to-use-worlds-largest-15-billion-fab-to-produce-dram-report/

Semiconductors	Design, fabrication, test / qualification & packaging of semiconductor devices.	Plessey. Infineon Fabrication Plant Newport, Plessey Fabrication Plant Plymouth, IQE Compound Semiconductor Facility Cardiff, Compound Semiconductor Applications Catapult (S Wales), Dialog Semiconductors, BAE Systems MEMS Fab Bristol
Photonics	Design, prototyping, fabrication, test / qualification & packaging of photonic devices	Specialist companies including Gooch and Housego, Oclaro, II-VI Laser Enterprise, Plessey Semiconductors, EFFECT Photonics, Bay Photonics, Venture Photonics.

The region is home to around 685[15] microelectronics companies with particular concentrations around Bath, Bristol, Cardiff, Exeter, Plymouth and Torbay see figure NGM2. These companies have a combined turnover in excess of £1.6Bn and employ 8400 people across the region[16]. Such employment is particularly important as the wages within the sector are substantially higher than the regional average.

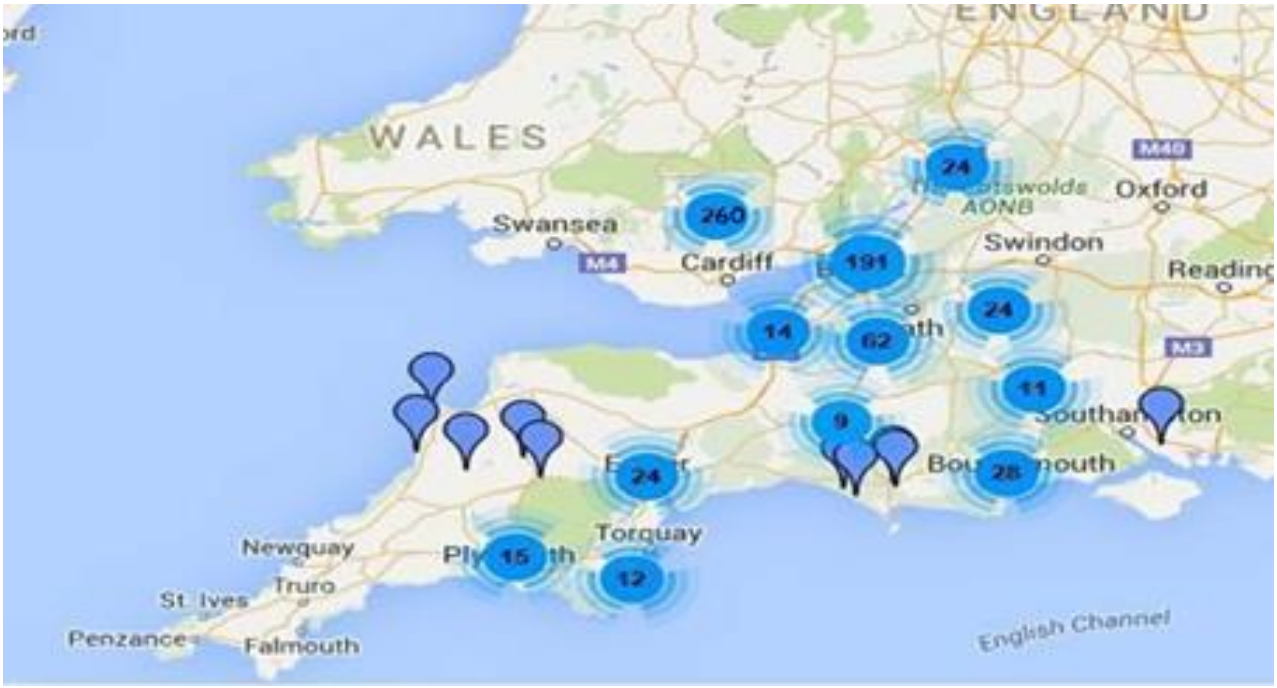


Figure NGM2 Location of microelectronics companies (no data for Cornwall).

[15] Evidence based on iNET list of 425 companies + EstNet 260 companies
[16] http://techspark.co/cluster-map/

Systems integration
As well as individual components, the region is also home to a number of world-leading prime system integrators such as General Dynamics, Airbus, Rolls-Royce, Boeing Defence UK and BAE Systems. These systems integrators bring together various components and sub-systems to provide the technological solutions that drive advances in defence, aerospace, healthcare, Internet of Everything, robotics and many other areas.

Key clusters
The region has established a number of clusters which support the microelectronic industries including:

- Silicon South West
- Torbay High Tech Forum
- Electronic and Software Technologies Network for Wales

These clusters provide advice, innovation support, networking opportunities and seed funding to promising electronic companies. Such clusters provide direct support to the industry and have proven to be very successful - iNets South West (which was funded 2009-2015), for example, supported over 400 companies and resulted in 426 new jobs, 362 new products and £14.3m GVA[17]. However, many such clusters are dependent on external funding and have a very localised remit which hampers collaboration across the entire region.

Innovation support
The region has a strong track record of entrepreneurship which has been supported by dedicated university incubators such as the Set Squared Partnership which was recently ranked as the global number 1 university business incubator by UBI Global[18] having raised over £1bn investment into businesses[19].

The region has invested in a number of science parks including the development of a new £8m Electronics and Photonics Innovation Centre (EPIC) in Torbay which will focus on, collaboration between academia and industry, commercialising R&D, enabling knowledge transfer and accelerating innovation, prototyping and product development. This relatively small cluster is highly innovative and has been awarded 3 Queen's awards this year, including an innovation award for Gooch and Housego development of a new fibre optic control technology, and home to the fastest growing company on the Silicon Valley 150 index, Oclaro.

5. National and international engagement
The next generation microelectronics industry is highly international with supply chains spanning many different countries and companies. UK photonics companies, for example, will typically export >75% of their output.

The analysis showed that the region's academics are well connected as 59% of these publications included at least one international author. The countries that the region's scientists frequently collaborate with most frequently are the US followed by Germany, France, China and Italy. The region also collaborates with leading universities such as Cornell University, Massachusetts Institute of Technology and CERN.

[17] PACEC - Evaluation of Microelectronics iNet, July 2015
[18] http://ubi-global.com/research/ranking/rankings-2015/#globalubi2015
[19] http://www.setsquared.co.uk/global-1-university-business-incubator

In addition to academic collaboration, the region's universities also have a higher than average level of engagement with industrial partners (4.3% vs 2.9%). This includes joint publications with companies as diverse as Toshiba, IBM, Airbus and General Electric.

The region's universities are engaged with major UK science initiatives and are involved in 3 out of 4 of the EPSRC's recent £120M Quantum Hubs initiative. They are also involved in 2 of the 3 Quantum Technologies Training Hubs and host the UK's only dedicated quantum training centre for Post-Doctoral researchers - the Quantum Technologies Enterprise Centre. The University of Bristol also hosts the UK centre for Quantum Photonic Integrated Circuit Fabrication.

The region's universities are also very engaged with the skills agenda with 4 of the 18 UK Electronic Skills Foundation partner universities being based in the region.

6. Developments in science and technology – international markets and opportunities

Microelectronics are enabling technologies which drive innovation across a number of key market sectors such as automotive, aerospace, ICT etc. Within the microelectronics industry itself there are a number of key technological and commercial developments which present a major opportunity for the region.

Photonics

Photonics technologies are increasingly being used in smartphones, laptops, the Internet, lighting and medical devices. Their disruptive potential is becoming increasingly apparent given their ability to overcome a wide range of barriers inherent with present technologies. Some have even suggested that the 21st century will depend as much on photonic technologies as the 20th century depended on electronics. The overall global market for photonic technologies is huge (~ £250Bn) and is expected to continue to grow at an annual growth rate of 8-10%[20]. The economic importance of photonics has even been recognised by the EU which have identified them as one of their 6 key enabling technologies[21].

Photonic technologies are set to have a major impact in the areas of lighting, optical data communications, laser manufacturing and biophotonics. In future, further developments in nanophotonics, quantum information and extreme light sources are expected to be even more disruptive and lead to new application areas and markets.

The commercial availability of high power, high efficiency LEDs has led to their rapid mass adoption for lighting applications and is driving demand for higher efficiencies through techniques such as nano-patterning, multi-level structures and thermal substrate matching. The market for LED lighting technologies is continuing to grow and is expected to reach £55Bn by 2020[22]. The region is particularly well placed to take advantage of this growth as Plessey (based in Plymouth) have developed a novel technology to exploit the cost benefit of using standard Silicon substrates on which the GaN layer is grown. By utilising the inherent advantages of a large wafer scale silicon based approach, Plessey is able to

[20] Photonics: A Key Enabling Technology for Europe, http://tinyurl.com/hyctqbb
[21] https://ec.europa.eu/growth/industry/key-enabling-technologies_en
[22] Towards 2020 – Photonics driving economic growth in Europe Multiannual Strategic Roadmap 2014 – 2020

exploit advanced packaging technology from the silicon industry and is bringing to the market novel LED products that will enable high performance cost effective solutions.

Photonics technologies will also be required to underpin the communications revolution and will find increasing use as low-cost high efficiency interconnects. In telecommunications, trends such as video consumption, cloud storage, network virtualisation have driven an exponential growth in data transfer. This places increased pressure on the “backbone network” and a drive towards the deployment of advanced all-optical switching (to avoid the inefficiencies and bottlenecks of conversion and switching back and forth to the electrical / copper connection domain.). Novel photonic technologies will be increasingly required to cope with the ever-increasing demands for capacity, especially in the backbone networks, for which a transmission capacity of several times 100 Tbps per fibre is predicted by 2020.

The data rate increase is also driving the need for inclusion of optical interface components and optical processing components together with traditional microelectronic components all on a single chip. E.g. 1Tbps software-defined transceivers (array transmitters and receivers with integrated RF electronics) achieving 3x throughput of conventional systems). The trend is driving research into multi-layer optical PCBs, 3D integrated devices, active optical cables and optical backplanes.[23]

Photonics will be used to solve the bandwidth limitation of data interconnects at rack, board and chip level. A major challenge for the coming years will be the development of high-bandwidth, low energy consumption optical interconnects at low cost. The demand for more energy efficient ways of computing and moving data is particularly important for data centres which already use a significant fraction of the UK’s total electricity consumption in 2015. New services such as cloud computing continue to drive this trend and will require significant improvements in the network architecture and high-speed (fibre-based) access to meet customer demand.

Another important use of photonic technologies is the transfer of high powered light along Hollow Core Photonic Crystal Fibres which allows energy to be transferred along a flexible connection from a laser to a cutting head. This technology is increasingly revolutionising many manufacturing process and has applications in cutting, shaping and sintered metal powder based additive manufacturing. Such developments are driving research into high brilliance / high power lasers, tunable lasers, novel laser array and beam steering techniques.

Wireless

The wireless market covers electronic devices that communicate wirelessly such as mobile phones, smartphones, mobile networks, WiFi, smart metering, satellite navigation, and a plethora of other connected devices. The wireless communications market has grown rapidly in recent years reflecting the increased adoption of wireless technology, coupled with the need for an increased compound semiconductor content to support greater sophistication of mobile devices.

The ever increasing flow of information across the internet and increased use of internet enabled devices across the globe will drive the demand for the next generation of wireless technologies. The trend for all devices to become connected and the near exponential

[23] Towards 2020 – Photonics driving economic growth in Europe Multiannual Strategic Roadmap 2014 – 2020

rate in mobile data consumption driven by increasing direct video content, improved formats such as 4K and 8K video, new services and content are driving the wireless sector research in multiple fields including emerging technologies such as Software Defined Networking (SDN), Network Functions Virtualization (NFV), Mobile Edge Computing (MEC) and Fog Computing (FC) to achieve the required performance, scalability and agility[24].

New technologies will require supporting higher operating frequencies, increased spectral efficiency, latency reduction, higher energy efficiency, complex legacy co-existence scenarios, increased data rate, spectrum aggregation, interference cancellation and new modes of communication. New techniques such as Massive MIMO, new waveforms, Joint cell processing, beam steering and increased frequencies operation from VHF (~100 MHz) to Millimetric Microwave (~30 GHz) are being developed as part of the Long Term Evolution (LTE) / 4G, LTE- Advanced and 5G programmes.

Supporting the diverse services envisaged for LTE/LTE-A/5G and the Internet of Things is proving to be challenging for all aspects of mobile devices, network topologies and core network elements. It requires techniques to be developed to ensure user experience continuity in challenging situations such as high mobility (e.g. in trains), very dense or sparsely populated areas (e.g. satellite access), and journeys covered by heterogeneous technologies. In addition, wireless will be a key enabler for the Internet of Things by providing a platform to connect a massive number of sensors, rendering devices and actuators with stringent energy and transmission constraints. It has been predicted that the Internet of Everything will see 50 billion connected devices by 2020 and this will place unprecedented demand on the LTE, 4G, 5G and the evolution of WiFi.

Sensors

The global market for sensors is expected to reach $154.4bn by 2020, and is demonstrating a compound annual growth rate of 10.1% over the five-year period from 2015 through 2020*[25].

The development of smaller more energy efficient sensors which can monitor external factors (such as temperature, air flow, speed, exhaust gas content sensing within an internal combustion engine) are enabling electronic systems to interact with the real world. The development of such “smart” systems are becoming increasingly important for IoT, Smart Building, Smart City wide area applications and digital manufacturing. Microelectronics companies are increasingly incorporating micro-scale sensors onto microchips to drastically reduce the costs and power requirements thus enabling electronic devices to better engage with the outside world. For example, Renishaw (based within the region) has integrated a Laser interferometry onto a micro-chip to provide a low-cost device which was capable of measuring dimensions to the accuracy of a few parts per million in a non-contact manner.

Sensor technologies are already widely used in smartphones with the number of sensors per mobile expected to rise from 15 today to 22 by 2029[26]. Such sensors will include

[24] 3GPP Work Items for 5G , https://5g-ppp.eu/wp-content/uploads/2015/02/5G-Vision-Brochure-v1.pdf

[25] http://www.bccresearch.com/market-research/instrumentation-and-sensors/sensors-ias006f.html)

[26] International Technology Roadmap for Semiconductors, Executive Report 2.0, 2015

MEMS accelerometers for tilt, movement, inertial positioning; acoustic transducers for voice and audio applications; pressure sensors for barometric altitude; finger print sensors; touch screens, light level sensors; and camera components. The development of low cost, reliable sensors includes research into wide bandgap semiconductors, devices for medical applications, wearable/ implantable systems, novel materials, nanotechnology, biosensing and chemical sensing techniques.

Sensors are also increasingly been used in manufactured items with the number of sensor on cars expected to increase from 100 to 200. Sensor technologies will also play an increasingly important role in the aviation industry with Airbus planning to equip future aircraft with over 10,000 sensors per wing producing over 7.5Tb of data per day. Such technologies will also drive new applications such as wearables (for fitness and health monitoring purposes) or smart building monitoring and will require the integration of multiple low power sensors into miniature packages capable of being powered for long periods with small batteries, super-capacitors or through energy harvesting.

One of the fastest growing applications for sensors are as medical diagnostics and this market is expected to reach $22.68Bn by 2020. In particular, photonic and sensor technologies are increasingly being used to provide low cost point of care screening methods. Novel biosensors, including devices with nano-crystalline semiconductor substrates, optically active nano-materials and Micro-Engineered Mechanical Systems (MEMS) will also be required to address the expanding markets for environmental and health monitoring.

Semiconductors

The overall global market for semiconductors is £230Bn and expected to grow by 4% over the next two years. Within this, the market for compound semiconductors is currently worth around £23Bn but has an anticipated growth rate of 17.3%[27].

The development of lower power, higher performance and an increasing number of transistors has dominated semiconductor technology over the past few decades. Semiconductor development have been characterised by “Moore’s law” where the number of transistors on a microprocessor chip will double every two years. As top-of-the-line microprocessors currently have circuit features that are around 14 nanometres across, smaller than most viruses, the industry is running out of later space. Although there may be still be potential to extend in 3D and increased the integration of memory and micro processing chips, the increased use of mobile devices and more embedded devices in placing a new emphasis on low power.

Another key challenge for the industry is the increased integration of micro-scale elements such as power transistors and electo-mechanical switches directly onto the chip (see previous Sensors section). These so called “More than Moore” technologies will substantial reduce the cost and power requirements of integrated circuits thus enabling developments such as the Internet of Things[28].

Another key development is the increase use of the remarkable capabilities (light emission, speed etc.) of compound semiconductors. To date, the compound

[27] http://www.bccresearch.com/

[28] EC Strategy micro and nano electronic components and systems, http://tinyurl.com/h5cs634

semiconductors have been grown on small area native substrates using bespoke device fabrication purposes. By contract the success of Si electronics have been due to a foundry approach, where devices are created using common fabrication processes on large area substrates. The growth of compound semiconductors on Si substrates and the subsequent use of standardise foundry process on 200mm+ wafers will substantially reduce cost and enable development such as the “Internet of Everything”

7. Conclusions

The microelectronics sector is of vital importance to the region but will only prosper if there is a continual flow of highly qualified individuals with the right blend of technical and commercial skills. In particular, there is a shortage of graduates and PhD students in those emerging key technologies, such as quantum technologies and compound semiconductors, which will underpin the next generation microelectronic devices. Such continued investment in people and skills will be essential to ensure that the region remains competitive in such a global industry. A key focus for future sustainability of the sector will be to ensure that there is a supply of postgraduate qualified R&D staff via PhD level training initiatives.

The microelectronic industry is particularly innovative and continues to develop technologies that will transform established market sectors such as automotive, health and the Internet of Things. Such rapid technological achievements can only be sustained if there is continued investment in the underlying research base and enhanced incentives for private sector investment. The region’s universities already have a strong track record of world leading research and working closely with industry partners. The private sector also requires increased support to compete on a global scale such as additional incentives to undertake the necessary product and process qualification and verification prior to large scale production. Such late stage developments are often unsupported by funding bodies but are a critical stage in translating promising research to manufactured product. The recent announcement of the Compound Semiconductor Applications Catapult is very much welcome and addresses both the regional strength in this area but also the global opportunity for this market for UK plc.

Finally, microelectronics is a highly globalised industry but still benefits from local interactions. The region has previously benefited from establishing clusters such as iNets and Silicon South West but both were dependant on external funding and were unable to continue the scale of activity required without external funding. Our Audit has clearly identified a need for a sustained funding model which can support effective networking across the region.

Appendices

Appendix NGM1 Underpinning of other SIA Themes by Next Generation Microelectronics

	Aerospace and Advanced Engineering	New Energy Systems	Digital Living	Digital Living – Digital Health
Photonics	Lighting, high speed inter component comms, 3D scanning, metrology, laser powered manufacturing (additive and subtractive), photonic integrated circuits, sensors, Non destructive testing.	Efficient LED lighting, optical power transfer, efficient Solar cells.	Internet Petabit communications backbone, All optical switching, optical short range communications, RF over fibre, virtualisation, fibre to the premises, optical backplane connectivity, OLED display technology	Minimally invasive sensing (biophotonic sensing, fibre raman spectroscopy), enabler for additive/subtractive custom implants and orthotics
Wireless	Communications capability, situational awareness,	Intelligent built environments, responsive load balancing, dynamic tariffs, dynamic energy market.	Higher bandwidth support through LTE evolution, 5G, Integrated IoT connectivity, software defined radios	Wellness monitoring, fitness tracking and pervasive diagnostics. Electronic patient records.
Sensors	Engine optimisation, navigation, autonomous operation (collision avoidance, obstruction detection)	Intelligent grid, smart environment (Occupancy, predictive environment control.)	Integrated IoT sensors, context sensitive services, improved interaction methods	Diagnostics, implantable devices, smart home care / telecare environments. Wearable sensors.

Semiconductors	Size, cost and power reduction, processing power increase for autonomous operation, machine vision, machine learning, high efficiency motors and switching components.	Efficient LED lighting and power controllers, high efficiency solar cell inverters, low power IT equipment,	Size, cost and power reduction, processing power increase to enable advanced applications VR, 360 degree video, natural language recognition, smaller and lighter portable devices, inference deduction, large data, processing power and algorithms for network virtualisation and signal processing to support 5G data rates,	Low cost / disposable medical sensors, lab on a chip diagnostics devices, low power devices for medical implants, pervasive monitoring.

Appendix NGM2 List of Assets

Asset	Location	Host/Lead	Descriptor
Centre for Quantum Photonics	Bristol	University of Bristol	The Centre encompasses over 100 staff and undertakes research into Quantum Communication and Networks, Quantum Sensing and Metrology, Quantum Information and computation.
Quantum Sensing and Imaging Hub	UK	University of Bristol	Aims to build ultrasensitive light detectors for a range of applications including medical imaging, security monitoring and manufacturing, led by the University of Glasgow
Quantum Communications Hub	UK	University of Bristol	Aims to create quantum-encryption systems for secure communications that can be widely and cheaply deployed, led by the University of York
Communication Systems & Networks Research Group	Bristol	University of Bristol	The Communication Systems & Networks Research Group aims to address the research demands of the fixed and wireless communication sectors. It performs fundamental academic research with strong levels of industrial application.
Centre for Doctoral Training in Communications	Bristol	University of Bristol	The Centre for Doctoral Training in Communications offers an integrated, cohort-driven environment in which to undertake world-leading research and provides a coherent advanced training network for the communications community nationally, and develops the skilled and entrepreneurial engineers needed to underpin the future of the industry.
Microelectronics Research Group	Bristol	University of Bristol	The Bristol Microelectronics Research Group is a team of world-leading academic experts in computer architecture, design verification, fault tolerance, reconfigurable technologies and high performance computing.
Quantum Engineering Technology Labs	Bristol	University of Bristol	QET Labs is a global centre for research, development and entrepreneurship in the emerging quantum technology industry and is an international node for collaboration with industrial and academic world leaders, and the EPSRC UK Quantum Technology Hub Network. It hosts the EPSRC funded CDT in Quantum Engineering, Quantum

			Technologies Enterprise Centre and QuPIC quantum fabrication service.
Centre for Device Thermography and Reliability	Bristol	University of Bristol	The CDTR is a world-leading center focused on improving the reliability of novel semiconductor devices, circuits and packaging. Since 2001 the group have been applying key technologies developed in Bristol for thermal and reliability research of semiconductor devices, in particular for microwave and power electronic devices.
Electron Microscopy Group	Bristol	University of Bristol	Analytical facilities include energy dispersive X-ray microanalysis (EDX), electron energy loss spectroscopy (EELS) and cathodoluminescence (CL). Much of our current work is on semiconductors, including the wide band gap semiconductors gallium nitride (GaN), silicon carbide (SiC) and diamond.
High Performance Networks	Bristol	University of Bristol	High Performance Networks group (HPN) led by Professor Dimitra Simeonidou specialises in the application of advanced hardware and software technologies, targeting future optical communication networks for data centers, cloud based applications and distributed technologies etc.
Bristol Centre for Functional Nano Materials	Bristol	University of Bristol	BCFN Centre for Doctoral Training is a World-leading interdisciplinary training centre for PhD and MSc in Functional Nanomaterials funded by EPSRC.
Photonics Group			The Photonics group is pursuing world leading research topics for affordable and faster information and communication technologies and sensors to revolutionise healthcare and new methods of harvesting renewable energy.
Biomedical Physics research group	Exeter	University of Exeter	The group has extensive expertise in magnetic and photonics imaging for medical applications including next generation based diagnostic techniques
Electromagnetic and Acoustic Materials group	Exeter	University of Exeter	This group explores the fundamental interaction of light (from X-ray to microwave) with matter and how this can be manipulated with synthetic metamaterials and at nanometre scales

			with plasmonic materials.
Quantum Systems and Nanomaterials	Exeter	University of Exeter	The Quantum Systems and Nanomaterials Group has a wide range of cutting edge nanofabrication facilities used to research the physical properties of materials at the nano-scale including quantum effects.
EPSRC Centre for Doctoral Training in Metamaterials	Exeter	University of Exeter	The CDT is a key UK investment in training for this cutting edge new technology.
Centre for Graphene Science	Exeter / Bath	Universities of Exeter and Bath	The Centre for Graphene Science brings together the Universities of Exeter and Bath in internationally leading research in graphene and aims to bridge gap between science and industrial applications.
Semiconductor Physics Group	Exeter	University of Exeter	This group is concerned with both the experimental and theoretical properties of semiconductors.
Savchenko Centre for Nanoscience	Exeter	University of Exeter	
Centre for Photonics and Photonic Material	Bath	University of Bath	The Centre for Photonics and Photonic Materials perform research across a range of topics to extend a deeper understanding of photonics, photonic materials and photonic devices into applications
Centre for Advanced Sensor Technologies	Bath	University of Bath	The Centre for Advanced Sensor Technologies brings together expertise in microelectronics, optoelectronics and novel materials. The Centre's interdisciplinary research focuses on highly accurate sensors, devices and related technologies
David Bullett Nanofabrication Facility	Bath	University of Bath	The Nanofabrication Facility comprises a range of equipment within a suite of cleanrooms of ISO Class 6. Photo- and nano- lithography is combined with etching and deposition to create structures for the fundamental studies of the electronic, magnetic and optical properties of materials, as well as devices such as Hall sensors or Light Emitting Diodes (LEDs). £1.5m planned upgrades to infrastructure will provide additional capability in

			Electron Beam Lithography, Focused Ion Beam, and electron microscopy, underpinning many of the technologies described in this report and increasing the facility's industrial engagement.
Centre for Advanced Engineering Systems and Interactions	Plymouth	University of Plymouth	The research Centre for Advanced Engineering Systems and Interactions conducts research across a wide range of engineering subject areas and has expertise relevant to those developing electronic and photonic systems for the marine environment and with in-depth understanding of requirements of the marine sector e.g. in structural monitoring where photonics is increasingly being deployed
Centre for High Frequency Engineering	Cardiff	Cardiff University	The Centre for High Frequency Engineering is internationally renowned in the fields of non-linear measurement systems, device characterisation, and circuit design.
Institute for Compound Semiconductors	Cardiff	Cardiff University	The Institute for Compound Semiconductors is a major £80M investment aimed at positioning Cardiff as the European leader in compound semiconductors. The Institute has cutting-edge facilities and works closely with industry to develop academic research to a point where it can be introduced reliably and quickly into the production environment.
Compound Semiconductor Centre	Cardiff	Cardiff University	The Compound Semiconductor Centre (CSC) is Europe's new home for product, services and skills development in compound semiconductor technologies. Providing cutting-edge facilities that help researchers and industry work together CSC, based in Wales, will position Cardiff as the UK and European leader in compound semiconductors. CSC is a joint venture between compound semiconductor specialists IQE and Cardiff University.
Bio-Photonics & Quantum Optoelectronics Group	Cardiff	Cardiff University	The Bio-Photonics & Quantum Optoelectronics Group undertake research at the interface between life and physical sciences. The group has developed novel microscopy methods for studying biological systems.

Institute of Bio sensing	Bristol	University of West of England	The Institute of Bio-Sensing Technology is a collaborative venture with research groups from universities across the south west and elsewhere and aims to develop novel technologies for the detection and measurement of biological systems as well as the integration of biological systems into novel sensing technologies

Appendix NGM3 Research Excellence Framework 2014 (REF) data

The main units of assessment for the Next Generation Microelectronics theme are shown below. Not all institutions within relevant departments submitted a return to the relevant UoA.

UoA		Submitted staff associated with theme	No of Institutions	UoA overall profile (% 3 or 4*)
9.	Physics	59	4	91.3%
11.	Computer Science	49	6	69.5%
13	Electrical and Electronic Engineering	14	2	78%
15.	General Engineering	55	6	79.8%

Appendix NGM4 Publication data

The region has identified 220 academics whose research interests are directly aligned to the next generation microelectronics theme. To capture the academic output of the region, a key word analysis was performed of the SciVal database using the following keywords: photonics, semiconductors, microelectronics, optoelectronics, gallium nitride and sensors.

	Keyword dataset
Scholarly Output (publications)	2029
Field-Weighted Citation Impact	2.08
Citations per publication	10.7
Outputs in Top Percentiles (Publications in top 10% most cited worldwide) %	29
International Collaboration % (Publications co-authored with researchers in other countries)	59
Academic-Corporate Collaboration % (Publications with both academic and corporate affiliations)	4.3

Academic-Corporate collaborations

In terms of collaboration with corporate partners, the following companies and organisations had the most publications:

Company	Number of publications
Toshiba	16
IBM	13
Airbus Group	7
General Electric	5
Nokia	5
U.S. Army Research Laboratory	5
Hitachi	4
IBM Zurich Research Laboratory	4
Intel	3
Nippon Telegraph & Telephone	3
QinetiQ	3

Appendix NGM5 Income data

HESA funder type		Total research income as related to theme (£k)						
		2008/09	**2009/10**	**2010/11**	**2011/12**	**2012/13**	**2013/14**	**2014/15**
BIS Research Councils, Royal Society, British Academy and Royal Society of Edinburgh	1	8,330	10,021	10,184	11,278	10,615	13,566	18,311
UK-based charities (open competitive process)	2	398	212	332	302	689	1,041	1,372
UK-based charities (other)	3	36	30	1	37	54	15	6
UK central government bodies, local authorities, health and hospital authorities	4	1,322	1,074	894	1,082	2,146	1,983	1,859
UK industry, commerce and public corporations	5	1,065	1,136	1,456	1,338	1,303	1,372	1,417
EU government bodies	6	1,427	2,370	2,651	4,483	4,618	5,988	6,723
EU-based charities (open competitive process)	7	58	20	66	166	3	73	33
EU industry, commerce and public corporations	8	332	232	648	30	32	149	45
EU other	9	1,143	1,396	1,114	1,462	1,366	1,561	1,932
Non-EU based charities (open competitive process)	10	99	126	128	132	78	136	198
Non-EU industry, commerce and public corporations	11	263	303	404	312	336	617	659
Non-EU other	12	11	46	267	329	272	249	260
Other sources	13	9	60	118	404	137	104	177
		14,494	**17,027**	**18,264**	**21,356**	**21,648**	**26,855**	**32,990**

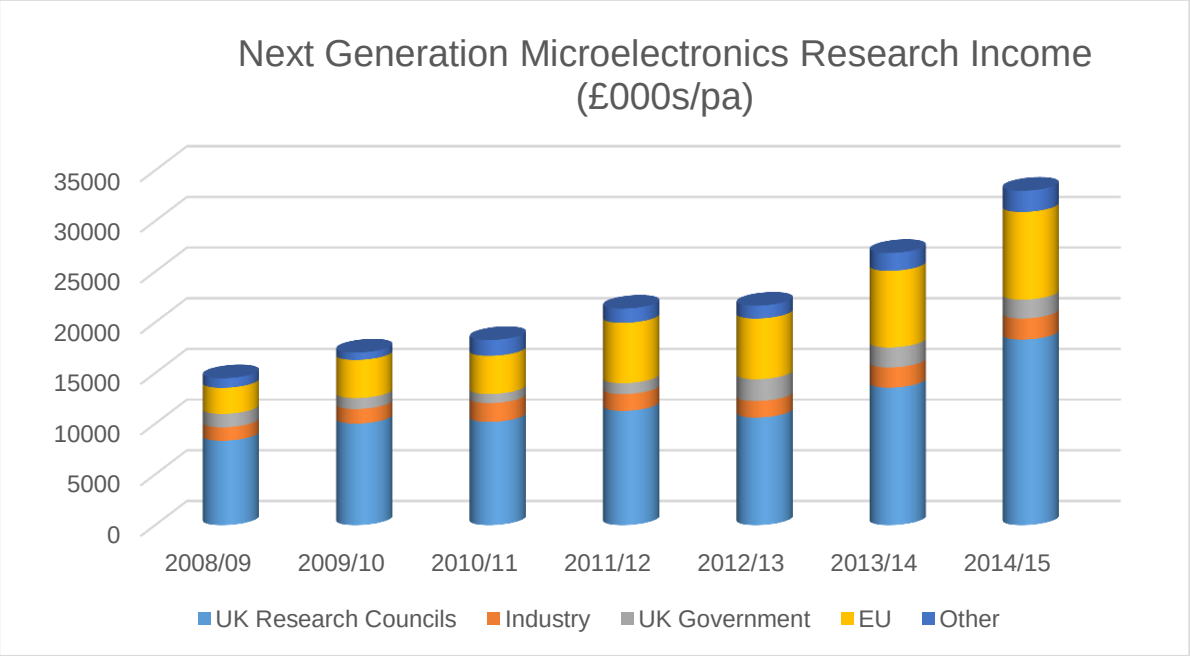


Figure NGM3 Research Income 2008-2015

Appendix NGM6 Major Companies in Theme

Company: II-VI Laser Enterprises
Location: Paignton
Description: VI Laser Enterprise is an industry-leading manufacturer of high-power semiconductor laser components enabling fibre and direct diode laser systems for material processing, medical, consumer and printing applications. In addition, II-VI Laser Enterprise manufactures pump lasers for optical amplifiers for both terrestrial and submarine applications and vertical cavity surface emitting lasers (VCSELs) for optical navigation, optical interconnects and optical sensing applications.

Company: Airbus Defence & Space Ltd., Location: Bristol, Newport
Description: Europe's No. 1 defence and space supplier with business sectors spanning Military Aircraft, Space Systems, Communications, Intelligence and Security. Annual revenues for the group exceed €14Bn. The Newport site specialises in secure information services, cyber solutions and the security of critical infrastructure in the UK, which includes cyber security for Parliament and for 90% of Ministry of Defence networks

Company: Cisco; Location: Swindon
Description: Cisco (NASDAQ:CSCO) the San Francisco based multinational IT company with 71,000 employees and $49Bn turnover acquired the small cell/femtocell experts Ubiquisys in 2013 and undertake small cell development in their Swindon location.

Company: DELTA Microelectronics Ltd., Location: Hengoed
Description: DELTA Microelectronics is part of the DELTA (Danish Electronics, Light and Acoustics) group with €42M turn-over earned from activities in development, test, certification, and advice to all phases of product development including electronics, microelectronics, software technology, optics and light technology, acoustic and vibration technology, and sensor systems

Company: General Dynamics UK Ltd., Location
Description: General Dynamics UK, part of the global defence and aerospace company General Dynamics Group (NYSE:GD) whose turn over exceeds $30Bn. General Dynamics UK is a defence contractor employing 550 people at its South Wales site into which it has invested £12M to become the UK Armoured Fighting Vehicle Centre of Excellence and a unique capability for the integration and digitisation of MoD's 16,000 vehicle fleet. The group also specialises in avionics equipment for fixed and rotary wing aircraft, mission and video management systems, communications and systems integration. It has contributed >£4.5Bn to UK economy since 2001.

Company: Gooch and Housego, Torquay and Ilminster
Description (FTSE AIM: GHH) Gooch & Housego is a UK based global leader in photonics technology with expertise from R&D to volume manufacturing with £78M turnover. It supplies innovation and manufacturing in the aerospace & defence, industrial, life sciences and scientific research sectors from 8 manufacturing sites worldwide, 2 of which are in the SIA region.

Company: Huawei; Location: Bristol
Description: Huawei is a major global ICT company headquartered in China. Its global turnover exceeds $60Bn US and employs 170,000 people. Of these 1,100 people are employed at 15 offices across the UK from where it has contributed £950M to UK GDP since 2012. In 2014 it opened a new £125M R&D centre in Bristol. The group is planning to invest £650M in the UK by 2017.

Company: Imagination Technologies Ltd., Location: Bristol, Chepstow
Description: The group employs 1,700 people in 15 countries and creates processor solutions for graphics, video and vision processing, general purpose and embedded processing and communications chip designs for consumer electronics. It has design centres in Chepstow and Bristol where they develop graphics processor technology. The group ships over £1Bn units a year and had revenues of £177M in 2015.

Company: Infineon Technologies, Location: Newport, Bristol
Description: Infineon designs and manufactures semiconductor devices for consumer, industrial and automotive use. The global business with a €6Bn turnover employs over 35,000 staff. Production is undertaken at 19 locations including its Newport fabrication plant and R&D is undertaken across 34 locations including Bristol.

Company: Intel, Location: Swindon, Bath and Bristol
Description: Intel corporation employs more than 100,000 people worldwide and generates > $50Bn revenues annually. Intel acquired the Bath based wireless silicon and software company (formerly Picochip) in 2013 and between its Swindon and Bath offices undertakes development of wireless communications systems and software for mobile devices and small wireless basestations. The Bristol R&D lab develops algorithms and software for Intel's processor graphics hardware for low-power devices such as tablets and smartphones.Swindon is home to Intel's main UK site and is one of the headquarters for the EMEA sales region as well as carrying out R&D on High Performance Computing, Wearable Technology and Memory Devices.

Company: Microsemi Semiconductor Ltd., Location: Caldicott
Description Microsemi Corporation (Nasdaq: MSCC) design and supply semiconductors and systems for aerospace and defence and industrial markets. The company is headquartered in the US has sales of $1.25Bn and employs 4,800 people globally. The Caldicot R&D centre specialises on medical technology packing and miniaturisation for implantable communications and energy harvesting devices.

Company: Mitel Networks Ltd., Location: Caldicot
Description: (NASDAQ:MITL). Mitel is a business communication technology and service company with a $1.2Bn turnover and 60 million users in 100 countries. It employs 1,300 people globally conducting R&D at multiple sites including Caldicot.

Company: Oclaro, Location: Paignton
Description: (NASDAQ: OCLR) An optical components and technology company (turnover >$500M) specialising in laser technology, photonic integration, and transceiver/subsystem design. Their products are components of fast optical networks and high-speed

interconnects within streaming video, cloud computing, voice over IP and other high-speed and bandwidth-intensive data communication applications. Oclaro has R&D production sites across the world including its facility in Paignton Oclaro Paignton where it develops components and subsystems for use in Gbit /s optical telecommunications systems.

Company: Plessey, Location: Swindon, Plymouth
Description: Plessey is a privately held UK company and is a leading manufacturer of semiconductor products used in lighting, sensing, measurement and control applications. Plessey has design and technology centres in Swindon and Cambridge, and a state of the art Gallium Nitride LED semiconductor manufacturing facility in Plymouth.

Company: Renishaw PLC, Location: Wotton-under-Edge,
Description: Renishaw is a global company advanced engineering company manufacturing products for measurement, motion control, healthcare, spectroscopy and manufacturing. Its turnover was £490M in 2015 and it operates from 70 locations in 33 countries. The majority of its R&D is carried out in Gloucestershire with production on many sites including Miskin, Cardiff. 95% of Renishaw's sales are from export markets.

Company: Spirent Communications PLC
Location: Paignton
Description: a global leader in networks and applications, wireless and service experience across the entire technology lifecycles from proof of concept to subscriber experience. It specialises in test and measurement services along with innovation and development services across communications networks and IT organisations. The company is leading in Global Navigation Satellite Systems (GNSS) venerability and has supported NASA and the European Space Agency.

Appendix NGM7 Project Portfolios

The table shows current and proposed initiatives in Next Generation Microelectronics related areas across the region. This includes funded programmes and those looking to access funding through a variety of routes including Research Councils, Local Growth Fund LEP round 3 submissions, City deals and other Government programmes.

Project/Scheme	Funding Source	Description
QTIC - Bristol	LGF – business case under development	Quantum Technologies Innovation Centre – offering facilities to support early stage companies developing products and services utilizing emerging quantum technologies. Aligned with the Quantum Technologies Lab at the University of Bristol
UEZ - Bristol	BIS UEZ pilot/LGF	Opens 2016 - ….
Open Programmable City Region (OPCR)	West of England LEP Local Growth Fund	Description: A distributed Software Defined Network (SDN), Research and Development test-bed using existing but upgraded fibre infrastructure in Bristol and across the West of England as a research and development test bed for companies to be able to test their technologies, systems and services on a unique open and programmable communication service platform. The test bed will work across Bristol, the Temple Quarter Enterprise Zone and the five Enterprise Areas at Avonmouth/Severnside, Filton, Emersons Green, Bath City Riverside and Weston's J21. (In phased deployment Summer 2016)
Advanced Engineering Campus (Bristol and Bath Science Park extension)	West of England Devolution Deal	Description: Building on existing infrastructure of the National Composites Centre, Centre for Modelling and Simulation + facilities of the Bristol and Bath Science Park the Advanced Engineering Campus will use local & regional assets and further & higher expertise to deliver the training of the engineers of the future, as well as the next generation of teachers and tutors in STEM subjects. Its mission is to offer further education from apprenticeship to postgraduate level including Doctoral Training Entities in manufacturing and Industry 4.0. Stage of development: Funded as part of Devolution Plan, Commencing Summer 2016
Developing a globally relevant Compound Semiconductor Pilot Line in the South West and	£20M Various	Project EFFICACY will help enable the European CS industry to build and regain global market share in competitive application segments that are of high strategic importance, fiscally attractive, and technologically rich. In doing so, EFFICACY will also help underpin many of the major UK and

East Wales Innovation Region		European initiatives under Horizon 2020, embracing Excellence in Science, Industrial Leadership and will help tackle the major Societal challenges. Within the overall project there are powerful links to the existing PPPs of 5G, Big Data, Robotics, Photonics and Factories of the Future. The vision is a creation of globally competitive, low cost, high throughput, open access CS Epitaxy Foundry pilot line in the UK, forming a key pillar in the creation of Europe's 5th Semiconductor Cluster and the World's first cluster dedicated to Compound Semiconductors. To date, the Cluster has already been successful in establishing both a CS Institute (TRL 1-3), and a Prototyping RTO (TRL 4-6), and an CS Applications Catapult with over £200M funding already committed from both public and private sources. The European Advanced Semiconductor Epi Foundry (EASEF) pilot line, which would be created within EFFICACY at TRL 6-8, would provide the third pillar to building the CS Cluster, and provide the bedrock for establishing globally competitive CS Anchor companies within Europe at TRL 9.
EPIC - Torbay (HotSW LEP)	£8M - Growth Deal, CCF, TBC & ESIF	Electronics and Photonics Innovation Centre (EPIC), building on existing hi-tech cluster. £8M project for a 3,700 Sqm Centre of Excellence - providing laboratories, clean rooms and specialist equipment for R&D, enabling collaboration, start-ups and new underpinning technologies to market, plus bespoke business support. Completing April 2018, EPIC will catalyse collaboration and growth of the photonics sector in HotSW.
EPSRC Future Compound Semiconductor Manufacturing Research Hub - Cardiff	£10M - EPSRC	Starting in late 2016, this project will establish a centre of excellence in manufacturing technologies related to compound semiconductors. This collaborative Hub will be based in Cardiff but will also involve Manchester, UCL and Sheffield universities
Compound Semiconductor Centre for Doctoral Training	£10M - EPSRC	Cardiff University is currently preparing a proposal to establish a CDT in compound semiconductor technologies, addressing a number of the higher level skills issues highlighted in this report.

Department for
Business, Energy
& Industrial Strategy

South West England and South East Wales Science and Innovation Audit

Annex J: Digital Living Innovation Theme Report

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

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Annex J Digital Living Innovation Theme Report

1. Introduction

As a recognised and evidenced powerhouse of Electronics and Computing both in industry and in academia, the region has taken a leading role in developing the digital technologies that have transformed our lives over the past 20 years. The region fully intends to continue in that mission through strong established partnerships with corporates, SMEs and universities. Based on recent experience we can expect the impacts of these technologies on society to be complex and subtle - the huge socio-economic and cultural diversity of the region makes it an ideal test bed for the responsible development of new digital technologies that meet the needs, embrace the aspirations and understand the concerns of local communities and businesses, large and small.

As defined by Michael Hill-King, Huawei Collaboration Director, UK R&D Centre: *"Digital Living is the way in which our lives are affected by digital products and services. Digital means connectivity; digital means storage; digital means computation. But digital enables much more. Digital means applications become possible to offer new experiences for living, new ways of living and more convenient ways of living"*

Numerous reports have been published highlighting the strategic importance of the Digital Industries sector for the UK economy, a number identifying the audit regions strengths and clusters of national importance, including for example the 2016 Tech Nation report[1] and the 2014 Centre for Cities report "Industrial Revolutions: capturing the Growth Potential"[2]

Through the audit process, convergence occurred around the following top level thematic subsets and technical underpinning of Digital Living:

Thematic subsets

- Digital Health
- Digital Creative Economy
- Smart Cities & Transport

Underpinning technology themes

- Cloud Computing (Including Communications & IoT).
- Digital Media (including Virtual/Augmented Reality, Creative Media)
- Robotics / Autonomous Systems

Appendix DL7 gives a definition for each of these thematic areas.

It should be noted that digital technologies related strengths and opportunities in both Environmental Risk and Resilience and in Aerospace and Advanced Manufacturing were identified and mapped. These are underpinned by many of the same technologies but are covered elsewhere in the audit report.

[1] www.techcityuk.com/wp-content/uploads/2016/02/Tech-Nation-2016_FINAL-ONLINE-1.pdf
[2] www.centreforcities.org/wp-content/uploads/2014/07/FINAL_Centre-for-cities-report2014.pdf

Underpinning technologies encompass a wide number of areas of technical capacity including: *cloud computing, cyber security/cryptography, quantum technologies, data analytics, machine learning, sensors, radio frequency, wireless/5G, high performance computing, autonomous systems, digital media production, wired and photonic networks, machine vision*

The region is home to a significant population of companies both small and large, local and international, operating at both the applications and underpinning technology levels. Its major conurbations have been highlighted as digital technology clusters of national and international significance in a range of informed reports, which stress the economic impact of the clusters[3].

The region's Universities have a strong track record of cutting edge research being translated into real application with the Digital Living theme covering a wide group of researchers across 29 different areas of research (REF Units of Assessment).

The region punches massively above its weight in this space; for example as described herein despite representing just 9.5% of the UK's population, the region produces 25% of the UK's patents in Digital Communications and was identified as the home of one of the UK's two leading smart cities.

2. Regional science and innovation assets

Our nationally recognised strengths are built upon a long history of academic and industry excellence and innovation in underpinning digital technologies and of innovative companies, large and small, delivering applications across many sectors. The region has a large number of research and innovation assets related to this theme, including academic research centres and groups, industry innovation, development capacity and focused innovation support, which we are harnessing to maintain and grow our world leading position.

Science and innovation assets of scale are described by sub theme in Appendix DL1.

Given the nature of the theme, with applications areas underpinned by fundamental technologies the academic assets are spread across a large number of Schools and Departments in all of the region's Universities. The region is home to the Universities of Bath, Bristol, Cardiff, Cardiff Metropolitan, Exeter, Falmouth, Gloucestershire, Plymouth, South Wales and UWE with research and innovation activities related to this theme.

The relevant research assets are to be found in University Departments of Electrical and Electronic Engineering and of Computer Science. The region is home to seven Electronic and Electrical Engineering Departments (Bath, Bristol, Cardiff, Plymouth, Exeter, UWE and University of South Wales) which produce 435 graduates, 175 postgraduates and 55 PhD students per annum. Approximately 50% of the research within these schools aligns with this theme, including particular strengths in fixed and mobile communications. Total research income is £18m per annum.

The region hosts nine University Computer Science Departments (Bath, Bristol, Cardiff, Cardiff Metropolitan, Exeter, Gloucestershire, Plymouth, UWE and USW), producing 849 graduates, 300 postgraduates and 55 PhD students per annum and with total research

[3] www.duedil.com/technation/2015

income of £12m per annum. More than 90% of research activity within these Departments is of relevance to this theme, including for example the £12m digital health-care project, SPHERE.

Bristol hosts the EPSRC Centre for Doctoral Training in Communications. Bath, together with Bournemouth, hosts the Centre for Digital Entertainment, the EPSRC Centre for Doctoral Training in Games, Visual effects and Animation. The EPSRC Centre for Doctoral Training in Future Autonomous and Robotic Systems: FARSCOPE is delivered jointly by the University of Bristol and the University of the West of England through the Bristol Robotics Laboratory.

3. Excellence in science and research

We have identified a total of 634 researchers (at Principal Investigator level) working in fields directly related to the Digital Living theme at in the region's Higher Education Institutions. Of these 431 were submitted to the 2014 Research Excellence Framework.

Research Evaluation Framework 2014

Researchers active in the Digital Living theme were submitted to the 2014 REF across 29 different Units of Assessment (UoA) of the 36 defined in the REF. The large number of UoAs is indicative of the very wide footprint that the Digital Living theme has across academic disciplines. In order to better analyse the REF submission a threshold was used of greater than 10% of the regional researchers submitted directly identified with the theme. This reduced the UoAs under consideration to 10 (Appendix DL2). Submissions to these UoAs included 322 researchers directly identified with the theme from a total of 1363 FTE researchers submitted in these UoAs (33% of all regional researchers submitted). 79.2% of the overall REF quality profile for the 10 UoAs rated as world-leading (4*) or internationally excellent (3*). 86.5% of the related impact case studies were rated as having outstanding (4*) or very considerable (3*) impact.

Publications Analysis. (Appendix DL3).

Analysis of publications data undertaken using SciVal and Scopus identified a total of 3,899 research publications in the broad area of digital living for the period 2011-15 (defined via institutional publication competencies in SciVal). Regional publications represent 5% of world research outputs and 25% of UK outputs in this thematic area.

Further analysis shows that regional publications in the digital living thematic area outperform the UK as a whole, in terms of publications in the top citation percentiles (27% vs. 23% in the top 10% most highly cited publications worldwide) and in terms of publications in the top journal percentiles (32% vs 28% in the top 10% most highly cited journals worldwide). The Field Weighted Citation Index (which measures how the citations received by the region's publications compare with the world average) is also considerably higher (2.47 for the region vs. 2.13 for the UK).

In addition, 3% of papers have industry co-authors (UK = 2%) and 52% have international co-authors (UK = 45%), which can be used as a proxy for collaboration, recognising that it will under report the levels of collaboration with industry as, in a number of technology fields, companies do not allow employees to co-author academic publications.

University Research Income

Research grants and contracts income in fields related to the Digital Living theme totalled £52.6m in 2014/15, and shows a steady upward trend from £29.6m in 2008/9. Total research income for the period 2008-2015 totalled £261.7m. This increase of 78 % for Digital Living compares with a 43 % increase over the same period for the sector.

The region's research income in Digital Living shows a healthy balance of funders with Research Councils making long-term investments in strong underpinnings alongside funders of more applied work.

Appendix DL4 provides further details of research income by institution and funder type.

4. Innovation strengths and growth points

Using standard measures of economic activity, employment data and counts of active enterprises is challenging in this field. Many companies that are connected with the theme will identify themselves across a range of product and service sector industrial classifications which in themselves struggle to represent the changing business models and new technologies in this area.

As digital technologies are seen as nationally critical this has led to experimentation by a range of bodies such as NESTA in new ways of capturing data about the broad sector.

These methods and the associated reports identify that the audit region has a number of well-established and nationally significant high tech/digital clusters. The 2016 Tech Nation report highlights digital technology clusters in Bristol and Bath, Cardiff, Exeter and Truro & Redruth. Clusters were identified using quantitative indicators such as the density of digital tech companies in an area, economic performance and growth rates and the level of community activity (networks, meetups etc.) Figure 1 in Appendix DL8 gives key data from this report.

Patents

Technologies underpinning the Digital Living theme make up a significant proportion of the patenting activity in the SIA region. Regional patenting in Digital Communications makes up 20% and Computer Technology 12% of the UK total in these fields. With Telecommunications they are also within the top 5 areas for patent activity in the region, each representing more than 10% of total patents in the SIA area. Companies in the region hold significant global patents pertaining to the underpinning technologies such as cloud computing, business intelligence/analytics, high performance computing and machine learning. See Figure 2 in Appendix DL8.

Digital Health

The region is unusually well endowed with health related data collected on its citizens whether as individuals, within households and across the wider population. In Bristol, for example, this data is collected routinely as part of people's clinical care and through monitoring airborne exposures (pollutants, allergens), via existing major research projects such as ALSPAC, the MRC Integrative Epidemiology Unit, and the EPSRC funded SPHERE project, or through other programmes such as Bristol City Council's Quality of Life Survey.

Distinctive Regional Demographics: Our stable and ageing population presents a significant opportunity to develop health and life science industries in the region. In particular the South West peninsular has a significant over-representation of older people with 49.5% of the population aged over 45 and 22% above the age of 65; 6% higher than the national average[4]. In Wales, the Public Health Wales Observatory highlighted in early 2016 that the number of people aged 65-84 has increased by 17% between 2005 and 2014 and the number of people aged 85+ has increased by 27% over the same period. Between 2016 and 2036 the number of people aged 65-84 is expected to increase by 40% and those aged 85+ is expected to increase by 145%.

A number of regionally commissioned reports[5,6] highlight the opportunities for economic regeneration arising from this demographic and the resulting changing nature of healthcare provision, including an increased focus on prevention, early intervention and community-based service models with an older population providing a test bed for digitally enabled innovations which can help support the health and care of older. Significantly, the diversity of the region (e.g. ethnicity, income, occupation, connectivity, urban/rural) makes the region an ideal location for proving new technologies that can ultimately be marketed worldwide to the majority of developed nations that face the same demographic challenges.

Further analysis of these findings by the SW Academic Health Science Network (AHSN) in 2014 suggests these demographics, alongside the regions strength in leading the development of integrated care systems presents an opportunity to catalyse innovation, including attracting businesses to research, pilot and test innovations[7] in the region, alongside catalysing the region's hi-tech SME cluster and the broader entrepreneurial community to respond to clearly defined challenges in the health system identified through the increased investment into health research.[8]

An exceptional capability in population health research provides companies with access to world-leading expertise in evaluating the performance of digital technologies in improving population and individual health in the region. When combined with underpinning world leading capabilities in fields such as designing and evaluating complex health interventions wireless and optical communications technologies, data security and encryption and other major projects that are integrating data across, for example, primary, secondary and social care this provides a unique proposition to SMEs and larger corporations and will attract them to develop and grow in our region.

E-Health and E-Wellbeing is a priority in the Cornwall and Isles of Scilly LEP SMART specialisation framework. Healthy Ageing is identified for Cornwall and the Isles of Scilly and the Heart of the South West LEP areas, capitalising on regional assets and the distinctive demography of the SW Peninsula

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[4] ONS LEP Profiles (2012) www.neighbourhood.statistics.gov.uk/HTMLDocs/LEP/LEPD/atlas.html

[5] The Old and the New: New opportunities for education, research and economic regeneration arising from the needs of older people (2012).

[6] www.erdfconvergence.org.uk/_userfiles/files/GrowthProgramme/3C&IoSRD&IFramework.pdf

[7] Bain & Company (2013): Opportunities in Integrated for Pharma and Medtech- When, Where and How Should Manufacturers get involved?

[8] Ibid.p49

- NHS England - two Academic Health Science Networks (AHSN) cover the audit region. They are very active in supporting the development of the digital health sector and linking it into the NHS – the primary customer for digital interventions and into the local authorities who now have responsibility for public health in England.
- In Wales, the Welsh Government digital health and care strategy was announced in November 2015. NHS Wales is working with companies in the audit region to develop and trial services and products, working with innovators, entrepreneurs and suppliers in a digital health network and increasing NHS access to future technologies and innovations.

TechSPARKs Cluster map[9] (Appendix DL7) identifies that the regional Digital Health sector is made of 70 companies in the region. The UK digital health sector is estimated to be worth £2bn, forecast to rise to £2.9bn by 2018, with a 2015 turnover of £886m and 7,400 employees.[10] The global market value is estimated to be €17.6bn in 2017[11].

Innovation support mechanisms include:-

- **Development programme to support healthcare innovators in the West of England**. - SETsquared & West of England Academic Health Science Network (AHSN) - The Programme is an intensive four day course that is open to healthcare professionals, health and life science academics, small businesses and public contributors. It is focused on innovators with a clear business proposition, or with an innovative idea that has an application in the healthcare sector and can bring substantive benefits. These are frequently in the Digital Health field
- **South West Interactive Healthcare Programme**, Announced in July 2016 the South West Academic Health Science Network, Creative England, West of England Academic Health Science Network and SETsquared – Fund of £500,000 for creative and digital companies to develop innovative healthcare technology and solutions
- **Webstart**[12] is developing a specialist e-health accelerator
- **University Enterprise Zone,** University of the West of England – A Health Tech Hub has been proposed by UWE with the West of England AHSN focusing on innovation for independent living and citizen-centric health, bringing together expertise in robotics, biosensing, microelectronics, data analytics (for healthcare) and communications to provide businesses with a comprehensive suite of advanced R&I facilities and specialist expertise to improve their rate of innovation, reducing time to market, cost and risk associated with product development
- **Assisted Living Action Network,** a platform for businesses, healthcare professionals, service user groups and academic researchers to stimulate the development of innovative assisted living products and services in the South West. ALAN is managed by executive members, Designability, the University of Bath Innovation Centre, and Bath Research & Development (NHS BANES, Swindon, Wiltshire)
- The EPSRC-funded **SPHERE** programme is now making available health-focussed IoT devices and platforms available to a number of companies and academic consortia nationally and internationally for the purposes of conducting clinical trials of

[9] techspark.co/cluster-map/
[10] http://www.sehta.co.uk/wp-content/uploads/2016/06/Stephanie-Parker-Office-for-Life-Sciences.pdf
[11] https://ec.europa.eu/digital-single-market/news/mhealth-what-it-infographic
[12] www.webstartbristol.com/

interventions and self-management tools. As SPHERE matures its technology and pool of 100 researchers will naturally underpin regional aspirations in this space.

Digital Creative Economy

The creative industries, based on digital technology, is the fastest growing sector of the UK economy at 8.9% a year (against an average of 4.6%), and makes up 5.2% of the economy as a whole.

According to the Department for Culture, Media and Sports January 2016 economic estimates[13,14] in the South West creative industries grew 21.5% in 2013-14, overtaking the North West. Bristol and Edinburgh are the only UK cities outside the London/SE region to appear in the top 20 for their concentration of both creative industries and technology, defined by location quotient.

The Geography of the UKs Creative and High Tech Clusters Report[15] demonstrates that Bristol is one of only five clusters in the UK that demonstrate high concentrations of employment in both the creative economy and in high tech, making it well positioned to lead in creative digital applications and technologies.

According to research[16] published in 2015 by the Creative Industries Council, Bristol is one of three UK cities outside London identified as having the best prospects for future growth in the creative industries. The Cardiff and South East of Wales area has been increasingly recognised as a significant cluster in this thematic area and in particular the subset of activates around the film industry. This sub theme is dominated by small SMES or sole traders, who come together to deliver particular projects or programmes of work. Film and video post-production companies, who are typically very heavy users of digital technologies have grown up, in particular in Bristol and Cardiff, originally driven by the presence of the BBC in both cases.

TechSPARKs Cluster map[17] (Appendix DL7) shows a Digital Creative economy which is made of 500 companies in the region, totalling revenues of £660m with 15,900 employees.

- **Aardman Animations,** based on two sites in Bristol, and employs 250 people is celebrating its 40th year in 2016. In 2015 it purchased a majority stake in US animator Nathan Love creating its first overseas production facility.
- The **BBC** has a very strong TV and media production presence in Cardiff, with 1300 staff and Bristol with 1000 staff.
- Cardiff is home to a significant proportion of BBC creative output (such as *Doctor* Who and many other popular programme making). It hosts Roath Lock Studios, the BBC's 17,000 m^2 drama production studio complex in Porth Teigr

[13] www.gov.uk/government/uploads/system/uploads/attachment_data/file/523024/Creative_Industries_Economic_Estimates_January_2016_Updated_201605.pdf
[14] www.gov.uk/government/publications/digital-sector-economic-estimates-january-2016/digital-sector-economic-estimates-2016-key-findings
[15] www.nesta.org.uk/publications/geography-uks-creative-and-high-tech-economies
[16] www.gov.uk/government/groups/creative-industries-council
[17] techspark.co/cluster-map/

- Bristol is the home to the BBC Natural History Unit (300 staff), and part of the following teams are also based in the city - Arts programming, Factual formats, features and daytime, Documentary production
- **Pinewood Studios**, in Cardiff has a 7,000 m^2 site. It collaborates with Bath-Spa University on degree programmes in Film, Television and Digital Production

The region hosts a number of innovation assets to support this activity

- **Launchpad** is a major games and creative tech incubation model in Falmouth, designed to respond directly to market needs.
- **Pervasive Media Studio** – Hosted by Watershed, PMS is a world leading open innovation centre and a community of over 100 artists, creative companies, technologists and academics exploring experience design and creative technology. Projects can be cultural or commercial and span play, robotics, location-based media, food, connected objects, interactive documentary and new forms of performance.
- The **SETsquared centres** in Bristol, Bath and Exeter[18], along with the **Welsh ICE: Innovation Centre** for start-ups in Wales[19] and the **Alacrity Foundation**[20] in Newport, Europe's only charitable technology incubator, are notable business incubator assets.
- The **Formation Zone** (Plymouth) has supported 180 businesses to develop, mainly in the Digital Creative Economy,
- Plymouth University operates a network of **Innovation Centres** (Pool, Tremough and the Health and Wellbeing Innovation Centres) on behalf of Cornwall Council. Plymouth Science Park is host to some 43 Digital and Creative companies
- The new **Devonport Market Hall**[21] – RIO (Real Ideas Organisation, an ACE funded body), due to open in June 2018 is a new digital hub, with 3,000 square feet of bespoke, quality office, lab for digital creative companies and organisations; a cultural, corporate events space with a seating for up to 350 people and an expo capacity of 600, and a digital visitor experience of touring programmes, screen and installation based work and programmed activity.
- **GloWorks**, Cardiff - 3200 m^2 Creative Industries Centre in Cardiff. Opened in 2014 and now fully let with tenants including leading television production company Boom Pictures and digital agency Sequence.
- **Cardiff Start** - a network of entrepreneurs, start-up founders, creatives, students and investors. Founded by creative/digital industries experts.
- **Bristol Media** - Industry led organisation, whose primary role is to facilitate collaboration and growth within the region, delivering projects, events and opportunities for over 550 members. Its mission is to drive creativity and innovation across the southwest creative and media sectors.
- **Digital Exeter** and **Tech Exeter** – networks supporting the grassroots development of digital creative, visualisation businesses
- **Gloucestershire Growth Hub,** operated by the University of Gloucestershire for GFirst LEP is working with the University's **School of Media and School of Computing and**

[18] www.setsquared.co.uk/
[19] welshice.org/
[20] alacrityfoundation.co.uk/
[21] themarkethall.co.uk/

Technology to support business incubation and development of creative economy enterprises.

- **The Imagarium** - Europes leading motion capture studio and production company based in Bath, in partnership with **CAMERA** – motion capture facility and researchers at the University of Bath

Smart Cities/Regions and Smart Transport

In the May 2016 Huawei sponsored UK Smart City Index Report[22] Bristol was identified as one of two UK leader cities, alongside London. The report identified that when it comes to technologies, strategies and visions, Bristol shows unique characteristics. Whilst London, as a global megacity, operates on a different scale than any other UK centre and benefits from its global financial centrality, Bristol's competitive advantage lies in its vision and its world-leading city-networking project, **Bristol Is Open (BIO)**. Other city strengths included its deep understanding of the open data revolution, energy-management innovations and community engagement. The report highlighted the importance of **playable city** ideas – a Bristol innovation - a reminder of the need for smart cities to be attractive, engaging and efficient.

In May 2016, **BIO** was awarded the global 'Smart City Innovator' award at the TM Forum 2016 – Digital World Awards[23]. TM Forum is the global member association for digital business. BIO[24], is a city networking project with the potential to emerge as a world-leading large-scale environment for the testing of technological, social and urban innovation. **Monmouthshire Made Open**, and **MonmouthpediA**, are examples of digital-social innovation built on co-creation approaches. **Exeter City Futures** a public private partnership is driving forward a smart city ambition for the Exeter region.

The West of England is host to **Venturer** and **Flourish**, two of the UK pilot connected autonomous vehicle (CAV) projects. Exeter hosts the Innovate UK funded **Engaged Smart Transport project**, led by NTT Data, which aims to better understand and influence real time travel behaviour through traffic management systems and individual smart technology. The audit region has strengths in rail automation and control systems. **Siemens Rail Automation** has its UK centre for manufacturing and its global centre for R&D in Chippenham, Wiltshire. **Knorr-Bremse Rail Systems** is based in Melksham, Wiltshire and **Brecknell Willis** has its UK centre for manufacturing and its global centre for innovation in railway electrification systems in Chard, Somerset.

There is an emerging group of companies specialising in smart cities or transport related products and services in the audit region. Corporates such as **ARUP**, **Atkins**, **Buro Happold Engineering** and **Altran** are developing regional high level expertise in both smart cities and connected autonomous vehicles, and Bristol is Open (BIO) is attracting international corporate partners including major automotive manufacturers, **NEC** and **Nokia**.

Demonstrator programmes, such as **BIO** and **Smart Islands** (Scilly Islands), offer allow companies already active in digital applications opportunities to enter this emergent market area.

[22] www.huawei.com/en/news/2016/5/UKs-leading-smart-cities
[23] www.tmforum.org/about-tm-forum/awards-and-recognition/digital-world-awards/
[24] www.bristolisopen.com/

Underpinning Technologies: Cloud Computing, Communications and IoT

The underpinning technology theme is dominated by number of key corporates with assets in the region, together with a network of SMEs and start-ups.

Toshiba, Cray, Google, Huawei, ORACLE, IBM UK, Hewlett Packard Enterprise, Amazon, PCS, Intel and **Amdocs** all have a digital R&D and innovation oriented presence in the region. Specialist areas include Infrastructure as a Service (IaaS); Platform as a Service (PaaS) – including Data/Analytics, IoT; Software as a Service (SaaS) applications; high performance communications, storage and compute; machine learning; human computer interaction/immersion; chip design and cyber security.

Cray – in 2015 the US advanced supercomputer manufacturer chose to set up its European, Middle East and Africa (EMEA) R&D Centre in Bristol following its acquisition of Gnodal, an HPC technology company that has been supported by SETsquared.

Hewlett Packard Enterprise – Product Development teams in Bristol lead HPE's global investment in IaaS – storage and compute – products and are one of the most significant contributors to the OpenStack cloud computing initiative. HP also have product development teams in Bristol focussed on Data/Analytics R&D.

IBM UK – Cloud Data Services product development team in Bristol. IBM led the Network and Information Sciences International Technology Alliance, involving Cardiff University, along with other leading academic and industry partners such as Airbus UK Ltd. & Systems Engineering and Assessment UK Ltd.

Intel – Swindon, Intel's UK headquarters, hosts the Intel High Performance Computing Lab which gives partners early access to Intel processors and HPC technologies, and the Memory IP Lab which creates designs for Intels silicon processes to be used on Intel's system on a chip products. It also hosts the Internet of Things Ignition Lab, designed to work with innovators to develop end to end IoT solutions.

Intel Graphics and Media Lab - algorithms and software for Intel's processor graphics hardware. It focuses on 3D, media and Android core software and has extensive expertise in low power devices such as tablets and smartphones.

Oracle – Strategic product development centre and innovation centre in Bristol hosting Oracle's Analytics/Business Intelligence, Data Visualisation, Cloud (IaaS and PaaS) product development teams. In 2014 Oracle announced Bristol as one of four globally strategic product development centres.

Toshiba Telecommunications Research Lab - Bristol – since its inception in 1998 TRL has been at the cutting edge of research into technologies such as next generation wireless networking, reconfigurable architectures, and smart systems for energy, mobile and medical applications

The innovation support infrastructure for growth oriented tech companies is well developed, examples include:

- **SETsquared**, the University business incubator partnership with centres in Bath, Bristol and Exeter is now ranked no1 globally.
- Network/meetups groups are widespread and very active, examples include **TechSPARK**, **Digital Plymouth**, **TechSouthWest**, **Tech Exeter** and **Software**

Cornwall. I**nnovation Point**, Newport - provides services to help companies develop new and disruptive technology ideas that deliver growth

- **National Software Academy,** a new technology hub in Newport led by Cardiff University, trains industry-ready software engineers in partnership with industry and local businesses.
- **The Gloucestershire Science and Technology Park at Berkeley** is developing state of the art facilities for cyber and computing, including dirty lab and secure testing facilities for businesses. The Park is being developed in partnership by South Gloucestershire and Stroud College, the University of Gloucestershire and Gfirst LEP.
- **The Cheltenham Cyber Business Park** is a proposed Local Growth Deal 3 development adjacent to GCHQ in Cheltenham. The proposal builds on the county's strengths in computing and cyber security, and the announcement last year by the then Chancellor of the Exchequer of a new Cyber Innovation Centre in Cheltenham.
- **Exeter Science Park** hosts the Met Office collaboration space and new supercomputer.

Underpinning Technologies: Digital media, Virtual and Augmented Reality

The region has a significant track record pioneering innovation in digital media including for media production, virtual and augmented reality, simulation, 3D modelling and moving image research.

Hewlett Packard in Bristol has led significant advances in animated film production technologies in collaboration with Pervasive Media Studios, Bristol University and regional film production companies. SMEs such as YellowDog are pushing the boundaries of high performance cloud computing to establish a new generation of film production techniques.

Virtual and Augmented Reality are emerging technology areas, with significant economic development potential. As a set of creative design practices and skills this area draws heavily on CGI, vision technologies, immersive media (such as Data/Fulldomes) and a history of simulation and 3D modelling.

VR and related digital content is a major opportunity for the UK's world leading creative industries. The UK, as one of the world's leading creative sectors (film, TV, games, theatre and fashion), built on strengths in both creative talent and technology, is well positioned to lead in this area. VR is commonly applied to the games industry, but visionary start-ups in the region such as Interactive Scientific, Opposable group and ZUBR are applying VR to scientific and educational applications with broader citizen focused use cases. The region is host to aerospace, high tech digital and nuclear clusters. All these sectors have on their agenda the use of virtual or augmented reality to improve their operations and lower the cost of maintenance.

Airbus, GKN and EDF Energy have a strong interest in virtual and augmented reality applications to their businesses. EDF - *"VR/AR is firmly on our top level requirements list for improving the preparation of operations"*. This applies to both the nuclear new build agenda, and decommissioning. **Intel** Swindon hosts the Intel Wearable IP Lab which focuses developing the building blocks for a range of applications areas including Virtual and Augmented Reality.

The ecosystem is primarily based within the Bristol and Bath High Tech cluster and in Cardiff with clusters of computer games related activity and innovation support in Devon and Cornwall. The West of England has a connected group of firms that are already integrating VR into their businesses or products, from health, engineering, aerospace, training, education, film and media related content producers including digital and games. Recent investments including the high speed data connections through Bristol is Open and the Bristol Data Dome allow experimentation that cannot occur anywhere else, and the high profile VR World Congress conference further focuses attention on Bristol as a location for the future of VR and AR development

The Bristol Games Hub has been bringing the community together in the West of England, and organises the annual VR world congress conference, attended in 2016 by 750 delegates. Six companies make up the driving force behind this industry in the West of England: Opposable games, Auroch Digital, Big Robots Games, Evil Twin Artworks, Force of Habit, Esportsify and Yogscast. Notable Cardiff companies include On Par, Atticus, 4Pi Production and Orchard.

Prominent regional organisations with a role in supporting these technologies and content development include:

- The Pervasive Media Studio
- @Bristol
- Bristol Games Hub
- The Centre for Modelling and Simulation
- Games Wales South - a meetup for video-games developers in Cardiff
- The Games Academy, Falmouth University
- i-DAT at Plymouth University
- Formation Zone, Plymouth University
- The Interactive Systems Studio, an open innovation R&D studio, hosted by Plymouth University
- Oracle UK
- Plans are developing for a Bristol based VR Hub to support this emergent area (Appendix DL6)

Underpinning Technologies: Robotics and autonomous systems

Robotics and Autonomous Systems was identified by the previous Government as one of the 8 Great Technologies[25] in which the UK has the potential to be a global leader.

This theme has a strong concentration of activity around the West of England area with notable Plymouth based activity in marine autonomous systems research and innovation. The EPSRC knowledge map[26] highlights the West of England and the **Bristol Robotics Lab** as the main national research cluster in autonomous systems with additional presence in Plymouth, Exeter and Bath.

[25] www.gov.uk/government/uploads/system/uploads/attachment_data/file/249255/eight_great_technologies_overall_infographic.pdf

[26] www.epsrc.ac.uk/research/ourportfolio/knowledgemap/

The West of England LEP Strategic Economic Plan identifies robotics as a key strength of West of England's High Tech Cluster. The TechSPARK cluster map highlights twenty six companies working in this sector in the region, with economic revenues of £40M and one thousand three hundred employees.

This sector is underpinned by the regional presence of major corporates within the aerospace and advanced engineering sector (**Airbus, GKN, Rolls-Royce)** with an interest in robotics and autonomous systems. A number of other large companies and organisations are focused on sectoral applications including **Renishaw** in medical robotics, the **National Nuclear Laboratory** (NNL) who recognise that Robotics and Autonomous systems will play a key part in tomorrow's new build programme and decommissioning challenges and **GCHQ** Cheltenham which has identified the vulnerabilities in autonomous systems, including vehicles as a key risk in their deployment and is developing programmes to work with systems developers in this area. The region also hosts a number of large specialist engineering services companies with robotics domain expertise, such as **Altran.**

As identified previously The West of England is host to **Venturer** and **Flourish**, two of the UK pilot connected autonomous vehicle (CAV) projects and **ARUP** and **Atkins** are developing regional higher level competencies in autonomous vehicles. A number of smaller specialist companies have been successful, such as **OC Robotics**, who specialise in robotic systems for confined and hazardous environments and companies, such as **Applied Automation** and **MSubs**, who specialise in marine autonomous vehicles New companies are emerging such as **5AI** (Bristol and Cambridge) created by successful Bristol silicon entrepreneurs who are focusing on applications of AI in autonomous vehicles, **Imetec**, a Bristol University spinout company focused on remote monitoring for nuclear sites by autonomous UAV and **Open Bionics**, who are developing robotic prosthetics.

A range of organisations provide innovation assets to support organisations developing or using robotics and autonomous systems:

- The Bristol Robotics laboratory runs a business incubator[27], hosting currently ten start-up companies.
- Futurespace – the University Enterprise Zone at the University of the West of England provides start-up and grow-on space for technology/knowledge based businesses in robotics and autonomous systems and other related fields. Services will include provision of facilities and advanced tools for academic and industry innovators, collaborative projects and technology companies.
- The National Composites Centre is a centre of excellence in industrial robotics as applied to composites manufacture

5. National and international engagement

Digital technologies and applications are highly international with academic expertise and leading companies spanning many countries. As described in Section 4 many of the

[27] www.brl.ac.uk/businessengagement/technologybusinessincubation/brlincubatee companies.aspx

world's leading digital technology companies have innovation related operations in the audit region.

A total of 3,899 academic research publications were identified in the broad area of Digital Living for the audit region for the period 2011-15. Using SciVal, these papers were compared with UK, European and World publications in the same fields.

This analysis shows that the academic papers from the region's researchers have higher levels international co-authors than for the UK as a whole (52% vs 47%) and match that for corporate/industry co-authors (3%). Authorship can be used as a proxy for collaboration, recognising that it will under report the levels of collaboration with industry as in a number of technology fields companies do not encourage employees to co-author academic publications. A SciVal analysis indicated that the region's researchers collaborated most frequently with researchers from the USA, followed by Australia, Canada, Germany and France.

Academic research income data for the theme highlights that 22% is received from European Union research programmes and a further 3.3% from other international funders (Appendix DL4). The majority of this income is related to collaborative multinational research, and demonstrates significant levels of international collaboration and, given the competitive nature of this funding, regional excellence for researchers in the theme.

6. Developments in Science and Technology - international markets & opportunities

The UK digital economy contributes 7% of national output, 5% of jobs and 9% of businesses. This is similar to the US, but behind South Korea which leads the world at 11% of national output[28].

The UK Digital Catapult has recently refreshed its strategy to focus on technology layers offering UK businesses significant global opportunities. The audit region's research and innovation strengths map well onto this revised strategy. These layers are **Data** – including cyber security and privacy, **Connected** – Internet of Things and 5G, **Intelligent** – machine learning and artificial intelligence and **Immersive** – virtual and augmented reality and new forms of human machine interfaces. It highlights **Creative industries** and **Health** as sectors to target, alongside **Digital Manufacturing** which is addressed under the Aerospace and Advanced Manufacturing theme in this audit.

Clear market and technology opportunities have been identified across the main Digital Living themes and underpinning technologies.

Digital Health

NESTA published "The NHS in 2030"[29]in July 2015. This document offers a vision for the NHS in the medium–term future. It clearly identifies that the digital sector can play an important part in addressing the issues linked to an ageing population along with the reduction of the costs of care and the provision of better care, empowering the individual in term of access to their data and self-diagnosis.

- New improvements in digital technologies will enable an explosion in the use of personalised medicine

[28] The Economist , 11 June 2016
[29] www.nesta.org.uk/sites/default/files/the-nhs-in-2030.pdf

- New digital technologies also allow people to track and analyse their own health data, and to share this and other health knowledge with others in ways that will aid prevention and management of long–term illnesses

Precision medicine will be improved, for example machine learning could be a way to discover new signals of illness or monitor the effects of treatment.

Health knowledge and support, in the form of citizen empowered data access would be able to be delivered, leveraging on the following technologies/applications:

- Microelectronics & silicon design
- Cloud computing, infrastructure, bespoke platforms
- Vision
- Robotics/autonomous systems
- Communications

Virtual and augmented reality will play a role in diagnostics and other interventions, including robotic and remote surgery.

All of these opportunities will be enabled by advances in high speed communications, new sensors development, security and data analysis. As key customers and stakeholders the NHS and associated organisations will be drivers of an active UK supply chain, positioning UK industry as competitive on the world stage. In a report[30] for the UK Office of Life Sciences, Monitor Deloitte segments Digital Healthcare into four areas – *Telehealthcare* – where the UK (and the region) has high penetration rates but risks losing competitive advantage as we remain at the demonstrator stage, *mobile (m)health* - with predicted growth rates of c.35% in the UK (2014-18) but challenges in monitising developments due to the NHS reimbursement models, *Analytics* – where growth rates of c 24% are predicted up to 2018 with a strong UK academic base and the NHS offering a single data source and purchaser opportunity and *Digital Health Systems*, the largest and slowest growing segment, with particular challenges in driving the adoption of electronic health records into the secondary acute NHS hospital market and where US suppliers dominate.

The report identifies a total UK market size of £2bn (£23bn worldwide) in 2014 rising to £3bn (£43bn worldwide) in 2018, with Digital Health Systems representing 50% of this market.

Digital Creative Economy

A significant overlap and convergence exists between two significant UK sectors, 'digital/high tech' and 'creative industries' giving rise to the term 'Digital Creative Economy'. NESTAs report "Geography of the UK's creative and high tech economies"[31] highlights that the UK's creative economies sector has been growing more than three times faster than the workforce as a whole. The part of the UK workforce which straddles both the creative and high tech economies has been particularly dynamic growing at 8 % per annum

Digital Economy

[30] Digital Health in the UK: An industry study for the Office of Life Science, Sept 2015, Monitor Deloitte

[31] www.nesta.org.uk/publications/geography-uks-creative-and-high-tech-economies

- The Digital Sector accounted for 7.3 per cent of the UK Economy in 2014, the highest proportion recorded, up from 6.9 per cent in 2009
- The value of goods exported by the UK Digital Sector in 2014 was £15.9bn, a 3.3 per cent increase on the 2013 value of £15.4bn
- In 2009, GVA of the Digital Sector was £93.7bn, and accounted for 6.9 per cent of the UK economy. Between 2009 and 2014 it increased by 26.3 per cent, compared to an increase of 20.0 per cent for the UK economy as a whole over the same period
- In 2014, there were 2.0 million jobs in the Digital Economy, an increase of 1.7 per cent compared with 2013 and 6.4 per cent of the total number of jobs in the UK
- The number of jobs in the Digital Economy has increased by 7.1 per cent since 2011 to 2.0m, representing 6.4% of UK jobs, which increased by 4.2 per cent.

The Creative Economy

- The GVA of the Creative Industries was £84.1bn in 2014 and accounted for 5.2 per cent of the UK economy
- It increased by 37.5 per cent between 2008 and 2014, compared to an increase of 18.2 per cent for the UK economy as a whole
- IT, software and computer services continued to be the largest constituent part of the Creative Industries, accounting for 43.5 per cent of the Creative Industries GVA

Smart cities/region & transport

In a 2013 report for BIS[32] ARUP identified the market for Smart Cities products and services at greater than $400bn in 2020 with Smart Transport valued at $150bn and with a growth rate of greater than 20%. The ARUP report also suggests that the UK's main opportunities will be in design, finance and engineering services, which it estimates could constitute 25% of the global annual spend.

IoT and Smart Cities are clearly linked opportunities. The integration of data analytics with the cloud, sensors, software development, data storage, security and cryptography and resilience is ready to happen, and the convergence of different strands of technologies coming together will underpin future services and products. Bristol is Open is now at the stage of proving the concept of a truly smart city, where citizen could be empowered. The programme was featured in the Innovate UK commissioned report on Smart Cities[33].

The technologies are today ready for use and integration, as evidenced in the "Era of Living Services" produced by Fjord[34]. The audit region, from Bristol, to the Isles of Scilly through the Smart Islands programme is deploying test beds and running demonstrator projects (such as in connected autonomous vehicles) and is ready for the next revolution.

Underpinning Technology: Cloud Computing (including IoT & Communications)

This theme underpins all applications and sub-themes listed. In communications, trends in video consumption especially mobile video, new formats such as 4K and 8K, cloud computing and storage have driven an exponential growth in data transfer. The trend for all devices to be connected (IoT) and the emergence of new services and content are

[32] www.gov.uk/government/uploads/system/uploads/attachment_data/file/249423/bis-13-1217-smart-city-market-opportunties-uk.pdf
[33] https://issuu.com/senatepublishing/docs/smart_cities?e=24164424/36469903
[34] www.fjordnet.com/conversations/the-era-of-living-services/

driving communications and cloud computing research in a wide range of fields to achieve the required performance, scalability and agility.

Quantum engineering represents a promising emergent technology. From the development of a quantum computer to the improved cryptography using quantum key (QKD) methods, this is recognised at Governmental level as a UK's priority with £275m committed to fund developments. It is one of the EPSRC defined research themes.[35]

The 2016 Ericsson Mobility Report predicts that Internet of Things is expected to surpass mobile phones as the largest category of connected devices in 2018. Additionally it differentiates the two major emerging markets, each one with different requirements: massive and critical applications.

- Examples of massive applications include smart buildings, transport logistics, fleet management, smart meters and agriculture. All of these are characterised by the need for high connection volumes, low cost, low energy consumption and small data traffic volumes.
- Critical IoT connections, instead, require ultra-reliability and availability, with very low latency. This category includes traffic safety applications, driverless cars, industrial applications, remote manufacturing and healthcare applications.

The aerospace engineering industry, which is very strong regionally, offers a route to market for many of these technologies. For example IoT, cyber security and embodiment of high level of security / encryption from the design stage are at the forefront of Airbus Group strategic thinking. The company relies heavily on its specialist supply chain. Accelerating the product development cycles for regional SMEs and other suppliers would be of clear interest for the group.

Underpinning Technology: Digital media (including VR/AR)

Digi-Capital[36] highlights that the major VR /AR segments which will be generating revenues in the future are:

- Content (gaming, film and TV, healthcare, education and social)
- Hardware and distribution (headsets, graphic cards...)
- Software platforms and delivery services (content creation tools, B2B and enterprise uses).

Across these three segments VR and AR are expected to generate total revenues of about $150Bn 2020. As a comparison the film industry, generates content revenues of $104bn today.

The demands VR/AR applications and services place on data transfer is also driving many of the developments that will underpin 5G mobile wireless standards and will leverage future developments in cloud computing and storage, areas of strength for this region.

Other industrial applications of AR and VR have been proposed and researched including for example maintenance and operations support in aerospace and other advanced

[35] www.epsrc.ac.uk/research/ourportfolio/themes/quantumtech/

[36] www.fastcompany.com/3052209/tech-forecast/vr-and-augmented-reality-will-soon-be-worth-150-billion-here-are-the-major-pla

manufacturing fields. The technologies also offer opportunities to enhance workplace learning across a wide range of sectors. To date few applications have reached regular use and significant opportunities exist for content producers and end user companies. IHS[37] predicts that 14 million headsets will be sold in 2016 and 22 million by 2017. Juniper Research forecasts that wearable VR head mounted display shipments will approach 30 million globally by 2020.

Whilst headset and other high level hardware development is unlikely to take place in the UK, much of the content for such devices could and will come from this region, with our creative industries already significant players in the creation of mobile content, games, experiences and installations. The demands VR/AR applications and services place on data transfer is also driving many of the developments that will underpin 5G mobile wireless standards and will leverage future developments in cloud computing and storage, areas of strength for this region.

Other industrial applications of AR and VR have been proposed and researched including for example maintenance and operations support in aerospace and other advanced manufacturing fields. For example Airbus / Endeavr runs the SCADA/ICS Cyber test lab in Newport and are working on AR/VR directly with Microsoft as a Hololens early adopter. The technologies also offer opportunities to enhance workplace learning across a wide range of sectors. To date few applications have reached regular use and significant opportunities exist for content producers and end user companies.

The Centre for the Analysis of Motion, Entertainment Research and Applications (CAMERA) at Bath is working with Headley Court to use 3D scanning techniques to advanced gait analysis for the development of next generation prosthetic limbs for amputees. They are also providing a training platform for those who board naval ships, recreating the stress of such environments through realistic VR content is of high importance.

VR/AR is an emerging area, but there is a strong cross-sectorial case to be made for developing further capabilities in the region. As an example, operational VR capabilities are currently being imported into Airbus in the UK from other parts of the Airbus group, especially in the areas of maintenance and training. Thanks to the regional critical mass in the gaming industry detailed earlier, there is a strong case for ensuring the aerospace and advanced engineering and gaming industries work collaboratively on the development of VR/AR technologies transferrable across sectors.

Underpinning Technology: Robotics/Autonomous Systems (RAS)

A 2013 McKinsey study[38] into disruptive technologies estimates that by 2025 RAS technologies will have an impact on global markets of between $1.9 and $6.4 trillion per annum. Current estimates from Europe and Japan indicate that the market for RAS products and technology, for non-military sectors, will be in the order of £70 billion by 2020-2025.

The RAS sector is made up of a large number of sub sectors. Industrial robotics markets make up the majority of the current and future market. This sector is forecast to be valued

[37] technology.ihs.com/551073/virtual-reality-and-entertainment-bubble-or-next-big-thing
[38] Disruptive Technologies – advances that will transform life, business and the global economy, McKinsey Global Institute, May 2013

at $80bn by 2022 but is unlikely to be addressable to any degree through the regional science and innovation base. There are however many opportunities in niche and emergent sectors[39] that can and will be addressed. Examples include in nuclear decommissioning, where the audit region has leading research and commercial strengths in UAVs and in robotic manipulators and vehicles, RAS is projected to make up 20% of the £50bn per annum global decommissioning costs by 2020. In offshore energy and oil recovery autonomous underwater vehicles (a regional strength) are poised to revolutionise the sector.

In health and social care a 2010 study forecast that annual UK public expenditure on long-term care will increase from £11.3 to £31.1 billion by 2032, with private expenditure due to rise from £7.3 to £22.4 billion in the same period. RAS technologies are emergent in this sector with very significant potential impact on how a future aging population lives and how its healthcare is delivered.

The economic benefit in terms of national costs avoided thanks to the use of RAS as part of the intelligent mobility solutions in transportation over the next 20 years is estimated to be in the order of £1tn for the UK. The world connected autonomous vehicles (CAV) market alone has been valued at $30bn by 2030 by Frost and Sullivan, dominated by vehicle sales. Whilst the region will not capture the majority of this market, systems, communications and control form a significant part of the value add and science and innovation challenges in these areas are being addressed in the region.

7. Conclusions

Investment Opportunities

In both the applications areas and key elements of the underpinning technology base the region has considerable strengths. It has an attractive mix of leading large globally leading companies and innovative and high growth oriented smaller companies that can take advantage of rapidly moving markets with significant economic potential.

The region has also invested in a wide range of innovation resources to support particularly the smaller innovative companies in the fields highlighted. These include Innovation Centres and incubation support, demonstrator platforms and development funds. These resources are somewhat fragmented and investment has tended to be focused at the local (LEP) level with local economic growth as the focus, without considering the regional context. Project and support mechanisms continue to be developed and Appendix DL5 shows a portfolio of digital innovation projects currently under development at the regional level, targeting a range of sources of public investment.

An opportunity exists to better link these innovation support mechanisms, so as to ensure that each is adopting best practice and to link them to existing regionally based companies, large and small, with direct market related interest and technologies to bring to bear. Whilst Universities are frequently hosts or major partners in such initiatives there remains more to be done to integrate science base expertise and those organisations with the potential to collaborate with the researchers, exploit the research outcomes and identify the new research challenges and opportunities.

[39] RAS 2020 Robotics and Autonomous Systems National Strategy, July 2014

A significant opportunity exists to integrate the regional science base with the industry base to bring early stage underpinning research together with the demonstrator phase required to support transition and adoption, and the companies who are leading in the field.

Building on models that have operated both at the regional level in different applications areas (e.g. the National Composites Centre) and internationally in digital innovation (e.g. the Qualcomm Centre at the University of California San Diego) a business case is being developed for a hub-and-spoke based open innovation approach.

At its centre will be a **Digital Innovation Hub (DIH)**, a physical facility that reinvents for the 21st Century the concepts of university-industry partnership and of postgraduate-level education. The DIH will be embedded and integrated within a vibrant and nationally-leading digital technology industry cluster, housing academic researchers in a broad range of disciplines related both to underpinning digital technologies (e.g. cloud computing and HPC; digital media; robotics & autonomous systems; etc) and also to specific application-areas (e.g. digital health, smart cities, and transport systems). The DIH facilities will allow companies to base their employees in the DIH's dedicated office and lab spaces, and to use the DIH's specialist digital infrastructure. But, most significantly, the DIH will offer companies year-round access to working with the University's DIH students engaged in novel postgraduate degree courses with a focus on project-based and problem-based learning, where the content of the education courses is tailored via co-creation and co-delivery with industrial partners. Such courses will also likely be of great value for in-work skills re-training of existing employee. In this sense the primary focus of the DIH will be on the generation of "talent", the highly skilled workers needed for the digital technology companies in underpinning technologies and applications-related areas.

It is envisaged that large companies would wish to base programme or project teams in the building, making use of world leading digital infrastructure and that early stage companies may base themselves in the building from start-up through to the fast growth scale up stage (20-30 employees), supported by world class business advice from **SETsquared**. The Hub building design will recognise the need for commercial confidentiality but would also be designed so as to catalyse and accelerate informal communication between postgraduate students, academic researchers and company employees.

Rather than being an isolated ivory tower, the DIH will build on the region's expertise in community co-production and real world technology evaluation. A defining characteristic of Digital Living is the need to consider the impact of new technologies on daily lives. Recent months are replete with expensive examples of the unanticipated side-effects of digital technologies on the privacy, safety and livelihoods of individuals. There is both a moral and commercial imperative to ensure that acceptability and value are an inseparable part of digital research and development of the design and evaluation of pilots and of the training of young innovators, engineers and scientists.

The Hub will also act as a host location for collaborative project teams, specialist innovation support such as the cross sectoral **VR Hub** referenced previously and as a major demonstrator site in specific digital applications areas, showcasing technologies and applications to a wider audience and allowing early stage technology development to be

accelerated. Figure 4 in Appendix DL8 gives a graphical illustration of a city or region scale demonstrator, integrating many aspects of underpinning technologies with applications level integration.

Finally the Hub will be the home to new and novel postgraduate education programmes, with the focus being on technology project and challenge based learning delivery (normally in conjunction with partner companies), combined with underpinning enterprise education. This format is designed with the objective of producing highly skilled future employees for the digital technologies sector and ensuring they are equipped to be productive at a much earlier stage of their employment that conventional post graduates.

As a Hub it will also have a responsibility to link to other specialised Digital Centres at the regional and national level, (e.g. the 5G Centre at Surrey University), including those focused on supporting start-up and growth technology companies and to offer underpinning technology support to those working in specific application areas regionally, such as Environmental Resilience and Risk (see outline business case for the **Institute for Environmental Risk**- Appendix N), Robotics and Autonomous Systems and Digital Manufacturing.

It will work closely with Catapults at a national level particularly Digital, Future Cities, Energy Systems, Transport and Advanced Manufacturing, acting as a regional focal point or node as appropriate. In order to best link to the innovative SMEs around the region it will partner with Innovation Centres and incubators around the region, best placed to support and develop such companies.

The outline business case for the **Digital Innovation Hub** can be found in Annex N.

Appendices

Appendix DL1 - List of Assets

Digital Health

Asset	Host / Lead	Descriptor
Corsham Institute	Wiltshire	Citizen led data initiatives, Ark Data Centre which securely stores the majority of NHS Biobank/Genomics data.
Connecting for Care consortium	WoE AHSN, 3 Local Authorities, 100+ GP Practices	Around 1 million citizens so far on an NHS interoperability platform and growing is also significant. This is now starting to provide base for R&D activities, which are becoming exploitable
Anchor Robotics Personalised Assisted Living (ARPAL) facility	Bristol Robotics Lab – UWE, Univ. Bristol JV	Living lab that enables robotics researchers, elderly people with assistive needs and those supporting them, to work together to devise and test new robotic solutions in a home environment -
Neuro-Cognitive Research Centre	Plymouth Univ.	Designs and develops new computerised measures of cognitive functioning in neurodegenerative diseases and Health solutions for various diseases or conditions
South West NHS Genomic Medicine Centre	RD&E, Exeter	The South West GMC works with a number of national organisations to achieve the aim of sequencing 100,000 genomes.
SPHERE programme	Univ. Bristol	£ 12M programme - A synthesis of Digital Living technologies being brought together to deliver against the healthy ageing agenda, focusing on employing data-fusion and pattern-recognition from a common platform of largely non-medical/environmental networked sensors in a home environment. Uses local area as a test lab.
West of England Genomic Centre	WoE AHSN	Links longitudinal citizen data sets on over 20,000 individuals over 20 years.
The Diabetes Digital Coach Test Bed	WoE AHSN	NHS IoT Testbed Programme to link mobile health self-management tools (wearable sensors and supporting software) with the latest developments in connecting monitoring devices. Will enable people with Type 1 or Type 2 diabetes to self-manage their condition & encourage more timely and appropriate interventions from peers, healthcare professionals and carers.
MRC Integrated Epidemiology Unit	Univ. Bristol	Conducts some of the UK's most advanced population health science research. It uses genetics, population data and experimental interventions to look for the underlying causes of chronic disease.

ALSPAC	Univ. Bristol	A world-leading birth cohort study. Between April 1991 and December 1992 more than 14,000 pregnant women were recruited and these women, the children arising from the pregnancy, and their partners have been followed up intensively over two decades. It is the most detailed study of its kind in the world and a rich resource for the study of the environmental and genetic factors that affect a person's health and development.
Centre of Excellence - part of the Precision Medicine Catapult	Cardiff Univ.	Providing diagnostic tests and data-based insights into a patient's disease. Led by a consortium headed by Welsh Government, NHS Wales and the University, the Centre will collaborate with local, national and global stakeholders including Welsh Government, academia, health systems and SMEs, to identify and resolve barriers to building a leading UK precision medicine industry
Clinical diagnostics	Cardiff Univ.	Focus is obtaining pathophysiological information from members of the population as a means of providing data for digital processing or remote monitoring
CLIMB project	Cardiff Univ. (partner)	Cloud Infrastructure for Microbial Bioinformatics - develops and will deploy a world leading cyber-infrastructure for microbial bioinformatics; providing free cloud-based compute, storage and analysis tools for academic microbiologists in the UK.
Wellcome Trust Centre for Biomedical Modelling and Analysis	Univ. Exeter	Brings together scientists from quantitative disciplines including mathematics, computer science and physics with those from biology, biomedicine and clinical sciences to enable breakthroughs in biomedical and clinical research
EPSRC Centre for Predictive Modelling in Healthcare	Univ. Exeter	A world leading team of mathematicians, statisticians and clinicians with a range of industrial partners, patients and other stakeholders to focus on the development of new methods for managing and treating chronic health conditions using predictive mathematical models.
SMART lab	Univ. Exeter	Study of Maladaptive to Adaptive Repetitive Thought - work includes development of digital tools to support patient self-management and reporting.
EXTEND	NIHR Clinical Research Facility Exeter	Provides a database of nearly 10,000 people who have agreed to participate in healthcare research carried out at the University of Exeter and have donated samples to a biobank.
European Centre for Environment and Human Health	Truro, Univ. Exeter	Leads the Medical & Environmental Data Mash-up Infrastructure (MEDMI) project which aims to connect diverse databases to improve our understanding of the links between climate, environment, and human health.

Telecare & Telehealth	Cornwall College	Delivery of qualifications for telecare and telehealth practitioners for well over 10 years strong links with the Telecare Services Association (TSA) - the industry body for telecare and telehealth. extensive links with local business
National Centre for Excellence in telehealth and telecare	Cornwall, BT	
Centre for Robotics and Neural Systems	Plymouth Univ.	Ambient intelligence and robotics to support young patients and elderly users.
Interdisciplinary research initiatives	Plymouth Univ.	E-Health: health decision-making; telehealth (e.g. e-Caalyx and LiveWell); “big data” (e.g. BioPattern); user-led e-health (e.g. SharpTalk and Diabetes App Challenge); social robotics (e.g. ALIZ-E and ROBOT-ERA); computer-aided diagnosis (e.g. ACEmobile); development of novel eHealth interventions (e.g. Face It); and e-health implementation studies (e.g.Superfast evaluation, Plymouth SeniorNet)
Cognition Institute’s CogNovo	Plymouth Univ.	Exploring different methods of iterative and bidirectional communication and engagement with communities to understand the barriers and enablers of technology to deliver prevention, health and social care;); Establishing the full impact of technology-based health and wellbeing social care throughout a person’s life in home, workplace and community; Extending the application of gaming technology to the health and wellbeing sector; Understanding the impact on other health and social care services of prolonged use of assistive and innovative communication and delivery technologies;
Institute of Health and Community	Plymouth Univ.	VOYAGE is an inter-disciplinary initiative that harnesses research and innovation in the field of ageing across Plymouth University and its many external partners.
NHS Digital Exemplars	NHS Foundation Trusts	Taunton and Somerset NHS Foundation Trust and University Hospitals Bristol NHS Foundation Trust have been selected as two of twelve “digital exemplar” sites in England to lead the use of digital technology to drive radical improvements in the care of patients. They will each received £10m from NHS England in a bid to inspire a digital revolution across the health service.

Digital Creative Economy

Asset	Host / Lead	Descriptor
Knowle West Media Centre	WoE	Develops opportunities for a wide range of people to 'imagine' the future, by testing ideas and digital technology within communities, public spaces and homes
REACT Hub	UWE, Bristol, Cardiff, Exeter	One of 4 knowledge exchange hubs funded by the AHRC, which connected arts and humanities researchers to creative technology businesses to make new prototype products or services. REACT has been bringing together a local cluster of micro-companies around the Persuasive Media Studio, which acted as a Hub
Digital Cultures Research Centre	UWE	Concerned with the meaning and uses of media technologies in everyday life, focusing upon Pervasive Media, Play, and User-Generated Content.
iDAT	Plymouth Univ.	Vehicle for world-class research and development activities alongside commercial and cultural projects which extend the University's cultural and arts programmes and support the delivery of the enterprise agenda.
Digital Humanities	Univ. Exeter	The Digital Innovation Lab will offer to create labs and research space for the examination and preservation of important historical, literary and visual artefacts.
Creative Arts & Games	Falmouth Univ.	UK's highest ranking Arts University, leading in the creation of the future talent pool for the creative industry sector. Falmouth Launchpad (Games) is designed to prove an innovative methodology, building high-growth/high-value businesses to market demand, meeting challenges set by industry partners in the digital games sector
Playable City	Watershed	An initiative that brings creatives and smart cities technologies together to create connections and play, exploring the implications of embedding technologies within city infrastructure and developing imaginative prototypes that rethink public spaces
Connected Performance	Falmouth Univ.	Building on EU research programmes, Falmouth conducts leading edge research into connected performance, which is applied to areas such as immersive games and telehealth. Projects such the "Online Orchestra" have utilised the internet to provide opportunities for children and practitioners in remote communities to participate in a combined dance or orchestral performance.
School of Media	Cheltenham,	The School covers the full range of creative media,

	Univ. of Glos	including film, TV, radio, popular music, animation, with strong professional links to the media industry. The School supports the University's Research Centre for Innovation, Design and Technology, which includes VR/AR/Digital solutions in design, music technology and digital innovation.
Gloucestershire Growth Hub	Gloucester, Univ. of Glos	The Hub was established by the University in October 2014 in partnership with Gfirst LEP. It provides a wide range of business services for creative media and other sectors. With investment from Growth Deal 1, it will be moving to new, purpose built premises in 2018, co-locating the Growth Hub, the University Business School and the LEP.
Creative Cardiff	Cardiff	A network connecting people working in any creative organisation, business or job in the Cardiff region. Runs events and initiatives that support increased collaboration and innovation.
CAMERA	Bath	Motion capture facility and researchers at the University of Bath**,** in close partnership with The Imagarium, Bath, Europe's foremost motion capture studio.
Digital Innovation Fund for the Arts in Wales	Cardiff, Arts Council of Wales/ NESTA	Supporting arts organisations to explore digital technology uses to enhance audience reach and engagement and to embed and scale demonstrators
DC Labs	Falmouth, RCUK	Digital Creativity Labs (DC Labs) is a major (£18 million) investment by three UK research councils, four universities, and over 80 collaborative partner organisations to create a world centre of excellence for impact-driven research, focusing on digital games, interactive media and the rich space where they converge. Based at The University of York, with "spoke" sites at the Cass Business School, Goldsmiths (University of London) and Falmouth University.

Smart Cities/Regions and Transport

Asset	Host / Lead	Descriptor
Bristol is Open / Open Programm-able City	JV Co - City Council & Univ. Bristol	World leading city scale digital research infrastructure with: fibre in the ground; a mesh bouncing from lamppost to lamppost across the City; and a mile of experimental wireless connectivity along Harbourside. The networks are controlled in Software – creating a Software Defined Network. It uses Network Function Virtualisation to make the infrastructure super-fluid, sliceable, and usable by many different projects at once. Extension across the WoE is planned.
REPLICATE	Bristol – 1 of 3 Light-house Cities City Council / Univ. Bristol	£29m euro H2020 project developing and validating a Sustainable City Business Model; enhancing transition to smart cities in the areas of energy efficiency, sustainable mobility and ICT infrastructure. The main purpose is to accelerate the deployment of innovative technologies, organisational and economic solutions to significantly increase resource and energy efficiency, improve the sustainability of urban transport and drastically reduce urban greenhouse gas emissions
High Performance Network Group	Univ. Bristol	Specialises in the application of advanced hardware and software technologies, targeting future optical communication networks for data centres, cloud based applications and distributed technologies including in smart cities applications
Communica-tions and Networks Group	As above	At the forefront of world research and development for more than 25 years with many major technological achievements to its credit including: Wireless LAN technology, Wideband CDMA for 3G, SMART Antennas, Smart Grid/Smart Metering, Sensor Networks, Wireless Network Coverage CAD software and power efficient RF transmitters for Digital Video Broadcast (DVB) and cellular communications. Now focused on developments in 5G technologies and applications areas from smart cities to connected trains and road vehicles
Flourish/ Venturer		Funded by Innovate UK the VENTURER consortium is trialling autonomous vehicles in the Bristol and South Gloucestershire council areas to explore the feasibility of driverless cars in the UK. The trial is being funded by Innovate UK to investigate the legal and insurance aspects of the new technology and explore how the public react to such vehicles. FLOURISH focuses on the core themes of wireless

		connectivity, security and customer interaction. The three-year project, worth £5.5 million, will develop products and services that maximise the benefits of connected and autonomous vehicles (CAVs) for users and transport authorities. By adopting a user-centred approach, it will achieve a better understanding of consumer demands and expectations, including the implications and challenges of an ageing society.
UK Collaboratorium for Research and Infrastructure in Cities (UKCRIC)	Univ. Bristol, Cardiff Univ.	Urban areas are serviced by complex, interdependent systems provided by a number of interacting infrastructures at high density. Digital infrastructure is increasingly enabling real-time, in situ testing of infrastructure performance. UKCRIC will establish a network of interlinked urban infrastructure observatories at sites across the UK including Bristol and Cardiff for the digital capture, mapping, sensing, monitoring and testing of real urban infrastructure systems over the long-term.
Centre for Transport and Society	UWE	Research to understand the inherent links between lifestyles and personal travel in the context of continuing social and technological change
The Bristol Urban Area Diagnostics Pilot	UWE/ Univ. Bristol	One of 5 pilots under the new Innovate UK/RCUK (UKRI) URBAN Living programme looking at complex problems across four 'Challenge Themes': Mobility & Accessibility, Health & Happiness, Equality & Inclusion and the 'Carbon Neutral' city
SMART Islands	Council for the Isles of Scilly	Proposed smart grid/smart energy programme to meet the islands energy objectives energy cost reduction, renewables and low carbon vehicles
Exeter City Futures	Exeter City Council	A private-sector led initiative to grow the region's economy, safeguard its natural resources and improve quality of life through the innovative use of data. It has links to investors creating a fund of up to £100m to invest in enterprises with growth potential.

Underpinning Technologies: Cloud Computing, Communications and IoT

Asset	Host / Lead	Descriptor
The Bristol Vision Institute	Univ. Bristol	Host to the EPSRC's only Platform Grant in Vision Science and Engineering, which brings together BBC, ARRI, QinetiQ, Thales, and The Academy of Motion Pictures, Arts and Sciences.
Jean Golding Data Institute	As above	University Research Institute focusing on interdisciplinary research involved in creating, processing, investigating and exploring big data
Smart Internet Lab	As above	Strategic and applied research on key communications and digital technologies, a hub for Internet Research, fusing research expertise and innovation in a range of areas such as Smart Cities, Autonomous Vehicles, IoT and eHealth; 200 experts across the boundaries of wireless, networks and photonics.
Advanced Computing Research Centre	As above	World-leading research into the efficient use of many-core parallel computer architectures and open parallel programming standards.
Communication Systems & Networks (CSN) Group	As above	Addresses topics such as the Internet of Things (IoT), Massive MIMO, robust vehicular communications, dynamic mmWave networks, full duplex communications, wearable wireless technologies and wireless/optical network integration. Many of these subjects are critical in the development of efficient and cost-effective 5G networks.
Cryptography and Information Security Group	As above	Conducts research into cryptography, the underlying hard problems on which it is based and the hardware and software needed to implement secure systems including techniques for proving security of cryptographic systems, the efficient implementation of such systems on small computing devices and the verification that such implementations do what they say they do. Unique in its combination of theoretical and practical work it is a world leading research group. The University hosts a GCHQ/EPSRC Academic Centre of Excellence in Cyber Security Research.
Heilbronn Institute	Univ. Bristol / GCHQ	The Heilbronn Institute is a partnership between the University and GCHQ. Each member of the Institute spends half their time pursuing research directed by the Government Communications Headquarters, and the other

		half doing personal academic research. Fields of expertise include topics in number theory, algebraic geometry, algebra, combinatorics, probability, quantum information, computational statistics and statistical learning
Bristol Interaction and Graphics (BIG) Group	Univ. Bristol	BIG acts as a hub for collaboration between social scientists, artists, scientists and engineers to combine efficient, aesthetic and innovative design. Research areas include human-computer interaction, visual, auditory and haptic perception, visualisation and sonification, touch and gestural input, tangible interfaces, augmented and virtual reality, wearable and on-body computing, sustainable interaction design, digital engagement, interactive fabrication as well as flexible and actuated devices.
Intelligent Systems Group	As above	Extraction of information and knowledge from data. Research includes machine learning, pattern recognition, web technologies, data mining, bioinformatics, semantic image analysis and natural intelligent systems.
Bristol Robotics Lab	Univ. Bristol/ UWE joint venture	Research Themes Aerial robots Assisted Living Bioenergy & Self Sustainable Biomimetic and neuro-robotics Control for HRI Medical robotics Nonlinear control in robotics Robot vision Safe human robot interaction Smart automation Soft robotics Swarm robotics Unconventional computation Verification & validation
Bristol Is Open	Univ. Bristol/ Bristol City Council joint venture	brings together many technology strands from the Internet Of Things to the cybersecurity, block chain, big data management and communications
High Performance Computing Wales	All Wales initiative led by Bangor but with a hub in Cardiff (and three	Wales' national supercomputing service provider and host to the UK's largest distributed general purpose supercomputing network. a multi-million pound investment that

	other locations)	gives businesses and researchers access to world-class, secure and easy-to-use high performance computing technology
Data Innovation Institute	Cardiff Univ.	Fundamental research into the aspects of managing, analysing and interpreting massive volumes of textual and numerical information
Crime & Security Research Institute	As above.	Internationally-recognised research that generates new evidence and insights to help reduce crime and increase security, in partnership with organisations such as IBM, WHO, What Works Centre for Crime Reduction
Cardiff Social Data Science Lab	As above.	ESRC strategic 'Big data' investment to support real-time social data analytics for research, policy and practice. The Lab forms part of Cardiff University's Data Innovation Institute
Exeter City Futures	Exeter City Council	A private-sector led initiative to grow the region's economy, safeguard its natural resources and improve quality of life through the innovative use of data. It has links to investors creating a fund of up to £100m to invest in enterprises with growth potential.
Coelition	Devon	An independent not-for-profit company which supports a global ecosystem for the responsible use of behavioural data
Open Data Institute Nodes	Bristol, Cardiff, Cornwall & Devon	1/3 of total UK ODI Nodes - connect, equip and inspire people around the world to innovate with data, led by local experts.
Centre for Security, Communication and Network Research (CSCAN).	Plymouth Univ.	Leading the commercialisation of a novel security appliance aimed at Schools, working in collaboration with Devon and Cornwall Police, the South West Grid for Learning and the Internet Watch Foundation, with a nationwide rollout in September 2016
Microelectronics Research Group	Univ. Bristol	Research spanning the mobile/embedded and high performance computing spaces including parallel and reconfigurable computer architectures, energy efficient computing, fault tolerant systems, design verification, and next generation technologies, such as 3-D chip design and NEMS
Quantum Engineering Technology Laboratories	As above.	A globally significant centre for research, development and entrepreneurship in the emerging quantum technology industry and is an international node for collaboration with industrial and academic world leaders, and the EPSRC UK Quantum Technology Hub

		Network.
Met Office	Exeter	Europe's largest environmental High Performance Computer in the world at the Met Office, with its Informatics Lab and new collaborative space, based at Exeter Science Park
i-DAT	Plymouth Univ.	Co-creates and shares technological prototypes and practices that push and challenge the boundaries of digital arts and creative media practice. Main focus is on making 'data' tangible, playable and readily available as a material, to generate new meaning and inform participation, audience engagement and innovation in the arts.
School of Computing and Technology	Cheltenham and Berkeley University of Gloucestershire	Hosts teaching, research and business support facilities in Cheltenham and Berkeley. Covering computing, cyber and games, it has strong partnerships with the growing cluster of computing/cyber related agencies and businesses in Cheltenham, Gloucester and Malvern
Gloucestershire Science and Technology Park	Berkeley; University of Gloucestershire with South Gloucestershire and Stroud College	The Park is based on the former nuclear power station at Berkeley and continues to house nuclear research facilities. It is benefiting from Growth Deal investment to build construction and engineering skills, advanced computing and cyber facilities, a University Technical College specialising in computing and engineering. It is also the site for approved future Growth Deal investment in renewable energy
Human Computer Interaction Group	Univ. Bath	Research into issues related to understanding human tasks and activities, including collaboration, how these are influenced by Information and Communication Technologies and the associated implications for the design of future interactive systems
SW Centre of Excellence in Satellite Applications.	Goonhilly Earth Station	One of 5 CoEs under the Satellite Applications Catapult, this brings together the expertise of the Met Office, the Universities of Exeter and Plymouth, Falmouth and Rothamstead Research. Key initial themes are: Marine/Maritime industry, Agritech/food supply, eHealth/eWellbeing

Underpinning Technology: VR/AR

Asset	Host / Lead	Descriptor
Games Hub		Physical space and network bringing together developers and academics to create and study games. Regional VR/AR champion.
VR World Congress	Industry	UK's biggest VR trade event
AIRBUS Wing Integration Centre	AIRBUS	Includes VR engineering suite
CAMERA - Centre for Analysis of Motion, Entertainment Research and Applications	Univ. Bath	Motion Capture, Visual Effects and Video Game Research, Virtual and Augmented Reality, and Performance Analysis for elite sport, health and rehabilitation
@Bristol Datadome	@Bristol, BIO, Univ. Bristol	UK's only 3D 4K immersive presentation space (120 seats). Connected to a dedicated High Performance Computer & used to explore how new technologies can be used to visualise and manipulate data and information with engineering, medical and smart city applications
CFMS – the Centre for Modelling and Simulation		Independent not for profit specialist in high value engineering design capability underpinned by high performance computing, advanced modelling and simulation
Visual Information Laboratory	Univ. Bristol	Undertakes innovative, collaborative and interdisciplinary research resulting in world leading technology in the areas of computer vision, video communications, 3-D visual mapping and navigation, image and video communications, content analysis and image-sensor processing.
Intelligent Systems Group	Univ. Bath	Research into the two-way relationship between natural and artificial intelligence, with an emphasis on constructing and modelling complete systems.
The Immersive Vision Theatre at i-DAT	Plymouth Univ.	Research tool for simulation, VR and gaming
Bristol-BBC Immersive Technology Laboratory	Univ. Bristol/BBC R&D	In association with partners including Aardman Animations. An innovative research collaboration in Immersive Technology spanning engineering and psychology with application to the creative arts. Provides key underpinnings for future consumer and professional technology and services.

The Centre for Research in Applied Cognition, Knowledge, Learning & Emotion (CRACKLE)	University of Gloucestershire Cheltenham	The Centre specialises in psychology-driven research into neuroergonomics; situation awareness; virtual and augmented reality systems; impact of emotion on decision making in safety critical and pressured environments; application of VR in training for care settings / forensic settings. Current projects include psychological aspects of crime, decision-making in high-risk contexts such as the foreground, health psychology and counselling
Interactive Systems Studio	Plymouth University	An open innovation R&D studio, investigate current technologies, platforms and working processes to innovate in the field of interactive systems and 3D environments. This ranges from entertainment systems on mobiles through to serious games simulations, virtual and augmented reality environments. The studio team investigates new approaches and develops real world solutions both for undergraduate programme and working in collaboration with external partners.

Underpinning Technology: Robotics/Autonomous systems

Asset	Host / Lead	Descriptor
Bristol Robotics Laboratory	UWE/Univ. Bristol JV	Leading UK centre with research in a wide number of themes:- Aerial robots, Assisted Living, Bioenergy & Self Sustainable, Biomimetic and neuro-robotics Control for HRI, Medical robotics, Nonlinear control in robotics, Robot vision, Safe human robot interaction Smart automation, Soft robotics, Swarm robotics, Unconventional computation, Verification & validation, Intelligent Systems
Centre for Robotics and Neural Systems	Plymouth Univ.	Interdisciplinary research cluster, with international collaborations in robotics, machine learning and artificial intelligence
Communication Systems & Networks (CSN) Group	Univ. Bristol	Wireless communications – research into connected (train and car) vehicle systems
National Composites Centre	Univ. Bristol	Part of HVM Catapult - national centre of excellence for the development and application of robotics in composites manufacture
Autonomous Marine Systems (AMS) research group	Plymouth Univ.	Artificial intelligence (AI), advanced control systems engineering theory, multi-sensor data fusion, dynamics, thermodynamics and fluids, SMART materials, marine power plant, marine vehicle performance prediction, propulsors, integrated navigation systems and marine renewable energy.
Venturer, Flourish	Bristol	Industry led programmes - Autonomous and Connected Vehicles – see Smart Cities
SW Nuclear Hub	Univ. Bristol	Autonomous drone based monitoring of nuclear sites, spinout company created
Medical robotics	NHS Bristol	Research in the application of robotics in urology/prostate surgery & deep brain stimulation
ASTREA programme	AIRBUS South Wales	The programme focuses on enabling the routine use of Unmanned Aircraft Systems (UAS) in all classes of airspace without the need for restrictive or specialised conditions of operation.

Appendix DL2 Research Evaluation Framework

The Digital Living theme covers a broad range of academic disciplines, spanning 29 REF units of Assessment (UoAs), with 10 with greater than 10% of staff specialising in Digital Living related research:

UoA		Submitted staff associated with theme	No of HEIs	Doctoral awards 2008-16*	UoA overall profile (% 3 or 4*)	>10% related staff
1	Clinical Medicine	18.5	3	18	83%	10%
2	Public Health, Health Services and Primary Care	3	2	12	84%	
3	Allied Health Professions, Dentistry, Nursing and Pharmacy	26	4	63	85%	11%
4	Psychology, Psychiatry and Neuroscience	41	4	67	85%	19%
5	Biological Sciences	7	3	21	85%	
6	Agriculture, Veterinary and Food Science	3	2	4	73%	
7	Earth Systems and Environmental Sciences	13	3	40	86%	
8	Chemistry	5	1	22	96%	
9	Physics	11	2	50	89%	
10	Mathematical Sciences	4	2	12	74%	
11	Computer Science and Informatics	103.8	6	336	81%	80%
13	Electrical and Electronic Engineering, Metallurgy and Materials	7.8	1	24	65%	28%
14	Civil and Construction Engineering	1	1	5	97%	

15	General Engineering	64.5	5	251	90%	26%
16	Architecture, Built Environment and Planning	10	2	26	73%	
17	Geography, Environmental Studies and Archaeology	10	3	19	77%	
19	Business and Management Studies	12.7	3	54	74%	
20	Law	2	2	11	84%	
21	Politics and International Studies	1	1	6	81%	
22	Social Work and Social Policy	10	3	6	76%	
23	Sociology	7	2	46	82%	10%
25	Education	3	2	7	69%	
26	Sport and Exercise Sciences, Leisure and Tourism	4.2	2	9	89%	
28	Modern Languages and Linguistics	4	2	2	66%	
29	English Language and Literature	2	2	15	78%	
30	History	2.8	1	12	73%	
34	Art and Design: History, Practice and Theory	27.8	4	45	57%	28%
35	Music, Drama, Dance and Performing Arts	19	4	21	55%	17%
36	Communication, Cultural and Media Studies, Library and Information Management	7	2	16	80%	18%

Appendix DL3 - Publication data

An analysis of data relating to academic publications related to the Digital Living theme was undertaken, searching by a comprehensive list of keywords/phrases to focus the search on areas of particular relevance.

Regional Publications = 3899	No Publications	Regional Share
World	78,411	5%
Europe	40,739	10%
UK	15,312	25%

	FWCI	Outputs In Top Percentiles (10%)	Publications In Top Journal Percentiles (10%)	Academic-Corporate Collaboration	International Collaboration
World	1.71	18%	24%	2%	26%
Europe	1.73	18%	24%	2%	39%
UK	2.13	23%	28%	2%	45%
Region	2.47	27%	32%	3%	52%

Digital Living - Region:

	FWCI	Outputs In Top Percentile (10%)	Publication In Top Journal Percentile	Academic Corporate Collab	Intl Collab
Big data	2.3	28%	29%	1%	62%
Comms	2.12	14%	31%	0%	43%
Creative digital	2.39	30%	31%	1%	53%
Crypto	5.34	16%	14%	19%	63%
Digital health	1.91	14%	35%	5%	45%
Elec	2.34	23%	37%	5%	45%
Quantum	2.97	23%	25%	7%	72%
Robotics	1.91	14%	35%	5%	45%
Vision	1.17	7%	51%	0%	56%
Average	2.494	19%	32%	5%	54%

Digital Living: UK

	FWCI	Outputs In Top Percentile (10%)	Publication In Top Journal Percentile	Academic-Corporate Collab	Intl Collab
Big data	1.94	21%	27%	3%	51%
Comms	1.86	15%	29%	0%	40%
Creative digital	2.09	22%	26%	1%	43%
Crypto	3.88	11%	20%	18%	59%
Digital health	2.13	24%	28%	2%	37%
Elec	2.09	22%	38%	4%	47%
Quantum	2.64	28%	27%	5%	70%
Robotics	1.83	16%	37%	3%	48%
Vision	1.91	8%	47%	5%	50%
Average	2.263	19%	31%	5%	49%

Digital Living: Europe

	FWCI	Outputs In Top Percentile (10%)	Publication In Top Journal Percentile	Academic-Corporate Collab	Int. Collab
Big data	1.65	15%	22%	2%	40%
Comms	2.12	13%	34%	7%	35%
Creative digital	1.74	20%	22%	1%	42%
Crypto	3.22	10%	23%	10%	46%
Digital health	1.69	20%	22%	2%	33%
Elec	1.78	18%	36%	5%	38%
Quantum	1.83	23%	24%	4%	57%
Robotics	1.63	12%	31%	2%	32%
Vision	1.42	8%	36%	3%	36%
Average	1.898	15%	28%	4%	40%

Digital Living: World

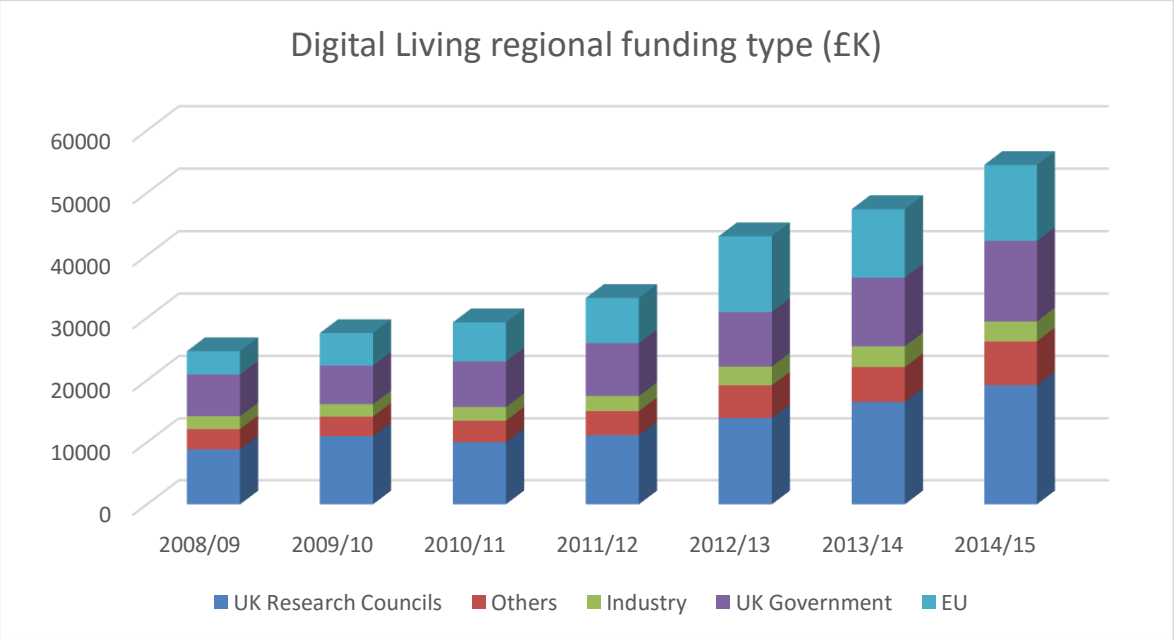
	FWCI	Outputs In Top Percentile (10%)	Publication In Top Journal Percentile	Academic-Corporate Collab	Int. Collab
Big data	1.49	14%	21%	2%	26%
Comms	1.75	9%	31%	5%	22%
Creative digital	1.6	17%	19%	1%	28%
Crypto	2.84	8%	21%	9%	27%
Digital health	2.19	27%	26%	2%	25%
Elec	1.47	15%	29%	4%	23%
Quantum	1.57	19%	23%	4%	36%
Robotics	1.48	10%	28%	3%	19%
Vision	1.12	7%	31%	4%	20%
Average	1.723	14%	25%	4%	25%

Appendix DL 4 - Theme income data

The tables below present the total research income related to the Digital Living theme since 2008, by HE institution and funders' type.

HESA funder type	Total research income as related to theme (£k)						
	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15
University of Bristol	10,137	11,713	12,123	15,232	17,599	22,195	24,139
Falmouth University	163	18	650	285	3,169	847	212
Bath University	1,316	1,344	1,614	1,511	1,911	2,406	2,930
Exeter University	348	336	318	295	1,266	2,936	2,347
Plymouth University	3,155	3,719	3,238	2,654	3,656	3,727	6,935
University of West of England	5,069	5,664	5,516	5,920	7,815	6,381	6,366
University of South Wales	57	42	162	712	277	152	892
Gloucester & Cheltenham University				12	32	32	125
Cardiff University	4,401	4,707	5,634	6,556	7,360	8,737	10,647
Regional Total income (£k)	24,645	27,542	29,255	33,176	43,085	47,413	54,593

HESA funder type	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15
1 BIS Research Councils, Royal Society, British Academy and Royal Society of Edinburgh	8,847	10,976	10,031	11,158	13,912	16,498	19,203
10 Non-EU based charities (open competitive process)	84	55	109	67	153	271	261
11 Non-EU industry, commerce and public corporations	189	107	122	210	53	67	74
12 Non-EU other	245	171	292	386	722	961	1,312
13 Other sources	127	272	161	217	339	265	491
2 UK-based charities (open competitive process)	2,642	2,534	2,743	2,895	3,478	3,641	4,398
3 UK-based charities (other)	180	122	145	289	555	485	542
4 UK central government bodies, local authorities, health and hospital authorities	6707	6223	7313	8472	8743	11,001	12,956
5 UK industry, commerce and public corporations	1,887	1,896	2,089	2,243	2,990	3,268	3,192
6 EU government bodies	3,332	4,813	5,417	6,859	12,051	10,763	11,902
7 EU-based charities (open competitive process)	0	3	35	168	8	39	8
8 EU industry, commerce and public corporations	351	233	703	142	69	117	165
9 EU other	55	137	95	70	12	37	89
Regional Total income (£K)	24,646	27,542	29,255	33,164	43,053	47,381	54,468


Digital Living regional funding type (£K)
60000
50000
40000
30000
20000
10000
0
2008/09
2009/10
2010/11
2011/12
2012/13
2013/14
2014/15
UK Research Councils
Others
Industry
UK Government
EU

Appendix DL5 - Major Companies in Theme

Major Digital companies

Aardman, Andromeda Capital, ATASS, Black Swan, BBC (Creative output in Cardiff & National History Unit in Bristol), Broadcom, Roath Lock Studios, Pinewood Studios, Launchpad, ClusterHQ, Cisco, Cray, Play Nicely, Auroch Digital, Opposable VR, BMT Defence, BDH Productions, the R Index, 422South, Zubr VR, Fourth reality, 360 Virtual Tours, VRGO, Motion Impossible, CRMS, Dashboard, Dyson, ForgeRock, Future Cities Catapult, Hitachi, Hewlett Packard, Huawei, IBM, Google, Nokia Networks, Oracle, Renishaw, Toshiba, Ultra, PCS, NFC, Nokia (Through BIO), Sift, E3, Zone, Mubaloo, Aerian, Complete Control, True Digital, Nomensa, Bristol Games Hub, Amdocs, Zynstra, Eden Ventures, Future Publishing

Companies with digital related applications on their top requirements list

EDF Energy, the Met Office, Airbus, Ashwoods Automotive, Leonardo (AgustaWestland), Avanti, BAE Systems, BMW, Boeing, Broadcom, Claverham, Cobham, Doncasters, Dowty, GE Aviation, GKN Aerospace, Goonhilly Earth Station, HiETA Technologies, Honda, Honeywell, Ipeco composites, JLR, Johnson Matthey, MBDA Systems, McLaren, Messier Dowty, Pall Aeropower, QuEST Global, Rolls-Royce, Renishaw, SKF Clevedon, Smith Industries, Thales, Horizon/Hitachi, Western Power Distribution, Toshiba, National Grid and Ofgem, Alstom, Atlantis, BAE Systems, Carnegie, Fugro, Marine Current Turbines, Met Office, Seabased, Seatricity, Searaser, Simply Blue, Sonardyne OWEL, QinetiQ, Tocardo, Valeport, Viper Subsea, Wello, Endeavr, Cassidien, ARUP, Atkins. The National Nuclear Laboratory, Buro Happold Engineering, Altran, BMT Defence Services, Babcock, IPL

Next generation of micro-electronics companies

Present in the region are: Avanti, BlueWireless, Broadcom, Cray, Dialog Semiconductor, General Dynamics, Gooch & Housego, Imagination Technologies, IQE plc, HP, Huawei, Plessey, Raytheon, Silicon Basis, Toshiba and Xmos, Intel.

Appendix DL6 - Project Portfolio

Projects in progress are outlined in the table below, which shows current and proposed initiatives in Digital Living related areas across the region. This includes funded programmes and those looking to access funding through a variety of routes including Research Councils, Local Growth Fund LEP round 3 submissions, City Deals and other Government programmes.

Project/Scheme	Funding Source	Description
QUTIC	Local Growth Fund 3 – business case under development	Quantum Technologies Incubation Centre – offering facilities to support early stage companies developing products and services utilizing emerging quantum technologies. Aligned with the Quantum Technologies Lab at the University of Bristol
Futurespace	BIS Univ. Enterprise Zone pilot, Local Growth Fund 2	First phase opened Aug. 2016 - The 4,000 square metre building provides laboratory space, offices and workshops, share start-up 'studio' space, communal space for networking and meeting, access to specialist equipment and technical support and business services.
Health Hub – UEZ Bristol	ESIF – applied for	Focused on innovation for independent living and citizen-centric health, bringing together expertise in robotics, biosensing, microelectronics, big data (for healthcare) and communications
Devonport Market Hall		A new digital hub, with 3,000 square feet of bespoke, quality office, lab for digital creative companies and organisations; a cultural, corporate events space with a seating for up to 350 people and an expo capacity of 600, and a digital visitor experience of touring programmes, screen and installation based work and programmed activity.
National Cyber Security Centre for Wales	City Deal proposal	National Cyber Security Centre for Wales (NCSCW) could be based in Newport. The vision is to advise, protect and secure businesses within the region.
Economics Centre of Excellence and Data Science Campus	ONS	A hub for the whole of Government to gain practical advantage from the wider investment in data science research and help cement the UK's reputation as an international leader in data science. By partnering with academia, the ONS will develop more 'real-time' economic statistics so that emerging issues and trends are

		spotted more quickly and understood in greater detail
Institute for Data Science – University of Exeter	Internal investment	A hub for development and use of innovative methodological data science approaches across the University, with a focus on four thematic areas: (1) environment and agritech (2) health, bioinformatics and the life course, (3) business innovation, and (4) security, ethics and governance.
SMARTLINE: Smart technology, linking innovation and needs for wellbeing in communities – University of Exeter, European Centre for Environment and Human Health	Cornwall & Isles of Scilly ESIF – applied for	SMARTLINE will identify the requirements and market potential for new eHealth/eWellbeing products and services, identify skills gaps, and create jobs. To achieve this it will investigate how new technology promotes improved health and wellbeing ("eHealth/eWellbeing") for individuals, their families and communities. This project will collect new data, and connect previously unlinked data and use innovative data analytical techniques to enable timely and targeted interventions, involving existing and new service providers. It will also provide a more efficient and effective lettings and asset management model for social housing, develop more resilient communities, and address issues of social isolation.
LABSTER Cornwall Centre of excellence for virtual laboratory simulations	ESIF – stage 2 bid due 30th Aug 2016	The project delivers new business-led innovations based on Labster's pioneering Virtual Laboratory Simulations that immerse users in real-world digital environments to enhance their learning, knowledge and experience in scientific experimentation and practice. Labster will work with the Exeter and Plymouth Universities to achieve: - the co-creation of new Virtual Laboratory Simulations: - R&D and innovation through product market testing and development intended to expand the product range to develop products that support.
Cheltenham Cyber Park	Local Growth Fund 3	A proposed business park, adjacent to GCHQ in Cheltenham, focused on incubation and support for companies related to computing and cyber; building on the 2015 Government announcement of a new Cyber Innovation Centre in Cheltenham

Environmental Futures and Big Data Impact Lab	Heart of the SW LEP	Recent proposal for an Environmental Futures and Big Data Impact Lab, which recognises the opportunity in the region to become a national centre of excellence for environment-related Big Data analytics, an underpinning technology / approach that is: key to understanding and addressing environmental issues; a driver for innovation; and central to productivity-led growth across the UK economy as a whole.
Bristol VR Lab		Private sector led proposal for the creation of a Lab which will deliver working space for VR/AR researchers and developers, access to latest technical innovation and hardware with introductory services to investors. It will have strong ties to the @Bristol Science centre, which will provide test space for VR content and hardware to be trialled with the public.
Bath Hacked	Bath	A joint council/community initiative that aims to put open data and smart thinking at the heart of the city. The primary mission is to bring bright people and quality data together to do useful things for the community.
National Arts and Technology Innovation Centre	Watershed /Arts Council Stage 1 Feasibility Study	Developed by the Watershed, the innovation centre will combine expertise in arts and technology, film and media, robotics and materials, education and engagement, business and entrepreneurship. Alongside the reknown Watershed cinemas, events suite, café/bar and Pervasive Media Studio the new centre will add facilities for showcasing, seminars, meetings, prototyping, collaboration and networking workspace for 100 people at early start-up and initial grow on stages

Appendix DL7 - Theme Definitions

Digital Health: Better use of data and technology has the power to improve health, transforming the quality and reducing the cost of health and care services. It offers patients and citizens more control over their health and wellbeing, empowers carers, reduces the administrative burden for care professionals, and supports the development of new medicines and treatments. A recent study[40] for the UK Office of Life Sciences segments Digital health into Telehealthcare, mobile (m)health (apps and wearable devices), health analytics and Digitial health systems (including electronic health records).

Digital Creative Economy: Creative Industries are those which have their origin in individual **creativity**, skill and talent and which have a potential for wealth and job creation through the generation and exploitation of intellectual property through the use of digital technologies[41].

Smart Cities & Transport: A Smart City will enable every citizen to engage with all the services on offer, public as well as private, in a way best suited to his or her needs. It brings together hard infrastructure, social capital including local skills and community institutions, and digital technologies to fuel sustainable economic development and provide an attractive environment for all.[42] Smart transport (or intelligent mobility) infrastructure is technology-enabled and demonstrates interconnectivity, with assets in a network that can communicate as well as respond to and shape demand and economic behaviour. For example, smart utilities and intelligent transport systems that use real-time traffic information to adjust traffic signal timings demonstrate these capabilities. Transport infrastructure that leverages big data analytics and data mining of user patterns is also smart.[43] Smart transport also encompasses the concept of connected and autonomous vehicles – the driverless car of the future.

Underpinning Technology: Cloud Computing (including Communications and IoT): The identified thematic areas are all underpinned by core technologies such as Infrastructure as a Service (Compute, storage and networking), Platform as a Service (including Application Development, Data/Analytics, Big Data, Identity Management, Business Process/Workflow Management, Event management and correlation, Internet of Things infrastructure), fixed and wireless communications, cyber security & cryptography, and sensing - from low cost distributed sensors through machine vision to satellite imaging. Collectively these technologies also form the underpinnings for the term of Cloud Computing.

Underpinning Technology: Digital Media, Virtual and Augmented Reality: Digital Media includes media production and storage, audio recognition and analysis, augmented and virtual reality, Augmented reality is about showing the user additional information or cues over and above what they can see in the real world, while virtual reality is used to project an entirely different environment from wherever the user is actually situated.

[40] Digital Health in the UK: An Industry Study for the Office of Life Science, Monitor Deloitte, Sept 2015
[41] From a definition developed by the former Department of Culture Media & Sport
[42] BIS Background Paper – Smart Cities - Oct 2013
[43] Routes to Prosperity, Ernst & Young, June 2016

Underpinning Technology: Robotics / Autonomous Systems: Robotic and Autonomous Systems (RAS) are interconnected, interactive, cognitive and physical tools, able to variously perceive their environments, reason about events, make or revise plans and control their actions. They perform useful tasks in the real world, extending human capabilities, increasing productivity and reducing risks. In the future, RAS will be used to enhance almost every aspect of our lives. They will be part of the response to national challenges: an ageing population, safer transport, efficient healthcare, productive manufacturing, and secure energy.

Appendix DL8 - Tables & Figures

Figure DL1: Tech Nation 2016 Cluster data

	Data				Growth		
	Jobs	**Digital salary**	**Density**	**GVA (£bn)**	**Employ-ment**	**Turn over**	**GVA**
UK	1,560,000	£50,000	18%	87	11%	32%	27%
London	328,223	£58,978	20%	35.9	13%	101%	127%
SW England & SE Wales							
Bristol & Bath	36,547	£45,501	18%	1.8	9%	53%	26%
Exeter & Newtown Abbot	11,412	£39,695	16%	0.133	161%	41%	84%
Truro, Redruth, Camborne	1,380	£34,367	17%	0.031	1%	153%	127%
Cardiff	18,925	£42,926	17%	0.369	21%	15%	94%
Our Area Total	68,264			2.33			
Density = Digital Tech businesses as % of total							

Figure DL2: Regional Patenting

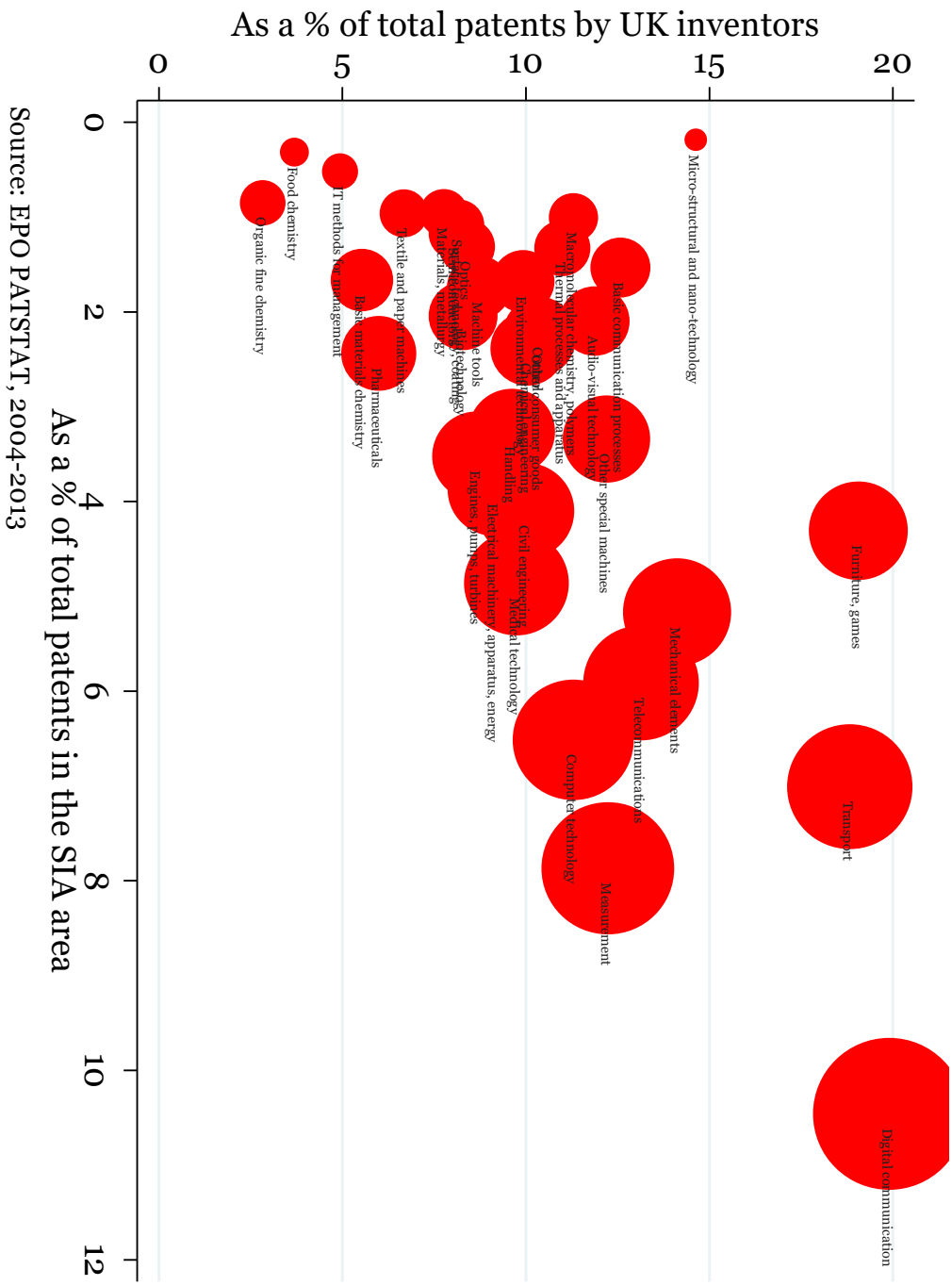
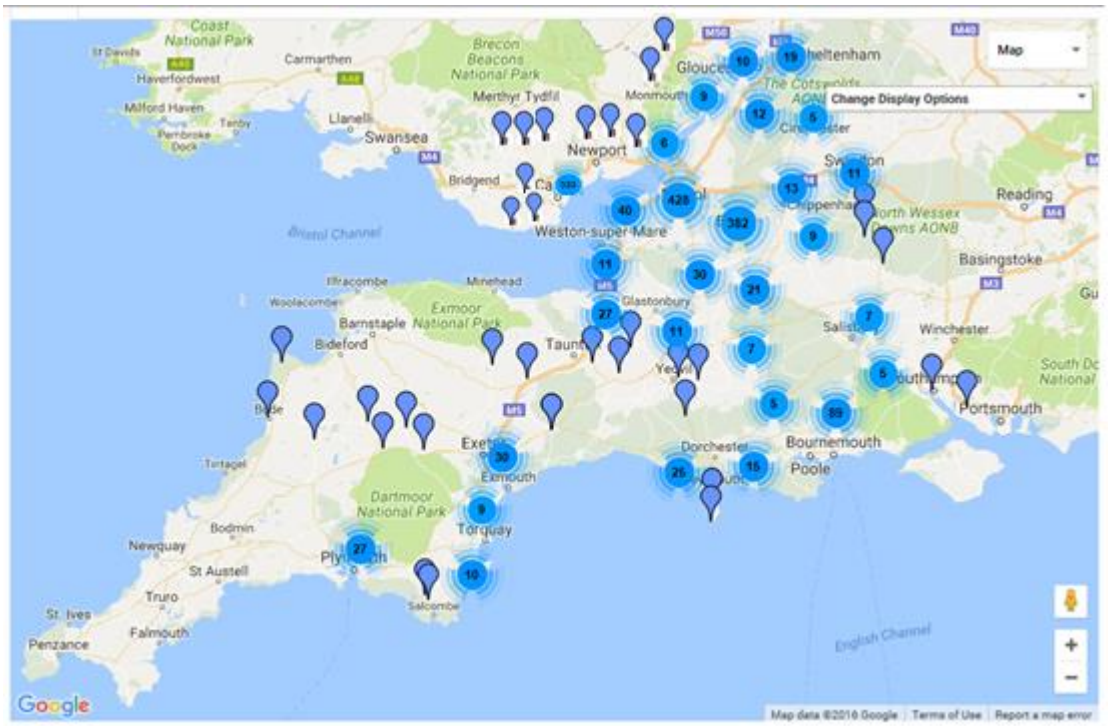
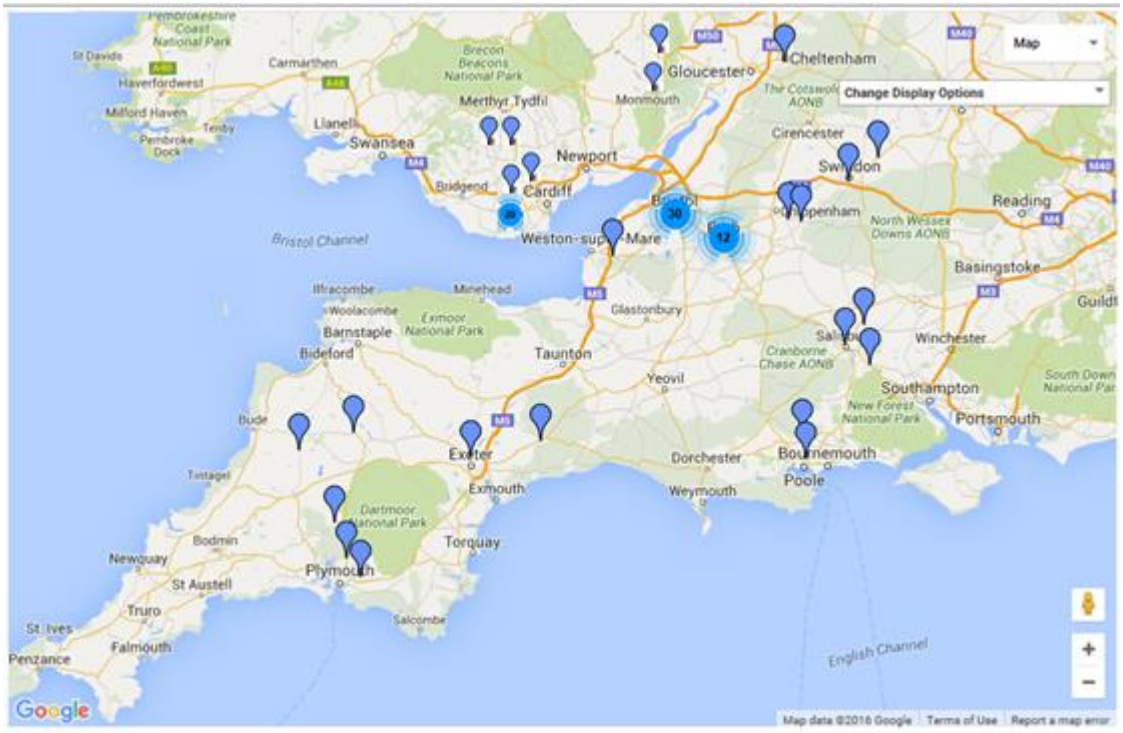


Figure DL3 a, b + c: Digital / High Tech Sector Cluster Maps

Using the TechSPARK Cluster map (*http://techspark.co/cluster-map/*) and the Electronic and Software technologies Network for Wales map (*http://www.estnet.uk.net/estnet-connect*) we estimate that the Digital/High Tech sector is worth £117.8bn in the region (data excludes South East Wales and Cornwall, but includes Dorset) with 1311 companies employing in excess of 129,000 people.



Digital Health Sector: 70 companies



Digital Creative Economy: 500 companies, estimated revenues of £660M with 15,900 employees

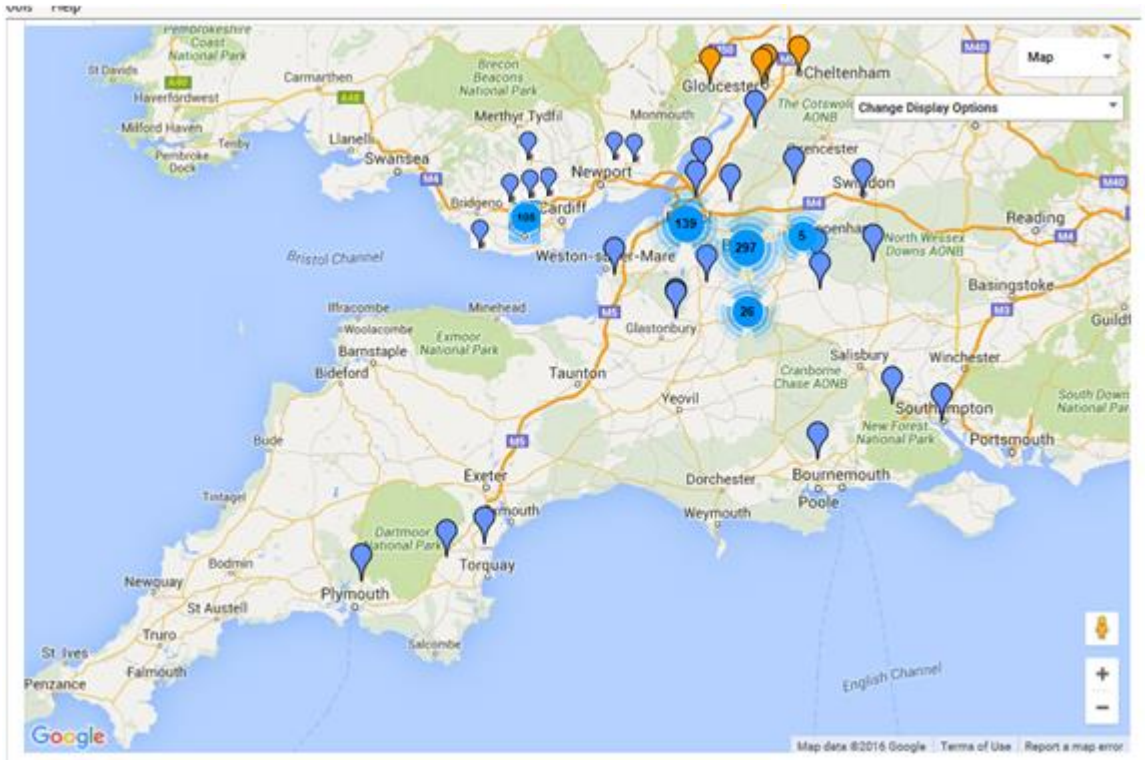
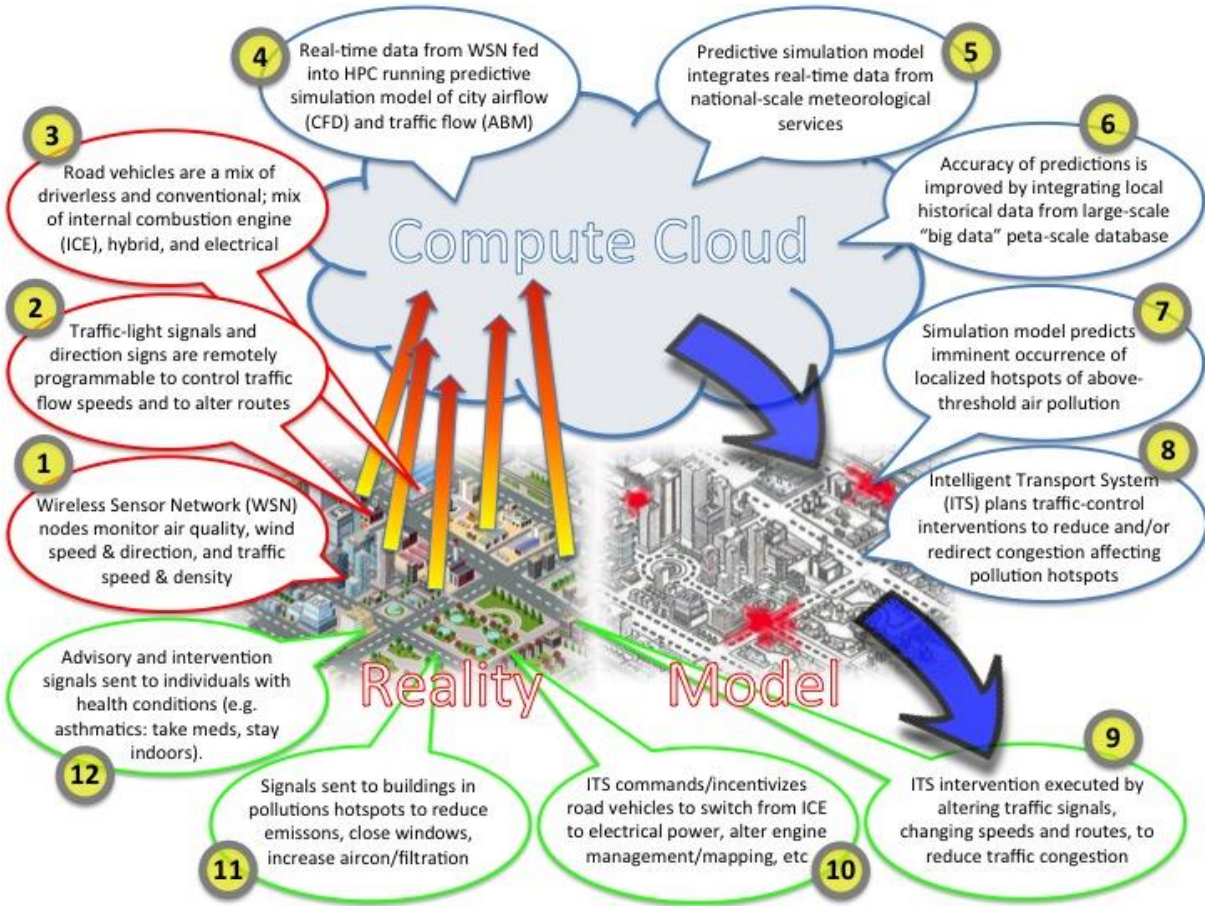


Figure DL4: Digital City Scale Demonstrator Use Case


4
Real-time data from WSN fed into HPC running predictive simulation model of city airflow (CFD) and traffic flow (ABM)
5
Predictive simulation model integrates real-time data from national-scale meteorological services
3
Road vehicles are a mix of driverless and conventional; mix of internal combustion engine (ICE), hybrid, and electrical
6
Accuracy of predictions is improved by integrating local historical data from large-scale "big data" peta-scale database
Compute Cloud
2
Traffic-light signals and direction signs are remotely programmable to control traffic flow speeds and to alter routes
7
Simulation model predicts imminent occurrence of localized hotspots of above-threshold air pollution
1
Wireless Sensor Network (WSN) nodes monitor air quality, wind speed & direction, and traffic speed & density
8
Intelligent Transport System (ITS) plans traffic-control interventions to reduce and/or redirect congestion affecting pollution hotspots
Advisory and intervention signals sent to individuals with health conditions (e.g. asthmatics: take meds, stay indoors).
12
Reality
Model
9
ITS intervention executed by altering traffic signals, changing speeds and routes, to reduce traffic congestion
Signals sent to buildings in pollutions hotspots to reduce emissons, close windows, increase aircon/filtration
11
ITS commands/incentivizes road vehicles to switch from ICE to electrical power, alter engine management/mapping, etc
10

Department for
Business, Energy
& Industrial Strategy

South West England and South East Wales Science and Innovation Audit

Annex K: Resilience, Environment and Sustainability Theme Report

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

K

Annex K: Resilience, Environment and Sustainability Theme Report

1. Introduction

The Resilience, Environment and Sustainability theme of the Audit has been undertaken to assess the opportunities for the region to enhance prosperity and resilience associated with climate and environmental change and sustainable development. Quotes from business, captured through an independently commissioned survey, highlight the essence of the theme: "*new business models will be unlocked through future energy and environmental demands and concerns*", "*the mood and the climate is think differently, do things differently, look for different opportunities*".

This theme recognises the extensive, vibrant and internationally excellent capability, assets, and research in the region and builds on a broad environmental goods and services sector, alongside regional priority sectors in environmental futures, agri-food/tech, energy, digital, water, low carbon and high value manufacturing. Over a quarter of the UK's major environmental research organisations have a base in the region and there are almost 2,000 scientists working in relevant areas. The total research expenditure on this theme in 2014-15 was £271m, and relevant university research activity is showing much stronger growth compared to the Russell Group. There are 25,000 enterprises in the region based in sectors relevant to the theme and 153,000 jobs. Employment has grown sixteen times faster than other sectors in the region. In Devon the concentration of environmental scientists is four times higher than the national average.

This theme is also aligned with global drivers, such as the recent development of the UN Sustainable Development Goals and the Paris Climate Agreement in 2015. Regional strengths and support for the climate change and sustainable development agendas, challenges and opportunities are extensive – for example, the region has a higher number of contributors to the 2014 UN IPCC 5th Assessment Report than any other area in the World. Addressing these challenges means there is an urgent need to utilise environmental data to tackle the risks from natural hazards and protect the resilience of socio-economic systems. There is also a huge opportunity surrounding the technology and innovation that will be required to live sustainably.

Building on this evidence, stakeholder and business communities have identified two areas where the region has the potential to be globally competitive in science and innovation: Environmental Risk and Data, and Sustainable Technologies and Development. These are reinforced by existing and planned regional and LEP strategies and investments. See Figure RES1 for a summary of the Audit findings for this theme.

This report references publically available and novel datasets and publications, and has been developed in consultation and dialogue with both the academic and business communities in the region, via a dedicated theme review panel, a workshop held on the 14th June 2016 representing over 30 stakeholders, and an independently commissioned industry survey (Appendix RES1).

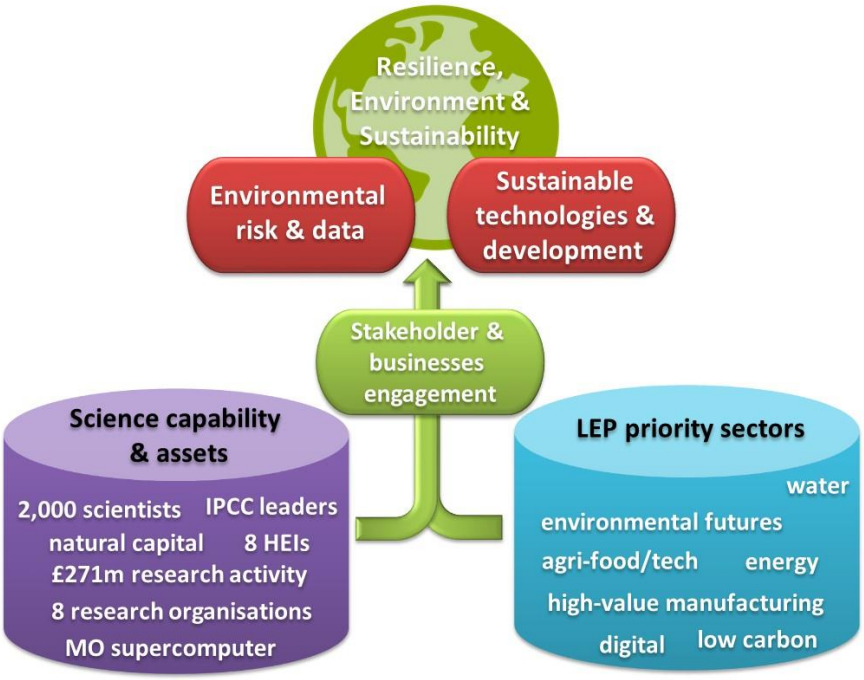


Figure RES1: Summary of Theme findings.

2. Regional science and innovation assets

27% of the major public research organisations in the UK with relevance to resilience, environment and sustainability are based in the South West. Priority industry sectors identified by LEPs include agri-food/tech, energy, water, low carbon and high value manufacturing building on a broad–based environmental goods and services sector, and including a number of large engineering service companies.

Research facilities

The region has a strong consortium of universities and research organisations working in a broad range of science areas relevant to the theme. Full details in Appendix RES2. Highlights include:

- University of Bath: Centre for Sustainable Chemical Technologies, Institute for Sustainable Energy and Environment, BRE Centre for Innovative Construction Materials, Weather Forecast Group.
- University of Bristol: Cabot Institute, world class and multidisciplinary expertise to tackle the challenges of environmental change, including research centres in Global Change, Food Security, Global Dynamic Environment, Glaciology, Environmental Risk, Bristol Water Initiative.
- University of Cardiff: Sustainable Places Research Institute, Sustainable Building Design, Building Systems and Informatics, Cardiff Catalysis Institute, Cardiff Water Research Institute.
- University of Exeter: Environment and Sustainability Institute, Land, Environment, Economics and Policy group, £9m ecotoxicology aquarium, Centre for Water Systems, Exeter Climate Systems, Sustainable Materials, Earth Systems Science, Food Security.

- University of Gloucestershire: Countryside and Community Research Institute, internationally-recognised centre of excellence in applied rural research, working at the interface of agriculture, environment, and society, on rural, urban, regional development.
- University of Plymouth: Marine Institute (coastal and ocean science, marine biology and conservation, marine geoscience etc.), and Sustainable Earth Institute (bringing researchers together with businesses, community groups and individuals to develop cutting-edge research and innovative approaches that build resilience to global challenges) with research centres in environment and sustainability covering earth and environmental science, transport and motilities, climate change, food security, sustainable business solutions, sustainable architecture and lifestyles, sustainable health and wellbeing and environmental pollution
- Met Office: world leading expertise in weather and climate science and data analytics, coupled to its soon to be opened next generation supercomputer (£97m), and supported by its leading Hadley Centre for Climate Science and Informatics Lab.
- Plymouth Marine Laboratory (PML): an independent, impartial provider of scientific research and contract services, developing and applying world-leading, integrated marine science towards the sustainable future of the ocean.
- Rothamsted North Wyke: longest running agricultural research station in the World, the most instrumented farm in the world, assessing whole life livestock grazing systems from an economic, animal husbandry, product quality and environmental perspective, a BBSRC National Capability, and a National AgriTech Centre of Innovation Excellence in Livestock node (University of Bristol also a partner).
- UK Hydrographic Office (UKHO): an executive agency of the MoD, producing nautical publications and services for the Royal Navy and merchant shipping, to protect lives at sea.
- Marine Biological Association (MBA): a charity which promotes the scientific research into all aspects of life in the sea and their complex interactions with the environment.
- Sir Alister Hardy Foundation for Ocean Science (SAHFOS): an international charity operating the Continuous Plankton Recorder Survey, focusing on the impacts of environmental change.

Science and innovation assets

In addition to the above research facilities the region also boasts a broad range of relevant science and innovation assets (Appendix RES2), highlights include; Goonhilly Earth Station; Satellite Applications Catapult Centre of Excellence; Flood Forecasting Centre; Environment Agency, HQ in Bristol; Natural Resources Wales, HQ in Cardiff; large R&D proactive water companies - South West Water (and wider Pennon Group), Wessex Water and Welsh Water; Water Research Centre (WRc), Swindon; Brixham Blue Environmental Hub; Westcountry Rivers Trust. Future Farm at Duchy College; UK Catalysis Hub, Exeter Science Park & Global Environmental Futures Campus, Plymouth Science Park –an established cluster of a range of future environmental technology companies. There are also a number of large engineering services companies based in the region that have broad capabilities in resilience, environment and sustainability (such as C2HM, WS Atkins, WSP, ARUP, RSKW).

Natural capital

The region is rich in natural capital - and the ecosystem services that derive from them - and is reliant upon them to power economic growth. Its National Parks, Areas of Natural Beauty and Heritage Sites attract more domestic tourists than any other UK region[1]. It is home to the three largest fishing ports in England and Wales, 24 shellfisheries[2] and, soon, the largest offshore mussel farm in Europe. Employment in sectors that depend directly on natural capital, such as agriculture and fisheries, and tourism is proportionately higher than any other UK area[3,4]. In addition, the Region has increasing activity within the renewable energy industry – including wave, wind and bioenergy assets. Each of these exploit regional natural capital and are imperative in development of a resilient and circular economy, but can have both positive and negative impacts on other ecosystem services. Efficient and effective development of this industry is therefore inherently connected with environmental science (for example, development of algae as a biofuel, modelling of atmospheric and oceanographic flow for wind and tidal energy, and economics of ecosystem services). Renewable energy is covered by the New Energy theme of the Audit and thus explicitly excluded from analysis.

Regional policymakers have identified the natural environment as a key driver of prosperity and wellbeing. The Cornwall and Isles of Scilly (CIoS) LEP[5] sees the area as 'a green exemplar' built around the concept of 'environmental growth'. This vision is shared by the Heart of the South West (HotSW) LEP, which has established an environmental resilience task and finish group and has recently published a report on 'The environment as a driver for economic growth[6]. Both these LEPs are prioritising the creation of higher value jobs in established natural capital sectors like farming, fisheries and tourism. Gloucestershire LEP[7] has identified key areas for investment in relation to natural capital including: developing quality habitats through green infrastructure; promoting natural capital as a driver for inward investment; and piloting biodiversity offsetting and markets for ecosystem services. The West of England LEP Strategic Economic Plan has identified Payments for Ecosystem Services Support as a new market with large growth potential[8].

[1] ONS 2010 Regional Trends 42, 43-59
[2] Pennon Group Annual Report 2016 - http://www.pennon-group.co.uk/sites/default/files/downloadable/pdf/Pennon_AR16_FINAL.pdf
[3] ONS (2016) Workforce jobs by region and industry, ONS, London
[4] Farm Business Survey (2013) The Contribution made by the farming sector in the South West
[5] http://www.cioslep.com/assets/file/LEP%20Strategic%20Economic%20Plan_V3.pdf
[6] THE ENVIRONMENT AS A DRIVER FOR ECONOMIC GROWTH - RECOMMENDATIONS REPORT, 2016
[7] ESIF Strategy, Gloucestershire 2014-2020. https://gw4colab.sharepoint.com/sites/ScienceInnovationAudit/Shared%20Documents/LEPs+WelshGov/Gfirst/ESIFFebruary2016.pdf
[8] West of England LEP Strategic Economic Plan, Outline business cases for the local growth fund current 2 year programme

Student population

According to the SIA Technopolis report[9], the number of students (HEI and FEI) produced by the region (excluding SE Wales) in 2015 in relevant subject areas is 111,635 (areas include Agriculture, Architecture, Building and Planning, Biological Sciences, Computer Science, Engineering, Geography, Physical Sciences). The largest cohort is in Biological Science in the HotSW (27,750) and Engineering in HotSW (17,025).

Further analysis of the 2013/14 HEFCE Local HE Profile data[10] (excluding SE Wales) was undertaken to determine higher education strengths (measured in terms of the proportion of all students studying each subject by LEP area, relative to the England average) (Appendix RES3). For HE students in universities particular strengths relevant to the theme were identified as follows: Geographical Studies in CIoS; Biological Sciences and Agriculture and related subjects in Gloucestershire; Biological Sciences and Geographical Studies in HotSW; Engineering and Technology in West of England. For HE students in further education: Biological Sciences and Agriculture and related subjects in CIoS; Biological Sciences and Agriculture and related subjects in Gloucestershire; Engineering and Technology in HotSW; Computer Science in West of England.

SIC employment and enterprise analysis

The Resilience, Environment and Sustainability sector is very broad and doesn't conform to standard industry classifications; this makes use of standard measures of economic activity challenging. However, through using a suite of proxy SIC codes, building on the traditional definition of 'environmental goods and services' we have undertaken some analysis to estimate the scale of relevant business activity in the region (Annex M).

On this basis the sector accounts for 153,100 jobs across the consortia area. The largest sectors are: other engineering activities (24,600), computer consultancy activities (20,800), other information technology and computer service activities (10,000) and business and domestic software development (8,600). Employment in the sector has grown strongly over the last 5 years, with total employment increasing by 16% across the region between 2009 and 2014 compared with the 1% growth recorded across all sectors locally. Taken as a whole, the sector accounts for a similar share of employee jobs (5.9%) to the Great Britain average (6.3%). Full details can be found in Annex M, but particularly high employee location quotients were found in sectors such as: Water collection, treatment and supply, Other research and experimental development on natural sciences, Sewerage, Engineering design activities for industrial process and production, Urban planning and landscape architectural activities, Data processing, hosting and related activities, Non-life insurance, Recovery of sorted materials.

As with employment, the number of enterprises has grown strongly over the last 5 years**Error! Reference source not found.**. In 2015, there were 25,295 enterprises operating within the Resilience, Environment and Sustainability sector across the region. The largest numbers of enterprises in Computer consultancy activities (6,610), Other

[9] Source - Underlying data for local growth 2013-14. Higher education and local growth. HEFCE (2015). Available at: http://www.hefce.ac.uk/analysis/maps/

[10] http://www.hefce.ac.uk/analysis/maps/

engineering activities (3,805), Other professional scientific and technical activities (3,125), Business and domestic software development (2,170), Other information technology and computer service activities (1,960), Specialised design activities (1,710). Particularly high enterprise location quotients where found in sectors such as Manufacture of other inorganic basic chemicals, Water collection, treatment and supply, Satellite telecommunication activities, Passenger rail transport, interurban, Manufacture of other organic basic chemicals.

Industry landscape and workforce by LEP area

Further detail on the industry landscape in the region, as described by the relevant LEPs, is provided in Appendix RES2C, specific highlights include:

- Agri-food is a key sector in CIoS, accounting for about 25,000 jobs[11]. Agriculture is responsible for about three times as much employment in Cornwall as it is generally in Great Britain[12].
- The agriculture and water sectors in Gloucestershire are over-represented relative to the UK[13].
- The Agri-food chain is an important part of the economy in the HotSW LEP area, and agriculture, forestry and fishing represent 17.7% of businesses compared to 5.2% for England[14].
- High value manufacturing and the low carbon economy have been identified as priority sectors by the Swindon and Wiltshire LEP[15]. 2,100 firms in the land-based agriculture, food and drink industries employ 6,100 people in the area, representing a 57% higher concentration compared with the national average, with an output of £347m per annum or 4% of total output.
- Low Carbon Industries[16] have a sustainable comparative advantage in the West of England LEP, employing 2,600 people within around 700 enterprises in 2010.
- The Energy and Environmental sector in Wales has a market value of £4.7bn employing about 58,000 people in 2,066 companies. This turnover has increase by

[11] Cornwall and the Isles of Scilly LEP: Strategy and Business Plan, Evidence Base Papers: 6 – Sectors across Cornwall and the Isles of Scilly. http://www.cioslep.com/assets/file/LEP%20Strategy/Evidence%20Base%206.pdf

[12] *A review of Cornwall's Agri-Food Industry* Centre for Rural Policy Research, University of Exeter, 2011.

[13] ESIF Strategy, Gloucestershire 2014-2020. https://gw4colab.sharepoint.com/sites/ScienceInnovationAudit/Shared%20Documents/LEPs+WelshGov/Gfirst/ESIFFebruary2016.pdf

[14] Heart of the SW Smart Specialisation Approach, 2015. http://www.heartofswlep.co.uk/sites/default/files/user-1889/Appendix%203%20-%20Smart%20Specialisation%20Approach.pdf

[15] SWLEP Strategic Economic Plan, http://www.swlep.co.uk/resources/document635997701081146000.pdf

[16] Sector Skills & Competitiveness Statement - Low Carbon Industries. http://www.westofengland.org/media/200539/environmental%20technology.pdf

90% between 2006 and 2014[17], and outperformed the majority of other sectors in Wales.

- Analysis undertaken for the HotSW and CIoS LEP areas, shows that the universities of Exeter, Plymouth and PML have directly worked with and supported over 1,000 businesses in the region in environmental science and sustainability related sectors since 2010 (agriculture, forestry & land management, aquaculture and fishing, environmental consultancy, environmental technologies and engineering, ICT and sensor technologies, utilities and renewables).

3. Excellence in science and research

The region demonstrates a significant intensity of internationally excellent science in a breadth of relevant academic disciplines, with nearly 2,000 scientists currently working in relevant areas, £271m research activity in 2014/15 and presence of 27% of the UK's major environmental research organisations. Devon in particular has 4 times more environmental scientists than the national average. The region's science strengths in comparison to the rest of the UK are in geography, chemistry, engineering, earth and environmental sciences. This science capability in the region is vibrant and growing faster than national comparators.

Research Excellence Framework 2014 (REF)
The theme covers a very broad range of academic disciplines, stretching across 35 REF Units of Assessment (UoAs), with 742 FTE academic staff relevant to the theme submitted to REF in 2014 (Appendix RES4). Based on this data, 77% of the science conducted across all relevant UoAs and institutions was judged to be internationally excellent (% 3* and 4*).

Particular disciplines where there was a concentration of high quality outputs and significant volumes of staff submitted (>40) to REF 2014 relevant to the theme were UoA 5: Biological Sciences, UoA 6: Agriculture, Veterinary & Food, UoA 7: Earth Systems & Environmental Science, UoA 8: Chemistry, UoA 15: General Engineering, UoA 16: Architecture, Built Environment & Planning, UoA 17: Geography.

When the Research Power[18] for these UoAs in REF 2014 was analysed against the leading UK HEIs, a particular strength of the consortium was identified in Geography (Appendix RES5)**.** There was also 32% more scientists working in these UoAs (based on staff submitted to REF 2014) in the consortium (27.5%) compared to the average for the UK (20.9%), showing an intensity of relevant academic expertise (Appendix RES6).

Other particular highlights for the consortium in REF 2014 compared to the rest of the UK include:

- UoA 6 (Agriculture, Veterinary & Food): Bristol 6th in proportion of 3* and 4* outputs.

[17] Mapping of the Energy & Environment Sector in Wales. http://gov.wales/docs/det/publications/140819-energy-environment-sector-mapping-study-executive-summary-en.pdf
[18] Research Power = calculated by multiplying the UoA's overall grade point average by the number of staff submitted to the REF for that UoA

- UoA 7 (Earth Systems & Environmental Science): Bristol 1st and Cardiff 4th in proportion of 3* and 4* outputs, Bristol and Exeter joint 1st in proportion of 3* and 4* impact
- UoA 8 (Chemistry): Bristol 4th in Research Power; Bath 2nd, Bristol 3rd, Cardiff 10th in proportion of 3* and 4* outputs.
- UoA 14 (Civil and Construction Engineering): Cardiff 1st in proportion of 3* and 4* outputs.
- UoA 15 (General Engineering): Bristol 4th in Research Power; Cardiff 6th, Exeter 7th, Bristol 15th in proportion of 3* and 4* outputs.
- UoA 16 (Architecture, Built Environment and Planning): Bath 1st, Gloucestershire 4th, Cardiff 8th in proportion of 3* and 4* outputs.
- UoA 17 (Geography): Exeter 4th and Bristol 5th in Research Power.

Current scientific activity

Our analysis of current academic activity indicates that there are nearly 2,000 scientists working in areas related to the theme. This is made up from a total of 1,119 staff at HEIs: Bath (209); Bristol (357); Cardiff (159); Cardiff Met (8); Exeter (193); Gloucestershire (16); Plymouth (103); Royal Agricultural University (RAU) (22); University of the West of England (52), and 858 at the major Research Organisations: MBA (8); Met Office (639); PML (98); Rothamsted North Wyke (25); SAHFOS (35); UKHO (53).

We have also undertaken a mapping exercise of the major UK Research Organisations relevant to the theme, and identified 33 separate organisations (Appendix RES7). 9 of these (27%) are within the South West and South East Wales area.

To give a further indication of the intensity of current relevant scientific expertise within the consortium, we have combined the numbers of relevant scientists (FTE submitted in REF 2014 UoAs 5, 6, 7, 8, 15, 16, 17) with current staff and scientist numbers in relevant research organisations. This has then been compared to the numbers of people in employment in 2016 (by workforce from Nomis[19]) in science professional roles. This analysis has identified a particular hot spot of relevant scientific activity in Devon (Appendix RES8), indicating that approximately 3.4% of people employed in professional science roles are working in areas relevant to the theme, this compares to a UK average of 0.8% (i.e. four times higher than the national average).

Doctoral training

Analysis of REF data indicates that during 2008-2012, 2,403 doctorates were awarded for the consortium in relevant UoAs (Appendix RES9). The highest numbers were seen in Chemistry (583) accounting for 12.3% of the UK total in this UoA, General Engineering (561) accounting for 10.3% of the UK total and Biological Science (500) accounting for 7.7% of the UK total. Further evidence of our production of quality relevant doctorates can be seen in the breadth of 11 current relevant doctoral training partnerships and collaborative doctoral training centres (Appendix RES910).

Publication analysis

[19] https://www.nomisweb.co.uk/

Analysis of publication data in SciVal was based on ASJC journal categories (Appendix RES11). These categories were chosen on the basis of those most relevant to the consortium within the theme. In all journal categories analysed the SIA consortium showed a greater proportion of outputs in the top 10% of the world compared to the rest of the UK, with the consortium showing the greatest differentiator from the rest of the UK in Process Chemistry and Technology (21.8% compared to 9.8%), General Earth and Planetary Sciences (27.9% compared to 20.7%), Civil and Structural Engineering (22.2% compared to 17%), and Environmental Science (25.4% compared to 20.2%). The SIA consortium also compared favourably to the average for the Russell Group in these categories, particularly in Process Chemistry (21.8% compared to 10.7%) and General Earth and Planetary Science (27.9% compared to 22.7%).

In the CWTS 2016 Leiden Rankings[20] for 'Life and Earth Sciences' Exeter was ranked 16th in the World, 2nd in Europe and 2nd in the UK for the proportion of publications in the top 10% of their field between 2011-2014 (using fractional counting, and min output of 100). Bristol was 35th in the World, 9th in Europe and 6th in the UK. For 'Physical Sciences and engineering' Exeter, Bristol and Plymouth were all in the top 20 in the UK and Europe.

In the Thompson Reuters Highly Cited list[21], representing some of the world's most influential scientists, Exeter has 3 scientists listed in Environmental Sciences (Friedlingstein, Adger, Cox), and the Met Office also has 3 scientists (Collins, Jones, Webb), Bristol has 2 listed in Agricultural Sciences (Nute, Richardson), while Cardiff has 1 in Chemistry (Hutchings). Prof Parmesan from Plymouth has also been reported to have authored the most highly cited climate change paper by Carbon Brief[22].

The Met Office has an international reputation for world-class environmental science: its climate research centre (Hadley Centre[23]), has been ranked as the world's leading geophysical institution, ahead of Harvard and Princeton, in terms of the influence of its peer reviewed publications[24].

The BIS mapping local comparative advantage report[25] mapped LEPs' publication intensity in relation to UK Industrial Strategy fields. Particular areas of research focus and impact as presented in the Technopolis report include Digital Economy and Resource Efficiency for HotSW LEP, and Agriculture & Food and the Built Environment for the West of England in terms of the volume of outputs. Agriculture & Food are strong areas for Gloucestershire and CIoS, as well as Resource Efficiency for CIoS, in terms of the impact of outputs.

Research funding

The total research income received by the universities in the consortium relevant to the theme (Appendix RES12) since academic year 2008/09 was in excess of £430m, growing

[20] http://www.leidenranking.com/ranking/2016/list
[21] http://hcr.stateofinnovation.thomsonreuters.com/
[22] http://www.carbonbrief.org/analysis-the-most-cited-climate-change-papers
[23] http://www.metoffice.gov.uk/climate-change/resources/hadleycentre
[24] http://www.publications.parliament.uk/pa/cm201012/cmselect/cmsctech/1538/1538we02.htm, section 4.9 c.
[25] Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015, p.120)

55% from £49m in 2008/09 to £76m in 2014/15. Around half of this research funding was from UK Research Councils, 13% from UK Government Bodies and 17% from the EU, with the remainder made up from a combination of charity, industry and other sources. By way of a comparison the growth in research income over the same period for the Russell Group (all disciplines) was 36% (Appendix RES13). The amount of research funding in the region is significantly bolstered by the theme related Research Organisations (SAHFOS, MBA, PML, Met Office, UKHO), whose combined funding for research was £195m in 2014/15, making the combined total research income of the theme £271m in 2014/15.

Research funding from EU government sources saw the greatest growth for the consortium between 2008/09 – 2014/15, increasing over 4.5 fold. To give an idea of the strength of European collaboration for the consortium, analysis of the CORDIS database[26] was undertaken (Appendix RES14). This focused on identifying the number and value of FP7 and Horizon 2020 projects, relevant to the theme, where a member of the SIA consortium (HEIs and research organisations) was the coordinating lead for projects undertaken between 2008-2016. There were 52 FP7 projects, worth over €110m, and 25 Horizon 2020 projects, worth over €44m, where a member of the SIA consortium was the coordinating lead institution. Exeter and Bristol led 19 projects each, Cardiff 14, Plymouth 6, Met Office 5, MBA 4, Rothamsted 2, Bath 2, PML 6. This data does not take into account projects where SIA consortium members were partners rather than coordinators on projects, which would be a much greater number.

4. Innovation strengths and growth points

The environmental goods and services sector in the region comprises 25,000 enterprises providing 153,000 jobs. This sector has grown 16 times faster than other sectors in the region. The stakeholder and business communities have identified two areas where our region has the potential to be globally competitive: Environmental Risk and Data Innovation, and Sustainable Technologies and Development. This is reinforced by existing and planned regional and LEP strategies and investments, as well as extensive innovation initiatives and activities.

Environmental Risk and Data Innovation, including areas such as: smart grids / metering and intelligent mobility; satellite communications and access / provision of data; understanding extreme weather; climate change resilience and adaptation strategies; asset management; resilient buildings and structures; flood modelling and monitoring.

Sustainable Technologies and Development - potential opportunities are linked to changes in legislation regarding the low carbon economy; energy storage and electric vehicles; sustainable buildings; trends in distributed energy generation and developing new materials.

These themes were explored through a workshop of 30 partners followed by an independently commissioned survey of 37 companies who were targeted to represent a broad range of relevant sectors, and who either have their headquarters, or other significant presence/interests, in the region (Appendix RES1). Of those interviewed, 31 described their business activities as being world-class, and nearly all indicated that their

[26] http://cordis.europa.eu/home_en.html

R&D expenditure would either increase, or stay the same, over the next 5 years, and that collaboration with universities is important to deliver this. Nearly all interviewees also anticipate introducing a new product, or service, process and/or entering a new market over the next 3-5 years.

Most of the interviewees confirmed that Environmental Risk and Data and Sustainable Technologies and Development are important areas for the region, where developments could add commercial value to their business over the next 5-10 years.

Others pointed out that all of these areas are connected, which could result in interesting growth dynamics. It was noted that "new business models will be unlocked through future energy and environmental demands and concerns" and "the mood and the climate is think differently, do things differently, look for different opportunities".

Further indicators of innovation strengths and growth points in the region in relation to Environmental Risk and Data include:

- Environmental Futures has been highlighted by the HotSW LEP[27] as a particular strength where it demonstrates significant comparative advantage in the UK, catalysed in part by the presence of the Met Office. This fits within a broader field of environmental expertise, which is highly connected to other sectors. A proposal for an Environmental Futures and Big Data Impact Lab has recently been submitted for ESIF funding (Appendix RES15A), and the concept for an Institute for Environmental Risk and Innovation is also being developed (Annex N)
- Met Office - employing approximately 2,000 people, with a supply chain of 1,598 companies many of which are located in Devon[28]. Estimated net benefits of their weather and climate services to the UK of £30bn over 10 years[29], and a £97m investment in a supercomputer to be located at Exeter Science Park is expected to deliver £2bn of socio-economic benefits alone to the UK due to increased operational weather and climate capabilities[30]. Taking into account the investment already committed, the benefit-cost ratio of the Met Office's services to the UK is estimated to be 14:1.
- Global Environmental Futures campus - a £350m vision for a transformative approach to place-based innovation focusing on applied environmental science. Based at Exeter Science Park and incorporating the Met Office collaboration space and new supercomputer. £8m Growth Deal funding has already been invested to build the campus

[27] HotSW Strategic Economic Plan 2014-2030. http://www.heartofswlep.co.uk/sites/default/files/user-88/SEP-%20Final%20draft%2031-03-14-website.pdf

[28] Heart of the SW Smart Specialisation Approach, 2015. http://www.heartofswlep.co.uk/sites/default/files/user-1889/Appendix%203%20-%20Smart%20Specialisation%20Approach.pdf

[29] Met Office General Review, Economic Analysis – Final Report, London Economics, April 2015

[30] https://www.gov.uk/government/news/97-million-supercomputer-makes-uk-world-leader-in-weather-and-climate-science

- Exeter City Futures - a private-sector led initiative to grow the region's economy, safeguard its natural resources and improve quality of life through the innovative use of data. It has links to investors creating a fund of up to £100m to invest in enterprises with growth potential.
- Innovation Exeter - a collaboration led by University of Exeter and Exeter City Council to drive place-based innovation, driving investment and raising productivity levels in the region, building on the Global Environmental Futures Campus.
- South West Satellite Applications Catapult Centre of Excellence – based at Goonhilly Earth Station in Cornwall, with the aim to support the growth of the Satellite Applications sector, particularly in relation to environmental science and resilience including marine and agri-tech.

Further indicators of innovation strengths and growth points in the region in relation to Sustainable Technologies and Development include:

- The West of England LEP has identified a number of relevant innovation priorities[31], including: a Food and Drink Enterprise Centre linked with advanced engineering, low carbon rural economy, skills & business support; Circular Economy Business Support Services - Research/business support into the circular economy to provide suppliers with knowledge to be able to move into this area; Increasing Business Resource Efficiency - advice and support reduces overhead costs and gains access to new markets.
- Gloucestershire LEP[32] have identified specific opportunities to promote innovation and growth including a new Agri-tech Research Centre, and RAU have already invested £1.2m into its Rural Innovation Centre. The LEP has also identified developing the UK's first zero carbon Skills Centre as a priority for investment.
- Growth Deal funding has been approved for investment by the University of Gloucestershire in renewables at the Berkeley Science and Technology Park in Gloucestershire. ESIF funding is being sought by the University to support a complementary low carbon programme centred at Berkeley, drawing on the University's research strengths in the Countryside and Community Research Institute and its long-established international profile in sustainability.
- Businesses in Swindon and Wiltshire invest heavily in the introduction of new or significantly improved products, services or processes, investing 3.5 times the national average in innovation[33]. The High Value Manufacturing Project[34] has a vision to support technology centres of excellence to enable SMEs to exploit opportunities in areas including Energy and Resources and Advanced Materials. The University of Bath and the Swindon and Wiltshire LEP are also developing plans for an Institute for

[31] West of England LEP Strategic Economic Plan, Outline business cases for the local growth fund current 2 year programme
[32] ESIF Strategy, Gloucestershire 2014-2020. https://gw4colab.sharepoint.com/sites/ScienceInnovationAudit/Shared%20Documents/LEPs+WelshGov/Gfirst/ESIFFebruary2016.pdf
[33] Community Innovation Survey 2011.
[34] Swindon and Wiltshire LEP: High Value Manufacturing Project, 2014. http://www.swlep.co.uk/resources/document635520986724410010.pdf

Sustainable Technology Innovation, focusing on advanced materials, energy production and storage, manufacturing processes, and the built environment. This initiative will build on the Porton Science Park, which complement state of the art, industry facing R&D facilities in biosciences.

- The West of England is at the forefront of the UK's sustainable growth agenda[35]. Relevant innovation activities include: a cluster of low carbon businesses in Avonmouth / Severnside Enterprise Area; Enterprise Zone and Areas with a low carbon focus; Bristol European Green Capital 2015; Sustainable Severn; National Composites Centre's work on alternative, low carbon materials; Green commitments within the City deal and Bristol Solar City.
- CIoS has identified Agri-tech as a priority market[36], based on existing significant relevant business activity, key natural asset, and strong local labour market/skills base. The LEP are also prioritising the development Low Carbon Enterprise Zone[37], a Food Enterprises Zone is also planned for March 2017, to help unlock the potential of local food and farming businesses, boosting local economies and attracting more investment. University of Exeter is also working with regional food and beverage SME's to support transition to a circular economy.
- HotSW LEP's strategies[38] point to huge economic opportunities linked to moving global economic activity onto a sustainable basis, with strengths in environmental sciences including, atmospheric, terrestrial, freshwater and marine, pollution, meteorological sciences, climate change, ecology and environmental monitoring, impacts on ecosystem services.

5. National and international engagement

The region shows excellent connectedness and capacity to work collaboratively regionally, nationally and internationally. In particular it had more contributors to the 2014 UN IPCC report than any other area in the World, and the presence of the Met Office and other world-leading research organisations also delivers significant national and international reach and influence.

The consortium is involved in an extensive range of theme related national and international alliances, demonstrating the connectedness of science and innovation activities locally, nationally and internationally. Further evidence of this is provided in Section 3 on doctoral training and European research funding. Full details of relevant alliances are provided in Appendix RES16, highlights include: Defra Sustainable Intensification Platform, Met Office Academic Partnership, Natural Hazard Partnership, EPSRC UK Catalysis Hub and the Intergovernmental Panel on Climate Change (IPCC) 5th

[35] West of England Strategic Economic Plan, Sector Prospectus.
[36] Cornwall and Isles of Scilly Research, Development and Innovation Framework, 2015. http://www.cioslep.com/assets/uploads/documents/1461574419_C&IoS%20RD&I%20Framework%20FINAL.pdf
[37] C&IoS – LEP Business Plan 2016-17. http://www.cioslep.com/assets/file/Business%20Plan%20FINAL%202016.pdf
[38] http://www.heartofswlep.co.uk/sites/default/files/user-88/SEP-%20Final%20draft%2031-03-14-website.pdf

Assessment Report. IPCC (the international body for assessing the science related to climate change[39]) involvement is particularly significant for the consortium, with a combined total of 16 authors from the Universities of Exeter, Bath and Bristol and the Met Office (12 from Exeter and Met Office alone). The lead contributing organisation is NOAA (US National Oceanic and Atmospheric Administration) with 13 authors; however, NOAA is geographically dispersed and thus the consortium represents a globally leading regional concentration of contributors. Exeter also contributed to the overarching IPCC 5th AR Synthesis Report[40].

The Met Office has significant international influence through its unified weather and climate model (UM), which is now relied on by some 1,000 scientists in the UK, as well as several hundred internationally, it is used in Australia, New Zealand, South Korea, India, South Africa and several other countries for the delivery of their weather services. The United States Air Force also chooses to use the Met Office model as the basis for its weather operations. Since 1981, the Met Office has co-authored papers with scientists from 163 different countries and over 1,900 institutions worldwide. The Met Office also makes significant contributions to the UN Framework Convention on Climate Change (UNFCCC) and the UN World Food Program[41]. The Met Office's scientific capability supports a number of UK Government ODA programmes such as the Newton Fund, and the Met Office is one of DFID's partners on the WISER programme (Weather and climate information services for Africa). The Met Office represents the UK at EUMETSAT[42] (European organisation for the exploitation of meteorological satellites - an intergovernmental organisation which supplies weather and climate-related satellite data, images and products from seven satellites to its member states, including the UK), in relation to scientific advice regarding the use of satellite data, ocean observations, instruments and missions, international relation and data policy. PML has also worked with 500 partners in more than 60 countries since 2010[43], including formal partnerships such as the Partnership for Observation of the Global Oceans (POGO).

Publication analysis in SciVal (Appendix RES17) was undertaken to assess the international collaboration of the consortium as a whole, based on the relevant journal categories identified in section 3. There were 2 key areas where the consortium demonstrates a significantly higher proportion of their publications being co-authored with international partners compared to the rest of the UK, between 2011-2015. These are Process Chemistry and Technology (60.9% of publications with international co-author for consortium, 50.7% for UK) and General Earth and Planetary Sciences (62.3 % for the consortium, 57.2% for UK). These categories also compared favourably with the Russell Group (Process Chemistry and Technology - 56.3%, General Earth and Planetary Sciences - 57.6%).

[39] https://www.ipcc.ch/report/ar5/
[40] http://ar5-syr.ipcc.ch/
[41] More information about this collaboration can be found online http://www.metoffice.gov.uk/climate-guide/climate-change/impacts/food
[42] http://www.eumetsat.int/website/home/index.html
[43] http://www.pml.ac.uk/Working-with-us/Partnerships

6. Developments in science and technology - international markets and opportunities

This theme is driven by global drivers, supporting the climate change and sustainable development agendas, challenges and opportunities. There is an urgent need to utilise environmental data to tackle the risks from natural hazards and protect the resilience of socio-economic systems. There is also a huge opportunity surrounding the technology and innovation that will be required to live sustainably.

Global challenges and drivers in Resilience, Environment and Sustainability

The UN Sustainable Development Goals were defined in 2015 – *Transforming our World: the 2030 Agenda for Sustainable Development* – incorporating the concept of 'planetary boundaries' that we need to stay within, and a plan of action for people, planet and prosperity. 17 key goals were identified, and those particularly relevant include: sustainable agriculture, sustainable management of water, access to energy, sustainable economic growth, resilient infrastructure, sustainable consumption, tackling climate change, sustainable use of the oceans and terrestrial ecosystems[44].

The majority of the world's nations have also recently signed up to a very challenging climate target to limit global warming to below 2°C, at the UN Paris Climate 2015 conference[45]. It is recognised that, if this target is to be reached before 2050 we have to largely decarbonise the global economy. This will represent an unprecedented rate of technological and societal change. There is also an urgent need, and indeed a critical opportunity in the context of international developments such as the UN Sendai Framework for Disaster Risk Reduction[46], and the UN Climate Resilience Initiatives[47] to address future environmental hazards in the context of our changing climate and vulnerability.

According to the MIT Technology Review 2016[48], 'technology innovation stands to reap billions from a warming planet'. From eliminating our dependence on fossil fuels to changing the paradigm of how we extract, manufacture, distribute, and consume products worldwide, all kinds of technology-enabled activities will be needed both to reduce the impact of future changes and to remediate the damage that has been done thus far. These will naturally involve companies, both large and small, that are making a difference in the value chain.

Environmental risk and data

Society's exposure to extreme weather and climate events is a growing threat to the sustainability of economic development and social welfare globally. Environmental pressures are having a growing impact on global and national economy and on key issues such as food, energy security, population movements, international diplomacy, conflict, agriculture and civil contingency. Climate and environmental change already has an impact on every aspect of business and society. Estimates from Munich Re suggest

[44] https://sustainabledevelopment.un.org/?menu=1300
[45] http://www.cop21.gouv.fr/en/
[46] http://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf
[47] https://www.wfp.org/climate-change/initiatives
[48] https://www.technologyreview.com/s/602001/the-business-of-climate-change/

natural hazards caused 23,000 fatalities globally in 2015, with 24% of these being due to climatological events[49]. Between 2010 and 2050 the costs of adapting to climate change globally have been estimated to be in the range of $70bn to $100bn a year[50] by 2050.

In the UK the economic and social impacts of severe weather and natural hazards are also significant. The Bank of England reports that the number of registered weather-related natural hazard loss events in the UK has tripled since the 1980's, and inflation-adjusted insurance losses from these events have increased from an annual average of around $10bn in the 1980's to around $50bn in the last decade[51]. The floods in 2007 generated £3.2bn in insured losses and killed 13 people[52]. In 2012, drought and water shortage in April, followed by the wettest summer in 100 years, led to major social and economic impacts for the agriculture sector[53]. More recently, the far-reaching impacts of extreme weather are brought into sharp focus by the flooding in winter 2013-14 which was estimated to have cost the UK £1.1bn[54]. In Dec 2015 windstorms Desmond, Eva and Frank resulted in over £1.2bn of property market insurance loss[55], with total UK economic loss estimated to total approximately £3bn[56].

The UK Climate Change Risk Assessment 2017 synthesis report[57], on which Exeter is an author, specifically sets out the areas where the UK is at greatest risk from climate change, and where more action is needed. These include flooding and coastal change, high temperatures and health, water shortage, risks to natural capital and food production and new and emerging pests and diseases.

The global market for commercial weather and climate services has been identified as being worth £35.3bn in 2015, having grown by a third between 2010 and 2015[58]. The UK Government has embraced the concept of 'Eight Great Technologies'[59] where the UK has a comparative advantage and potential for commercial exploitation across a global market,

[49] https://www.munichre.com/site/corporate/get/documents_E-397017904/mr/assetpool.shared/Documents/5_Touch/Natural%20Hazards/NatCatService/Annual%20Statistics/2015/2015_Torten_Ereignis_e.pdf
[50] Economics of Adaptation to Climate Change, the World Bank, 2011. http://www.worldbank.org/en/news/feature/2011/06/06/economics-adaptation-climate-change
[51] http://www.bankofengland.co.uk/pra/Documents/supervision/activities/pradefra0915.pdf
[52] Pitt Review section 9.2 - http://webarchive.nationalarchives.gov.uk/20100807034701/http:/archive.cabinetoffice.gov.uk/pittreview/thepittreview/final_report.html
[53]https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/440728/National_Drought_Framework.pdf
[54] http://www.newstatesman.com/staggers/2014/06/counting-1bn-cost-winter-floods
[55] https://www.perils.org/web/news/news-2016.html
[56] http://www.cityam.com/231565/economic-impact-of-storms-eva-desmond-and-frank-could-hit-3bn
[57] https://documents.theccc.org.uk/wp-content/uploads/2016/07/UK-CCRA-2017-Synthesis-Report-Committee-on-Climate-Change.pdf
[58] Space Innovation Strategy report on Leadership in Climate Technologies and Services, http://www.the-iea.org/wp-content/uploads/2016/03/IGS-Climate-Services-report.pdf
[59] David Willetts, 8 Great Technologies, Policy Exchange, 2013. http://www.policyexchange.org.uk/images/publications/eight%20great%20technologies.pdf

one of which is Big Data. It also identifies an urgent need for action to ensure that the UK is first to market with new and value adding services, building on the fact that the Met Office has one of, if not the best and most complete set of meteorological records in the world. The importance that the Government attaches to exploiting the Met Office's environmental big data assets is explicitly made[60].

A recent MIT Technology Review Business Report[61], identified that most businesses are yet to incorporate climate change into their business plans. A few industries are however dealing with risk and impacts of climate change, including agriculture – to take into account shifting temperatures and rainfall, and insurance – who are trying to predict the possible cost of storm damage for example. Other companies' supply chains are being disrupted by changing weather patterns, for example Ikea has suffered disruption from floods in South Asia and lost revenue in megastorms linked to climate change. Ford is also adapting to water shortages at its factories, by reducing water used in manufacturing by a third. The report goes on to say that many large corporates are concerned about water scarcity linked to climate change.

The significant potential for physical damage resulting from environmental risks means that the insurance sector is playing a leading role in the development of mechanisms by which to model financial impacts, with applications of catastrophe modelling starting to extend beyond traditional insurance into other sectors – the broader finance and international development sectors in particular. The Governor of the Bank of England recently noted "climate change is the tragedy of the horizon", threatening financial stability and long term prosperity[62]. He also highlights that it will take a combination of data, technology and expert judgement to measure and manage both physical and transition risks; having implication for investors, developers and policy makers. The UN Financial Stability Boards recent launch of a Task Force on Climate related Financial Disclosures further highlights the importance of environmental risk and data in driving sustainable development.

In 2013 the UK Government released their Agri-tech strategy[63], to drive the UK to become a world leader in agricultural technology, innovation and sustainability. This is an area that is one of the world's fastest growing markets, breakthroughs in technology in areas such as satellite imaging, meteorology, remote sensing and precision farming are driving major global investment.

[60] Big Data: Transforming the data revolution into new products and services infographic. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/249260/big_data_infographic.pdf

[61] MIT Technology Review, Business Report, Climate Change – Lessons from the companies and industries that are thinking seriously about how global warming will affect their future, 2016

[62] http://www.bankofengland.co.uk/publications/Pages/speeches/2015/844.aspx

[63] A UK Strategy for Agricultural Strategies, July 2013. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/227259/9643-BIS-UK_Agri_Tech_Strategy_Accessible.pdf

Sustainable technologies and development

In 2012, the European Commission adopted a strategy for 'Innovating for Sustainable Growth: A Bioeconomy for Europe'[64], in order to address the world's ecological, environmental, energy, food supply and natural resource challenges. The sustainable production and exploitation of biological resources will allow the production of more from less, while limiting negative impacts on the environment and reducing use of fossil resources. To create a smart, sustainable and inclusive European bioeconomy investment is needed in research and innovation to make sure that more of the knowledge developments are commercialised[65]. Estimates show that, just in terms of the EU's investment in bioeconomy research and innovation, each euro invested could generate ten euros of added value to the sector by 2025. The UK has a world-class science base in this area and many UK businesses are already leading the way to a more sustainable and efficient approach to resource use and management through innovative processes and technologies[66]. The annual turnover of the European bioeconomy is around €2 trillion with 22 million people employed[67], while in the UK it is estimated to be £36.1bn in gross value added and 600,000 jobs[68]. Of the 'Eight Great Technologies' mentioned above, two map directly onto Sustainable Technologies (Advanced Materials and Energy Storage), while Synthetic Biology and Agri-science are enablers.

There is potential to grow the gross value added of the chemical and chemistry-using sector from £195bn to £300bn by 2030 in the UK[69], with the acceleration of innovation. Furthermore utilising biomass or waste as a material could bring potential long-term benefits of £8bn over the period to 2030 and is an essential focus for increasing the opportunity for innovation. Alongside these new materials, the adoption of smart industrial biotechnology manufacturing processes is highlighted as playing a strong role in achieving the projected growth ambitions, with estimated economic potential of £4bn to £12bn per year. The catalysis sector has also been identified as important to sustainable development; and catalyst businesses that support manufacturing and refining have an annual turnover of $15bn globally, and the full value of the goods and products produced by those catalysts is in the region of $15,000bn.[70]

It has been identified that by adopting circular economy principles, Europe can take advantage of the impending technologies revolution to create a net benefit of €1.8 trillion

[64] Innovating for Sustainable Growth: A Bioeconomy for Europe 2012. http://ec.europa.eu/research/bioeconomy/pdf/bioeconomycommunicationstrategy_b5_brochure_web.pdf

[65] THE EUROPEAN BIOECONOMY IN 2030 Delivering Sustainable Growth by addressing the Grand Societal Challenges. http://www.epsoweb.org/file/560

[66] Building a high value bioeconomy – opportunities from waste

[67] Innovating for Sustainable Growth: A Bioeconomy for Europe 2012. http://ec.europa.eu/research/bioeconomy/pdf/bioeconomycommunicationstrategy_b5_brochure_web.pdf

[68] The British Bioeconomy: An assessment of the impact of the bioeconomyon the United Kingdom economy. http://www.bbsrc.ac.uk/documents/capital-economics-british-bioeconomy-report-11-june-2015/

[69] Strategy for delivering chemistry-fuelled growth of the UK economy. http://www.cia.org.uk/Portals/0/Documents/Growth%20Strategy%20FINAL.PDF'

[70] Adams C., Topics in Catalysis, 2009, 52, 924–934.

by 2030, or €0.9 trillion more than in the current linear development path. The circular economy could create tremendous opportunities for industrial renewal, regeneration, and innovation[71], as well as helping to deliver the ambitious Paris 2015 carbon reduction commitments[72]. Ten innovative, disruptive technologies which will underpin the development of new business models and thus represent an opportunity to embrace circular economy have been identified, two of which are advanced recycling technology and, life and material sciences technology[73]; the regional approach also embraces added value, integrative research areas within the Resilience Theme including Life Cycle and Supply Chain Analyses, which bridge across to Management, Business and Economics research expertise.

Construction is another important sector, and is the largest single activity in Europe (9.6% GDP) and is worth at least €1.2 trillion annually. The sector directly employs around 15 million people and a further 44 million indirectly. Buildings use around 40% of total EU energy and are responsible for around 36% of its greenhouse gas emissions. Decarbonisation of the built environment is therefore central to an EU strategy to reduce greenhouse gas emissions by 50% by 2050. New buildings must use significantly less operational energy but increasingly there is recognition that impact of materials used in construction has to reduce too: the production of cement alone is responsible for 7-8% of global CO_2 emissions. In addition the current replacement rate for existing building stock (1-2% per annum) means a huge programme of energy efficient building refurbishment is needed. The technologies required to meet these targets is still largely to be developed.

[71] "Growth Within: a circular economy vision for a competitive Europe", Ellen MacArthur Foundation, SUN, McKinsey & Co. (June 2015): https://www.ellenmacarthurfoundation.org/assets/downloads/publications/EllenMacArthurFoundation_Growth-Within_July15.pdf

[72] White Paper, Circular Economy: A key lever in bridging the emissions gap to a 1.5 °C pathway (June 2016): http://circle-economy.com/climatechange

[73] Accenture Strategy: Waste to Wealth (Peter Lacy and Jakob Rutqvist)

7. Conclusions

Through the Audit process we have identified two significant areas where we believe there are significant opportunities for the region in relation to the theme, as discussed further below. These sit alongside a number of existing strategic initiatives and projects in the region relevant to the theme, currently under development and targeting a range of sources of public investment (Appendix RES14).

Environmental risk and data

The region has globally significant environmental science research assets and infrastructure, and the strategic vision to create a globally significant centre of knowledge and innovation. However, this is not currently sufficiently supported by translational activities that enable these assets to fully support new policy, to support new markets for products and services, or to mitigate the cost of environmental hazards. A timely opportunity now exists to take global leadership in this area, and cement the UK's reputation in environmental science, by establishing a centre of excellence in environmental risk and data in the South West. Such an initiative would catalyse regional growth and productivity whilst also leveraging commercial opportunities from outside the region. Industry feedback indicated demand for related investment in:

- Infrastructure to allow access to and clarity of data, to facilitate its applications and services it delivers
- Investment to support becoming a global leader in providing solutions in environmental monitoring system/sensors, and application of big data
- An environmental risk institute integrating the best expertise in the region with business outside of the region
- Core funding to support a public and private sector partnership around environmental risk
- A payment for ecosystem services natural capital bank or fund
- Investments to support flooding and water management

The development of an Institute for Environmental Risk and Innovation (Annex N) involving a range of regional partners could significantly support regional growth; driving productivity gains, skills development and employment opportunities. Utilising the recent study 'Rates of return to investment in science and innovation'[74] as a guide, we estimate that productivity improvements could be significant, and that a £60m public sector investment in such an initiative could result in 5 year total return of approximately £263m; and private sector leverage could more than double this figure.

It is envisaged that, to be successful, this activity would need to operate within a 'hub and spokes' model throughout the region, providing a place where scientists and practitioners can work together on targeted projects in a well-supported environment. The focus will be guided by the UK's national and international priorities, and could therefore focus initially on floods and windstorms since, as these are the areas of most immediate concern in the UK. However the remit could ultimately encompass environmental risks of particular relevance to the sustainable development of transition and developing economies, such as

[74] *'Rates of return to investment in science and innovation', Frontier Economics, 2014.*

air quality; heat stress and other health-related risks; food security and crop production; water security and drought.

Through directed, interdisciplinary research, and a targeted innovation and translation programme this initiative would seek to deliver step change in our ability to model, manage and communicate environmental risk in the context of changing socio-economic pressures, climate and vulnerability.

Sustainable technologies and development

There is currently an unprecedented social, economic and technical opportunity to transform the energy, materials and information flows that support our economy and built environment towards sustainable and resilient models. This transformation towards low carbon and circular economic models will demand entrepreneurship and technical innovation as well as vision, great science and good governance. Our industry survey feedback indicated that investment should be made to support research and technology centres and innovative commercial technology development.

To fully exploit the globally competitive assets available in the region and to realise our vision for global leadership in sustainable technologies, we propose to develop an industry-facing Institute for Sustainable Technology Innovation (ISTI). To set out the need for and articulate the scope and benefits of ISTI, a Strategic Outline Case (SOC), developed according to Green Book guidance for public sector business cases, has been produced (Annex N). The Institute will entail a physical space, accessible to industry partners, where cross-disciplinary academics, PhD students, industrial stakeholders (start-ups, SMEs, multinationals), policy makers, entrepreneurs and other stakeholders will come together. The industry-facing facility will incorporate laboratory R&D, analytical and incubation facilities, with incubation support services. At the core of ISTI will be a Creative Hub and Academic Gateway that will focus on embedding creativity, innovation and entrepreneurship in the Institute's activities and which will bring together the world-leading fundamental research of the region with the applied innovation of the Institute to help deliver transformative sustainable technologies, underpinning the development of sustainable approaches to feedstocks, processes and advanced materials. To encourage entrepreneurship. ISTI development is being supported by the SETsquared partnership, the regionally-led Global leading University business incubator and to ensure smooth uptake of technologies, and thus maximum impact, ISTI will work in close partnership with appropriate Catapults, specifically the HVM Catapult via CPI, who have been instrumental in outlining the case for this institute.

Appendices

Appendix RES1 Industry survey, July 2016 – Summary of findings

Summary of interviewees

- 37 interviews were undertaken with a range of companies, who were targeted on the basis of their relevant to the Resilience, Environment and Sustainability theme, and to represent a broad range of relevant sectors including engineering, construction, energy, sustainable materials and manufacturing, insurance, software providers, satellite communications, statistics services, educational technology, IT, analytics, management technology consultant, transport, climate and weather services, earth observation, water companies, environmental consultancy, tourism, risk advisory services, space, agriculture and maritime.
- 35 of these companies either had their HQ or other sites/branches in the South West England and South East Wales, the other 2 identified key collaborators in the region.
- 31 interviewees described their business activities as being world-class, with respect to raising standards, cutting edge technology, software, services or skills, reach of business, and data centres.

R&D

- Interviewees were asked how they currently fund their R&D, the most common sources included internal funds, UK government and European grants and Innovate UK, other sources also included business contracts, R&D tax relief, private investors, UK and European Space Agencies, UK government, UK Water Industry Research Programme and charitable funding.
- Most of the interviewees (21) thought their R&D expenditure is likely to increase over the next 5 years, 13 thought it would stay the same and 1 said it would decline. Some interviewees also noted the uncertainty linked to Brexit and European funding which they are currently reliant on for R&D.
- When asked what factors will influence their R&D spend many interviewees said it was dependant on their own internal profits, market demand and the general economy. Government policy, incentives, regulation and availability of R&D funding were also thought to be important, as well as the uncertainty surrounding Brexit and future European funding.
- Most interviewees (31) said their R&D is conducted in house, combined with a mixture of working in partnerships and externally commissioned R&D. 4 interviewees said all their R&D is commissioned externally.
- Nearly all of the interviewees have existing links and conduct R&D with Universities, some of which are extensive partnerships.

Ambitions and aspirations for the future

- Nearly all of the interviewees (35) anticipate introducing a new product or service, process and/or entering a new market over the next 3-5 years. These include modelling technology, certifications, new materials, software, satellite communications and applications, education technology, insurance services, digital services, sensors, electric trains, engineering services, recycling, ecology and landscape services, advanced manufacturing, catchment management, training process, water treatment processes, digital consultancy and management consultancy services.
- 22 interviewees thought that availability of finance will pose a challenge in realising their ambitions, 25 thought availability of know-how/skills, 16 meeting regulations, 18 the availability of technology, 23 the level of market demand. Political instability, Brexit and impacts on global economy were also highlighted as key issues.

- Interviewees were asked about their technological challenges and what technology will be important for their business in the future, responses included construction technology and software, cloud based business, IT, digital and analytics services, computer modelling and satellite technology, risk modelling, robotics, energy storage, communications and intelligent infrastructure, design technologies, high performance materials, high performance computing, sensors, industrial process technology, water treatment technology.

Skills

- 8 of the interviewees stated that they are currently not able to recruit the skilled people they need
- Interviewees were then asked what current skills challenges they face:
- 16 of the interviewees expressed challenges associated with finding qualified and experienced engineering professionals (civil, mechanical, electrical, industrial process, operations, communications, chemical), from graduate level upwards.
- 9 interviewees said there are gaps in skilled programmers, IT, software engineers and data scientists, modelling and analytics, from graduate level upwards.
- Other gaps in skilled staff included scientists and lab technicians and skilled construction trades.
- Other concerns included finding people with flexible skills who can work across job functions, and have the softer interpersonal skills with a mix of technological ability.
- There were also concerns about retaining and attracting employees to the region and the implications of Brexit with companies who currently source staff and skills from Europe

Future opportunities for the region

Interviewees were asked their opinions on a number of specific sectors/fields, and asked whether they envisaged developments would add commercial value to their business over the next 5-10 year. These included:

- Internet of Things – 30 felt this was an important area; including areas such as smart grids/metering and intelligent mobility; 5G and satellite communications and access/provision of data (e.g. farming); big data from satellites; data science
- Environmental Risk – 26 felt this was an import area; including understanding extreme weather, climate change, resilience and adaptation strategies; the ability to monitor; insurance; Shale oil and gas; asset management; utilising existing environmental information and data; resilient buildings and structures; flood modelling and monitoring; monitoring assets in remote locations/remote sensing
- Ecosystems Services/Natural Capital – 22 felt this was an important area, including catchment management; reduced pesticide use; regulatory change in the water sectors
- Sustainable Development/Circular Economy – 31 felt his was an important area; potential opportunities are linked to changes in legislation regarding the low carbon economy; energy storage and electric vehicles; sustainable buildings; trends in distributed energy generation; developing new materials and understanding applications;

Others pointed out that all of these areas are connected, and that is where you could see some interesting growth dynamics, and that “new business models will be unlocked through future energy and environmental demands and concerns”. Also remote monitoring was thought to a key cross-cutting activity, “its all about monitoring the environment and providing the data to help for instance work out what the value is of the ecosystem

services, work out what the environment risks might be, to understand what's happening to the carbon cycle over all the global carbon cycle to feed into low carbon type requirements". Others went on to say "the mood and the climate is think differently, do things differently, look for different opportunities".

The interviewees were also asked who they would need to work with in order to realise these opportunities, and most recognised the need for collaboration and be part of a bigger team. Many of them indicated that working with academic institutions and other research organisations and specialists with expertise in particular areas would be important, as well as third sector organisations, data providers, big data/analytics companies, other large companies/consultancies as well as specific technology businesses.

When asked what investment they would like to see in the region to support innovation and global competitive advantage in their sector, skills shortages were seen as a key issue including:

- STEM skills investments starting from primary school, and particularly girls
- Skills shortage and knowledge gaps in construction
- Support for higher level skills at post-graduate level in science and engineering
- Technology training, education and skills – at all levels
- Data science skills

Other areas where the interviewees would like to see investment include:

- Research and technology centres in engineering and manufacturing
- Investment to support collaboration and innovation that crosses industry sectors and business models, and strengthening links with universities
- Infrastructure to allow access to and clarity of data and facilitating its applications and services it delivers, a plan to integrate communication systems
- Investment to support becoming a global leader in providing solutions in environmental monitoring
- Transport and communication and virtual infrastructure to reduced geographic fragmentation
- An environmental risk institute integrating the best expertise in the region with business outside of the region and in London
- Core funding to support a public and private sector partnership around environmental risk
- Environmental monitoring system/sensors, and application of bid data
- Funding for innovative highly commercial technology development
- Business support – e.g. tax relief for innovation, R&D grants, access to overseas markets, funding to support getting products to the market
- A payment for ecosystem services natural capital bank or fund
- Investments to support flooding and water management

Appendix RES2 List of Assets

Asset	Location	Host/Lead	Descriptor
A. Research Facilities			
University of Bath	Bath	NA	Relevant facilities include: the Centre for Sustainable Chemical Technologies, a multidisciplinary Research Centre and EPSRC CDT with industrial strengths, over £30M research portfolio and 70 current PhD students. Research themes include renewable resources and industrial biotechnology, energy and water and healthcare technologies. The Institute for Sustainable Energy and the Environment, which conducts fundamental and applied research across 10 interdisciplinary themes, including Climate change and its mitigation. The BRE Centre for Innovative Construction Materials (CICM), is a multidisciplinary Research Centre based in Dept. of Architecture & Civil Engineering, which has received industrial sponsorship from the Building Research Establishment trust for over 10 years. CICM has particular expertise in sustainable concrete materials/structures and bio-based construction technologies. CICM has a current research of over £10M and around 40 doctoral students. Specialist facilities include the Building Research Park and HIVE outdoor testing facility at Wroughton, Wiltshire. Weather Forecast Group
University of Bristol	Bristol	NA	University of Bristol - Cabot Institute, world class expertise and multidisciplinary research to tackle the challenges of uncertain environmental change, including research centres in Global Change, Food Security, Global Dynamic Environment, Glaciology, Environmental Risk and the Bristol Water Initiative.
University of Cardiff	Cardiff	NA	Sustainable Places Research Institute, and Sustainable Building Design, Building Systems and Informatics. Cardiff Catalysis Institute (CCI) has established itself as a global player in

			key areas of synthetic and environmental catalysis. It has an international reputation for gold catalysis, in which it is a driving force not only at the research phase but also, through its collaborations with industry, along the subsequent pathway to commercialisation. The CCI is now developing a pipeline of new catalyst technologies based on material design principles and a fundamental understanding of the correlations between structure and activity in catalytic materials. CCI leads an EPSRC CDT in Catalysis with Bath and Bristol as partners. The new Cardiff Water URI already has a record of success in aiding the users of water research and is catalysing activities across the GW4 water research with the recent launch of the GW4 Water Security Alliance, the largest water research group in the UK.
Cardiff Metropolitan University	Cardiff	NA	Centre for Health, Safety and Environment at the School of Health Sciences, focused on assessing and managing occupational and environmental issues.
University of Exeter	Exeter, Truro, Falmouth	NA	World-leading environmental research includes: the Environment and Sustainability Institute (ESI), a £30M interdisciplinary centre leading cutting-edge research into environmental change; the new Land, Environment, Economics and Policy (LEEP) Institute, a centre of excellence in environmental economics, agricultural and environmental policy. Exeter also has a £9m aquarium focusing on ecotoxicology, and has the world's largest academic group in conservation biology, expertise in ecology and conservation; environmental biology; water, sediment and nutrient cycling; ecosystem functioning; carbon dynamics; landscape restoration; climate modelling; sustainable materials; water engineering through the Centre for Water Systems (and

			Doctoral Training Centre in Water Informatics), sustainable water management; and marine renewable energy.
Gloucestershire University	Cheltenham	NA	Countryside and Community Research Institute which plays an important role in shaping rural development policy and practice in the UK, Europe and further afield. The Institute is currently active in 7 major EU-funded research consortia under the Horizon2020 programme[75]. In the most recent REF assessment, the CCRI submission into UoA 16 was ranked 9th nationally for overall quality. Within the University's School of Natural and Social Sciences, the Centre for Environmental Change and Quaternary Research undertakes work on geochronology, climate change, environmental change and human impacts.
Plymouth University	Plymouth	NA	Marine Institute and Sustainable Earth Institute with research centres in environment and sustainability covering earth and environmental science, transport, climate change, food security, sustainable business solutions, and pollution,. The Growth Acceleration and Investment Network (GAIN) to accelerate the creation, growth and investment in high quality businesses and ideas to create wealth and jobs in the South West, bring in together more than £120m of business infrastructure, world class research facilities and expertise in a network focused on growth and investment
Royal Agricultural University	Cirencester	NA	Sustainable Agriculture, Food and Rural Economy research group work to promote higher yield and quality food within sustainable agricultural production and social systems, research is carried out on their own and neighbouring farms, Farm 491 a space for innovators to grow their businesses by applying technology to

[75] RECARE, SMARTSOILS, VALERIE, PEGASUS, SUFISA, AGDEMO, SOILCARE. Previous EU-funded projects include RuDI, GLAMUR, SOLINSA, SUBURBfood, CAPRI-RD. For more information see www.ccri.ac.uk

			agriculture, providing high-spec facilities and 491 hectares of farmland for research and testing. The Rural Innovation Centre76, £1.2M investment on-farm facilities primarily for practical research, demonstration and knowledge exchange.
University of the West of England	Bristol	NA	Centre for Floods, Communities and Resilience which focusses on a range of issues concerning resilient communities, Centre for Sustainable Planning and Environments understanding how to achieve places that are environmentally sustainable, Centre for Architecture and Built Environment innovative approaches that support the design of environmentally sustainable buildings.
Marine Biological Association	Plymouth	NA	A charity which promotes the scientific research into all aspects of life in the sea and their complex interactions with the environment.
Met Office	Exeter	NA	World leading expertise in environmental science and data analytics, coupled to its soon to be opened next generation supercomputer (£97m), and supported by its leading Hadley Centre77 for Climate Science and Informatics Lab, it is also well connected to the academic sector via its Met Office Academic Partnership (of which Exeter is a member). The Met Office Unified Model (UM) provides seamless prediction systems for operational and research in weather forecasting, climate prediction and climate change projection.
Plymouth Marine Laboratory	Plymouth	NA	An independent, impartial provider of scientific research and contract services relating to the marine environment. The research at PML contributes to the issues of global change, sustainability and pollution delivering solutions for national and international needs, it also has extensive facilities such as ships and

[76] https://www.rau.ac.uk/about/farms/rural-innovation-centre
[77] http://www.metoffice.gov.uk/climate-change/resources/hadleycentre

			specialist labs, Environmental Single Cell Genomics centre, HPC cluster, remote sensing facilities, as well as extensive global time series data sets.
Rothamsted North Wyke Farm Platform	Okehampton	NA	Longest running agricultural research station in the world, a globally unique highly instrumented farm at Rothamsted Research, a BBSRC National Capability, and a National AgriTech Centre of Innovation Excellence in Livestock Systems node (£84m). Rothamsted Research are also involved in two other national Centres for Agricultural Innovation – The Centre for Crop Health and Protection and Agrimetrics.
Sir Alister Hardy Foundation for Ocean Science	Plymouth	NA	An international charity operating the Continuous Plankton Recorder Survey, driven by almost a century of observations and science, focusing on the impacts of environmental change on the health of oceans.
UK Hydrographic Office	Taunton	NA	An executive agency sponsored by the Ministry of Defence, it produces nautical publications and services for the Royal Navy and merchant shipping, to protect lives at sea.
B. Science and Innovation Assets			
Exeter Science Park & Global Environmental Futures Campus	Exeter	Exeter Science Park Company	Focused on new industries in mitigating climate change and connected environmental datasets. Partners include: Devon County Council, University of Exeter, East Devon District Council, Exeter City Council, Homes and Communities Agency, Met Office.
Goonhilly Earth Station	Cornwall	NA	Key national asset for the UKSA including commercial satellite communications and operations, and home for the SW Satellite Applications Catapult Centre of Excellence.
ONS Data Science Campus	Newport	ONS	5 themed research programmes including sustainability. Goal of the Campus will be to build a new generation of tools and technologies to exploit the growth and availability of innovative data sources and to provide rich informed measurement and analyses on the economy, the global

			environment and wider society.
SW Satellite Applications Catapult Centre of Excellence	Cornwall / Devon	Goonhilly, Met Office, Universities	Satellite and earth observation data are increasing considered important to climate and environmental science and resilience. The SWW has strong and well-established expertise in Satellite Applications and innovation; Goonhilly Earth Station acting as a catalyst for space communications and business growth, the Met Office setting a global standard for Earth and Space Weather observation and science, and a strong network of local, national and international universities and research centres.
Flood Forecasting Centre	Exeter	Met Office and Environment Agency	A partnership between the Environment Agency and the Met Office, combining their meteorology and hydrology expertise into a specialised hydrometeorology service. The centre forecasts for all natural forms of flooding - river, surface water, tidal/coastal and groundwater.
South West Regional Flood and Coastal Committee		Environment Agency	Established by the Environment Agency to ensure effective communication and planning for flooding and coastal erosion, to encourage investment in flood and coastal erosion risk management.
Environment Agency	HQ Bristol	NA	HQ in Bristol, and employing over 10,000 staff. Other regional offices can be found in Cornwall, Somerset and Gloucestershire, with specialist facilities in Bath with their geomatics group, and near Exeter, with its National Laboratory Service, a leading provider of high quality environmental testing and analysis.
Natural Resources Wales	HQ in Cardiff	NA	HQ in Cardiff, the largest Welsh Government body, employing 1,900 staff across Wales. With the overarching objective to sustainably manage the air, land and water in Wales.
Brixham Blue Environmental Hub,	Brixham	NA	Ex-AstraZeneca laboratory, now in the ownership of Plymouth University to establish a world-class centre for collaboration and translational research with emphasis on the marine environment and coastal management

			issues.
Greenpeace Research Lab	Exeter	University of Exeter	Forms the Science Unit of Greenpeace International, based at the University of Exeter, it provides scientific advice and analytical support to Greenpeace worldwide, over a range of disciplines.
Future Farm at Duchy College	Cornwall	NA	Highly instrumented dairy farm, integrated with RRes-NW, providing skills development in precision agriculture. Also Food Innovation Centre, which works with businesses to deliver innovative solutions across all areas of food production.
EPSRC UK Catalysis Hub	Harwell	NA	Bath and Cardiff form two of the four national nodes (together with UCL and Manchester) of the recently established £20m UK Catalysis Hub which brings together the world-leading facilities of the Harwell Campus (including Diamond and ISIS) and national expertise from over 40 institutions in catalyst design, catalysis for energy, catalysis for the environment, chemical transformations and biocatalysis.
Building Research Park	Wiltshire	University of Bath	To develop and to explore innovative building materials and constructive systems.
Gloucestershire Science and Technology Park	Berkeley	University of Gloucestershire/ South Glos and Stroud College	Science and Technology Park being developed at the former Berkeley Nuclear Research Laboratories. Site of the proposed Advanced Renewables Research Centre, and proposed ESIF low carbon programme, working with industry partners and the University Growth Hub
South West Water	HQ in Exeter	NA	Employs 1,250 staff. Staff work in diverse areas including geotechnical, waste, water and infrastructure. It has strong links with the region and spends approximately £250m/year through its supply chain, with a strong focus on spend in the regional economy. SWW is part of the wider Pennon Group, an environmental utility infrastructure company which also owns Viridor Ltd. The Group currently has assets of around £5bn and a workforce of

			around 4,500 people and is based in Exeter, Devon. Viridor focuses on renewable energy, recycling and resource management and operates numerous energy recovery and material recycling facilities across England, with a turnover of £410m. The Pennon Group has recently acquired Bournemouth Water for £100m, which currently supplies around 440,000 customers.
Water Research Centre (WRc)	Swindon		WRc is an Independent Centre of Excellence for Innovation and Growth, operating across different sectors including Water, Environment, Gas and Resource Management. Their clients include regulators, water and gas utility companies, governmental organisations, NGOs, trade organisations, industrial manufacturers and waste management companies.
Wessex Water	HQ in Bath	NA	Serving 2.8m customers and employing 1,800 staff. It has a partnership with Bath University, and together have established the Water Innovation and Research Centre, providing a unique environment to engage globally in research and policy on water technologies and resource management.
Westcountry Rivers Trust	Cornwall	NA	An environmental charity established in 1994 to help restore and protect the water environment in the Westcountry for the benefit of people, wildlife and the local economy. We also aim to advance the understanding of community groups and the public about water and the importance of a healthy, functioning environment. The Westcountry Rivers Trust is engaged in a wide array of activities and projects in the South West and in other parts of the UK
LEAF Innovation Centre	Okehampton	Rothamsted Research North Wyke	Rothamsted Research North Wyke is one of the LEAF Innovation Centres across the UK. They work alongside the LEAF Demonstration Farms to promote good practices from the farm. As a LEAF Innovation Centre they investigate and communicate practices

	which underpin the continual improvement of the Integrated Farm Management approach to help deliver more sustainable food production through grassland and grazing livestock system.
C. Industry Landscape by LEP area	
Cornwall and Isles of Scilly	Agri-food is an important, but varied, sector across Cornwall and the Isles of Scilly. The core agri-food sector is estimated to account for about 25,000 jobs in the LEP area of which around half are in agriculture; across the wider industry, the total number of jobs is over 60,000 in Cornwall and the Isles of Scilly[78]. Agriculture is responsible for about three times as much employment in Cornwall as it is generally in Great Britain[79]. Agri-food and agri-tech make up 8 of the top 20 sectors in the CIoS Regional Economic Plan[80].
Gloucestershire	The structure of the Gloucestershire economy broadly reflects national trends but with some important exceptions[81]. The agriculture sector is over-represented relative to the rest of the UK, with a location quotient of 2.0, but still comparatively small in terms of the numbers it employs and its contribution to output. The energy and water sector is over-represented in the county relative to the UK and important in relation to its contribution to GVA.
Heart of the South West	Environmental Futures, was highlighted in the Strategic Economic Plan 2014-2030[82], as a particular niche where, the Heart of the SW already demonstrates significant comparative advantage, catalysed in part by the relocation of the Met Office into Exeter. Investment in developing this niche was an important ask of the 15/16 Growth Deal. This niche sits within a broader field of environmental expertise, which is highly connected to the agricultural sciences. The agri-food chain is an important part of the economy with significant potential to benefit from innovative technology, practices and processes. Agriculture, forestry and

[78] Cornwall and the Isles of Scilly LEP: Strategy and Business Plan, Evidence Base Papers: 6 – Sectors across Cornwall and the Isles of Scilly. http://www.cioslep.com/assets/file/LEP%20Strategy/Evidence%20Base%206.pdf

[79] *A review of Cornwall's Agri-Food Industry* Centre for Rural Policy Research, University of Exeter, 2011.

[80] CIoS Regional Economic Plan. http://www.cioslep.com/assets/file/Strategic%20Economic%20Plan/LEP%20Strategic%20Economic%20Plan%20FINAL.pdf

[81] ESIF Strategy, Gloucestershire 2014-2020. https://gw4colab.sharepoint.com/sites/ScienceInnovationAudit/Shared%20Documents/LEPs+WelshGov/Gfirst/ESIFFebruary2016.pdf

[82] HotSW Strategic Economic Plan 2014-2030. http://www.heartofswlep.co.uk/sites/default/files/user-88/SEP-%20Final%20draft%2031-03-14-website.pdf

	fishing represent 17.7% of HotSW businesses compared to 5.2% for England[83]. Sustainable Solutions to Flood and Water Catchment Management were also identified as a priority in the HotSW Strategic Economic Plan. Exeter saw the highest productivity growth of any city in England during 2000-2010[84]. The wider Exeter area is, and will continue to be, the key growth engine for the Heart of the South West LEP area and the wider Peninsula, with a population that is set to grow by a third in the next 15 years.
Swindon and Wiltshire	Identified priority sectors for growth include: high value manufacturing and the low carbon economy.[85] For the Sustainable Chemical Technologies and Built Environment areas, the LEP have identified the need for Research and innovation to deliver a number of economic development objectives. Health and Life Sciences has also been identified as a key sector and a LEP strategic priority[86], along with the synergies to sectors such as engineering, agriculture and agri-food. GVA per head in Swindon (£27,900) is among the highest in the country outside London and considerably above the UK average (£21,360), reflecting its concentration of highly productive firms[87]. There are also strong prospects for employment growth in the area. 78.5% of the land LEP area is farmed, and Land management and food production play a valuable role in direct employment and also through wider economic benefits including the tourism and visitor economy and quality of life. 2,100 firms in the Land-based agriculture, food and drink industries employ 6,100 people in the Swindon and Wiltshire area, representing a 57% higher concentration compared with the national average, with an output of £347 milliion per annum or 4% of total output. As well as these tangible outputs, the SWLEP rural landscape boasts significant assets including three Areas of Natural Beauty and a National Park, as well as the internationally renowned World Heritage Site at Stonehenge and Avebury. The tourism that these attract are an important employer for young workers (40% of staff in tourism are under 30), and are a significant source of employment for local groups, e.g. military spouses. Tourism contributes £826 GVA annually to Wiltshire's economy (2014), supporting 28,062 jobs (VisitWiltshire, Headline Economic Impact Results 2014).
West of England	Has a £29.3bn economy, representing 2.3% of England's economic output, and supporting 616,000 jobs[88]. This economic evidence-base

[83] Heart of the SW Smart Specialisation Approach, 2015. http://www.heartofswlep.co.uk/sites/default/files/user-1889/Appendix%203%20-%20Smart%20Specialisation%20Approach.pdf
[84] http://www.ippr.org/files/publications/pdf/State-of-the-North_Nov2014.pdf?noredirect=1
[85] SWLEP Strategic Economic Plan, http://www.swlep.co.uk/resources/document635997701081146000.pdf
[86] SWLEP Health Life Sciences Review, Report 1: Review of Capabilities
[87] Swindon and Wiltshire ESIF Strategy 2014-2020. http://www.swlep.co.uk/resources/document635896681057556000.pdf
[88] West of England Economic Assessment, 2015

	points to five priority growth sectors where the West of England has a sustainable international comparative advantage[89]. These include Low Carbon Industries[90]. Consisting of enterprises engaged in developing, producing and installing materials, devices and techniques that are used in pollution prevention, reduction or containment. It covers water, waste management and recycling, alongside the production of renewable energy. In 2010, 2,600 people in the West of England were employed in the Low Carbon Industries within around 700 enterprises. Although relatively small in terms of the volume of jobs, the sector has been selected as a priority on the basis of its considerable growth potential. Significant clusters of low carbon businesses exist at Avonmouth, Bristol City Centre and Clifton. Some of the smaller firms are dependent upon Wessex Water as a major customer within the sub-region.
Wales	A number of priority and emerging sectors have been identified, including Digital, Life Sciences, Financial Services and Energy and the Environment[91]. Energy and Environmental sector (EE) in Wales has a market value of £4.7bn employing about 58,000 people in 2,066 companies. This turnover has increase by 90% between 2006 and 2014[92], and outperformed the majority of other sectors in Wales. Areas of strength include water supply and wastewater treatment and environmental monitoring and instrumentation. The vision for Wales is to be at the forefront of the transition to a low-carbon, low-waste economy in order to secure maximum economic, social and environmental benefits[93]. In SW and Central Wales the turnover within the EE sectors increases significantly between 2005 and 2013. Total turnover in 2005 was at £14bn, an increase of 156.4% saw total turnover in 2013 reaching £38bn. This suggests the EE sector is one of socio-economic importance as well as one which continues to grow exponentially year on year[94]. The sector has the potential to create a significant number of jobs in the region over the coming years.

[89] West of England Strategic Economic Plan 2015-2030.
[90] Sector Skills & Competitiveness Statement - Low Carbon Industries. http://www.westofengland.org/media/200539/environmental%20technology.pdf
[91] Powering the Welsh Economy. http://gov.wales/docs/det/publications/150212-powering-the-welsh-economy-en.pdf
[92] Mapping of the Energy & Environment Sector in Wales. http://gov.wales/docs/det/publications/140819-energy-environment-sector-mapping-study-executive-summary-en.pdf
[93] Energy and Environment Sector -Summary Advice from the Sector Panel. http://gov.wales/docs/det/publications/121210eeadviceen.pdf
[94] Energy and the Environment – A detailed analysis for South West and Central Wales. http://www.rlp.org.uk/wp-content/uploads/Energy-and-Environment-report.pdf

Appendix RES3 Higher education subject strengths, measured in terms of the proportion of all students studying each subject by LEP area, relative to the England average (excluding SE Wales), based on 2013/14 HEFCE Local HE Profile data[95].

A. Higher Education students studying in Universities

	% of HE students by subject		
	Cornwall & IoS	England	Difference %
Biological Sciences	10.3%	9.4%	0.9%
Veterinary Sciences	0.0%	0.3%	-0.3%
Agriculture and related subjects	0.0%	0.6%	-0.6%
Physical Sciences	2.8%	3.5%	-0.7%
Computer Science	0.0%	3.9%	-3.9%
Engineering and Technology	5.6%	7.1%	-1.5%
Architecture, Building and Planning	0.0%	2.3%	-2.3%
Geographical Studies	4.0%	1.7%	2.2%

	% of HE students by subject		
	Gloucestershire	England	Difference %
Biological Sciences	18.4%	9.4%	9.0%
Veterinary Sciences	0.0%	0.3%	-0.3%
Agriculture and related subjects	7.0%	0.6%	6.4%
Physical Sciences	0.0%	3.5%	-3.5%
Computer Science	4.3%	3.9%	0.4%
Engineering and Technology	0.0%	7.1%	-7.1%
Architecture, Building and Planning	4.5%	2.3%	2.3%
Geographical Studies	1.7%	1.7%	0.0%

	% of HE students by subject		
	HotSW	England	Difference %
Biological Sciences	12.1%	9.4%	2.7%
Veterinary Sciences	0.0%	0.3%	-0.3%
Agriculture and related subjects	0.6%	0.6%	-0.1%
Physical Sciences	3.4%	3.5%	-0.1%
Computer Science	2.5%	3.9%	-1.4%
Engineering and Technology	5.5%	7.1%	-1.6%
Architecture, Building and Planning	1.3%	2.3%	-1.0%
Geographical Studies	4.5%	1.7%	2.8%

	% of HE students by subject		
	West of England	England	Difference %
Biological Sciences	8.2%	9.4%	-1.2%

[95] http://www.hefce.ac.uk/analysis/maps/

Veterinary Sciences	1.1%	0.3%	0.8%
Agriculture and related subjects	0.2%	0.6%	-0.4%
Physical Sciences	5.0%	3.5%	1.5%
Computer Science	3.2%	3.9%	-0.6%
Engineering and Technology	10.2%	7.1%	3.1%
Architecture, Building and Planning	3.4%	2.3%	1.1%
Geographical Studies	2.2%	1.7%	0.5%

B. Higher Education students studying in Further Education

	% of HE students by subject		
	Cornwall & IoS	England	Difference %
Biological Sciences	16.1%	8.3%	7.8%
Veterinary Sciences	0.0%	0.0%	0.0%
Agriculture and related subjects	13.8%	5.7%	8.2%
Physical Sciences	1.5%	0.6%	0.9%
Computer Science	5.1%	6.3%	-1.3%
Engineering and Technology	4.2%	12.1%	-7.9%
Architecture, Building and Planning	1.5%	2.1%	-0.6%
Geographical Studies	2.1%	0.1%	2.0%

	% of HE students by subject		
	Gloucestershire	England	Difference %
Biological Sciences	24.1%	8.3%	15.8%
Veterinary Sciences	1.1%	0.0%	1.0%
Agriculture and related subjects	41.9%	5.7%	36.2%
Physical Sciences	0.0%	0.6%	-0.6%
Computer Science	3.7%	6.3%	-2.6%
Engineering and Technology	5.0%	12.1%	-7.1%
Architecture, Building and Planning	0.0%	0.1%	-0.1%

	% of HE students by subject		
	HotSW	England	Difference %
Biological Sciences	8.9%	8.3%	0.5%
Veterinary Sciences	0.0%	0.0%	0.0%
Agriculture and related subjects	3.9%	5.7%	-1.7%
Physical Sciences	1.0%	0.6%	0.4%
Computer Science	7.4%	6.3%	1.0%
Engineering and Technology	25.4%	12.1%	13.3%
Architecture, Building and Planning	1.5%	2.1%	-0.5%
Geographical Studies	0.0%	0.1%	-0.1%

	% of HE students by subject		
	Swindon & Wilts	England	Difference %
Biological Sciences	8.3%	8.3%	-0.1%

Veterinary Sciences	0.0%	0.0%	0.0%
Agriculture and related subjects	1.4%	5.7%	-4.2%
Physical Sciences	0.0%	0.6%	-0.6%
Computer Science	3.5%	6.3%	-2.8%
Engineering and Technology	10.0%	12.1%	-2.1%
Architecture, Building and Planning	1.1%	2.1%	-0.9%
Geographical Studies	0.0%	0.1%	-0.1%

	% of HE students by subject		
	West of England	England	Difference %
Biological Sciences	4.3%	8.3%	-4.0%
Veterinary Sciences	0.0%	0.0%	0.0%
Agriculture and related subjects	3.1%	5.7%	-2.6%
Physical Sciences	0.0%	0.6%	-0.6%
Computer Science	9.3%	6.3%	2.9%
Engineering and Technology	5.9%	12.1%	-6.2%
Architecture, Building and Planning	1.2%	2.1%	-0.9%
Geographical Studies	0.1%	0.1%	-0.1%

Appendix RES4 REF data

UoA	Submitted staff associated with theme (FTE)	No. of Institutions	UoA Overall profile (% 3*or 4*)
2 - Public Health, Health Services and Primary Care	2	3	82
3 - Allied Health Professions, Dentistry, Nursing and Pharmacy	12	4	77
4 - Psychology, Psychiatry and Neuroscience	11	4	85
5 - Biological Sciences	71	4	85
6 - Agriculture, Veterinary and Food Science	50	4	53
7 - Earth Systems and Environmental Sciences	100	4	89
8 - Chemistry	42	3	97
9 - Physics	9	2	88
10 - Maths	21	2	85
11 - Computer Science	12	1	87
12 - Aeronautical, Mechanical, Chemical and Manufacturing Engineering	20	1	89
13 - Electrical and Electronic Engineering, Metallurgy and Materials	13	1	91
14 - Civil and Construction Engineering	6	1	97
15 - General Engineering	82	5	85
16 - Architecture, Built Environment and Planning	48	4	67
17 - Geography	41	3	45
18 - Economics and Econometrics	4	1	88
19 - Business and Management Studies	24	4	72
20 - Law	11	2	85
21 - Politics and International Studies	14	2	72
22 - Social Work and Social Policy	17	3	74
23 - Sociology	4	2	81
25 - Education	12	2	67
26 - Sport and Exercise Sciences, Leisure and Tourism	3	1	100
27 - Area Studies	1	1	68
28 - Modern Languages and Linguistics	16	1	67
29 - English Language and Literature	2	1	68
30 - History	3	1	73
32 - Philosophy	3	1	82
34 - Art and Design: History, Practice	0	1	72

and Theory			
16A - Architecture, Built Environment and Planning	5	1	85
16B - Architecture, Built Environment and Planning	2	1	75
17A - Geography	75	2	81
17B - Archaeology	7	2	53
35A - Music, Drama, Dance and Performing Arts	1	1	84
Grand Total	**742**	**76**	**77**

*Awarded to students supervised by academic staff associated with the theme

Appendix RES5 REF 2014 Research Power in key UoAs, compared to the leading HEI

UoA	Total Consortium Research Power	Leading HEI Research Power
5 - Biological Science	627	Oxford: 761
6 – Agriculture, Veterinary & Food	190	Edinburgh: 383
7 - Earth Systems & Env Sciences	328	Edinburgh: 309
8 - Chemistry	379	Oxford: 288
15 - General Engineering	706	Southampton: 621
17A - Geography	456	Durham: 200
16 - Architecture, Built Env. & Planning	285	UCL: 442

Appendix RES6 Analysis of REF 2014 data showing proportion of consortium staff submitted to key theme UoAs compared to the rest of the UK.

	Total of all staff submitted to REF 2014 (FTE)	Total of staff submitted to REF 2014 UoAs 5, 6, 7, 8, 15, 16, 17 (FTE)	Proportion
All UK	52,061	10,861	20.9%
SIA consortium	3,842	1,056	27.5%

Appendix RES7 UK not for profit research organisations
As recognised by the British Council[96], and other significant UK research institutions relevant to Resilience, Environment and Sustainability (theme specific institutions in the Region are highlighted in bold)

	Research Organisation	Location
1	Agri-Food and Biosciences Institute	Northern Ireland
2	Animal and Plant Health Agency	Weybridge, Surrey
3	British Antarctic Survey	Cambridge
4	British Geological Survey	Keyworth and Edinburgh
5	Centre for Ecology and Hydrology	Wallingford, Lancaster, Bangor
6	Centre for Environment, Fisheries & Aquaculture	Dorset and East Anglia
7	**Centre for Process Innovation**	**Wilton, Teesside**
8	**Environment Agency**	HQs Bristol and London
9	European Centre for Medium Weather Forecasts	Reading
10	Marine Scotland	Scotland
11	Food and Environment Research Agency	York
12	Game and Wildlife Conservation Trust	Hampshire, London, Dundee, Leicester, Dorset
13	**UK Hydrographic Office**	Taunton
14	Institute for European Environmental Policy	London
15	Institute of Food Research	Norwich
16	International Institute for Env. & Development	London
17	James Hutton Institute	Aberdeen
18	John Innes Centre	Norwich
19	**Marine Biological Association**	Plymouth
20	**Met Office**	Exeter
21	Moredun Research Institute	Scotland
22	National Centre for Atmospheric Science	Leeds
23	National Centre for Earth Observation	Leicester
24	National Institute of Agricultural Botany	York
25	National Oceanography Centre (NOC)	Southampton, Liverpool
26	**Natural Resources Wales**	HQ in Cardiff
27	Pirbright Institute	Woking
28	**Plymouth Marine Laboratories**	Plymouth
29	**Rothamsted Research**	Luton, North Wyke
30	Sainsbury Laboratory	Cambridge
31	Scottish Association for Marine Science	Oban
32	Scottish Environment Protection Agency	HQ in Stirling, Scotland
33	**Sir Alister Hardy Foundation for Ocean Sciences**	Plymouth

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https://www.britishcouncil.org/sites/default/files/eligible_uk_research_organisations_v.8.pdf

Appendix RES8 Scientists and employment in Theme

Comparison of relevant scientists in the theme (based on REF 2014 and Research organisation scientist numbers) with numbers of people in employment in professional science roles in the region.

Area	Total staff submitted to REF in theme related UoAs (FTE)	Total theme related RO staff	Total no. theme related scientists (REF + RO)	Total no. people in employment (science professionals)	% of theme related scientists compared to science prof employment
Theme area	1,056	852	1908	207,100	0.9
UK	10,861	7015	17876	2,197,000	0.8
Devon	314	799	1113	32,900	3.4
Bristol City	443		443	31,200	1.4
Somerset	86	53	139	14,600	1.0
Cornwall & IOS LEP			0	7,800	0.0
Gloucestershire LEP	31		31	21,700	0.1
Heart of the South West LEP	314	852	1166	57,900	2.0
South East Wales	182		182	37,100	0.5
Swindon & Wiltshire LEP			0	29,100	0.0
West of England LEP	529		529	53,700	1.0

Appendix RES9 REF Doctorate award data 2008-2012

UoA	Doctorate Degrees Awarded	% of UK Total
8 - Chemistry	**583**	**12.31%**
University of Bath	105	2.22%
Cardiff University	168	3.54%
University of Bristol	310	6.55%
15 - General Engineering	**561**	**10.26%**
Plymouth University	21	0.39%
University of the West of England	32	0.60%
University of Exeter	82	1.50%
Cardiff University	157	2.87%
University of Bristol	269	4.90%
5 - Biological Sciences	**500**	**7.67%**
University of Bath	84	1.28%
University of Exeter	103	1.60%
Cardiff University	147	2.25%
University of Bristol	166	2.54%
17 - Geography, Environmental Studies and Archaeology	**236**	**9.44%**
University of Gloucestershire	3	0.10%
University of the West of England	10	0.40%
Cardiff University	26	1.04%
Plymouth University	40	1.60%
University of Exeter	74	3.00%
University of Bristol	83	3.30%
7 - Earth Systems and Environmental Sciences	**232**	**9.32%**
University of Exeter	28	1.10%
Cardiff University	59	2.39%
Plymouth University	70	2.83%
University of Bristol	75	3.00%
6 - Agriculture, Veterinary and Food Science	**147**	**8.31%**
Royal Agricultural University	6	0.34%
University of the West of England	21	1.20%
Plymouth University	54	3.06%
University of Bristol	66	3.71%
16 - Architecture, Built Environment and Planning	**144**	**10.20%**
University of Gloucestershire	6	0.40%
Plymouth University	7	0.50%
University of the West of England	31	2.20%
University of Bath	39	2.77%
Cardiff University	61	4.33%
Grand Total	**2403**	

Appendix RES10 Relevant current Doctoral Training Partnerships and Centres for Doctoral Training

Project/Scheme	Funding Source	Description
Great Western 4+ Doctoral Training Partnership	NERC	Broad spectrum of academic and non-academic partners to create an innovative training programme that responds to current and future needs in earth and environmental sciences, led by Bristol and also involving Cardiff, Bath, Exeter, Met Office, PML
Centre for Doctoral Training in Catalysis	EPSRC & industry	Led by Cardiff with Bath and Bristol as the other partners
Centre for Doctoral Training in Sustainable Chemical Technologies	EPSRC & industry	Led by Bath
Water Informatics: Science and Engineering Centre for Doctoral Training (WISE)	EPSRC & industry	Led by Exeter and also involving Bristol, Bath and Cardiff
Stream Industrial Doctoral Training Centre	EPSRC & industry	Aligned with national requirements for sustainable water management, led by Cranfield University, Exeter is a core partner.
Sustainable Materials and Manufacturing Centre for Doctoral Training	EPSRC & industry	Led by Warwick with Exeter as a partner, will address industry-driven challenges around natual and recovered material and, high value materials from waste.
Synthetic Biology Centre for Doctoral Training	EPSRC and BBSRC	Led by Oxford, Bristol as a partner, offers training in the new field of Synthetic Biology, the “Engineering of Biology”
Centre for Doctoral Training in Decarbonisation of the Built Environment	EPSRC	Led by Bath, multidisciplinary research into the design and creation of zero-carbon buildings and technologies.
South West Doctoral Training Partnership	BBSRC	Focusing on agriculture and food security and world-class bioscience, led by Bristol and also involving Bath, Exeter, Cardiff and Rothamsted
South West Doctoral Training Centre	ESRC	Led by Bristol with Exeter and Bath as partners, for training in the social sciences.
Wales Doctoral Training Centre	ESRC	Led by Cardiff, to train top-level social scientists across Wales and Gloucestershire.

Appendix RES11 Publications Analysis
SciVal analysis of relevant journal categories - proportion of outputs in the 10% of the world (based on number of citations with field weighting, 2011-2015)

Journal Category	Theme consortium (%)	UK (%)	Difference between consortium and UK	World (%)	Russell Group (%)	Difference between SIA and Russell Group
Process Chemistry and Technology	21.8	9.8	12	9.7	10.7	11.1
General Earth and Planetary Sciences	27.9	20.7	7.2	10	22.7	5.2
Civil and structural engineering	22.2	17	5.2	10.9	20.5	1.7
Environmental Science	25.4	20.2	5.2	11.5	22.5	2.9
Geography, Planning and Development	23.2	19.1	4.1	10.8	22.1	1.1
Aquatic Science	20.5	16.7	3.8	9	17.2	3.3
Agriculture and Biological Sciences	23	19.2	3.8	10.3	21.5	1.5
Statistics, Probability and Uncertainty	17.9	14.2	3.7	8.6	14.9	3
Building and Construction	18	15.1	2.9	10.5	18.8	-0.8
General Chemistry	22.6	21.1	1.5	13.2	23.9	-1.3
General Engineering	22.2	21.5	0.7	11.7	24.3	-2.1
General Materials Science	18.7	18.2	0.5	13.2	20.8	-2.1

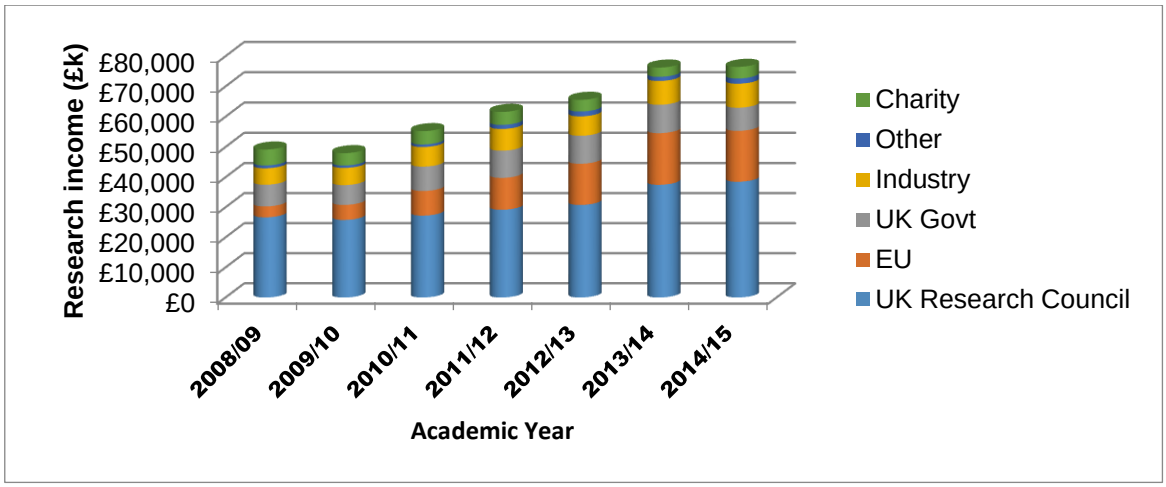
Appendix RES12 Consortium research income data

Total research income as related to the theme (£k)

HESA Funder*	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	**Total**
1	26,682	25,810	27,247	29,194	30,795	37,499	38,510	215,738
2	2,404	2,505	2,371	2,630	3,044	2,440	3,064	18,458
3	503	327	422	386	478	439	627	3,182
4	7,213	6,592	8,097	9,008	9,244	9,388	7,646	57,187
5	4,708	4,917	5,028	5,647	4,860	6,189	6,784	38,133
6	3,626	4,997	8,193	10,613	13,695	17,086	16,839	75,049
7	364	87	20	57	12	9	2	550
8	377	406	911	1,008	761	685	308	4,456
9	15	27	67	155	237	277	268	1,046
10	1,978	1,153	1,579	1,204	326	185	153	6,578
11	395	384	548	506	780	988	830	4,429
12	587	431	565	691	944	719	1,082	5,018
13	332	351	212	515	431	365	392	2,598
Total	49,183	47,986	55,261	61,613	65,608	76,268	76,504	432,423

*HESA funder categories:

1. BIS Research Councils, Royal Society, British Academy and Royal Society of Edinburgh
2. UK-based charities (open competitive process)
3. UK-based charities (other)
4. UK central government bodies, local authorities, health and hospital authorities
5. UK industry, commerce and public corporations
6. EU government bodies
7. EU-based charities (open competitive process)
8. EU industry, commerce and public corporations
9. EU other
10. Non-EU based charities (open competitive process)
11. Non-EU industry, commerce and public corporations
12. Non-EU other
13. Other sources



Appendix RES13 Russell Group research income (£k) by academic year

	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	% growth
Durham	45,084	48,297	48,740	47,765	50,878	54,086	55,745	23.6
UCL	248,666	275,077	283,511	300,734	334,733	374,503	409,113	64.5
York	55,368	57,487	51,668	46,749	49,890	55,124	58,112	5.0
Warwick	72,979	79,802	86,334	85,588	83,756	90,121	100,811	38.1
Southampton	88,349	96,323	93,642	95,717	102,562	110,971	112,860	27.7
Sheffield	98,048	98,820	101,350	108,785	114,567	129,097	144,117	47.0
Oxford	340,886	361,450	372,296	405,790	429,381	471,957	515,536	51.2
Nottingham	93,484	104,176	100,377	100,208	111,873	105,202	107,764	15.3
Newcastle-upon-Tyne	84,455	85,195	88,497	86,053	93,621	102,002	105,035	24.4
Manchester	191,335	194,603	197,380	188,113	199,790	213,726	262,419	37.2
Liverpool	96,795	111,259	110,498	115,858	125,540	83,655	93,206	-3.7
Leeds	112,570	119,319	123,975	120,541	128,561	132,677	132,596	17.8
Glasgow	126,708	129,209	128,371	124,355	128,398	133,618	152,613	20.4
Exeter	33,315	37,892	46,393	49,946	54,422	60,071	62,178	86.6
Edinburgh	174,648	185,279	181,002	194,213	200,123	215,934	225,522	29.1
Cambridge	260,652	267,895	284,316	293,785	332,623	371,148	396,932	52.3
Bristol	100,847	104,396	110,144	117,944	126,281	136,793	146,635	45.4
Birmingham	98,083	104,835	101,542	103,334	104,624	111,769	118,751	21.1
Queen's Belfast	59,613	66,833	64,419	61,210	61,838	64,546	67,050	12.5
Queen Mary	63,840	68,472	73,657	80,654	81,340	87,246	83,775	31.2
LSE	20,272	23,868	25,596	23,525	24,772	28,229	27,124	33.8
King's College	134,959	144,061	147,107	154,945	164,059	171,547	193,050	43.0
Imperial College	287,384	297,191	300,336	313,954	329,450	350,853	366,902	27.7
Cardiff	89,209	87,962	84,643	87,744	88,311	93,550	98,009	9.9
Total	**2,977,549**	**3,149,701**	**3,205,794**	**3,307,510**	**3,521,393**	**3,748,425**	**4,035,855**	**35.5**

Appendix RES14 EU FP7 and Horizon 2020 projects

Number and value of EU FP7 and Horizon 2020 projects where a member of the Consortium was the Coordinating Institution, from CORDIS database.

Coordinating Institution	Number FP7 projects	Value of FP7 projects (€k)
University of Exeter	13	€38,725
University of Bristol	13	€20,978
Cardiff University	10	€17,305
Plymouth Marine Laboratory	5	€14,992
University of Plymouth	3	€6,406
Met Office	2	€5,967
University of Bath	2	€3,521
Marine Biological Association	2	€1,398
University of Plymouth Enterprise Ltd	1	€867
Rothamsted Research	1	€279
Total	**52**	**€110,438**

Coordinating Institution	Number H2020 projects	Value of H2020 projects (€k)
University of Exeter	6	€20,975
University of Bristol	6	€10,049
Cardiff University	4	€6,199
Met Office	3	€5,564
Marine Biological Association	2	€784
University of Plymouth	2	€701
Rothamsted Research	1	€195
Plymouth Marine Laboratory	1	€195
Total	**25**	**€44,662**

Appendix RES15 Strategic regional projects relevant to theme, including current and proposed initiatives and those looking to access funding

A. European Structural Investment Funds (ESIF) proposals 2016		
Project/Scheme	**Funding Source**	**Description**
Environmental Futures and Big Data Impact Lab	Heart of the SW LEP	Recent proposal for an Environmental Futures and Big Data Impact Lab, which recognises the opportunity in the region to capitalise on unique local assets, and to attain a competitive advantage by becoming a national centre of excellence for environment-related Big Data analytics. It will also build regional capacity in Big Data analytics, an underpinning technology / approach that is: key to understanding and addressing environmental issues; a driver for innovation across the LEP's Smart Specialisation priorities; and central to productivity-led growth across the UK economy as a whole[97, 98].
Cornwall Agri-tech Partnership (CAP)	Cornwall & Isles of Scilly LEP – PA1	Will drive growth, productivity and exploit new market opportunities through a business-led and market-driven RD&I approach within C&IOS's agri-tech smart specialisation theme. It will achieve this through a partnership of the region's leading stakeholders in agri-tech R&D, innovation, skills development and economic development; delivering an intensive, well managed programme of business-focussed initiatives, driving RD&I participation across the supply chain. Higher Education and other knowledge providers will work proactively with companies in solving sector growth challenges using R&D. This will lead to new and improved products and processes which in turn will drive growth and productivity.
University of Gloucestershire Low Carbon programme	Gfirst LEP	The "Shifting Gear" project aims to secure the gear shift required for a low carbon economy across Gloucestershire. It will: engage businesses in improving energy efficiency through diagnostic audits, improving efficiency of existing technology, re-utilising energy

[97] *Data Equity, Unlocking the Power of Big Data, Centre for Economics & Business Research, 2012.* http://www.sas.com/offices/europe/uk/downloads/data-equity-cebr.pdf,

[98] *Big Data Analytics, Assessment of Demand for Labour and Skills 2013–2020, Tech Partnership October 2014.* https://www.thetechpartnership.com/globalassets/pdfs/research-2014/bigdata_report_nov14.pdf

		wasted in one process for another, adopting low carbon technologies where feasible; deliver a business-to-business mentoring network through which early adopters of low carbon opportunities support their peers; provide a development space in which low carbon technology businesses engage with up-to-date research and develop new technologies; and deliver opportunities for technology businesses to test new techniques/technologies and show case them within a 'live laboratory' in mentor business environments.
B. RCUK proposals 2016		
South West Partnership for Environment and Economic Prosperity (SWEEP)	NERC	A £5m proposal to the NERC Environmental Sciences Impact Programme, led by University of Exeter in partnership with PML and the University of Plymouth. It will support regional policy makers and businesses to make better decisions around the use of natural capital, supporting the economic growth of the region.
C. Internal investments		
Global Systems Institute	Internal business case being developed	The Global Systems Institute will be a new world-leading institute on the Streatham campus of the University of Exeter. The Institute's raison d'être will be to more accurately predict global changes, by taking into account interactions between the physical climate, natural ecosystems, and human social systems; to identify transformative solutions to the corresponding global challenges faced by humankind; and to train a new generation of change agents to work with global partners to implement those solutions.
D. Growth Deal 3 LEP submissions 2016		
Centre for Innovation Excellence in Livestock, Bicton	Heart of the SW LEP	New facility to enable data analysis and research into livestock feed and forage
Infrastructure improvement with links to the Environmental Futures smart specialisation.	Heart of the SW LEP	Support for the Global Environmental Futures Campus on the Exeter Science Park.
The Cirencester Enterprise Quarter (CEQ)	Gloucestershire LEP	Provides an opportunity to create a sustainable future for Cirencester and the surrounding rural community - links with RAU

		Agri-tech investments; £14.48m
Goonhilly Earth Station	Cornwall & Isles of Scilly LEP	Cornwall Airport Newquay and Goonhilly Earth Station which together form AEROHUB+7 Enterprise Zone.; Goonhilly Swindon College Centre of Excellence in Sustainable Technologies - centre of excellence in sustainable technologies at Swindon College to directly support learning and vocational skills development in sustainable construction and advanced engineering; £9m Antenna Upgrades to create a Space Communications Gateway; Goonhilly Science Outreach Centre
Swindon College Centre of Excellence in Sustainable Technologies	Swindon and Wiltshire LEP	Centre of excellence in sustainable technologies at Swindon College to directly support learning and vocational skills development in sustainable construction and advanced engineering; £9m.

Appendix RES16 List of theme related National and International Alliances

Name	Host/Lead	Description
Defra Sustainable Intensification Platform	Defra	A multi-partner research programme involving farmers, industry experts and policymakers, Exeter is the lead for one of the 3 overarching projects on 'opportunities and risks for farming and the environment at landscape scales', also involving Bristol and Rothamsted.
Met Office Academic Partnership	Met Office	Launched in 2010 to strengthen links and collaborative working, including universities of Exeter, Reading, Leeds and Oxford, a cluster of research excellence that brings together the Met Office and institutions who are among the leading UK Universities in weather and climate science through a formal collaboration to advance the science and skill of weather and climate prediction.
Peninsula Partnership for Rural Environment	Universities of Plymouth and Exeter, Rothamsted, Duchy College, Bicton College	To address the needs of the rural environment.
Food Security and Land Research Alliance	Universities of Bath, Bristol, Exeter, Cardiff and	To undertake research to secure global food security and resilient land management.

	Rothamsted Research	
The Natural Hazard Partnership	Met Office	Homed at the Met Office in Exeter, brings together expertise from across the UK's leading public sector agencies (researchers, operational experts and policy makers) with the aim of drawing upon scientific advice in the preparation, response and review of natural hazards.
South Coast Marine Cluster	NA	Expertise in marine research, innovation and training aligned to industry clusters in agri-food and marine industries.
EPSRC UK Catalysis Hub	Harwell	The UK Catalysis Hub is based at the Harwell Research Campus and is led by four UK universities, including Bath and Cardiff. The hub aims to maintain and enhance the UK's international reputation for catalysis through collaborative projects, meetings, conferences and research outputs. The Hub has a broad scientific program to develop new catalysts, reactions and processes. The UK Catalysis Hub also aims to develop the next generation of students, through courses, conferences, PhD programs, summer schools and outreach activities.
BRE Trust	Bath	BRE Trust sponsor Centre for Innovative Construction Materials at Bath and Centre for Sustainable Engineering at Cardiff; both centres are based in top ranked REF2014 departments. BRE Trust also sponsors university centres at Edinburgh (Fire Safety) and Strathclyde (Energy) as well as Brasilia (Brazil) and Tsinghua (China), forming a world class international research network. These Centres are also affiliated to the UK National Centre for Resilience.
Willis Research Network	Willis	The world's largest collaboration between academic and the finance and insurance industries in order to confront the challenges of managing risk and delivering resilience. Exeter was one of the founding partners, also involving Bristol and the Met Office.
OASIS Loss Modelling Framework	Insurance industry	A not for profit company limited by guarantee and owned by its members who come from the insurance and reinsurance community, its mission is to create and foster collaboration around modelling catastrophic risk, the Met Office is an Associate Member.
Intergovernmental Panel on Climate Change	NA	The Region's international engagement and expertise can be evidenced by its combined contributions into the IPCC 5th Assessment Report, the international body for assessing the science related to climate change[99]. The Region's contributions are internationally significant, with a combined total of 16 authors from the Universities of Exeter, Bath and Bristol and the Met Office (12 from Exeter and MO alone), compared to 13 authors from the

[99] https://www.ipcc.ch/report/ar5/

		US National Oceanic and Atmospheric Administration (NOAA). The Region's expertise was evidenced within: Physical Science - the Climate System and Climate Change including climate models, projections, air, land and ocean temperatures, satellite data and other data and causes and attribution of climate change; and Impacts, Adaptation & Vulnerability with a focus on socio-economic and natural systems of climate change and options for adaptation. Exeter also contributed to the overarching IPCC 5th AR Synthesis Report[100], one of only 75 authors worldwide.
European Construction, built environment and energy efficient building Technology Platform (ECTP)	NA	Bath is a member of ECTP, a pan-European organisation set up to develop research, development and innovation strategies to 'improve competitiveness, meet societal needs & take up environmental challenges through an Innovative Built Environment'. ECTP is a lead author of the EC's research Road Map for Energy Efficient Buildings (2013) for the delivery of near zero carbon buildings in accordance with the EU's 2010 Energy Performance of Buildings Directive (2010) and the Energy Efficiency Directive (2012).
UN Regional Centre of Expertise Severn	University of Gloucestershire	The University hosts one of the Regional Centres of Expertise designated by the United Nations University, promoting education for sustainable development. The global network of RCEs was established as part of the UN Decade of Education for Sustainable Development. The University also co-ordinated a curriculum development programme on education for sustainable development funded and sponsored by the HEFCE.

[100] http://ar5-syr.ipcc.ch/

Appendix RES17 International Co-author Publication Analysis
SciVal analysis of relevant journal categories - proportion of outputs with an international co-author (2011-2015).

Journal Category	Theme consortium (%)	UK (%)	Difference between consortium and UK	World (%)	Russell Group (%)	Difference between consortium and Russell Group
Process Chemistry and Technology	60.9	50.7	10.2	16.3	56.3	4.6
General Earth and Planetary Sciences	62.3	57.2	5.1	22.9	57.6	4.7
Environmental Science	55.2	55	0.2	22.3	55.1	0.1
Aquatic Science	67.1	67	0.1	28.1	64.2	2.9
Geography, Planning and Development	29.5	29.7	-0.2	16.6	29.4	0.1
General Chemistry	55.5	58.1	-2.6	20.4	57.2	-1.7
Agriculture and Biological Sciences	62.2	65.2	-3	25.7	64.4	-2.2
General Materials Science	55.4	58.4	-3	20.8	59.5	-4.1
General Engineering	42	45.9	-3.9	10.1	47.6	-5.6
Building and Construction	33.2	38	-4.8	15.9	44.2	-11
Statistics, Probability and Uncertainty	46	56.2	-10.2	28.2	55.1	-9.1
Civil and Structural Engineering	39.6	43	-3.4	17.6	47.2	-7.6

Department for
Business, Energy
& Industrial Strategy

South West England and South East Wales Science and Innovation Audit

Annex L: National Data – Technopolis

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

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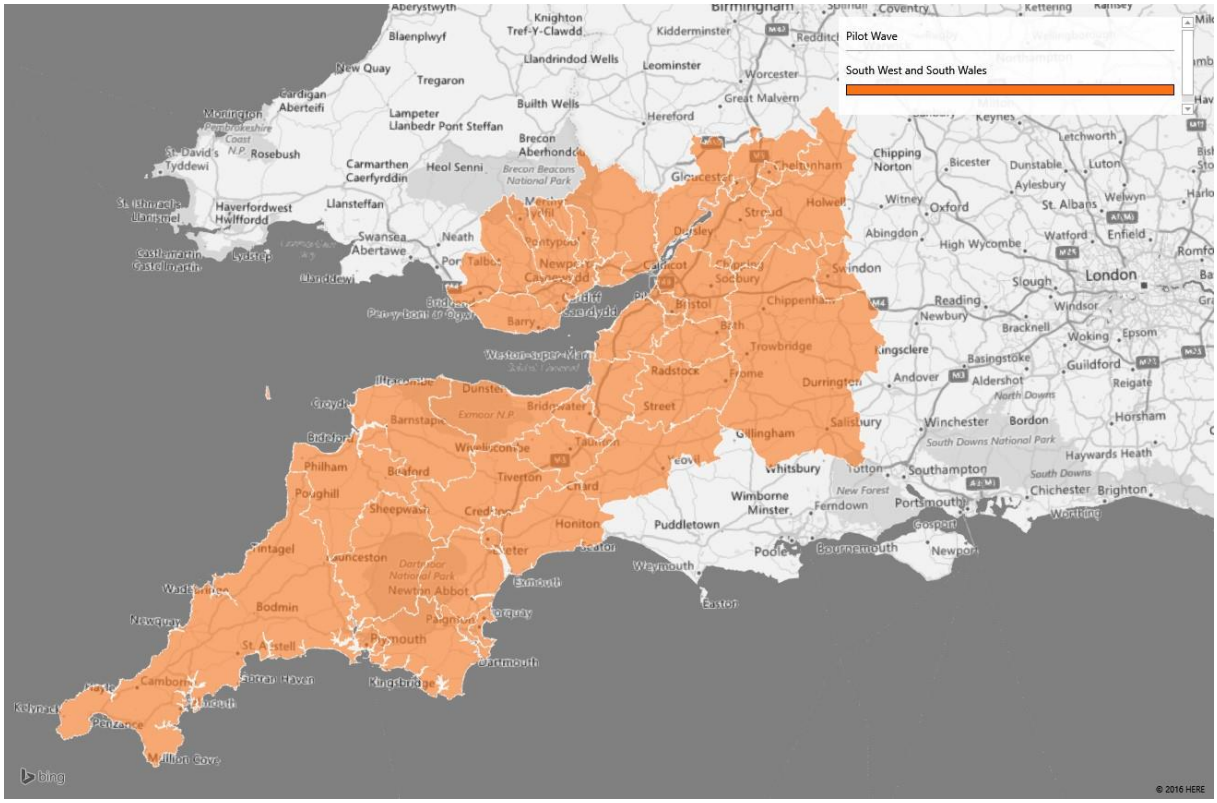
Annex L: National Data – Technopolis

SIA 03: South West England and South East Wales

1.1 Geography



SIA_ID	LEP	LAU	NUTS3	ONS_CODE
SIA0003	Cornwall and Isles of Scilly	Cornwall		E06000052
SIA0003	Cornwall and Isles of Scilly	Isles of Scilly		E06000053
SIA0003	Gloucestershire	Cheltenham		E07000078
SIA0003	Gloucestershire	Cotswold		E07000079
SIA0003	Gloucestershire	Forest of Dean		E07000080
SIA0003	Gloucestershire	Gloucester		E07000081
SIA0003	Gloucestershire	Stroud		E07000082
SIA0003	Gloucestershire	Tewkesbury		E07000083
SIA0003	Heart of the South West	Torridge		E07000046

SIA_ID	LEP	LAU	NUTS3	ONS_CODE
SIA0003	Heart of the South West	West Devon		E07000047
SIA0003	Heart of the South West	South Hams		E07000044
SIA0003	Heart of the South West	Teignbridge		E07000045
SIA0003	Heart of the South West	Exeter		E07000041
SIA0003	Heart of the South West	East Devon		E07000040
SIA0003	Heart of the South West	Mid Devon		E07000042
SIA0003	Heart of the South West	North Devon		E07000043
SIA0003	Heart of the South West	Plymouth		E06000026
SIA0003	Heart of the South West	West Somerset		E07000191
SIA0003	Heart of the South West	Taunton Deane		E07000190
SIA0003	Heart of the South West	Sedgemoor		E07000188
SIA0003	Heart of the South West	Mendip		E07000187
SIA0003	Heart of the South West	South Somerset		E07000189
SIA0003	Heart of the South West	Torbay		E06000027
SIA0003	Swindon and Wiltshire	Swindon		E06000030
SIA0003	Swindon and Wiltshire	Wiltshire		E06000054
SIA0003	West of England	South Gloucestershire		E06000025
SIA0003	West of England	Bristol, City of		E06000023
SIA0003	West of England	Bath and North East Somerset		E06000022
SIA0003	West of England	North Somerset		E06000024
SIA0003		Bridgend	Central Valleys	W06000013

SIA_ID	LEP	LAU	NUTS3	ONS_CODE
SIA0003		Vale of Glamorgan	Central Valleys	W06000014
SIA0003		Cardiff	Gwent Valleys	W06000015
SIA0003		Rhondda Cynon Taf	Gwent Valleys	W06000016
SIA0003		Caerphilly	Gwent Valleys	W06000018
SIA0003		Blaenau Gwent	Bridgend and Neath Port Talbot	W06000019
SIA0003		Torfaen	Monmouthshire and Newport	W06000020
SIA0003		Monmouthshire	Monmouthshire and Newport	W06000021
SIA0003		Newport	Cardiff and Vale of Glamorgan	W06000022
SIA0003		Merthyr Tydfil	Cardiff and Vale of Glamorgan	W06000024

1.2 Thematic areas

SIA_ID	Broad Domain	Sector (as mentioned in the EoI)
SIA0003	Energy	New Energy Systems
SIA0003	Health	
SIA0003	Advanced Manufacturing	Aerospace and Advanced Engineering
SIA0003	Advanced Manufacturing	Next generation microelectronics
SIA0003	Digital	Digital Living Innovation Platform
SIA0003	Bio-economy	Environment and Sustainability
SIA0003	Other	Resilience

1.3 Notes

Note on the Global Research Identifier Database (GRID): The Global Research Identifier Database (GRID) is an open database of research institutions created by Digital Science. Its objective is to catalogue the world's research organisations. GRID is constructed using national grant data and other open resources, and it uses advanced extraction and cleaning techniques to resolve unstructured text affiliations to unique institution IDs. While GRID tends to be very comprehensive in terms of healthcare facilities, it does not usually cover for example science parks. These were manually compiled for the English LEPs in the BIS Study 'Mapping local comparative advantages in innovation' (Annexes, Table D5 p.326).

The first tables of this report are a non-comprehensive inventory of the institutions and facilities in GRID that fall within your SIA area, generated using the GRID database and your geographical definition of the SIA Area. These queries are based on the 25-01-2016 snapshot of GRID. Technopolis complemented GRID's UK records by updating them to the NUTS2015 classification and adding approximate postcode information through reverse geo-coding, using public APIs available from postcode.io (which use ONS data). GRID can be reused and improved under a Creative Commons Attribution 4.0 International licence. More information about GRID at: https://grid.ac/pages/policies

Note on queries that report on data of the Research Excellence Framework (REF): Across this document, queries based on REF data also leverage the GRID database, which includes UKPRN identifiers for UK HEIs. In this case, we link the definition of your SIA area, the GRID database, and HEFCE's REF results databases (available at http://results.ref.ac.uk/DownloadSubmissions/SelectForm) in order to provide relevant REF results for your area of interest. Aggregation of REF results to combined output/performance at Unit of Assessment level for the whole SIA Area is possible in most cases, using direct or weighted averages. However, this document presents disaggregated data at institution level, as SIA averages can sometimes mask the strengths of particular institutions.

1.4 Regional Science and Innovation Assets

1.4.1 Science and innovation assets: Universities and research organisations

Table 1 Number of research organisations per type (2015) – SIA Area

Type (GRID)	Number
Archive	3
Company	26
Education	16
Facility	9
Government	26
Healthcare	45

Nonprofit	15
Other	5
Grand Total	145

Source: Global Research Identifier Database (GRID). Digital Science (2016). Available at: https://grid.ac Note: Data constructed from public GRID snapshot of 01-2016, using postcode-level matching of institution's main address.

Table 2 List of research organisations per type (2015) – SIA Area

LAU	name	type
Bath and North East Somerset	Bath and North East Somerset Council	Government
	Bath Institute for Rheumatic Diseases	Nonprofit
	Bath Labs	Facility
	Bath Spa University	Education
	Royal National Hospital for Rheumatic Diseases	Healthcare
	Royal United Hospital	Healthcare
	Royal United Hospital Bath NHS Trust	Healthcare
	University of Bath	Education
	YTL (United Kingdom)	Company
Bridgend	Control 2K	Company
	Princess of Wales Hospital	Healthcare
Bristol, City of	Association for Science and Discovery Centres	Nonprofit
	At Bristol	Nonprofit
	Bristol City Council	Government
	Bristol Clinical Commissioning Group	Other
	Bristol Eye Hospital	Healthcare
	Bristol Royal Hospital for Children	Healthcare
	Bristol Royal Infirmary	Healthcare
	Highways Agency	Government
	IT Power (United Kingdom)	Company
	Jisc	Nonprofit
	Knowle West Media Centre	Other
	National Co-ordinating Centre for Public Engagement	Government
	National Eye Research Centre	Nonprofit
	NIHR Bristol Cardiovascular Biomedical Research Unit	Government

	NIHR Bristol Nutrition Biomedical Research Unit	Government
	North Bristol NHS Trust	Healthcare
	Simitive (United Kingdom)	Company
	South West Screen	Nonprofit
	Southmead Hospital	Healthcare
	St Michael's Hospital	Healthcare
	Sustrans	Nonprofit
	Ultrahaptics (United Kingdom)	Company
	University Hospitals Bristol NHS Foundation Trust	Healthcare
	University of Bristol	Education
	Victim Support	Nonprofit
	Watershed	Company
	West of England Local Enterprise Partnership (United Kingdom)	Company
	Western Power Distribution (United Kingdom)	Company
Cardiff	Cardiff and Vale University Health Board	Healthcare
	Cardiff Metropolitan University	Education
	Cardiff Royal Infirmary	Healthcare
	Cardiff University	Education
	Chapter Arts Centre	Archive
	Higher Education Funding Council for Wales	Nonprofit
	Natural Resources Wales	Facility
	Research Capacity Building Collaboration Wales	Nonprofit
	Royal Welsh College of Music and Drama	Education
	Science made simple	Other
	Techniquest	Facility
	University Hospital of Wales	Healthcare
	University of South Wales	Education
	University of Wales	Education
Cheltenham	Cheltenham Festivals	Nonprofit
	Cheltenham General Hospital	Healthcare
	University of Gloucestershire	Education
Cornwall	Cornwall Council	Government
	Eden Project	Archive

	Falmouth University	Education
	PV3 Technologies (United Kingdom)	Company
	Royal Cornwall Hospital	Healthcare
	Royal Cornwall Hospital Trust	Healthcare
	University of Exeter Cornwall Campus	Education
	Westcountry Rivers Trust	Nonprofit
Cotswold	PVOH Polymers (United Kingdom)	Company
	Royal Agricultural University	Education
Exeter	Ashwoods Automotive (United Kingdom)	Company
	Exeter City Council	Government
	Hadley Centre	Facility
	Met Office	Government
	Princess Elizabeth Orthopaedic Centre	Healthcare
	Royal Albert Memorial Museum	Archive
	Royal Devon & Exeter NHS Foundation Trust	Healthcare
	Royal Devon and Exeter Hospital	Healthcare
	Scimar Engineering Ltd	Company
	University of Exeter	Education
Forest of Dean	Fountain Way	Healthcare
	Meningitis Research Foundation	Facility
	Raytheon (United Kingdom)	Company
Gloucester	Gloucestershire Hospitals NHS Foundation Trust	Healthcare
	Gloucestershire Royal Hospital	Healthcare
Mendip	Systems Engineering and Assessment (United Kingdom)	Company
Merthyr Tydfil	Prince Charles Hospital	Healthcare
Monmouthshire	Maindiff Court Hospital	Healthcare
Newport	Office for National Statistics	Government
	Royal Gwent Hospital	Healthcare
	St Cadoc's Hospital	Healthcare
	St Woolos Hospital	Healthcare
North Somerset	Weston Area Health NHS Trust	Healthcare
Plymouth	Derriford Hospital	Healthcare
	Marine Biological Association of the United Kingdom	Facility

	Plymouth College of Art	Education
	Plymouth Hospitals NHS Trust	Healthcare
	Plymouth Marine Laboratory	Facility
	Plymouth University	Education
	Sir Alister Hardy Foundation for Ocean Science	Nonprofit
Rhondda Cynon Taf	Royal Glamorgan Hospital	Healthcare
South Gloucestershire	Airbus (United Kingdom)	Company
	Airbus Group (United Kingdom)	Company
	Bristol Institute for Transfusion Sciences	Facility
	Forestry Commission England	Government
	Frenchay Hospital	Healthcare
	Higher Education Funding Council for England	Government
	Infineon Technologies (United Kingdom)	Company
	Inmos	Company
	National Composites Centre	Other
	Oliver Crispin Robotics (United Kingdom)	Company
	University of the West of England	Education
South Hams	New Generation Biogas	Company
South Somerset	Gooch & Housego (United Kingdom)	Company
	J P Kenny	Company
	Yeovil District Hospital	Healthcare
	Yeovil District Hospital NHS Foundation Trust	Healthcare
Stroud	Renishaw (United Kingdom)	Company
Swindon	Arts and Humanities Research Council	Government
	Biotechnology and Biological Sciences Research Council (BBSRC)	Government
	Economic and Social Research Council	Government
	Engineering and Physical Sciences Research Council	Government
	European Space Agency	Other
	Great Western Hospital	Healthcare
	Innovate UK	Government
	Natural Environment Research Council	Government
	Precision Varionic International (United Kingdom)	Company
	Research Councils UK	Government

	Science and Technology Facilities Council	Government
	Swindon Borough Council	Government
	United Kingdom Space Agency	Government
Taunton Deane	Dene Barton Community Hospita	Healthcare
	Musgrove Park Hospital	Healthcare
	Somerset County Council	Government
Tewkesbury	Gloucestershire County Council	Government
	Safran (United Kingdom)	Company
Torbay	South Devon Healthcare NHS Foundation Trust	Healthcare
	Torbay Hospital	Healthcare
Torfaen	Blaenavon Hospital	Healthcare
	Llanfrechfa Grange Hospital	Healthcare
Vale of Glamorgan	University Hospital Llandough	Healthcare
Wiltshire	Avon and Wiltshire Mental Health Partnership NHS Trust	Healthcare
	Council for the Central Laboratory of the Research Councils	Government
	Enigma Diagnostics (United Kingdom)	Company
	Inspire Foundation	Nonprofit
	Parkinson's UK	Nonprofit
	Salisbury District Hospital	Healthcare
	Wessex Regional Genetics Laboratory	Facility
	Wiltshire Council	Government

Source: Global Research Identifier Database (GRID). Digital Science (2016). Available at: https://grid.ac Note: Data constructed from public GRID snapshot of 01-2016, using postcode-level matching of institution's main address.

Table 3 Number of Universities and further education centres (2015)

	FEC	**HEI**
Cornwall and Isles of Scilly	2	2
Gloucestershire	3	2
Heart of the South West	9	4
Swindon and Wiltshire	3	
West of England	4	5
South East Wales	6	5

Source: Underlying data for local growth 2013-14. Higher education and local growth. HEFCE (2015). Available at: http://www.hefce.ac.uk/analysis/maps/; HEFCW and Colegaucymru

Table 4 List of Universities and further education centres (2015)

LEP	Institute name	Campus name
Cornwall and Isles of Scilly	Cornwall College	Entire institution
	Falmouth University	Entire institution
	Truro and Penwith College	Entire institution
	University of Exeter	Cornwall campus
Gloucestershire	Cirencester College	Entire institution
	Gloucestershire College	Entire institution
	Hartpury College	Entire institution
	The Royal Agricultural University	Entire institution
	University of Gloucestershire	Main campus
Heart of the South West	Bridgwater College	Entire institution
	City College Plymouth	Entire institution
	Exeter College	Entire institution
	Petroc	Entire institution
	Plymouth College of Art	Entire institution
	Richard Huish College	Entire institution
	Somerset College	Entire institution
	South Devon College	Entire institution
	Strode College	Entire institution
	University of Exeter	Main campus
	University of Plymouth	Entire institution
	University of St Mark & St John	Entire institution
	Yeovil College	Entire institution
Swindon and Wiltshire	New College Swindon	Entire institution
	Swindon College	Entire institution
	Wiltshire College	Entire institution
West of England	Bath College	Entire institution
	Bath Spa University	Entire institution
	City of Bristol College	Entire institution
	South Gloucestershire and Stroud	Entire institution

	College	
	The Conservatoire for Dance and Drama	BOVTS
	The University of Bath	Entire institution
	University of Bristol	Entire institution
	University of the West of England, Bristol	Entire institution
	Weston College of Further and Higher Education	Entire institution
South East Wales	Cardiff University	Entire institution
	Cardiff Metropolitan University	Entire institution
	The Open University in Wales	Entire institution
	University of South Wales (incl. Royal Welsh College of Music and Drama)	Entire institution
	University of Wales	Entire institution
	Coleg Gwent	Entire institution
	St David's Catholic College	Entire institution
	Cardiff and Vale College	Entire institution
	Coleg y Cymoedd	Entire institution
	The College Merthyr Tydfil	Entire institution
	Bridgend College	Entire institution

Source: Underlying data for local growth 2013-14. Higher education and local growth. HEFCE (2015). Available at: http://www.hefce.ac.uk/analysis/maps/; HEFCW and Colegaucymru

1.4.2 Science and innovation talent: Human capital and talent

Table 5 General S&T staff - % workforce in 'science, research, engineering and technology' professions and associated professions (Jul 2013 - Jun 2014)

	Cornwall and Isles of Scilly	**Gloucestershire**	**Heart of the South West**	**Swindon and Wiltshire**	**West of England**	**South East Wales**
% workforce in 'science, research, engineering and technology' professions and associated professions (Jul 2013 - Jun 2014)	5.2%	7.5%	5.6%	9.1%	10.2%	5.8%
- % all in employment	3.2%	5.7%	4.0%	6.7%	8.2%	3.8%

who are - 21: science, research, engineering and technology professions (SOC2010) (Jul 2013 - Jun 2014 English LEPs and Jan 2015 – Dec 2015 South East Wales)						
% all in employment who are - 31: science, engineering and technology associate professions (SOC2010) (Jul 2013 - Jun 2014 English LEPs and Jan 2015 – Dec 2015 South East Wales)	2.0%	1.8%	1.6%	2.4%	2.0%	2.0%

Source: Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015). Available at: https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths; Welsh data calculated as an average of Local Authority Districts, taken from Annual Population Survey [Jul 2013-Jun 2014]. Available at: https://www.nomisweb.co.uk.

Table 6 Retention of local skills (2013/14) – English LEPs and Wales

LEP	% in London	Retention in HOME REGION (where known) SW
Cornwall and Isles of Scilly	9.6	74.9
Gloucestershire	13.4	60.7
Heart of the South West	11.1	71.6
Swindon and Wiltshire	14.5	61.3
West of England	10.6	72.7
Wales (all, calculated)	5.5%	73.6

Source: Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015). Available at: https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths and HESA Destinations of Leavers from Higher Education 2013/14

Table 7 Qualified working population (2013) England LEPs and Wales Local Authorities in SIA Area

LEP / LA	% with no qualifications (NVQ) - aged 16-64	% with NVQ3 only - aged 16-	% with NVQ4+ - aged 16-64

		64	
Cornwall and Isles of Scilly	6.8	19.3	32.1
Gloucestershire	7.3	20.5	35.0
Heart of the South West	6.5	20.5	31.0
Swindon and Wiltshire	7.5	17.6	34.9
West of England	6.2	18.7	38.1
South East Wales	6.5	18.5	38.1
Consortium area average	6.8	19.2	34.9

Source: Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015). Available at: https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths; and ONS annual population survey [Jan 2015-Dec 2015] for Welsh Local Authorities. Available at: https://www.nomisweb.co.uk/. Note: the South East Wales figure is calculated as an average of each of the Local Authority areas in the area, drawn from the UK Annual Population Survey (12 months to June 2015). The consortium area average is calculated using the figures in the table.

REF Researchers

Table 8 REF Researchers - Number of FTE staff Submitted to the REF (SIA Area)

Institution Name / Unit of Assessment	**Total Category A FTE**	**% of institution Total**	**% of UK Total**
Bath Spa University	**74.02**	**100.00%**	
Art and Design: History, Practice and Theory	14.17	19.14%	0.88%
Communication, Cultural and Media Studies, Library and Information Management	7.4	10.00%	0.79%
Education	13.2	17.83%	0.92%
English Language and Literature	21.05	28.44%	1.07%
History	6.2	8.38%	0.35%
Music, Drama, Dance and Performing Arts	12	16.21%	1.05%
Cardiff Metropolitan University	**35**	**100.00%**	
Allied Health Professions, Dentistry, Nursing and Pharmacy	12	34.29%	0.44%
Art and Design: History, Practice and Theory	10	28.57%	0.62%
Sport and Exercise Sciences, Leisure and Tourism	13	37.14%	1.65%
Cardiff University	**737.7**	**100.00%**	
Allied Health Professions, Dentistry, Nursing and Pharmacy	74.95	10.16%	2.73%

Architecture, Built Environment and Planning	42.2	5.72%	4.12%
Biological Sciences	54.7	7.41%	2.31%
Business and Management Studies	72.6	9.84%	2.19%
Chemistry	23	3.12%	1.87%
Civil and Construction Engineering	14.3	1.94%	3.67%
Clinical Medicine	59.01	8.00%	1.65%
Communication, Cultural and Media Studies, Library and Information Management	13.4	1.82%	1.43%
Computer Science and Informatics	13.73	1.86%	0.67%
Earth Systems and Environmental Sciences	14.99	2.03%	1.09%
Education	20.6	2.79%	1.43%
English Language and Literature	24.01	3.25%	1.22%
General Engineering	33.8	4.58%	1.38%
Geography, Environmental Studies and Archaeology	13.13	1.78%	0.78%
History	14.4	1.95%	0.81%
Law	22	2.98%	1.42%
Mathematical Sciences	24.05	3.26%	1.25%
Modern Languages and Linguistics	14.8	2.01%	1.07%
Music, Drama, Dance and Performing Arts	13.2	1.79%	1.16%
Philosophy	10	1.36%	1.69%
Physics	19.5	2.64%	1.14%
Politics and International Studies	13.03	1.77%	1.02%
Psychology, Psychiatry and Neuroscience	69.33	9.40%	2.75%
Public Health, Health Services and Primary Care	24.29	3.29%	1.79%
Sociology	29.48	4.00%	4.19%
Theology and Religious Studies	9.2	1.25%	2.23%
Falmouth University	**50.39**	**100.00%**	
Art and Design: History, Practice and Theory	24.29	48.20%	1.51%
Music, Drama, Dance and Performing Arts	26.1	51.80%	2.29%
Plymouth University	**366.06**	**100.00%**	
Agriculture, Veterinary and Food Science	24.45	6.68%	2.35%
Allied Health Professions, Dentistry, Nursing and Pharmacy	34.9	9.53%	1.27%
Architecture, Built Environment and Planning	12.95	3.54%	1.26%
Art and Design: History, Practice and Theory	13.75	3.76%	0.86%

Business and Management Studies	32.6	8.91%	0.98%
Clinical Medicine	14.5	3.96%	0.41%
Computer Science and Informatics	12.4	3.39%	0.61%
Earth Systems and Environmental Sciences	44.92	12.27%	3.26%
Education	24	6.56%	1.66%
Electrical and Electronic Engineering, Metallurgy and Materials	7.8	2.13%	0.73%
English Language and Literature	10.97	3.00%	0.56%
General Engineering	17.2	4.70%	0.70%
Geography, Environmental Studies and Archaeology	29.2	7.98%	1.73%
History	11	3.00%	0.62%
Mathematical Sciences	14.4	3.93%	0.75%
Music, Drama, Dance and Performing Arts	8.2	2.24%	0.72%
Psychology, Psychiatry and Neuroscience	30.8	8.41%	1.22%
Social Work and Social Policy	22.02	6.02%	1.69%
Royal Agricultural University	**12**	**100.00%**	
Agriculture, Veterinary and Food Science	12	100.00%	1.15%
University of Bath	**461.53**	**100.00%**	
Aeronautical, Mechanical, Chemical and Manufacturing Engineering	61	13.22%	5.30%
Allied Health Professions, Dentistry, Nursing and Pharmacy	54.2	11.74%	1.97%
Architecture, Built Environment and Planning	28.38	6.15%	2.77%
Area Studies	26	5.63%	5.38%
Biological Sciences	24.5	5.31%	1.03%
Business and Management Studies	64.9	14.06%	1.95%
Chemistry	33.1	7.17%	2.69%
Computer Science and Informatics	24	5.20%	1.17%
Electrical and Electronic Engineering, Metallurgy and Materials	20.5	4.44%	1.91%
Mathematical Sciences	44.4	9.62%	2.30%
Physics	23	4.98%	1.35%
Social Work and Social Policy	35.55	7.70%	2.73%
Sport and Exercise Sciences, Leisure and Tourism	22	4.77%	2.78%
University of Bristol	**1137.73**	**100.00%**	

Agriculture, Veterinary and Food Science	34.03	2.99%	3.27%
Allied Health Professions, Dentistry, Nursing and Pharmacy	16.18	1.42%	0.59%
Art and Design: History, Practice and Theory	8	0.70%	0.50%
Biological Sciences	64.6	5.68%	2.72%
Business and Management Studies	27.5	2.42%	0.83%
Chemistry	58.6	5.15%	4.77%
Classics	15	1.32%	3.9%
Clinical Medicine	84.45	7.42%	2.4%
Computer Science and Informatics	41.6	3.66%	2.0%
Earth Systems and Environmental Sciences	44.28	3.89%	3.2%
Economics and Econometrics	18.6	1.63%	2.5%
Education	34.5	3.03%	2.4%
English Language and Literature	21	1.85%	1.1%
General Engineering	123.38	10.84%	5.0%
Geography, Environmental Studies and Archaeology	55.75	4.90%	3.3%
History	18.8	1.65%	1.1%
Law	39	3.43%	2.5%
Mathematical Sciences	83.5	7.34%	4.3%
Modern Languages and Linguistics	31.1	2.73%	2.2%
Music, Drama, Dance and Performing Arts	21.5	1.89%	1.9%
Philosophy	14.5	1.27%	2.5%
Physics	44.15	3.88%	2.6%
Politics and International Studies	25.8	2.27%	2.0%
Psychology, Psychiatry and Neuroscience	68.81	6.05%	2.7%
Public Health, Health Services and Primary Care	74.6	6.56%	5.5%
Social Work and Social Policy	35.9	3.16%	2.8%
Sociology	17	1.49%	2.4%
Sport and Exercise Sciences, Leisure and Tourism	7	0.62%	0.9%
Theology and Religious Studies	8.6	0.76%	2.1%
University of Exeter	**736.18**	**100.00%**	
Area Studies	14.54	1.98%	3.0%
Biological Sciences	54.58	7.41%	2.3%
Business and Management Studies	49.05	6.66%	1.5%

Classics	19	2.58%	5.0%
Clinical Medicine	24.5	3.33%	0.7%
Computer Science and Informatics	10	1.36%	0.5%
Earth Systems and Environmental Sciences	34.7	4.71%	2.5%
Economics and Econometrics	24.5	3.33%	3.2%
Education	25.92	3.52%	1.8%
English Language and Literature	53.2	7.23%	2.7%
General Engineering	44	5.98%	1.8%
Geography, Environmental Studies and Archaeology	63	8.56%	3.7%
History	41.53	5.64%	2.3%
Law	14.95	2.03%	1.0%
Mathematical Sciences	34.6	4.70%	1.8%
Modern Languages and Linguistics	32	4.35%	2.3%
Music, Drama, Dance and Performing Arts	15.86	2.15%	1.4%
Physics	40.2	5.46%	2.4%
Politics and International Studies	24.2	3.29%	1.9%
Psychology, Psychiatry and Neuroscience	32.3	4.39%	1.3%
Public Health, Health Services and Primary Care	24.85	3.38%	1.8%
Sociology	24.2	3.29%	3.4%
Sport and Exercise Sciences, Leisure and Tourism	23.3	3.16%	2.9%
Theology and Religious Studies	11.2	1.52%	2.7%
University of Gloucestershire	**56.1**	**100.00%**	
Architecture, Built Environment and Planning	8.2	14.62%	0.8%
English Language and Literature	9.1	16.22%	0.5%
Geography, Environmental Studies and Archaeology	11.1	19.79%	0.7%
History	4.8	8.56%	0.3%
Sport and Exercise Sciences, Leisure and Tourism	17.6	31.37%	2.2%
Theology and Religious Studies	5.3	9.45%	1.3%
University of South Wales	**116.96**	**100.00%**	
Allied Health Professions, Dentistry, Nursing and Pharmacy	7.4	6.33%	0.3%
Art and Design: History, Practice and Theory	6.96	5.95%	0.4%
Business and Management Studies	3	2.56%	0.1%
Computer Science and Informatics	13.5	11.54%	0.7%

English Language and Literature	8	6.84%	0.4%
General Engineering	14.5	12.40%	0.6%
History	7.8	6.67%	0.4%
Mathematical Sciences	9.2	7.87%	0.5%
Music, Drama, Dance and Performing Arts	16	13.68%	1.4%
Psychology, Psychiatry and Neuroscience	9.2	7.87%	0.4%
Social Work and Social Policy	14.4	12.31%	1.1%
Sport and Exercise Sciences, Leisure and Tourism	7	5.98%	0.9%
University of the West of England	**299.3**	**100.00%**	
Agriculture, Veterinary and Food Science	13.9	4.64%	1.3%
Allied Health Professions, Dentistry, Nursing and Pharmacy	45.4	15.17%	1.7%
Architecture, Built Environment and Planning	30.7	10.26%	3.0%
Art and Design: History, Practice and Theory	20.6	6.88%	1.3%
Business and Management Studies	34.1	11.39%	1.0%
Communication, Cultural and Media Studies, Library and Information Management	18	6.01%	1.9%
Computer Science and Informatics	14.8	4.94%	0.7%
Education	10.2	3.41%	0.7%
English Language and Literature	12.8	4.28%	0.6%
General Engineering	14	4.68%	0.6%
Geography, Environmental Studies and Archaeology	13.1	4.38%	0.8%
History	13.2	4.41%	0.7%
Law	14	4.68%	0.9%
Modern Languages and Linguistics	9.7	3.24%	0.7%
Philosophy	6	2.00%	1.0%
Politics and International Studies	9	3.01%	0.7%
Social Work and Social Policy	19.8	6.62%	1.5%
University of Wales	**12.35**	**100.00%**	
Modern Languages and Linguistics	12.35	100.00%	0.9%

Source: Research Excellence Framework (REF). Results. Higher Education Funding Council for England (HEFCE). Available at: http://results.ref.ac.uk/

Table 9 REF Doctorates - Doctorate degrees awarded (2008-2012) (SIA Area)

Institution Name / Unit of Assessment	Doctorate Degrees	% of Institution	% of UK Total

	Awarded	Total	
Bath Spa University	**26**	**100.00%**	
Art and Design: History, Practice and Theory	2	7.69%	0.1%
Education	7	26.92%	0.2%
English Language and Literature	14	53.85%	0.5%
History	1	3.85%	0.0%
Music, Drama, Dance and Performing Arts	2	7.69%	0.2%
Cardiff Metropolitan University	**103**	**100.00%**	
Allied Health Professions, Dentistry, Nursing and Pharmacy	36	34.95%	0.7%
Art and Design: History, Practice and Theory	14	13.59%	0.8%
Sport and Exercise Sciences, Leisure and Tourism	53	51.46%	5.8%
Cardiff University	**1,893**	**100.00%**	
Allied Health Professions, Dentistry, Nursing and Pharmacy	222	11.73%	4.5%
Architecture, Built Environment and Planning	61	3.22%	4.3%
Biological Sciences	147	7.77%	2.2%
Business and Management Studies	113	5.97%	2.4%
Chemistry	168	8.85%	3.5%
Civil and Construction Engineering	49	2.59%	5.9%
Clinical Medicine	151	7.98%	1.9%
Communication, Cultural and Media Studies, Library and Information Management	32	1.69%	3.3%
Computer Science and Informatics	49	2.56%	1.2%
Earth Systems and Environmental Sciences	59	3.12%	2.4%
Education	39	2.06%	1.1%
English Language and Literature	63	3.33%	2.4%
General Engineering	157	8.27%	2.9%
Geography, Environmental Studies and Archaeology	26	1.37%	1.0%
History	29	1.51%	1.3%
Law	21	1.11%	1.3%
Mathematical Sciences	36	1.88%	1.4%
Modern Languages and Linguistics	8	0.42%	0.5%
Music, Drama, Dance and Performing Arts	23	1.19%	1.7%
Philosophy	21	1.08%	2.9%

Physics	53	2.80%	1.5%
Politics and International Studies	23	1.22%	1.0%
Psychology, Psychiatry and Neuroscience	242	12.76%	4.3%
Public Health, Health Services and Primary Care	20	1.06%	1.2%
Sociology	74	3.88%	6.1%
Theology and Religious Studies	11	0.58%	0.8%
Falmouth University	**19**	**100.00%**	
Art and Design: History, Practice and Theory	6	31.58%	0.4%
Music, Drama, Dance and Performing Arts	13	68.42%	1.0%
Plymouth University	**517**	**100.00%**	
Agriculture, Veterinary and Food Science	54	10.44%	3.1%
Allied Health Professions, Dentistry, Nursing and Pharmacy	14	2.71%	0.3%
Architecture, Built Environment and Planning	7	1.35%	0.5%
Art and Design: History, Practice and Theory	43	8.32%	2.6%
Business and Management Studies	38	7.35%	0.8%
Clinical Medicine	28	5.42%	0.4%
Computer Science and Informatics	21	4.06%	0.5%
Earth Systems and Environmental Sciences	70	13.54%	2.8%
Education	12	2.32%	0.3%
Electrical and Electronic Engineering, Metallurgy and Materials	27	5.22%	0.7%
English Language and Literature	5	0.97%	0.2%
General Engineering	21	4.06%	0.4%
Geography, Environmental Studies and Archaeology	40	7.74%	1.6%
History	6	1.16%	0.3%
Mathematical Sciences	10	1.93%	0.4%
Music, Drama, Dance and Performing Arts	13	2.51%	1.0%
Psychology, Psychiatry and Neuroscience	50	9.67%	0.9%
Social Work and Social Policy	58	11.22%	3.8%
Royal Agricultural University	**6**	**100.00%**	
Agriculture, Veterinary and Food Science	6	100.00%	0.3%
University of Bath	**951**	**100.00%**	
Aeronautical, Mechanical, Chemical and Manufacturing Engineering	145	15.25%	4.1%

Allied Health Professions, Dentistry, Nursing and Pharmacy	101	10.62%	2.0%
Architecture, Built Environment and Planning	39	4.10%	2.8%
Area Studies	23	2.42%	3.3%
Biological Sciences	84	8.83%	1.3%
Business and Management Studies	108	11.36%	2.2%
Chemistry	105	11.04%	2.2%
Computer Science and Informatics	45	4.73%	1.1%
Electrical and Electronic Engineering, Metallurgy and Materials	53	5.57%	1.4%
Mathematical Sciences	63	6.62%	2.5%
Physics	48	5.05%	1.3%
Social Work and Social Policy	115	12.09%	7.4%
Sport and Exercise Sciences, Leisure and Tourism	22	2.31%	2.4%
University of Bristol	**2,202**	**100.00%**	
Agriculture, Veterinary and Food Science	66	2.98%	3.7%
Allied Health Professions, Dentistry, Nursing and Pharmacy	38	1.70%	0.8%
Art and Design: History, Practice and Theory	10	0.47%	0.6%
Biological Sciences	166	7.55%	2.5%
Business and Management Studies	14	0.64%	0.3%
Chemistry	310	14.09%	6.6%
Classics	13	0.59%	2.8%
Clinical Medicine	162	7.34%	2.1%
Computer Science and Informatics	82	3.71%	2.0%
Earth Systems and Environmental Sciences	75	3.41%	3.0%
Economics and Econometrics	21	0.95%	2.8%
Education	181	8.22%	5.0%
English Language and Literature	18	0.83%	0.7%
General Engineering	269	12.20%	4.9%
Geography, Environmental Studies and Archaeology	83	3.75%	3.3%
History	25	1.13%	1.1%
Law	29	1.29%	1.8%
Mathematical Sciences	66	2.98%	2.6%
Modern Languages and Linguistics	7	0.30%	0.4%

Music, Drama, Dance and Performing Arts	31	1.41%	2.4%
Philosophy	27	1.21%	3.7%
Physics	97	4.39%	2.7%
Politics and International Studies	38	1.70%	1.7%
Psychology, Psychiatry and Neuroscience	151	6.86%	2.7%
Public Health, Health Services and Primary Care	61	2.75%	3.6%
Social Work and Social Policy	108	4.91%	7.0%
Sociology	34	1.54%	2.8%
Sport and Exercise Sciences, Leisure and Tourism	8	0.36%	0.9%
Theology and Religious Studies	17	0.75%	1.3%
University of Exeter	**1,401**	**100.00%**	
Area Studies	74	5.29%	10.6%
Biological Sciences	103	7.36%	1.6%
Business and Management Studies	76	5.44%	1.6%
Classics	26	1.82%	5.6%
Clinical Medicine	37	2.67%	0.5%
Computer Science and Informatics	18	1.30%	0.4%
Earth Systems and Environmental Sciences	28	2.03%	1.1%
Economics and Econometrics	17	1.23%	1.6%
Education	189	13.45%	5.2%
English Language and Literature	88	6.30%	3.3%
General Engineering	82	5.86%	1.5%
Geography, Environmental Studies and Archaeology	74	5.29%	3.0%
History	75	5.36%	3.3%
Law	13	0.95%	0.8%
Mathematical Sciences	30	2.14%	1.2%
Modern Languages and Linguistics	41	2.96%	2.4%
Music, Drama, Dance and Performing Arts	40	2.87%	3.1%
Physics	72	5.15%	2.0%
Politics and International Studies	69	4.89%	3.1%
Psychology, Psychiatry and Neuroscience	127	9.06%	2.2%
Public Health, Health Services and Primary Care	16	1.16%	1.0%
Sociology	43	3.06%	3.6%
Sport and Exercise Sciences, Leisure and Tourism	36	2.56%	3.9%

Theology and Religious Studies	25	1.81%	1.9%
University of Gloucestershire	**35**	**100.00%**	
Architecture, Built Environment and Planning	6	17.14%	0.4%
English Language and Literature	6	17.14%	0.2%
Geography, Environmental Studies and Archaeology	3	8.57%	0.1%
History	1	2.86%	0.0%
Sport and Exercise Sciences, Leisure and Tourism	8	22.86%	0.9%
Theology and Religious Studies	11	31.43%	0.8%
University of South Wales	**234**	**100.00%**	
Allied Health Professions, Dentistry, Nursing and Pharmacy	24	10.26%	0.5%
Art and Design: History, Practice and Theory	12	5.13%	0.7%
Business and Management Studies	39	16.67%	0.8%
Computer Science and Informatics	57	24.36%	1.4%
English Language and Literature	7	2.99%	0.3%
General Engineering	30	12.82%	1.2%
History	6	2.56%	0.3%
Mathematical Sciences	10	4.27%	0.4%
Music, Drama, Dance and Performing Arts	19	8.12%	1.4%
Psychology, Psychiatry and Neuroscience	8	3.42%	0.1%
Social Work and Social Policy	11	4.70%	0.7%
Sport and Exercise Sciences, Leisure and Tourism	11	4.70%	1.2%
University of the West of England	**368**	**100.00%**	
Agriculture, Veterinary and Food Science	21	5.71%	1.2%
Allied Health Professions, Dentistry, Nursing and Pharmacy	95	25.84%	1.9%
Architecture, Built Environment and Planning	31	8.40%	2.2%
Art and Design: History, Practice and Theory	17	4.69%	1.0%
Business and Management Studies	31	8.42%	0.6%
Communication, Cultural and Media Studies, Library and Information Management	9	2.31%	0.9%
Computer Science and Informatics	56	15.12%	1.3%
Education	18	4.89%	0.5%
English Language and Literature	2	0.54%	0.1%
General Engineering	32	8.59%	0.6%

Geography, Environmental Studies and Archaeology	10	2.74%	0.4%
History	7	1.90%	0.3%
Law	8	2.17%	0.5%
Modern Languages and Linguistics	9	2.45%	0.5%
Philosophy	3	0.68%	0.3%
Politics and International Studies	2	0.41%	0.1%
Social Work and Social Policy	19	5.14%	1.2%
Grand Total	**7,754**		

Source: Research Excellence Framework (REF). Results. Higher Education Funding Council for England (HEFCE). Available at: http://results.ref.ac.uk/

1.4.3 Student Population

Table 10 Number of students per thematic area, HEIs and FEIs (2015) – English LEPs

Subjects	Cornwall and Isles of Scilly	Gloucestershire	Heart of the South West	Swindon and Wiltshire	West of England	South East Wales
Agriculture & related subjects	220	540	205	10	60	
Architecture, building & planning	10	100	220	10	620	
Biological Sciences	475	745	1,850	70	1,515	
Business & admin studies	200	480	2,005	75	1,920	
Combined	0		185	0	85	
Computer Science	80	180	575	15	680	
Creative arts & design	1,110	440	1,475	95	1,960	
Education	355	250	625	115	530	
Engineering & technology	150	80	1,135	80	1,700	
Geographical_Studies	130	45	605		435	
Historical & philosophical studies	85	45	620		730	
Initial teacher training	30	130	310	10	145	

languages	190	55	1,385		955	
Law	15	50	550	10	735	
Mass comm & documentation	210	85	120	35	260	
Mathematical sciences		5	265		650	
Medicine & dentistry			355		325	
Physical Sci.	70		475		710	
Social studies	245	235	1,355	70	1,415	
Subjects allied to medicine	60	105	2,430	45	2,620	
Veterinary sciences					145	
Grand Total	**3,635**	**3,570**	**16,745**	**640**	**18,195**	**82,545**

Source: Underlying data for local growth 2013-14. Higher education and local growth. HEFCE (2015). Available at: http://www.hefce.ac.uk/analysis/maps/. Welsh data drawn from Enrolments, during the year, at Welsh HEIs by institution, level and mode of study, available at: https://statswales.gov.wales/Catalogue/Education-and-Skills/Post-16-Education-and-Training/Higher-Education/Students/Enrolments-at-Welsh-HEIs/enrolmentsduringtheyear-by-institution-level-modeofstudy. More granular data available through customised data extract. See: https://www.hesa.ac.uk/stats

1.4.4 Business Demography

Table 11 Enterprises - active, births, deaths and net change (2004-2014)

LEP	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Cornwall and Isles of Scilly											
Active Enterprises	39,530	39,420	39,450	40,270	40,760	40,800	40,340	39,920	39,670		
Births	2,300	2,175	2,045	2,145	1,930	1,660	1,525	1,715	1,735		
Deaths	2,170	1,955	1,710	1,725	1,665	2,185	1,810	1,840	1,900		
Net Change	130	220	335	420	265	-525	-285	-125	-165		
Gloucestershire											
Active Enterprises	48,750	49,100	49,540	50,770	51,680	51,920	52,510	52,410	52,830		
Births	2,850	2,660	2,570	2,775	2,540	2,245	2,300	2,470	2,605		

Deaths	2,480	2,315	2,155	2,170	2,150	2,555	2,490	2,410	2,635		
Net Change	370	345	415	605	390	-310	-190	60	-30		
Heart of the South West											
Active Enterprises	110,235	111,000	111,825	114,920	117,435	118,640	117,330	116,670	117,240		
Births	7,860	6,925	6,335	6,820	6,250	5,180	4,835	5,405	5,480		
Deaths	6,430	5,975	5,625	5,960	6,005	6,890	5,855	5,640	6,095		
Net Change	1,430	950	710	860	245	-1,710	-1,020	-235	-615		
Swindon and Wiltshire											
Active Enterprises	48,260	48,790	49,540	50,930	51,610	51,930	52,380	52,300	53,000		
Births	2,945	2,895	2,725	2,985	2,695	2,325	2,460	2,685	2,735		
Deaths	2,515	2,310	2,270	2,325	2,180	2,725	2,500	2,285	2,555		
Net Change	430	585	455	660	515	-400	-40	400	180		
West of England											
Active Enterprises	73,960	74,520	75,900	78,630	79,520	80,680	81,470	81,720	83,250		
Births	4,475	4,360	4,350	4,720	4,335	3,830	4,030	4,505	4,670		
Deaths	3,995	3,635	3,335	3,680	3,555	4,560	4,055	3,810	4,255		
Net Change	480	725	1,015	1,040	780	-730	-25	695	415		
South East Wales											
Active enterprises	37395	37895	38365	38900	38900	38960	39015	38350	38220	39590	41540
Births	5270	4900	4445	4310	4220	3925	3640	4025	4020	5760	5965
Deaths	4250	3945	3775	3945	3790	4590	4240	3915	4050	3805	4105
Net change	1020	955	670	365	430	-665	-600	110	-30	195	186

										5	0
Total – consortium area											
Active enterprises	358,130	360,725	364,620	374,420	379,905	382,930	383,045	381,370	384,210		
Births	25,700	23,915	22,470	23,755	21,970	19,165	18,790	20,805	21,245		
Deaths	21,840	20,135	18,870	19,805	19,345	23,505	20,950	19,900	21,490		
Net change	3,860	3,780	3,600	3,950	2,625	-4,340	-2,160	905	-245		

Source: Building Local Advantage. Review of LEP area economies 2014. LEP Network and Athley Consulting (2014). Available at: http://www.mylocaleconomy.org/review-of-lep-area-economies-2014/ (English LEPs); Stats Wales. Available at: https://statswales.gov.wales/Catalogue/Business-Economy-and-Labour-Market/Businesses/Business-Demography (South East Wales, aggregated from Local Authority Districts)

1.4.5 Productivity

Table 12 GVA per capita and GVA per hour worked (2013) – SIA Area

LEP	Cornwall and Isles of Scilly	Gloucestershire	Heart of the South West	Swindon and Wiltshire	West of England	South East Wales	Consortium area average
Gross Value Added per capita (£s)	15,403	23,269	18,098	23,219	26,820	17,903	20,785
GVA per hour worked (£) (2013)	21.7	28.1	25.2	31.3	30.1	-	27.28 *

Source: Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015). Available at: https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths and Stats Wales. Available at: https://statswales.gov.wales/Catalogue/Sustainable-Development/Sustainable-Development-Indicators/gva-by-measure-welsheconomicregion-year. Note: * = average excludes South East Wales, for which this data was not available.

Table 13 Annual Average Gross Full Time Earnings, workplace based (2014 English LEPs and 2015 South East Wales)

	Cornwall and Isles of	Gloucestershire	Heart of the South	Swindon and Wiltshir	West of England	South East Wales	Consortium area average

	Scilly		West	e			
Average annual gross full-time pay, workplace-based	25,468	31,659	27,602	30,771	32,955	24,196	28,775

Source: Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015). Available at: https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths (England); Localisation of Industrial Activity across England's LEPs: 2008 & 2012. Enterprise Research Centre (ERC) (2013). Available at: http://www.enterpriseresearch.ac.uk/publications/localisation-industrial-activity-across-englands-leps-2008-2012/ Neighbourhood statistics. Available at: http://www.neighbourhood.statistics.gov.uk/HTMLDocs/dvc126/index.html (Wales)

1.4.6 Quality of place / life

Table 14 Median rank value in the Halifax Quality of Life survey (2014) – English LEPs

LEP	Cornwall and Isles of Scilly	Gloucestershire	Heart of the South West	Swindon and Wiltshire	West of England
Highest ranking LA	237	65	125	97	60
Lowest ranking LA	251	240	251	197	251
Median rank	244	129	183	147	140

Source: Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015). Available at: https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths

Table 15 Wales' top 7 areas for quality of life, according to Halifax Quality of Life survey (2015) – Wales Local Authorities

Wales Local Authorities	Wales Ranking	UK Ranking
Monmouthshire	**1**	**61**
Anglesey	2	141
Pembrokeshire	3	149
Flintshire	4	181
Vale of Glamorgan	**5**	**182**
Powys	6	209
Ceredigion	7	224

Source: WalesOnline, based on data from Halifax.
http://www.walesonline.co.uk/news/wales-news/wales-seven-best-places-live-10620322

Table 16 Average travel to work distance (2011)

LEP	South West England	South East Wales	Consortium area average
Average travel to work time (km)	16.3	15.8	16.1

Source: Nomis Official Labour Market Statistics, using census 2011 data. Available at: https://www.nomisweb.co.uk/census/2011/qs702ew

Table 17 Digital infrastructure (2014)

LEP	South West England	South East Wales	UK
Average download speed (Mbit/s) by Local Authority	21.4	22.8	21.2
Super-Fast Broadband Availability (% premises) by Local Authority	87.2%	93.3%	85.4%

Source: ThinkBroadband. Available at: https://labs.thinkbroadband.com/local/index.php?tab=2. Averages calculated from regional and Local Authority data

1.5 Excellence in Science and Research

1.5.1 Scientific production

Table 18 Number of outputs submitted to the REF, per output type

Institution / Unit of Assessment	Artefact	Authored book	Chapter in book	Composition	Conference contribution	Design	Digital or visual media	Edited book	Exhibition	Journal article	Other form of assessable output	Patent/published patent application	Performance	Research datasets and databases	Research report for external body	Scholarly edition	Software	Website content	Working paper	Grand Total
Bath Spa University	**4**	**70**	**54**	**7**	**2**		**10**	**10**	**52**	**91**	**20**		**10**		**2**	**1**				**333**
Art and Design: History, Practice and Theory	4	1	5		1			2	49	4	8		2							76
Communication, Cultural and Media Studies, Library and Information Management		4	1				3			19	4									31
Education		4	7		1			1		33					2					48
English Language and Literature		53	21				4	5		14	6		5			1				109
History		4	13							9	1									27
Music, Drama, Dance and Performing Arts		4	7	7			3	2	3	12	1		3							42

Institution / Unit of Assessment	Artefact	Authored book	Chapter in book	Composition	Conference contribution	Design	Digital or visual media	Edited book	Exhibition	Journal article	Other form of assessable output	Patent/published patent application	Performance	Research datasets and databases	Research report for external body	Scholarly edition	Software	Website content	Working paper	Grand Total
Cardiff Metropolitan University		**1**	**7**		**5**			**1**	**4**	**112**		**a**	**2**							**132**
Allied Health Professions, Dentistry, Nursing and Pharmacy										45										45
Art and Design: History, Practice and Theory		1	7		3			1	4	24			2							42
Sport and Exercise Sciences, Leisure and Tourism					2					43										45
Cardiff University		**148**	**132**	**6**	**16**	**6**		**22**		**2,478**	**1**				**13**	**6**			**5**	**2,833**
Allied Health Professions, Dentistry, Nursing and Pharmacy			1							275					1					277
Architecture, Built Environment and Planning		10	6		6	6				121					3					152
Biological Sciences										222										222
Business and Management Studies		1	2							267									2	272

Institution / Unit of Assessment	Artefact	Authored book	Chapter in book	Composition	Conference contribution	Design	Digital or visual media	Edited book	Exhibition	Journal article	Other form of assessable output	Patent/published patent application	Performance	Research datasets and databases	Research report for external body	Scholarly edition	Software	Website content	Working paper	Grand Total
Chemistry										103										103
Civil and Construction Engineering										57										57
Clinical Medicine										249										249
Communication, Cultural and Media Studies, Library and Information Management		16	7					2		28					4					57
Computer Science and Informatics					1					55										56
Earth Systems and Environmental Sciences										65										65
Education		5	1							72										78
English Language and Literature		23	23					5		37	1								2	91
General Engineering										112										112
Geography, Environmental Studies and Archaeology		8	12		5			3		18					2					48

Institution / Unit of Assessment	Artefact	Authored book	Chapter in book	Composition	Conference contribution	Design	Digital or visual media	Edited book	Exhibition	Journal article	Other form of assessable output	Patent/published patent application	Performance	Research datasets and databases	Research report for external body	Scholarly edition	Software	Website content	Working paper	Grand Total
History		10	20					2		22						5				59
Law		11	13					1		58					2					85
Mathematical Sciences										80										80
Modern Languages and Linguistics		13	5		1			2		24					1				1	47
Music, Drama, Dance and Performing Arts		7	26	6				2		11										52
Philosophy		5	4							22										31
Physics										74										74
Politics and International Studies		19	4					1		26										50
Psychology, Psychiatry and Neuroscience										260										260
Public Health, Health Services and Primary Care										103										103
Sociology		11	1							101										113

Institution / Unit of Assessment	Artefact	Authored book	Chapter in book	Composition	Conference contribution	Design	Digital or visual media	Edited book	Exhibition	Journal article	Other form of assessable output	Patent/published patent application	Performance	Research datasets and databases	Research report for external body	Scholarly edition	Software	Website content	Working paper	Grand Total
Theology and Religious Studies		9	7		3			4		16						1				40
Falmouth University	**23**	**13**	**38**	**5**	**15**		**4**	**1**	**22**	**34**	**3**	**1**	**13**		**1**			**2**		**175**
Art and Design: History, Practice and Theory	23	5	13		14			1	19	16	1				1			2		95
Music, Drama, Dance and Performing Arts		8	25	5	1		4		3	18	2	1	13							80
Plymouth University		**72**	**57**	**1**	**6**		**2**	**5**	**26**	**1,210**	**1**		**9**		**5**			**1**		**1,395**
Agriculture, Veterinary and Food Science										97					2					99
Allied Health Professions, Dentistry, Nursing and Pharmacy										121										121
Architecture, Built Environment and Planning		8	6							30										44

Institution / Unit of Assessment	Artefact	Authored book	Chapter in book	Composition	Conference contribution	Design	Digital or visual media	Edited book	Exhibition	Journal article	Other form of assessable output	Patent/published patent application	Performance	Research datasets and databases	Research report for external body	Scholarly edition	Software	Website content	Working paper	Grand Total
Art and Design: History, Practice and Theory		9	10				1		24	6			1					1		52
Business and Management Studies		5	1					2		117										125
Clinical Medicine										60										60
Computer Science and Informatics					2					50										52
Earth Systems and Environmental Sciences			1							184										185
Education		6	7		1					68										82
Electrical and Electronic Engineering, Metallurgy and Materials					1					35										36
English Language and Literature		13	9					1		12										35
General Engineering			1		2					64					1					68
Geography, Environmental Studies and Archaeology		8								95										103

Institution / Unit of Assessment	Artefact	Authored book	Chapter in book	Composition	Conference contribution	Design	Digital or visual media	Edited book	Exhibition	Journal article	Other form of assessable output	Patent/published patent application	Performance	Research datasets and databases	Research report for external body	Scholarly edition	Software	Website content	Working paper	Grand Total
History		13	7							22										42
Mathematical Sciences										56										56
Music, Drama, Dance and Performing Arts		3	5	1			1	2	2	12			8							34
Psychology, Psychiatry and Neuroscience										113	1									114
Social Work and Social Policy		7	10							68					2					87
Royal Agricultural University			**6**		**1**					**37**					**3**					**47**
Agriculture, Veterinary and Food Science			6		1					37					3					47
University of Bath		**29**	**42**		**32**					**1,518**	**2**				**5**				**1**	**1,629**
Aeronautical, Mechanical, Chemical and Manufacturing Engineering										210										210
Allied Health Professions, Dentistry,										202										202

Institution / Unit of Assessment	Artefact	Authored book	Chapter in book	Composition	Conference contribution	Design	Digital or visual media	Edited book	Exhibition	Journal article	Other form of assessable output	Patent/published patent application	Performance	Research datasets and databases	Research report for external body	Scholarly edition	Software	Website content	Working paper	Grand Total
Nursing and Pharmacy																				
Architecture, Built Environment and Planning		4	7							89										100
Area Studies		13	21							61										95
Biological Sciences										83										83
Business and Management Studies		1								206										207
Chemistry										122										122
Computer Science and Informatics			3		32					57										92
Electrical and Electronic Engineering, Metallurgy and Materials										74										74
Mathematical Sciences		1								163										164
Physics										84										84

Institution / Unit of Assessment	Artefact	Authored book	Chapter in book	Composition	Conference contribution	Design	Digital or visual media	Edited book	Exhibition	Journal article	Other form of assessable output	Patent/published patent application	Performance	Research datasets and databases	Research report for external body	Scholarly edition	Software	Website content	Working paper	Grand Total
Social Work and Social Policy		8	11							99	2				5				1	126
Sport and Exercise Sciences, Leisure and Tourism		2								68										70
University of Bristol		**146**	**259**	**12**	**64**			**44**		**3,547**	**27**	**4**	**5**		**32**	**2**	**1**		**7**	**4,150**
Agriculture, Veterinary and Food Science										131										131
Allied Health Professions, Dentistry, Nursing and Pharmacy										67										67
Art and Design: History, Practice and Theory		6	7		1			3		10										27
Biological Sciences										253										253
Business and Management Studies		2	1		1					77					1				3	85
Chemistry			1							235										236
Classics		7	18		1			7		17										50

Institution / Unit of Assessment	Artefact	Authored book	Chapter in book	Composition	Conference contribution	Design	Digital or visual media	Edited book	Exhibition	Journal article	Other form of assessable output	Patent/published patent application	Performance	Research datasets and databases	Research report for external body	Scholarly edition	Software	Website content	Working paper	Grand Total
Clinical Medicine										319										319
Computer Science and Informatics					58					97		4								159
Earth Systems and Environmental Sciences										155										155
Economics and Econometrics			3							56									4	63
Education		11	32		1			2		104	1				3					154
English Language and Literature		8	21					3		24	1					2				59
General Engineering		1								445										446
Geography, Environmental Studies and Archaeology		5	15							161					8		1			190
History		14	20					5		27	2									68
Law		21	35							69					4					129
Mathematical Sciences		1	1							248	21									271

Institution / Unit of Assessment	Artefact	Authored book	Chapter in book	Composition	Conference contribution	Design	Digital or visual media	Edited book	Exhibition	Journal article	Other form of assessable output	Patent/published patent application	Performance	Research datasets and databases	Research report for external body	Scholarly edition	Software	Website content	Working paper	Grand Total
Modern Languages and Linguistics		19	31					6		53										109
Music, Drama, Dance and Performing Arts		10	18	12				5		26	1		5							77
Philosophy		7	7					1		42										57
Physics										191										191
Politics and International Studies		13	11					1		65										90
Psychology, Psychiatry and Neuroscience										262										262
Public Health, Health Services and Primary Care										253										253
Social Work and Social Policy		9	18					2		91					16					136
Sociology		8	9					6		41										64
Sport and Exercise Sciences, Leisure and Tourism										17										17

Institution / Unit of Assessment	Artefact	Authored book	Chapter in book	Composition	Conference contribution	Design	Digital or visual media	Edited book	Exhibition	Journal article	Other form of assessable output	Patent/published patent application	Performance	Research datasets and databases	Research report for external body	Scholarly edition	Software	Website content	Working paper	Grand Total
Theology and Religious Studies		4	11		2			3		11	1									32
University of Exeter		**237**	**194**		**11**			**35**		**2,008**	**6**		**2**	**1**	**1**	**1**		**2**	**16**	**2,514**
Area Studies		14	12							19										45
Biological Sciences										187										187
Business and Management Studies		1	2		1					165									2	171
Classics		17	32					1		18										68
Clinical Medicine										90										90
Computer Science and Informatics					7					31										38
Earth Systems and Environmental Sciences										114										114
Economics and Econometrics		1	1							70									11	83
Education		7	9							84					1					101
English Language and Literature		65	30					7		54	2			1		1		1		161

Institution / Unit of Assessment	Artefact	Authored book	Chapter in book	Composition	Conference contribution	Design	Digital or visual media	Edited book	Exhibition	Journal article	Other form of assessable output	Patent/published patent application	Performance	Research datasets and databases	Research report for external body	Scholarly edition	Software	Website content	Working paper	Grand Total
General Engineering										148										148
Geography, Environmental Studies and Archaeology		20	7					1		181								1		210
History		38	27					10		56									3	134
Law		5	14							37										56
Mathematical Sciences										122										122
Modern Languages and Linguistics		18	25					10		47										100
Music, Drama, Dance and Performing Arts		10	13					2		18	4		2							49
Physics		1			3					142										146
Politics and International Studies		7	5					1		77										90
Psychology, Psychiatry and Neuroscience		1								117										118
Public Health, Health Services and										89										89

Institution / Unit of Assessment	Artefact	Authored book	Chapter in book	Composition	Conference contribution	Design	Digital or visual media	Edited book	Exhibition	Journal article	Other form of assessable output	Patent/published patent application	Performance	Research datasets and databases	Research report for external body	Scholarly edition	Software	Website content	Working paper	Grand Total
Primary Care																				
Sociology		20	10							56										86
Sport and Exercise Sciences, Leisure and Tourism										70										70
Theology and Religious Studies		12	7					3		16										38
University of Gloucestershire		**25**	**29**					**4**		**187**										**245**
Architecture, Built Environment and Planning										34										34
English Language and Literature		14	11							17										42
Geography, Environmental Studies and Archaeology										47										47
History		7	6					4		11										28
Sport and Exercise Sciences, Leisure and Tourism										70										70

Institution / Unit of Assessment	Artefact	Authored book	Chapter in book	Composition	Conference contribution	Design	Digital or visual media	Edited book	Exhibition	Journal article	Other form of assessable output	Patent/published patent application	Performance	Research datasets and databases	Research report for external body	Scholarly edition	Software	Website content	Working paper	Grand Total
Theology and Religious Studies		4	12							8										24
University of South Wales		**30**	**39**		**7**		**10**	**9**	**10**	**338**	**1**		**2**		**4**	**1**				**451**
Allied Health Professions, Dentistry, Nursing and Pharmacy										32										32
Art and Design: History, Practice and Theory		2	5				8		9	3										27
Business and Management Studies										12										12
Computer Science and Informatics					7					40										47
English Language and Literature		13	11						1	6										31
General Engineering										53										53
History		9	4					2		19										34
Mathematical Sciences										38										38
Music, Drama, Dance and Performing Arts		4	9				2	7		31	1		2		2	1				59

Institution / Unit of Assessment	Artefact	Authored book	Chapter in book	Composition	Conference contribution	Design	Digital or visual media	Edited book	Exhibition	Journal article	Other form of assessable output	Patent/published patent application	Performance	Research datasets and databases	Research report for external body	Scholarly edition	Software	Website content	Working paper	Grand Total
Psychology, Psychiatry and Neuroscience										30										30
Social Work and Social Policy		2	10							41					2					55
Sport and Exercise Sciences, Leisure and Tourism										33										33
University of the West of England	**9**	**79**	**129**		**7**		**10**	**10**	**23**	**837**	**9**	**4**	**5**		**3**			**4**	**9**	**1,138**
Agriculture, Veterinary and Food Science										53										53
Allied Health Professions, Dentistry, Nursing and Pharmacy										177		1								178
Architecture, Built Environment and Planning		3	4				1			101	1				3			1		114
Art and Design: History, Practice and Theory	7	7	6		3		2	6	23	5	5	2	5						2	73
Business and Management Studies		9								121									1	131

Institution / Unit of Assessment	Artefact	Authored book	Chapter in book	Composition	Conference contribution	Design	Digital or visual media	Edited book	Exhibition	Journal article	Other form of assessable output	Patent/published patent application	Performance	Research datasets and databases	Research report for external body	Scholarly edition	Software	Website content	Working paper	Grand Total
Communication, Cultural and Media Studies, Library and Information Management	2	7	32				7			15	1							3		67
Computer Science and Informatics		2			2					51										55
Education		1	4					1		37										43
English Language and Literature		9	23							13	1									46
General Engineering										50		1								51
Geography, Environmental Studies and Archaeology		2	1		1					47										51
History		6	26					1		16	1								5	55
Law		12	9							28										49
Modern Languages and Linguistics		6	10		1			1		16										34
Philosophy		5	3							12										20
Politics and International Studies		3	7							21									1	32

Institution / Unit of Assessment	Artefact	Authored book	Chapter in book	Composition	Conference contribution	Design	Digital or visual media	Edited book	Exhibition	Journal article	Other form of assessable output	Patent/published patent application	Performance	Research datasets and databases	Research report for external body	Scholarly edition	Software	Website content	Working paper	Grand Total
Social Work and Social Policy		7	4					1		74										86
University of Wales		**11**	**12**					**4**		**20**				**1**		**12**				**60**
Modern Languages and Linguistics		11	12					4		20				1		12				60
Grand Total	**36**	**861**	**998**	**31**	**166**	**6**	**36**	**145**	**137**	**12,417**	**70**	**9**	**48**	**2**	**69**	**23**	**1**	**9**	**38**	**15,102**

Source: Research Excellence Framework (REF). Results. Higher Education Funding Council for England (HEFCE). Available at: http://results.ref.ac.uk/

1.5.2 *Scientific quality*

Table 19 Output profile of REF in the relevant field

Institution / Unit of Assessment	Four Star	Three Star	Two Star	One Star	Unclassified	Category A FTE
Bath Spa University						
Art and Design: History, Practice and Theory	18.4	40.8	29.0	10.5	1.3	14.2
Communication, Cultural and Media Studies, Library and Information Management	19.4	38.7	32.2	9.7	0.0	7.4
Education	8.2	32.6	36.8	18.3	4.1	13.2
English Language and Literature	22.9	46.8	19.3	6.4	4.6	21.1
History	3.7	25.9	44.5	25.9	0.0	6.2
Music, Drama, Dance and Performing Arts	16.7	28.5	31.0	23.8	0.0	12.0
Cardiff Metropolitan University						
Allied Health Professions, Dentistry, Nursing and Pharmacy	11.1	66.7	22.2	0.0	0.0	12.0
Art and Design: History, Practice and Theory	10.4	51.1	34.3	2.1	2.1	10.0
Sport and Exercise Sciences, Leisure and Tourism	23.8	56.0	19.0	0.0	1.2	13.0
Cardiff University						
Allied Health Professions, Dentistry, Nursing and Pharmacy	23.1	67.2	9.7	0.0	0.0	75.0
Architecture, Built Environment and Planning	61.4	78.1	44.5	16.0	0.0	42.2
Biological Sciences	31.1	45.0	20.3	2.2	1.4	54.7
Business and Management Studies	27.2	50.7	20.3	1.8	0.0	72.6
Chemistry	22.3	72.8	4.9	0.0	0.0	23.0
Civil and Construction Engineering	24.6	70.1	5.3	0.0	0.0	14.3
Clinical Medicine	33.3	53.4	11.3	0.4	1.6	59.0
Communication, Cultural and Media Studies, Library and Information Management	40.4	42.1	15.7	1.8	0.0	13.4

Computer Science and Informatics	21.4	59.0	19.6	0.0	0.0	13.7
Earth Systems and Environmental Sciences	33.8	60.0	4.7	1.5	0.0	15.0
Education	32.1	43.5	20.6	3.8	0.0	20.6
English Language and Literature	36.3	50.5	9.9	3.3	0.0	24.0
General Engineering	18.8	76.7	3.6	0.0	0.9	33.8
Geography, Environmental Studies and Archaeology	31.3	39.5	25.0	4.2	0.0	13.1
History	35.6	39.0	23.7	1.7	0.0	14.4
Law	22.4	55.2	22.4	0.0	0.0	22.0
Mathematical Sciences	20.0	65.0	15.0	0.0	0.0	24.1
Modern Languages and Linguistics	21.3	61.7	17.0	0.0	0.0	14.8
Music, Drama, Dance and Performing Arts	36.5	40.4	23.1	0.0	0.0	13.2
Philosophy	9.7	54.8	29.0	6.5	0.0	10.0
Physics	21.6	77.0	1.4	0.0	0.0	19.5
Politics and International Studies	22.0	48.0	22.0	8.0	0.0	13.0
Psychology, Psychiatry and Neuroscience	41.5	50.0	8.1	0.4	0.0	69.3
Public Health, Health Services and Primary Care	25.2	45.7	26.2	2.9	0.0	24.3
Sociology	17.7	60.2	20.3	1.8	0.0	29.5
Theology and Religious Studies	35.0	40.0	20.0	5.0	0.0	9.2
Falmouth University						
Art and Design: History, Practice and Theory	3.1	21.6	36.1	28.9	10.3	24.3
Music, Drama, Dance and Performing Arts	9.9	23.4	39.5	21.0	6.2	26.1
Plymouth University						
Agriculture, Veterinary and Food Science	8.1	42.4	41.4	6.1	2.0	24.5
Allied Health Professions, Dentistry, Nursing and Pharmacy	18.2	45.4	33.1	1.6	1.7	34.9
Architecture, Built Environment and Planning	11.4	47.7	34.1	6.8	0.0	13.0
Art and Design: History, Practice and Theory	19.2	40.4	34.6	3.9	1.9	13.8
Business and Management Studies	9.6	35.2	42.4	12.0	0.8	32.6

Clinical Medicine	48.3	36.7	15.0	0.0	0.0	14.5
Computer Science and Informatics	23.1	53.8	21.2	1.9	0.0	12.4
Earth Systems and Environmental Sciences	14.6	64.9	18.3	2.2	0.0	44.9
Education	13.4	35.4	34.1	17.1	0.0	24.0
Electrical and Electronic Engineering, Metallurgy and Materials	0.0	61.1	38.9	0.0	0.0	7.8
English Language and Literature	33.3	36.1	22.3	8.3	0.0	11.0
General Engineering	11.8	57.3	28.0	2.9	0.0	17.2
Geography, Environmental Studies and Archaeology	17.5	44.6	29.2	8.7	0.0	29.2
History	14.3	42.8	40.5	2.4	0.0	11.0
Mathematical Sciences	10.7	57.2	30.3	1.8	0.0	14.4
Music, Drama, Dance and Performing Arts	20.6	29.4	35.3	14.7	0.0	8.2
Psychology, Psychiatry and Neuroscience	19.3	61.4	19.3	0.0	0.0	30.8
Social Work and Social Policy	12.6	51.8	32.2	3.4	0.0	22.0
Royal Agricultural University						
Agriculture, Veterinary and Food Science	4.3	6.3	42.6	34.0	12.8	12.0
University of Bath						
Aeronautical, Mechanical, Chemical and Manufacturing Engineering	13.3	70.0	16.7	0.0	0.0	61.0
Allied Health Professions, Dentistry, Nursing and Pharmacy	35.1	53.0	10.9	1.0	0.0	54.2
Architecture, Built Environment and Planning	35.0	50.0	12.0	3.0	0.0	28.4
Area Studies	18.9	39.0	28.4	12.6	1.1	26.0
Biological Sciences	31.3	51.8	15.7	0.0	1.2	24.5
Business and Management Studies	27.5	50.8	19.8	0.9	1.0	64.9
Chemistry	18.9	78.6	2.5	0.0	0.0	33.1
Computer Science and Informatics	15.2	56.5	27.2	1.1	0.0	24.0
Electrical and Electronic Engineering, Metallurgy and Materials	13.5	73.0	13.5	0.0	0.0	20.5
Mathematical Sciences	21.3	64.7	14.0	0.0	0.0	44.4
Physics	15.5	75.0	9.5	0.0	0.0	23.0
Social Work and Social Policy	22.2	46.8	28.6	1.6	0.8	35.6

Sport and Exercise Sciences, Leisure and Tourism	35.7	48.6	15.7	0.0	0.0	22.0
University of Bristol						
Agriculture, Veterinary and Food Science	23.7	58.0	17.5	0.0	0.8	34.0
Allied Health Professions, Dentistry, Nursing and Pharmacy	29.9	38.8	28.3	1.5	1.5	16.2
Art and Design: History, Practice and Theory	11.1	44.5	40.7	3.7	0.0	8.0
Biological Sciences	26.1	52.6	20.5	0.0	0.8	64.6
Business and Management Studies	15.3	56.5	28.2	0.0	0.0	27.5
Chemistry	28.0	69.5	2.5	0.0	0.0	58.6
Classics	32.0	40.0	28.0	0.0	0.0	15.0
Clinical Medicine	13.5	56.7	28.2	1.3	0.3	84.5
Computer Science and Informatics	23.3	57.2	17.6	1.9	0.0	41.6
Earth Systems and Environmental Sciences	31.0	65.8	3.2	0.0	0.0	44.3
Economics and Econometrics	22.2	58.8	19.0	0.0	0.0	18.6
Education	29.9	39.6	29.2	0.7	0.6	34.5
English Language and Literature	15.3	42.3	32.2	10.2	0.0	21.0
General Engineering	22.2	69.7	7.0	0.9	0.2	123.4
Geography, Environmental Studies and Archaeology	45.7	69.4	70.9	14.0	0.0	55.8
History	26.5	42.6	26.5	4.4	0.0	18.8
Law	24.8	52.7	20.9	1.6	0.0	39.0
Mathematical Sciences	28.4	52.8	17.3	0.8	0.7	83.5
Modern Languages and Linguistics	23.9	44.9	30.3	0.9	0.0	31.1
Music, Drama, Dance and Performing Arts	53.0	94.7	50.0	2.3	0.0	21.5
Philosophy	21.1	54.3	22.8	1.8	0.0	14.5
Physics	18.8	62.9	17.8	0.5	0.0	44.2
Politics and International Studies	13.3	36.7	38.9	11.1	0.0	25.8
Psychology, Psychiatry and Neuroscience	24.0	45.1	27.1	1.9	1.9	68.8
Public Health, Health Services and Primary Care	23.7	55.0	18.9	2.0	0.4	74.6
Social Work and Social Policy	29.4	40.5	26.4	3.7	0.0	35.9
Sociology	23.4	39.1	35.9	1.6	0.0	17.0

Sport and Exercise Sciences, Leisure and Tourism	52.9	47.1	0.0	0.0	0.0	7.0
Theology and Religious Studies	28.1	37.5	31.3	3.1	0.0	8.6
University of Exeter						
Area Studies	26.7	44.4	26.7	2.2	0.0	14.5
Biological Sciences	26.7	55.1	16.6	0.0	1.6	54.6
Business and Management Studies	17.5	50.9	23.4	6.4	1.8	49.1
Classics	22.1	44.1	32.3	1.5	0.0	19.0
Clinical Medicine	35.6	41.1	18.9	0.0	4.4	24.5
Computer Science and Informatics	31.6	50.0	15.8	2.6	0.0	10.0
Earth Systems and Environmental Sciences	22.8	59.7	16.6	0.0	0.9	34.7
Economics and Econometrics	13.3	57.8	19.3	9.6	0.0	24.5
Education	37.6	40.6	21.8	0.0	0.0	25.9
English Language and Literature	28.0	35.4	30.4	6.2	0.0	53.2
General Engineering	20.9	74.4	4.0	0.0	0.7	44.0
Geography, Environmental Studies and Archaeology	42.4	97.6	57.0	2.4	0.6	63.0
History	38.1	38.8	22.4	0.7	0.0	41.5
Law	21.4	60.7	17.9	0.0	0.0	15.0
Mathematical Sciences	15.6	63.9	20.5	0.0	0.0	34.6
Modern Languages and Linguistics	27.0	32.0	36.0	5.0	0.0	32.0
Music, Drama, Dance and Performing Arts	22.4	49.0	20.4	8.2	0.0	15.9
Physics	21.9	65.8	10.2	2.1	0.0	40.2
Politics and International Studies	22.2	53.4	23.3	1.1	0.0	24.2
Psychology, Psychiatry and Neuroscience	31.4	51.7	16.1	0.8	0.0	32.3
Public Health, Health Services and Primary Care	16.9	59.5	21.4	2.2	0.0	24.9
Sociology	19.8	47.6	30.3	2.3	0.0	24.2
Sport and Exercise Sciences, Leisure and Tourism	27.1	55.8	17.1	0.0	0.0	23.3
Theology and Religious Studies	21.1	52.6	21.0	5.3	0.0	11.2
University of Gloucestershire						
Architecture, Built Environment and Planning	29.4	53.0	17.6	0.0	0.0	8.2

English Language and Literature	7.1	31.0	33.3	28.6	0.0	9.1
Geography, Environmental Studies and Archaeology	10.6	34.1	34.0	19.2	2.1	11.1
History	7.1	25.0	39.3	28.6	0.0	4.8
Sport and Exercise Sciences, Leisure and Tourism	5.7	44.3	44.3	5.7	0.0	17.6
Theology and Religious Studies	4.2	29.1	45.9	20.8	0.0	5.3
University of South Wales						
Allied Health Professions, Dentistry, Nursing and Pharmacy	25.0	37.5	37.5	0.0	0.0	7.4
Art and Design: History, Practice and Theory	10.4	51.1	34.3	2.1	2.1	7.0
Computer Science and Informatics	0.0	21.3	68.1	8.5	2.1	13.5
English Language and Literature	19.4	29.0	38.7	12.9	0.0	8.0
General Engineering	1.9	75.5	20.7	0.0	1.9	14.5
History	11.8	52.9	32.4	2.9	0.0	7.8
Mathematical Sciences	0.0	47.4	50.0	2.6	0.0	9.2
Music, Drama, Dance and Performing Arts	11.9	38.9	35.6	11.9	1.7	16.0
Psychology, Psychiatry and Neuroscience	3.3	10.0	66.7	20.0	0.0	9.2
Social Work and Social Policy	21.8	40.0	30.9	5.5	1.8	14.4
Sport and Exercise Sciences, Leisure and Tourism	33.3	45.5	21.2	0.0	0.0	7.0
University of the West of England						
Agriculture, Veterinary and Food Science	9.4	51.0	35.8	3.8	0.0	13.9
Allied Health Professions, Dentistry, Nursing and Pharmacy	12.9	57.3	28.7	1.1	0.0	45.4
Architecture, Built Environment and Planning	3.5	50.0	41.2	5.3	0.0	30.7
Art and Design: History, Practice and Theory	13.7	37.0	42.5	5.4	1.4	20.6
Business and Management Studies	9.9	40.5	43.5	6.1	0.0	34.1
Communication, Cultural and Media Studies, Library and Information Management	20.9	40.3	29.8	7.5	1.5	18.0
Computer Science and Informatics	14.5	51.0	25.4	9.1	0.0	14.8
Education	18.6	34.9	44.2	2.3	0.0	10.2

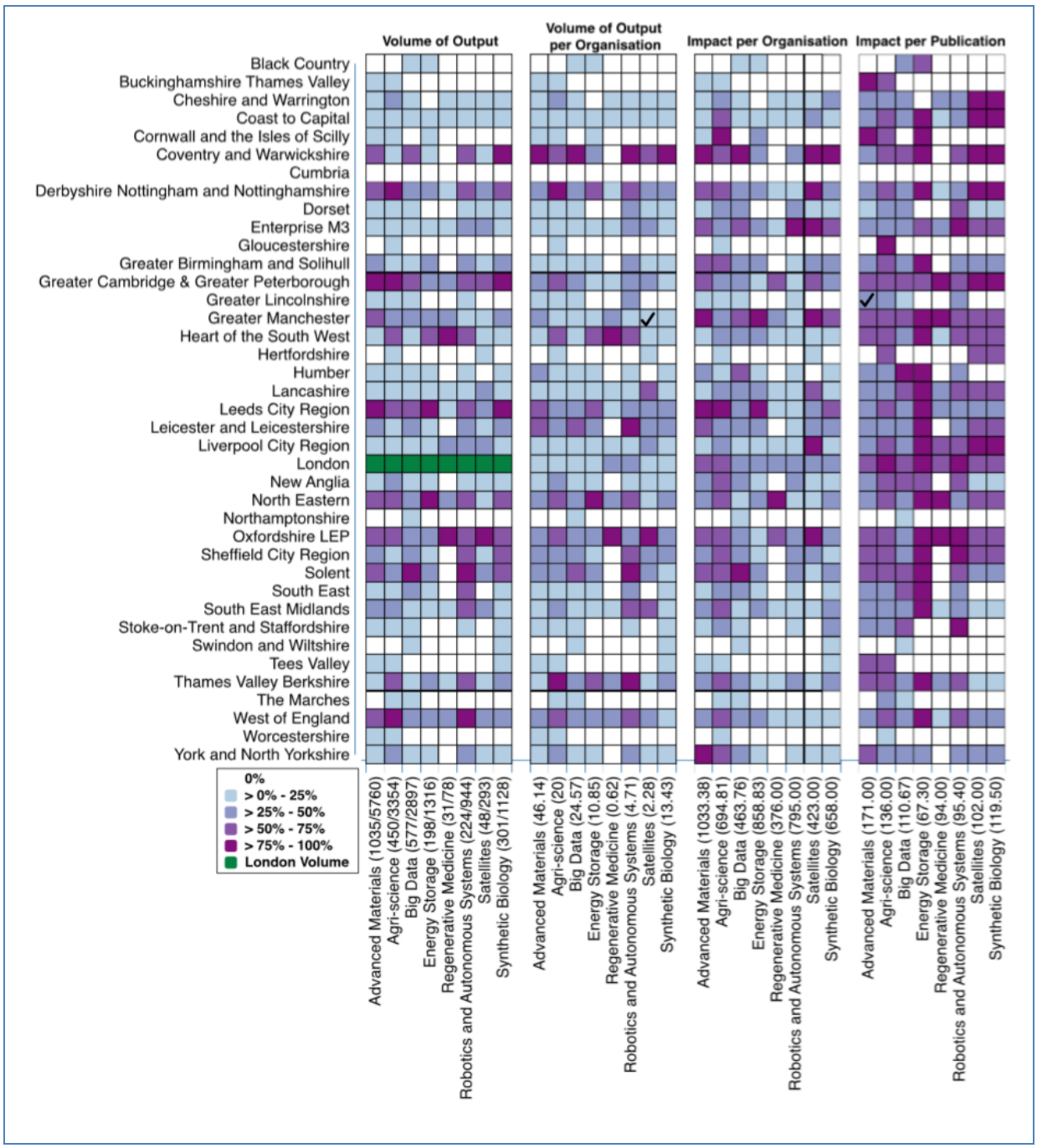
English Language and Literature	26.1	47.8	19.6	6.5	0.0	12.8
General Engineering	15.7	78.4	5.9	0.0	0.0	14.0
Geography, Environmental Studies and Archaeology	7.8	15.7	49.0	23.6	3.9	13.1
History	1.8	52.7	41.9	3.6	0.0	13.2
Law	6.1	30.6	51.1	12.2	0.0	14.0
Modern Languages and Linguistics	11.8	32.3	47.1	8.8	0.0	9.7
Philosophy	5.0	35.0	50.0	10.0	0.0	6.0
Politics and International Studies	3.1	37.5	40.7	18.7	0.0	9.0
Social Work and Social Policy	7.0	30.2	44.2	18.6	0.0	19.8
University of Wales						
Modern Languages and Linguistics	23.1	32.3	35.4	9.2	0.0	12.4
Grand Total	**3,291.3**	**7,712.7**	**4,197.8**	**805.5**	**92.7**	**4,092.3**

Source: Research Excellence Framework (REF). Results. Higher Education Funding Council for England (HEFCE). Available at: http://results.ref.ac.uk/

1.5.3 Scientific specialisation

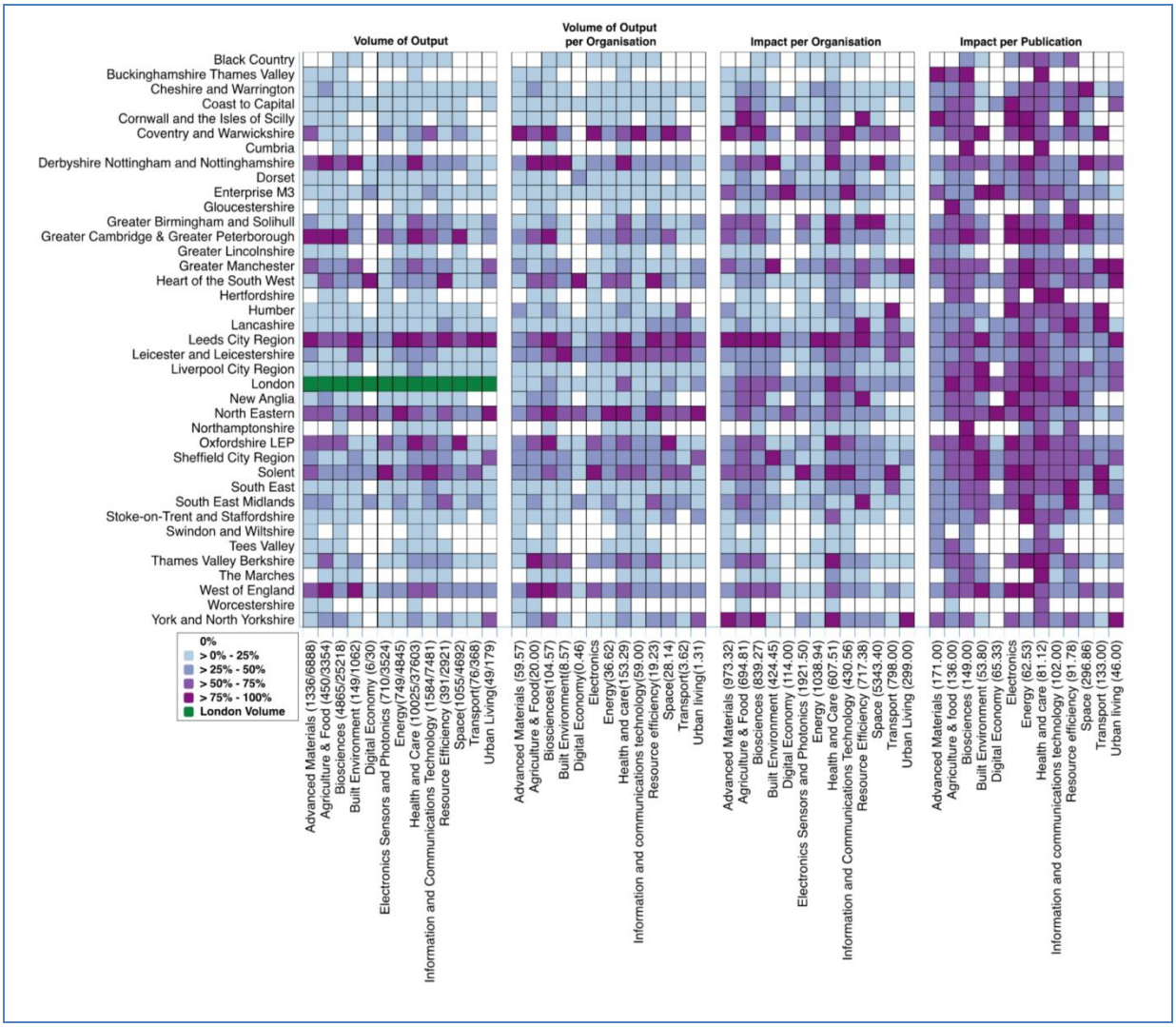
English LEPs

Figure 1 Publication intensity in the Eight 'Great Technologies'



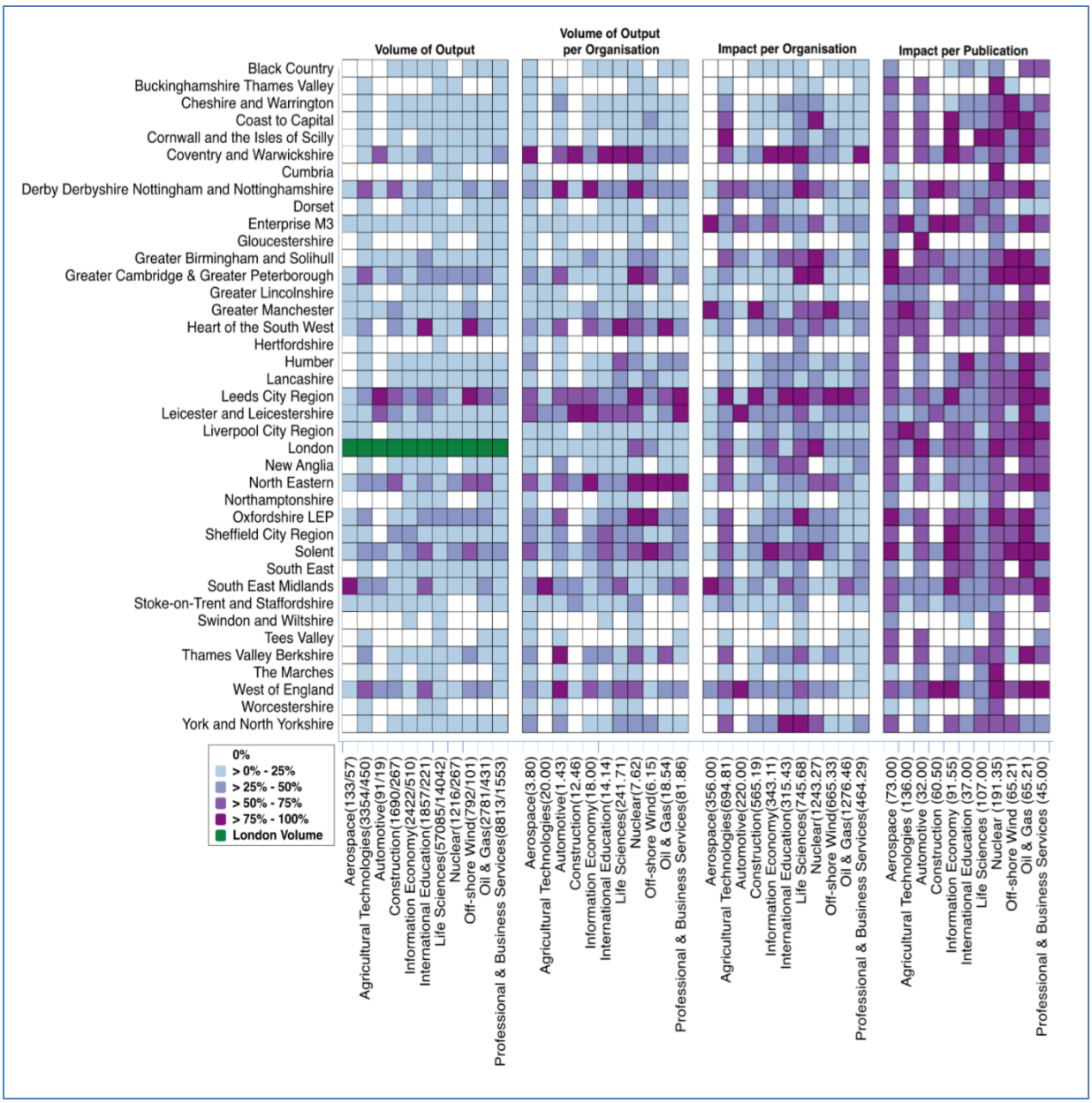
Source: Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015). Available at: https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths

Figure 2 Relative intensity of publications in areas related to the Industrial Strategy Sectors (2014)



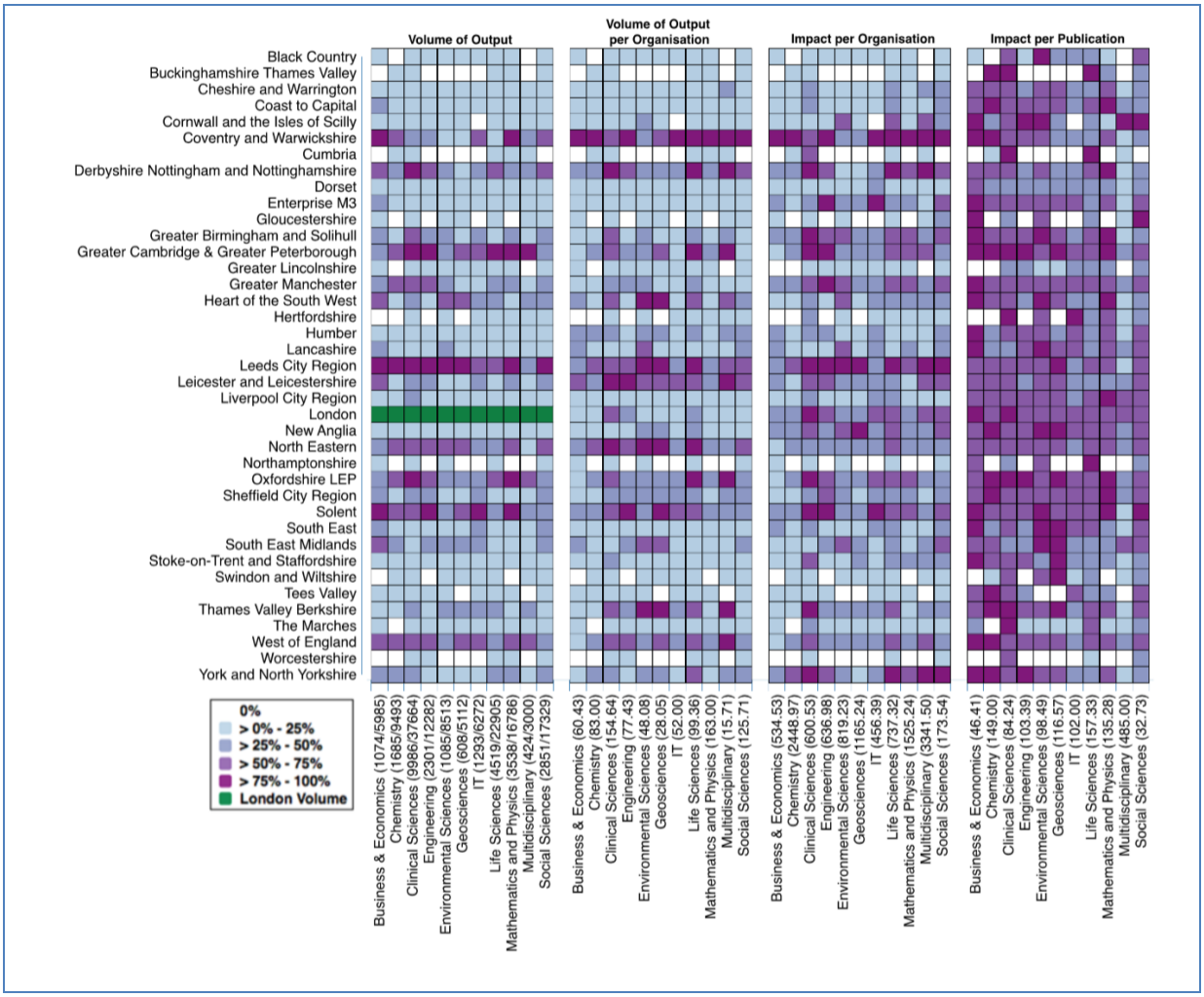
Source: Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015). Available at: https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths

Figure 3 Relative intensity of publications in Innovate UK priority topics (2014)



Source: Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015). Available at: https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths

Figure 4 Relative intensity of publications in research domains (2014)



Source: Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015). Available at: https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths

Wales

Table 20 Impact of publications in broad domains, selected universities in Welsh SIA area

MNCS	2006–2009	2007–2010	2008–2011	2009–2012	2010–2013	2011–2014
Cardiff University	**1.10**	**1.09**	**1.08**	**1.11**	**1.10**	**1.12**
Biomedical and health sciences	1.07	1.09	1.09	1.11	1.11	1.13
Life and earth sciences	1.32	1.25	1.19	1.13	1.11	1.17
Mathematics and computer science	1.08	1.06	1.12	1.14	1.08	1.13
Physical sciences and engineering	1.20	1.14	1.11	1.12	1.19	1.21

Social sciences and humanities	0.97	0.97	0.99	1.06	0.99	0.98

Source: CWTS Leiden Ranking, based on Thompson Reuters data. MNCS: "average number of citations of the publications of a university, normalized for field and publication year. An MNCS value of two for instance means that the publications of a university have been cited twice above the average of their field and publication year." - See more at: http://www.leidenranking.com/information/indicators#sthash.1T9Yajtd.dpuf

More information about the research performance of Wales using bibliometric analysis can be found in: International Comparative Performance of the Welsh Research Base 2013. A report prepared by Elsevier for HEW, the Higher Education Funding Council for Wales, and the Welsh Government.

1.5.4 Strength and competitiveness in Research (national)

Table 21 UK Research - Annual number of projects led

Year	2010	2011	2012	2013	2014	2015	Grand Total
AHRC	96	64	43	39	39	24	305
BBSRC	38	50	71	65	60	94	378
EPSRC	114	100	122	135	100	120	691
ESRC	45	69	46	42	46	33	281
MRC	31	29	43	48	39	44	234
NC3Rs	1	1		2		2	6
NERC	104	97	81	85	67	76	510
STFC	20	15	25	19	18	29	126

Source: Gateway to Research (GtR). Research Councils UK (RCUK) (2016). Available at: http://gtr.rcuk.ac.uk/ Note: Data is constructed from projects in a public GtR snapshot dated 02-2016, using postcode-level matching of the lead organisation to the SIA area. RCUK can provide custom curated data if we forward a precise definition of the geography and the topics of interest. RCUK have indicated that there would be an approximate 3-week delivery time for these queries.

Table 22 UK Research - Annual number of organisations

Year	Number of organisations
2006	45
2007	27
2008	44
2009	56
2010	70
2011	88

2012	132
2013	209
2014	193
2015	209
Grand Total	**1,073**

Source: Gateway to Research (GtR). Research Councils UK (RCUK) (2016). Available at: http://gtr.rcuk.ac.uk/ Note: Data is constructed from projects in a public GtR snapshot dated 02-2016, using postcode-level matching of the lead organisation to the SIA area. RCUK can provide custom curated data if we forward a precise definition of the geography and the topics of interest. RCUK have indicated that there would be an approximate 3-week delivery time for these queries.

Table 23 UK Research - Annual value of funding (£)

Awarding body	2010	2011	2012	2013	2014	2015
AHRC	12,569,358	4,960,981	10,082,622	6,792,239	10,385,274	3,206,105
BBSRC	14,325,224	13,941,663	24,144,566	22,030,120	31,382,179	24,679,921
EPSRC	42,716,761	48,260,716	64,259,822	107,467,553	118,168,810	62,215,790
ESRC	11,158,098	44,142,627	6,714,869	11,721,387	15,321,464	13,985,465
MRC	13,286,806	18,169,079	25,153,463	30,004,922	37,239,846	30,573,583
NC3Rs	337,693	362,955		398,829		164,255
NERC	20,496,175	19,153,441	21,810,539	21,582,720	21,338,025	18,963,163
STFC	7,879,796	2,260,488	10,049,834	5,864,850	2,493,835	7,710,980
Grand Total	**122,769,911**	**151,251,950**	**162,215,715**	**205,862,620**	**236,329,433**	**161,499,262**

Source: Gateway to Research (GtR). Research Councils UK (RCUK) (2016). Available at: http://gtr.rcuk.ac.uk/ Note: Data is constructed from projects in a public GtR snapshot dated 02-2016, using postcode-level matching of the lead organisation to the SIA area. RCUK can provide custom curated data if we forward a precise definition of the geography and the topics of interest. RCUK have indicated that there would be an approximate 3-week delivery time for these queries.

Table 24 REF Research Income - Annual value of income (£), domestic sources

Unit of Assessment	2008	2009	2010	2011	2012
Aeronautical, Mechanical, Chemical and Manufacturing Engineering	5,454,293	4,450,449	5,112,406	4,823,828	4,213,532
Agriculture, Veterinary and Food Science	6,046,793	4,439,907	3,676,367	3,987,404	3,528,536
Allied Health Professions, Dentistry, Nursing and Pharmacy	17,308,135	18,977,287	16,737,689	15,655,777	16,187,889
Architecture, Built Environment and Planning	5,825,181	6,160,111	6,291,346	7,424,865	5,917,114
Area Studies	542,023	955,102	904,275	620,225	486,217
Art and Design: History, Practice and Theory	1,791,206	1,786,363	1,810,652	1,772,138	1,460,767
Biological Sciences	26,509,397	26,789,935	27,006,426	27,514,198	27,230,909
Business and Management Studies	6,834,792	5,501,275	4,567,856	4,131,368	3,829,804
Chemistry	16,895,583	17,438,233	17,230,931	16,402,431	16,640,203
Civil and Construction Engineering	2,103,729	1,133,225	1,415,757	1,832,852	1,854,183
Classics	257,830	289,996	363,724	389,706	303,407
Clinical Medicine	37,882,031	36,986,653	30,345,965	33,024,992	32,238,355
Communication, Cultural and Media Studies, Library and Information Management	484,900	433,627	325,711	631,134	1,030,912
Computer Science and Informatics	6,110,292	6,017,906	6,218,849	6,343,122	7,529,108
Earth Systems and Environmental Sciences	9,514,754	8,161,127	8,452,740	9,359,291	10,256,681
Economics and Econometrics	1,342,029	1,640,956	1,473,388	1,606,755	1,954,570
Education	3,926,307	4,492,123	4,016,873	3,612,320	4,676,310
Electrical and Electronic Engineering, Metallurgy and Materials	2,004,839	2,020,144	2,416,543	2,237,754	1,708,111
English Language and Literature	636,538	722,100	814,708	964,318	787,455
General Engineering	22,932	21,192	22,302	24,085	33,750

	,818	,896	,146	,144	,627
Geography, Environmental Studies and Archaeology	4,662,895	5,377,172	6,152,531	6,582,149	7,593,049
History	2,361,593	2,210,446	1,723,713	1,666,898	1,665,789
Law	1,366,537	1,563,063	1,623,265	1,624,546	1,114,071
Mathematical Sciences	5,480,460	5,054,810	6,503,785	6,931,666	6,884,435
Modern Languages and Linguistics	520,662	879,837	1,357,451	1,572,020	1,639,379
Music, Drama, Dance and Performing Arts	851,995	982,159	1,253,285	1,278,175	1,176,162
Philosophy	662,793	573,927	415,056	284,273	55,134
Physics	27,325,567	24,886,193	22,310,694	21,964,087	20,326,493
Politics and International Studies	1,010,252	1,361,612	1,293,851	1,197,872	580,592
Psychology, Psychiatry and Neuroscience	18,947,857	18,153,225	17,627,815	18,599,802	20,607,425
Public Health, Health Services and Primary Care	19,826,458	26,692,917	31,825,100	32,262,136	35,119,124
Social Work and Social Policy	3,873,611	3,538,725	4,676,240	4,683,467	5,291,911
Sociology	3,998,939	3,460,199	3,923,519	3,784,275	1,889,704
Sport and Exercise Sciences, Leisure and Tourism	1,349,434	1,668,432	1,841,239	1,712,412	1,912,676
Theology and Religious Studies	732,292	540,118	484,477	289,838	262,350
Grand Total	**267,374,815**	**266,532,250**	**264,496,373**	**270,853,238**	**281,702,984**

Source: Research Excellence Framework (REF). Results. Higher Education Funding Council for England (HEFCE). Available at: http://results.ref.ac.uk/

1.5.5 Strength and competitiveness in Research (international)

Table 25 REF Research Income - Annual value of income (£), international

Unit of Assessment	2008	2009	2010	2011	2012
Aeronautical, Mechanical, Chemical and	284,2	273,8	714,1	768,1	1,093,

Manufacturing Engineering	32	77	03	50	166
Agriculture, Veterinary and Food Science	919,143	726,054	576,157	504,527	895,448
Allied Health Professions, Dentistry, Nursing and Pharmacy	2,798,254	3,162,096	2,643,651	2,739,924	3,274,090
Architecture, Built Environment and Planning	1,306,084	1,331,968	1,128,974	1,419,217	1,976,038
Area Studies	188,095	114,827	121,887	165,999	333,165
Art and Design: History, Practice and Theory	194,229	319,189	443,203	791,286	509,168
Biological Sciences	3,796,580	5,625,700	6,478,243	7,209,092	7,120,755
Business and Management Studies	349,944	264,816	337,446	377,914	635,535
Chemistry	2,539,440	2,793,169	3,110,913	3,059,540	4,487,962
Civil and Construction Engineering	72,584	80,660	127,179	295,950	398,024
Classics	19,155	10,120	1,052	22,777	4,283
Clinical Medicine	2,408,387	3,031,383	3,357,156	3,734,333	4,286,279
Communication, Cultural and Media Studies, Library and Information Management	77,463	9,935	23,724	20,083	49,961
Computer Science and Informatics	2,688,106	2,821,552	3,027,242	4,079,481	3,918,756
Earth Systems and Environmental Sciences	2,483,021	2,621,750	3,924,296	5,577,382	7,062,907
Economics and Econometrics	0	9,922	63,908	180,021	94,995
Education	264,684	305,451	610,864	768,968	616,707
Electrical and Electronic Engineering, Metallurgy and Materials	407,157	476,187	604,701	793,897	691,067
English Language and Literature	87,995	208,016	145,496	127,434	119,085
General Engineering	5,275,820	5,172,733	7,654,677	11,069,663	11,702,716
Geography, Environmental Studies and	829,0	868,3	1,204,	1,647,	2,419,

Archaeology	99	39	837	090	609
History	30,053	43,189	43,292	130,965	266,486
Law	53,760	78,452	214,910	266,712	292,958
Mathematical Sciences	379,724	515,784	786,411	1,164,728	1,285,485
Modern Languages and Linguistics	3,892	30,438	44,895	8,852	87,434
Music, Drama, Dance and Performing Arts	13,553	15,043	49,350	53,891	193,502
Philosophy	112,374	89,895	9,235	29,472	218,105
Physics	1,343,617	2,349,436	2,739,779	2,649,247	2,911,616
Politics and International Studies	173,161	386,328	562,318	507,112	458,881
Psychology, Psychiatry and Neuroscience	1,629,019	1,880,274	2,373,818	2,255,805	2,279,358
Public Health, Health Services and Primary Care	1,087,328	900,228	1,335,199	1,432,437	924,603
Social Work and Social Policy	736,744	657,918	992,513	777,661	648,461
Sociology	705,615	613,610	754,230	810,397	1,244,548
Sport and Exercise Sciences, Leisure and Tourism	108,860	235,365	479,561	396,576	466,807
Theology and Religious Studies	46,183	35,897	39,406	12,241	45,034
Grand Total	**33,413,355**	**38,059,601**	**46,724,626**	**55,848,824**	**63,012,994**

Source: Research Excellence Framework (REF). Results. Higher Education Funding Council for England (HEFCE). Available at: http://results.ref.ac.uk/

1.6 Innovation Strengths

1.6.1 Private sector investment

Table 26 Business Enterprise R&D expenditure (BERD), £s per person employed (FTE), 2013 – English LEPs and Wales

	Cornwall and Isles	Gloucestershire	Heart of the South	Swindon and	West of England	South East

	of Scilly		West	Wiltshire		Wales
£s per person employed	114	1,079	354	1,682	1,022	533

Source: Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015). Available at: https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths and StatsWales. Available at: https://statswales.gov.wales/Catalogue/Business-Economy-and-Labour-Market/Businesses/Research-and-Development/latestresearchanddevelopmentexpenditure-by-area-expendituretype; Welsh figures drawn from the UK Annual Population Survey and UK Business Count, both available at http://www.nomisweb.co.uk. Note: South East Wales figure reached by estimating the gross R&D expenditure of South East Wales via the number of enterprises that are in South East Wales. This figure (£253.3m) was then divided by the total number of FTE jobs in South East Wales.

Table 27 Annual value of R & D Tax Credits in £s per person employed (FTE), 2013/14

	SME R&D scheme		All schemes	
	Number of claims	Amount claimed	Number of claims	Amount claimed
South West England	1,260	55	1,490	80
Wales	495	15	580	25
UK	**16,060**	**780**	**19,205**	**1,715**

Source: HM Revenue & Customs. Available at: https://www.gov.uk/government/statistics/regional-analysis-of-research-and-development-tax-credit-claims

Table 28 Foreign Direct Investment, 2013 – English LEPs (2013) and Wales (2015)

FDI indicator	Cornwall and Isles of Scilly	Gloucestershire	Heart of the South West	Swindon and Wiltshire	West of England	Wales
Share of UK (per cent) FDI projects	0.32	0.25	0.70	0.51	1.79	3.8
Total FDI successes	5	4	11	8	28	41

Source: Building Local Advantage. Review of LEP area economies 2014. LEP Network and Athley Consulting (2014). Available at: http://www.mylocaleconomy.org/review-of-lep-area-economies-2014/ (England); EY's attractiveness survey 2016. Available at:

http://www.ey.com/UK/en/Issues/Business-environment/ey-attractiveness-survey-2016-uk (Wales)

Table 29 Investment in the region (2012-2014)

Region	Indicator	2012	2013	2014
South West (England)	% of amount invested	3	9	5
	% of companies	6	6	7
	Amount invested £(m)	172	371	233
	Number of Companies	49	46	50
	of UK Investee Companies by Region			7
Wales	% of amount invested	2	1	1
	% of companies	4	4	6
	Amount invested £(m)	87	51	51
	Number of Companies	37	29	47
	of UK Investee Companies by Region			6

Source: Private Equity and Venture Capital Report on Investment Activity 2014. British Venture Capital Assocation Report(BVCA) (2015). Available at: http://www.bvca.co.uk/Portals/0/library/documents/IAR%20Autumn15.pdf

Table 30 Investment activity compared to total number of VAT registered local units (2012-2014) – England and Wales

Region	Indicator	2012	2013	2014
South West (England)	Companies invested in per 1,000 of total VAT registered local units	0.2	0.2	0.2
	Number of private equity backed companies	49	46	50
	Number of VAT registered local units	241,265	241,550	247,965
Wales	Companies invested in per 1,000 of total VAT registered local units	0.3	0.3	0.4
	Number of private equity backed companies	37	29	47
	Number of VAT registered local units	111,680	110,500	113,215

Source: Private Equity and Venture Capital Report on Investment Activity 2014. British Venture Capital Assocation Report(BVCA) (2015). Available at: http://www.bvca.co.uk/Portals/0/library/documents/IAR%20Autumn15.pdf

1.6.2 Innovate UK investment

Table 31 Innovate UK Investment in innovation by type (2016)

Thematic area	Total grant offered (£m)
Advanced Materials	23
Bioscience	22
BISF	1
Catapult	5
Development	10
Digital	31
Electronics, Photonics & Electrical Systems (EPES)	22
Emerging Technologies	2
Energy	81
European	1
Future Cities	1
Healthcare	28
High Value Manufacturing	41
Information & Communication Technology	16
KTP	4
Large	35
Low Impact Buildings	52
Nanotechnology	5
Reponsive	7
Responsive	262
Space Programmes	9
Sustainability	27
Sustainable Agri-Food (SAF) Protection	16
Transport	63
TSB Programmes	70
Urban Living	15
Grand Total	849

Source: Transparency data. Innovate UK funded projects since 2004. Innovate UK (2016). Available at: https://www.gov.uk/government/publications/innovate-uk-funded-projects
Note: Data is constructed from projects in the public snapshot of InnovateUK dated 14-04-2016, using postcode-level aggregation of the stated organisation to the SIA Area.

Table 32 Public expenditure on innovation (2013-14)

Funding body	South West	Wales
Research Councils research expenditure per head (£)	25	22.8
Higher Education Funding Councils per head (Recurrent research grants) (£)	18.7	22.8
Innovate UK expenditure per head	15.2	2.3

Source: Public Research And Innovation Expenditure (BIS). Geographic breakdown of public research and innovation expenditure. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/437447/bis-15-350-Public-expenditure-on-research-and-innovation-2013-14.pdf

Table 33 Innovate UK value of awarded projects/grants in innovation by product (£) (2010-2016) – SIA Area

	Business, Innovation & Skills Financed	Centre	Collaborative Research & Development	European	Fast Track	Feasibility Study	Innovation Voucher	Knowledge Transfer Partnership	Large Scale Demonstrator	Launchpad	Regional Development Agency	Responsive	Small Business Research Initiative	Smart - Development of Prototype	Smart - Proof of Concept	Smart - Proof of Market	Total
Advanced Materials			2,420,377			119,182											**2,539,559**
Bioscience			1,007,946			676,641											**1,684,587**
BISF									9,764,610								**9,764,610**
Buildings													100,000				**100,000**
Catapult		52,612,456															**52,612,456**
Development			123,455			455,064											**578,519**
Digital			3,475,341		188,251	423,767				221,915			1,017,100				**5,326,374**

	Business, Innovation & Skills Financed	Centre	Collaborative Research & Development	European	Fast Track	Feasibility Study	Innovation Voucher	Knowledge Transfer Partnership	Large Scale Demonstrator	Launchpad	Regional Development Agency	Responsive	Small Business Research Initiative	Smart - Development of Prototype	Smart - Proof of Concept	Smart - Proof of Market	Total
Electronics Photonics & Electrical Systems (EPES)			1,221,470	1,836,142	55,505	518,364											**3,631,481**
Emerging Technologies						0											**0**
Energy			10,350,207			1,950,151											**12,300,358**
European				3,230													**3,230**

	Business, Innovation & Skills Financed	Centre	Collaborative Research & Development	European	Fast Track	Feasibility Study	Innovation Voucher	Knowledge Transfer Partnership	Large Scale Demonstrator	Launchpad	Regional Development Agency	Responsive	Small Business Research Initiative	Smart - Development of Prototype	Smart - Proof of Concept	Smart - Proof of Market	Total
Future Cities			0														**0**
Healthcare			7,560,739	95,827	326,439	677,439				122,925			141,319				**8,924,688**
High Value Manufacturing			3,033,768	1,564,340		2,016,666											**6,614,774**
Information & Communication Technology			1,304,672	668,157		180,816							0				**2,153,645**

	Business, Innovation & Skills Financed	Centre	Collaborative Research & Development	European	Fast Track	Feasibility Study	Innovation Voucher	Knowledge Transfer Partnership	Large Scale Demonstrator	Launchpad	Regional Development Agency	Responsive	Small Business Research Initiative	Smart - Development of Prototype	Smart - Proof of Concept	Smart - Proof of Market	Total
KTP								156,827									**156,827**
Large	43,820,081		3,787,371			1,170,617			15,334,306								**64,112,375**
Low Impact Buildings			1,627,790	195,555		3,253,375							2,160,225				**7,236,945**
Nanotechnology			175,636			5,000											**180,636**
Reponsive							34,968								82,537	38,377	**155,882**
Responsive				806,857		24,750	1,014,555					246,462	614,906	5,604,837	4,675,939	944,653	**13,932,959**
Space			170,118		141,565	236,354											**548,037**

	Business, Innovation & Skills Financed	Centre	Collaborative Research & Development	European	Fast Track	Feasibility Study	Innovation Voucher	Knowledge Transfer Partnership	Large Scale Demonstrator	Launchpad	Regional Development Agency	Responsive	Small Business Research Initiative	Smart - Development of Prototype	Smart - Proof of Concept	Smart - Proof of Market	Total
Programmes																	
Sustainability			1,092,788			527,701											**1,620,489**
Sustainable Agri-Food SAF Protection			1,803,419			162,149											**1,965,568**
Transport			9,877,492	139,735	132,615	60,956			183,322	68,283							**10,462,403**
TSB Programmes								7,836,956			3,367,396						**11,204,352**

	Business, Innovation & Skills Financed	Centre	Collaborative Research & Development	European	Fast Track	Feasibility Study	Innovation Voucher	Knowledge Transfer Partnership	Large Scale Demonstrator	Launchpad	Regional Development Agency	Responsive	Small Business Research Initiative	Smart - Development of Prototype	Smart - Proof of Concept	Smart - Proof of Market	Total
Unknown																	**0**
Urban Living			73,419														**73,419**
Total	**43,820,081**	**52,612,456**	**49,106,008**	**5,309,843**	**844,375**	**12,458,992**	**1,049,523**	**7,993,783**	**25,282,238**	**413,123**	**3,367,396**	**246,462**	**4,033,550**	**5,604,837**	**4,758,476**	**983,030**	**217,884,173**

Source: Innovate UK funded projects since 2004. Innovate UK (2016). Available at: https://www.gov.uk/government/publications/innovate-uk-funded-projects Note: is constructed from projects in the 14-04-2016 snapshot, using postcode-level aggregation. funded projects since 2004. Innovate UK (2016). Available at: https://www.gov.uk/government/publications/innovate-uk-funded-projects Note: is constructed from projects in the 14-04-2016 snapshot, using postcode-level aggregation.

1.6.3 *Innovation in firms*

Table 34 % of firms engaged in product or process innovation (2010-2012)

	South West England (average)	South East Wales	Consortium Area (average)
Collaboration for innovation by local economic area (% of firms)	20	19	19
New to the market product and service innovation by Local Area (% innovating firms)	49	33	41
Percentage of firms undertaking R&D by local economic area (% innovating firms)	16	14	15
Process innovation by local economic area (% innovating firms)	13	9	11
Product and Service Innovation by Local Area (% firms)	21	16	18
Strategic and Marketing innovation by local economic area (% innovating firms)	29	28	29

Source: Benchmarking Local Innovation – The innovation geography of the UK. Enterprise Research Centre (ERC) (2015). Available at: http://www.enterpriseresearch.ac.uk/wp-content/uploads/2015/05/Benchmarking-Local-Innovation1.pdf. Note: South West England figure Is an average of the LEP areas within the region.

1.6.4 *Entrepreneurship*

Table 35 Number of businesses and private sector jobs (2013 and 2014)

Indicator	Cornwall and Isles of Scilly	Gloucestershire	Heart of the South West	Swindon and Wiltshire	West of England	South East Wales
Businesses	22,943	27,334	68,667	27,832	41,090	32,380
Private sector jobs	134,390	187,763	334,836	212,080	364,458	461,700

Source: UK Growth Dashboard 2015. Enterprise Research Centre (ERC) in partnership with Business Growth Service (2015) Available at: http://www.enterpriseresearch.ac.uk/uk-growth-dashboard-2015/; UK Business Count (2013), available at: http://www.nomisweb.co.uk; Employment in the public and private sectors by Welsh local authority and status (2013), available at: https://statswales.gov.wales/Catalogue/Business-

Economy-and-Labour-Market/People-and-Work/Employment/Persons-Employed/publicprivatesectoremployment-by-welshlocalauthority-status

Table 36 Businesses that reached at least £3m turnover by 2014, as a proportion companies that reached at least £1m turnover by 2011

Indicator	Unit	Cornwall and Isles of Scilly	Gloucestershire	Heart of the South West	Swindon and Wiltshire	West of England
Fast-growing firms	%	16	15	15	15	16
Net job creation ratio	%	4	4	3	2	1
Net jobs	number	5,292	7,126	8,132	3,477	4,942
Of £1m turnover businesses in 2011 grew to a minimum of £3m by 2014	%	5	7	5	4	7

Source: UK Growth Dashboard 2015. Enterprise Research Centre (ERC) in partnership with Business Growth Service (2015) Available at: http://www.enterpriseresearch.ac.uk/uk-growth-dashboard-2015/

Table 37 Start-ups surviving three years and start-ups reaching £1m turnover

Indicator	Cornwall and Isles of Scilly	Gloucestershire	Heart of the South West	Swindon and Wiltshire	West of England	South East Wales
3-year survival rate (%)	62	60	57	61	60	70 *
Number of new registered employer businesses	2,044	2,883	5,624	3,150	5,239	316 **
% of 2011 surviving start-ups grew to £1 million turnover by 2014	6	5	5	4	5	

Source: UK Growth Dashboard 2015. Enterprise Research Centre (ERC) in partnership with Business Growth Service (2015) Available at: http://www.enterpriseresearch.ac.uk/uk-growth-dashboard-2015/; VAT registered business 3 year survival rates by area and year (* data is 2002), available at: https://statswales.gov.wales/Catalogue/Business-Economy-and-Labour-Market/Businesses/VAT-Businesses/VATRegisteredBusiness3YearSurvivalRates-by-Area-Year; VAT registered business start-ups by area and year (** data is 2007), available at: https://statswales.gov.wales/Catalogue/Business-Economy-and-Labour-Market/Businesses/VAT-Businesses/VATRegisteredBusinessStartUps-by-Area-Year

1.6.5 Innovation activities

Table 38 HE-BCI income by business type (£ 000s) (2015) – English LEPs and Wales

Business type	Cornwall and Isles of Scilly	Gloucestershire	Heart of the South West	West of England	Wales
Consultancy Non-commercial	21	121	1,920	5,466	9,922
Consultancy Non-SME	15	70	419	2,015	2,839
Consultancy SME	15	233	1,182	1,700	2,207
Contract research Non-commercial	31	331	21,103	30,926	13,421
Contract research Non-SME	0	14	2,149	13,900	10,101
Contract research SME	0	89	321	595	3,209
Courses for business//and the community Individuals	0	237	80	5,272	4,810
Courses for business//and the community Non-commercial	0	433	1,472	7,006	22,492
Courses for business//and the community Non-SME	0	170	267	1,779	853
Courses for business//and the community SME	0	58	545	223	1,411
Facilities, equipment//services Non-commercial	1	1	446	1,898	363
Facilities, equipment//services Non-SME	0	3	167	1,045	250
Facilities, equipment//services SME	15	1	1,860	1,176	439

Source: Underlying data for local growth 2013-14. Higher education and local growth. HEFCE (2015). Available at: http://www.hefce.ac.uk/analysis/maps/ and Higher education-business and community interaction survey (HE-BCI). Results of the 2013/14 survey (2015) Available at: https://www.hesa.ac.uk/pr/3492-press-release-215

Table 39 HE-BCI income type (£m) (2015) – English LEPs and Wales

Indicator	Cornwall and Isles of Scilly	Gloucestershire	Heart of the South West	West of England	Wales
Collaborative research	0	1	20	23	83.1
Intellectual property//(including sale of shares)	0	0	0	2	1.2
Regeneration and//development programmes	2	0	8	1	44.3

Source: Underlying data for local growth 2013-14. Higher education and local growth. HEFCE (2015). Available at: http://www.hefce.ac.uk/analysis/maps/ and Higher education-business and community interaction survey (HE-BCI). Results of the 2013/14 survey (2015) Available at: https://www.hesa.ac.uk/pr/3492-press-release-215

Table 40 Number and type of HEB-CI interaction (2015) – English LEPs and Wales

Indicator	Cornwall and Isles of Scilly	Gloucestershire	Heart of the South West	West of England	Wales
Attendees at chargeable performance arts events	3,427	602	4,090	24,791	214,596
Attendees at free public lectures	757	4,537	12,968	52,875	37,009
Consultancy contracts	46	118	604	1,613	2,406
Contract research	3	40	1,107	1,188	954
Facilities and equipment-related services	61	10	435	1,303	1,220
Graduate start-ups established	0	6	25	57	336
New patent applications in year	0	0	30	62	59
Spin-offs still active and survived three years	0	0	24	31	421

Source: Underlying data for local growth 2013-14. Higher education and local growth. HEFCE (2015). Available at: http://www.hefce.ac.uk/analysis/maps/ and Higher education-business and community interaction survey (HE-BCI). Results of the 2013/14 survey (2015) Available at: https://www.hesa.ac.uk/pr/3492-press-release-215

1.7 Established Industrial Capacity and Growth Points

Table 41 Share of employee jobs in industry (location quotient)

Sector	Cornwall and Isles of Scilly	Gloucestershire	Heart of the South West	Swindon and Wiltshire	West of England
Activities of head offices					2.20
Banks		0.76			1.58
Building societies				12.11	
Computer consultancy activities				1.11	1.11
Construction of domestic buildings	1.19		1.31		

Defence activities				6.69	
Event catering activities				1.59	
First-degree level higher education					1.78
Freight transport by road		1.38	1.58		
General cleaning of buildings		0.65			1.18
General public administration activities	0.61	0.77	1.03	0.77	0.82
General secondary education	1.25	1.63	1.14	1.23	0.94
Hospital activities	0.90	1.04	1.21	0.84	1.04
Hotels and similar accommodation	2.75	1.14	1.32	0.88	
Licensed restaurants	1.55	0.79	0.89		1.13
Maintenance and repair of motor vehicles	1.42		1.41		
Management consultancy activities (other than financial management)		1.13		1.29	1.02
Manufacture of air and spacecraft and related machinery			3.76		4.66
Manufacture of electronic instruments, appliances for measuring, testing, and (...)		9.63			
Operation of warehousing and storage facilities for land transport act. of (...)				1.40	
Other business support service activities n.e.c.		1.18		1.09	
Other engineering activities (not including [...])					1.47
Other human health activities	0.76		0.78		0.91
Other research and experimental development on sciences and eng'ing				4.19	
Other residential care activities	1.25	1.29	1.64		
Other retail sale in non-specialised stores	1.11		1.21		
Other service act. incidental to land transportation, n.e.c. (not				4.34	

incl. rail [...])					
Other social work activities without accommodation n.e.c.	1.29	0.71	0.97	0.62	0.77
Primary education	1.10	1.14	1.05	1.04	0.80
Private security activities					1.73
Public houses and bars	1.76	1.21	1.57	1.16	0.99
Residential care activities for the elderly and disabled	2.05	1.56	1.72	1.25	
Retail sale in non-specialised stores with food, beverages or tobacco (...)	1.50	1.05	1.27	1.10	0.96
Retail sale of clothing in specialised stores	0.89	0.89	0.87	0.81	0.99
Social work activities without accommodation for the elderly and disabled	1.06		1.36		
Technical and vocational secondary education	2.88	1.79			
Temporary employment agency activities	0.50	0.71	0.80	0.83	0.93
Unlicensed restaurants and cafes	1.28				

Source: Localisation of Industrial Activity across England's LEPs: 2008 & 2012. Enterprise Research Centre (ERC) (2013). Available at: http://www.enterpriseresearch.ac.uk/publications/localisation-industrial-activity-across-englands-leps-2008-2012/

Table 42 Geographical concentration of industry (2015, location quotient)

Industry	**LQ (industry)**
01 : Crop and animal production, hunting and related service activities	1.75
02 : Forestry and logging	1.23
03 : Fishing and aquaculture	1.72
05 : Mining of coal and lignite	0.00

06 : Extraction of crude petroleum and natural gas	0.00
07 : Mining of metal ores	-
08 : Other mining and quarrying	1.33
09 : Mining support service activities	0.67
10 : Manufacture of food products	1.11
11 : Manufacture of beverages	1.41
12 : Manufacture of tobacco products	0.00
13 : Manufacture of textiles	0.91
14 : Manufacture of wearing apparel	0.51
15 : Manufacture of leather and related products	1.15
16 : Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	1.09
17 : Manufacture of paper and paper products	0.82
18 : Printing and reproduction of recorded media	0.93
19 : Manufacture of coke and refined petroleum products	0.00
20 : Manufacture of chemicals and chemical products	0.96
21 : Manufacture of basic pharmaceutical products and pharmaceutical preparations	0.64
22 : Manufacture of rubber and plastic products	1.12
23 : Manufacture of other non-metallic mineral products	1.26
24 : Manufacture of basic metals	0.88
25 : Manufacture of fabricated metal products, except machinery and equipment	0.99

26 : Manufacture of computer, electronic and optical products	0.98
27 : Manufacture of electrical equipment	0.96
28 : Manufacture of machinery and equipment n.e.c.	0.97
29 : Manufacture of motor vehicles, trailers and semi-trailers	0.91
30 : Manufacture of other transport equipment	1.61
31 : Manufacture of furniture	0.88
32 : Other manufacturing	1.10
33 : Repair and installation of machinery and equipment	1.25
35 : Electricity, gas, steam and air conditioning supply	1.45
36 : Water collection, treatment and supply	1.28
37 : Sewerage	1.16
38 : Waste collection, treatment and disposal activities; materials recovery	1.04
39 : Remediation activities and other waste management services. This division includes the provision of remediation services, i.e. the cleanup of contaminated buildings and sites, soil, surface or ground water.	0.73
41 : Construction of buildings	1.03
42 : Civil engineering	1.16
43 : Specialised construction activities	1.06
45 : Wholesale and retail trade and repair of motor vehicles and motorcycles	1.16
46 : Wholesale trade, except of motor vehicles and motorcycles	0.82
47 : Retail trade, except of motor vehicles and motorcycles	1.01

49 : Land transport and transport via pipelines	0.90
50 : Water transport	1.43
51 : Air transport	0.83
52 : Warehousing and support activities for transportation	0.83
53 : Postal and courier activities	1.01
55 : Accommodation	1.72
56 : Food and beverage service activities	1.13
58 : Publishing activities	0.99
59 : Motion picture, video and television programme production, sound recording and music publishing activities	0.78
60 : Programming and broadcasting activities	0.78
61 : Telecommunications	0.79
62 : Computer programming, consultancy and related activities	0.76
63 : Information service activities	0.76
64 : Financial service activities, except insurance and pension funding	0.60
65 : Insurance, reinsurance and pension funding, except compulsory social security	1.10
66 : Activities auxiliary to financial services and insurance activities	0.99
68 : Real estate activities	0.93
69 : Legal and accounting activities	0.81
70 : Activities of head offices; management consultancy activities	0.78
71 : Architectural and engineering activities; technical testing and analysis	0.87

72 : Scientific research and development	0.82
73 : Advertising and market research	0.77
74 : Other professional, scientific and technical activities	0.91
75 : Veterinary activities	1.40
77 : Rental and leasing activities	1.06
78 : Employment activities	0.69
79 : Travel agency, tour operator and other reservation service and related activities	0.77
80 : Security and investigation activities	0.91
81 : Services to buildings and landscape activities	1.14
82 : Office administrative, office support and other business support activities	0.88
84 : Public administration and defence; compulsory social security	1.67
85 : Education	0.97
86 : Human health activities	0.90
87 : Residential care activities	1.26
88 : Social work activities without accommodation	1.06
90 : Creative, arts and entertainment activities	0.82
91 : Libraries, archives, museums and other cultural activities	1.32
92 : Gambling and betting activities	0.90
93 : Sports activities and amusement and recreation activities	1.15
94 : Activities of membership organisations	1.01

95 : Repair of computers and personal and household goods	0.87
96 : Other personal service activities	0.92
97 : Activities of households as employers of domestic personnel	-
98 : Undifferentiated goods- and services-producing activities of private households for own use	-
99 : Activities of extraterritorial organisations and bodies	0.00

Source: UK Business Count data (2015), available at http://www.nomisweb.co.uk

An alternative (but older dataset) exists: Location Quotients for 2011 covering Local Authorities in Wales are available in the underlying data from a previous ONS study. The Spatial Distribution of Industries. Cecilia Campos and Richard Prothero, Regional Economic Analysis (2012). Available at: http://webarchive.nationalarchives.gov.uk/20160105160709/http://www.ons.gov.uk/ons/dcp171766_285278.pdf

1.8 National and International Engagement

1.8.1 International collaborations and engagement - Framework Programmes

Table 43 Participations in FP7 by organisation type

Organisation type	Higher of secondary education est.	Other	Private commercial	Public body (excl.research and education)	Research organisations	Grand Total	% of UK total
(blank)	2					2	10.0 %
2007	2		2	2	9	15	25.4 %
2008	68	4	42	12	89	215	9.3%
2009	76	5	31	9	65	186	8.8%
2010	100	1	49	9	79	238	9.8%

2011	103	2	43	19	96	263	9.2%
2012	115	2	57	13	69	256	8.7%
2013	136	6	62	15	68	287	8.8%
2014	64	2	19	7	26	118	7.4%
2015	10				4	14	10.5 %
Grand Total	**676**	**22**	**305**	**86**	**505**	**1,594**	**9.0%**

Source: Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015). Available at: https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths / European Commission

Table 44 EC contribution in FP7 by organisation type (£)

	Higher of secondary education est.	**Other**	**Private commercial**	**Public body (excl.research and education)**	**Research organisations**	**Grand Total**	**% of UK total**
(blank)	313,550					313,550	8.6 %
2007	146,034		99,705	296,982	1,225,216	1,767,937	15.0 %
2008	18,998,362	568,139	11,355,315	5,886,370	32,227,523	69,035,709	9.4 %
2009	32,008,076	253,816	11,810,292	4,885,016	29,713,772	78,670,973	10.0 %
2010	38,868,820	286,203	9,741,684	1,440,516	24,782,288	75,119,511	8.7 %

2011	35,246,166	272,747	9,256,691	4,462,474	40,736,607	89,974,685	8.5 %
2012	46,109,249	105,127	12,281,414	6,238,862	25,935,970	90,670,621	7.6 %
2013	64,640,515	1,603,058	20,524,172	4,481,449	27,377,750	118,626,944	8.1 %
2014	41,528,727	676,593	5,228,633	3,041,442	12,571,005	63,046,401	7.8 %
2015	12,985,468				5,081,302	18,066,770	22.3 %
Grand Total	**290,844,968**	**3,765,683**	**80,297,907**	**30,733,110**	**199,651,433**	**605,293,101**	**8.6 %**

Source: Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015). Available at: https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths / European Commission

Table 45 Participations in Horizon 2020 by organisation type

	Higher of secondary education est.	**Other**	**Private commercial**	**Public body (excl.research and education)**	**Research organisations**	**Grand Total**	**% of UK total**
(blank)	59	5	27	7	45	143	10.8%
2014	16	3	1	9	16	45	16.5%
2015	238	26	156	61	274	755	11.0%
2016	113	17	94	28	81	333	10.4%
2017	1				2	3	7.9%
Grand Total	**427**	**51**	**278**	**105**	**418**	**1,279**	**10.9%**

Source: Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015). Available at: https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths / European Commission

Table 46 EC contribution in Horizon 2020 by organisation type

	Higher of secondary education est.	**Other**	**Private commercial**	**Public body (excl.research and education)**	**Research organisations**	**Grand Total**	**% of UK total**
(blank)	22,074,309	1,168,750	8,011,405	1,740,278	10,662,150	43,656,892	8.9%
2014	1,529,832	126,506	50,000	4,396,626	1,167,029	7,269,993	9.0%
2015	109,853,255	7,674,805	46,300,925	44,884,124	125,599,216	334,312,325	11.3%
2016	60,986,364	4,756,460	39,895,729	43,503,208	61,210,260	210,352,022	11.4%
2017	183,455				378,910	562,364	6.3%
Grand Total	**194,627,216**	**13,726,522**	**94,258,058**	**94,524,236**	**199,017,565**	**596,153,597**	**11.1%**

Source: Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015). Available at: https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths / European Commission

Department for
Business, Energy
& Industrial Strategy

South West England and South East Wales Science and Innovation Audit

Annex M: Skills and Labour Market Analysis Report – Marchmont

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

M

Annex M: Skills and Labour Market Analysis Report – Marchmont

Produced by Marchmont Observatory, University of Exeter, July 2016.

Contents

1. INTRODUCTION

1.1. Background

This report presents supplementary data to aid the production of a Science and Innovation Audit covering the South West of England and South East of Wales being prepared by a consortia of Local Enterprise Partnerships (LEPs) and Higher Education Institutions (HEIs).

The work is required to meet, as far as is possible, the following guidance:

"This section of the SIA should also present an overview of the human capital and talent available in the region, presenting statistics on key indicators like the numbers of persons resident in the region in question that either have a STEM degree or are working in a S&T. The presentation should go beyond the main S&T indicators, to encompass data and information about entrepreneurs, where that is available for the territory in question (e.g. GEM statistics on entrepreneurial intention or statistics about the numbers of young people and students that have training in starting a business, at school or university)

The presentation should look at talent flows as well as the stock of human resources in the region, presenting an overview of the numbers of undergraduate and graduates graduating each year and the inflows and outflows of students and others from the region to other parts of the UK and internationally. It would be helpful if this section could also present a more qualitative analysis of capacities and capabilities in the region in question, for those high-growth potential sectors, whether that is the digital economy or tourism."

2. DEMOGRAPHY

2.1. Population estimates

The consortium area has a combined resident population of 6.2 million people. Overall, the area is less urbanized than England & Wales as a whole with 71% of the population living in an urban area compared to the national average of 82%[1]. The main built up areas (BUA) are:

- Bristol BUA 617,280
- Cardiff BUA 447,287
- Newport BUA 306,844
- Plymouth BUA 260,203
- Swindon BUA 185,609
- Gloucester BUA 150,053
- Exeter BUA 117,763
- Cheltenham BUA 116,447
- Paignton/Torquay 115,410

While overall, the area loses more residents than it gains through net commuting[2], several of the largest built up areas attract large flows of commuters.

Table 1 Net impact of commuting on daytime population: 2011

	Net change	Net change as % of usual resident population
Cardiff BUA	42,076	9.4
Bristol BUA	31,777	5.1
Exeter BUA	25,914	22.0
Truro BUA	14,725	63.9
Bath BUA	13,629	14.4
Bridgend BUA	11,548	19.8
Taunton BUA	10,093	15.6

Source: 2011 Census of Population

With 62% of population of 'working age[3]' the area's population has a similar age distribution as the country as a while. The remainder of the population is broadly evenly

[1] 2011 Census of Population

[2] According the 2011 Census of Population the resident population of the area (5,900,128) was 14,082 lower than its daytime population (5,886,046).

split between residents who are aged under 16 (18%) and those who are aged over 65 (20%). Young people (aged between 16 and 64) account for almost one-fifth (18%) of the working age population.

Table 2 Population structure by sub-area: 2015

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area	England and Wales
Under 16	17	18	17	19	19	18	18	19
16 and 17	2	2	2	2	2	2	2	2
18 and 19	2	2	2	3	2	3	3	2
20 to 24	5	6	6	7	5	8	7	7
25 to 44	21	24	22	25	25	27	24	26
45 to 64	28	28	27	26	27	24	26	25
65 and over	24	21	23	18	19	17	20	18
Total (=100%)	551,728	617,162	1,714,552	1,505,368	703,253	1,118,807	6,210,870	57,885,413

Source: ONS Population Estimates

2.2. Population projections

Looking ahead, the area's population is projected to increase by more than 400,000 people between 2014 and 2024. Some of the area's largest population centres are projected to increase the fastest – for example, Cardiff and City of Bristol – while Blaenau Gwent and the Isles of Scilly are expected to decline in population over the period.

[3] Aged between 16 and 64.

Table 3 Change in resident population: 2014 to 2024

Area	Number	%
Cardiff	45,457	12.7
Bristol, City of	46,006	10.4
South Gloucestershire	25,883	9.5
North Somerset	19,544	9.4
Swindon	18,502	8.6
Cornwall	43,006	7.9
Gloucestershire	46,296	7.6
Newport	10,681	7.2
Somerset	36,327	6.7
Devon	49,054	6.4
Wiltshire	28,249	5.8
Torbay	6,135	4.6
Bridgend	6,200	4.4
Plymouth	10,438	4
Merthyr Tydfil	2,155	3.6
The Vale of Glamorgan	3,925	3.1
Caerphilly	3,262	1.8
Torfaen	1,365	1.5
Rhondda, Cynon, Taf	2,177	0.9
Monmouthshire	530	0.6
Blaenau Gwent	-1066	-1.5
Isles of Scilly	-122	-5.4
Consortium area	404,004	6.7
England & Wales	4,211,025	7.3

Source: ONS (2014 based) mid-year population estimates via NOMIS;

The working age population is projected to increase far more modestly than the population as a whole, increasingly by 64,300 between 2014 and 2024. When expressed in percentage terms this is expected to be a smaller increase (1.7%) than projected across England & Wales as a whole (3.8%).

Table 4 Change in resident population aged 16 to 64: 2014 to 2024

Area	Number	%
Cornwall	24,950	8.3
Rhondda, Cynon, Taff	22,008	9
Swindon	9,530	5.5
Isles of Scilly	6,646	1.8
Devon	6,491	2
Plymouth	4,854	4
Torbay	4,226	3
Bath and North East Somerset	4,091	4.4
Gloucestershire	2,416	0.5
Bristol, City of	1,196	1
North Somerset	-195	-14.3
Caerphilly	-303	-0.8
Somerset	-595	-0.3
South Gloucestershire	-645	-0.2
The Vale of Glamorgan	-797	-0.9
Wiltshire	-1,233	-1.6
Cardiff	-2,032	-2.6
Torfaen	-2,141	-4.9
Monmouthshire	-2,693	-4.7
Blaenau Gwent	-2,804	-2.5
Newport	-3,229	-5.9
Bridgend	-4,019	-0.2
Merthyr Tydfil	-5,228	-3.6
Consortium	64,336	1.7
England & Wales	1,232,359	3.4

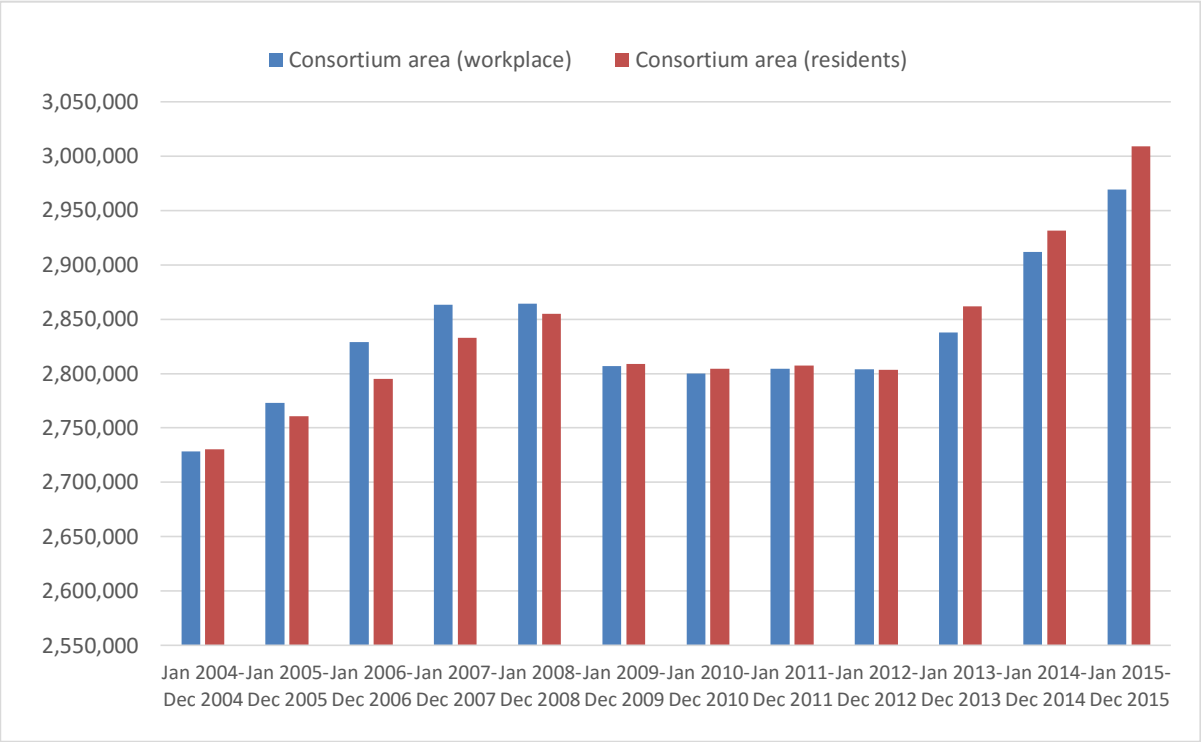
Source: ONS Population Projections

3. LABOUR MARKET PERFORMANCE

3.1. Employment

Figure 1 charts changes in two measures of employment locally: the number of residents in employment (residence based) and the number of people employed at workplaces within the consortium area (workplace based). The chart shows the impact of the 2008/09 recession on both measures and their subsequent growth post 2013.

Figure 1 Residence and workplace based estimates of employment: Consortium area: 2004 to 2015



Source: Annual Population Survey via NOMIS

During January to December 2015, around 2.97 million people were employed in workplaces within the consortium area and 3.0 million people who lived within the consortium area were in work. Compared to their pre-recession peaks - recorded in January to December 2008 - the current level of workplace based is 3.7% higher and residence based employment 5.4% higher.

The growth in residence-based employment locally is marginally lower than the UK average (of 5.9%). Growth rates within the consortium area are broadly similar:

- West of England (6.0%)
- Swindon & Wiltshire (5.9%)
- South East Wales (5.5%)

- Heart of the South West (5.1%)
- Cornwall and the Isles of Scilly (5.1%)
- Gloucestershire (4.2%)

3.2. Employment rate

Residence-based employment estimates are often expressed as a percentage of the working age population – the employment rate. Generally, a rate of 80% is thought to be at or near full employment. Latest estimates from the Annual Population Survey suggest that the consortium area has an employment rate that is slightly above the UK level but is around four percentage points below 'full employment'.

Within the consortium area, the employment rate is highest in Gloucestershire. Gloucestershire has the second highest employment rate of all LEP areas.

Table 5 Employment rate: April 2015 to March 2016

	Level	Percent	95% confidence interval of percent figure (+/-)	Rank of percent
Gloucestershire	300,500	79.9	2.5	2
Swindon and Wiltshire	337,000	78.6	1.8	11
Heart of the South West	787,400	77.5	1.3	13
West of England	549,600	77.1	1.4	15
Cornwall and Isles of Scilly	239,900	74.7	2.8	24
South East Wales	668,200	70.4	1.0	34
Consortium area	2,882,500	75.8	0.6	
United Kingdom	30,093,100	73.6	0.2	

Source: Annual Population Survey via NOMIS

Estimates of the employment rate at the local authority level should be treated with a degree of caution due to the fairly wide confidence intervals that apply, but they do suggest that rates vary substantially within the consortium area: from 81.0% in South Gloucestershire to 64.3% in Blaenau Gwent.

Table 6 Employment rate by local authority: April 2015 to March 2016

	Level	Percent	95% confidence interval of percent figure (+/-)	Rank of percent
South Gloucestershire	136,900	81.0	2.7	6
Gloucestershire	300,500	79.9	2.5	11
Wiltshire	227,000	78.9	2.4	25
Devon	359,500	78.8	2.5	26
Monmouthshire	42,900	78.8	2.6	27
Swindon	109,900	78.2	2.6	32
North Somerset	96,100	78.0	3.0	34
Somerset	246,500	77.8	2.9	40
Bath and North East Somerset	88,200	76.1	2.5	63
Bristol, City of	228,400	74.9	3.0	85
Cornwall	239,900	74.7	2.8	90
The Vale of Glamorgan	**57,200**	**74.7**	**3.0**	**91**
Plymouth	125,800	74.6	2.4	93
Torbay	55,500	74.5	2.8	94
Bridgend	**63,500**	**72.9**	**2.9**	**114**
Torfaen	40,900	72.1	3.0	127
Rhondda, Cynon, Taff	103,900	70.0	2.8	154
Cardiff	**166,600**	**69.2**	**2.8**	**164**
Caerphilly	78,000	69.1	2.8	165
Newport	62,700	68.3	3.4	174
Merthyr Tydfil	24,600	66.1	3.6	186
Blaenau Gwent	28,000	64.3	3.3	198
Consortium area	2,882,500	75.8	0.6	
United Kingdom	30,093,100	73.6	0.2	

Source: Annual Population Survey via NOMIS

3.3. Unemployment

Almost 143,000 people in the consortium areas are unemployed. The unemployment rate is lower than the national average in all parts of the area except South East Wales and is lowest in Heart of the South West ant Swindon & Wiltshire Table 7).

Table 7 Unemployment (Aged 16+): April 2015 to March 2016

	Level, 16+	Percent	95% confidence interval of percent figure (+/-)	Rank of percent
Heart of the South West	33,600	3.8	0.6	14
Swindon and Wiltshire	14,100	3.8	0.9	16
West of England	23,500	4.0	0.7	20
Gloucestershire	13,800	4.2	1.3	21
Cornwall and Isles of Scilly	13,500	5.0	1.5	28
South East Wales	44,200	6.0	0.6	31
Consortium area	142,600	4.5	0.3	
United Kingdom	1,698,000	5.2	0.1	

Source: Annual Population Survey via NOMIS

Young people are more likely to be unemployed than the population as a whole (Table 8). Youth unemployment is generally slightly lower locally than the UK average but is higher in Cornwall & the Isles of Scilly and South East Wales.

Table 8 Youth unemployment (16 to 24): April 2015 to March 2016

	Level, 16 to 24	Percent	95% confidence interval of percent figure (+/-)	Rank of percent
Gloucestershire	4,600	10.4	6.1	13
Heart of the South West	14,900	10.8	2.9	14
Swindon and Wiltshire	5,300	11.6	4.6	20
West of England	11,000	14.1	4.0	26
South East Wales	18,900	16.6	2.6	32
Cornwall and Isles of Scilly	7,700	18.7	7.8	38
Consortium area	62,500	13.5	1.5	
United Kingdom	636,900	14.0	0.5	

Source: Annual Population Survey via NOMIS

3.4. Entrepreneurship

Almost half a million people living within the consortium area are self-employed (Table 9). The rate of self-employment locally is particularly high in Cornwall & the Isles of Scilly and Heart of the South West where rates are the highest of all the LEP areas in England.

Table 9 Self-employment (aged 16+): April to 2015 to March 2016

	Level, 16+	Percent in employment who are self employed	95% confidence interval of percent figure (+/-)	Rank of percent
Cornwall and Isles of Scilly	58,600	22.9	3	1
Heart of the South West	160,200	19.1	1.3	2
Gloucestershire	54,100	17.2	2.6	6
Swindon and Wiltshire	53,300	15	1.7	12
West of England	83,200	14.6	1.3	18
South East Wales	79,200	11.5	0.8	36
Consortium area	488,400	16.1	0.6	
United Kingdom	4,599,200	14.7	0.2	

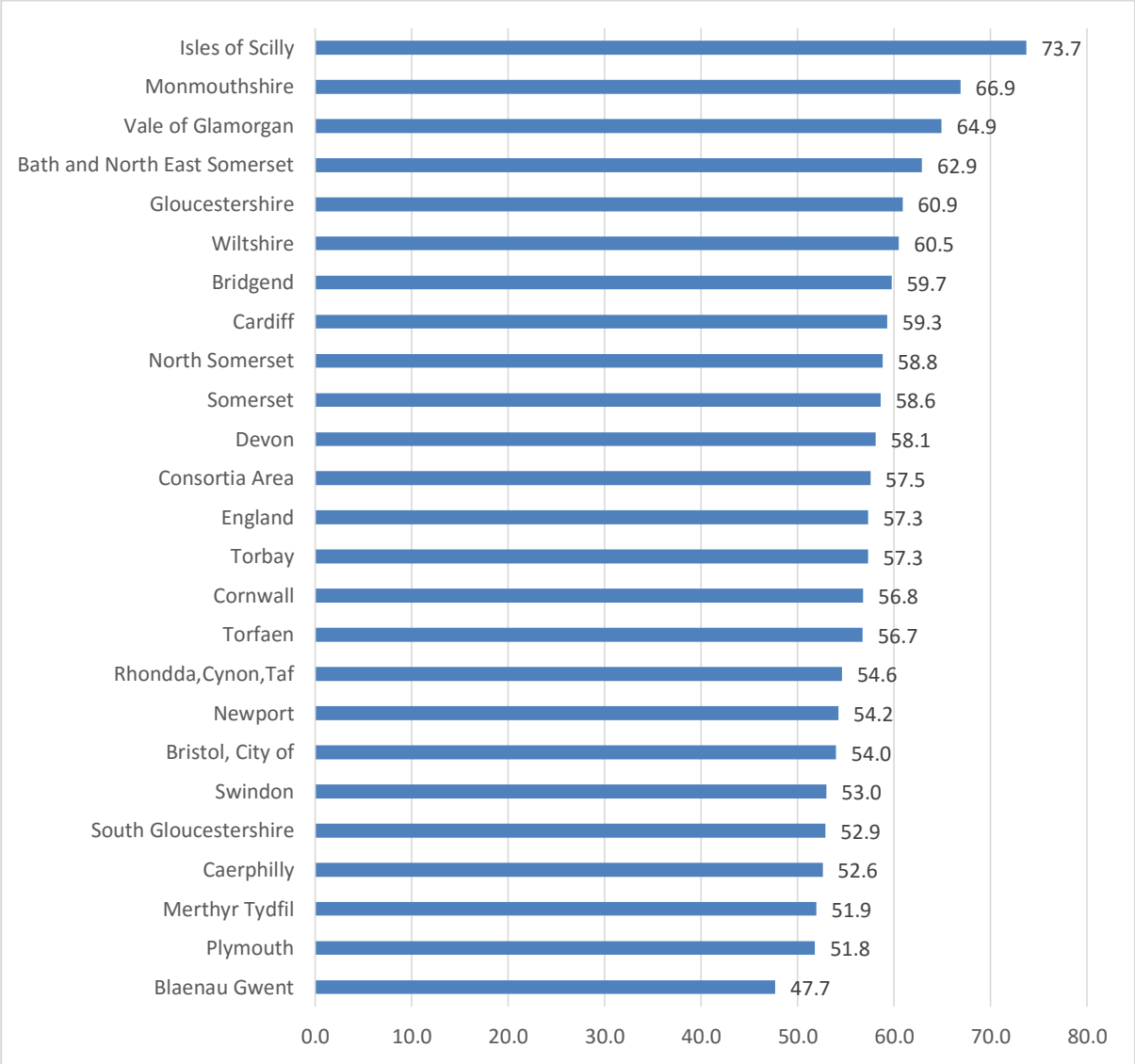
Source: Annual Population Survey via NOMIS

4. HUMAN CAPITAL AND TALENT

4.1. GCSE

While overall the percentage of school leavers achieving five good passes at GCSE including maths and English across the consortium area is broadly on par with the national average there is considerable variation in achievement at the local authority level within the area both within the South West and South East Wales.

Figure 2 Percentage achieving 5+ A*-C including English & mathematics GCSEs: 2014/15



Sources: England Dept for Education SFR 01/2016 https://www.gov.uk/government/statistics/revised-gcse-and-equivalent-results-in-england-2014-to-2015 Wales StatsWales https://statswales.gov.wales/Catalogue/Education-and-

Skills/Schools-and-Teachers/Examinations-and-Assessments/Key-Stage-4/examinationachievementsofpupilsaged15-by-localauthority

4.2. A levels

Four broad patterns emerge from the analysis of take up in STEM subjects at A level. The typical trend – affecting the largest number of subjects – is of rising popularity between 2010/11 and 2012/13 but then of subsequent decline – sometimes to levels below those reported in the baseline year. Biological sciences, chemistry, physics and mathematics are in part of this group. By contrast, entries for computing and ICT follow an opposing trend: falling initially but then reporting a resurgence in popularity more recently. The number of entries on design & technology courses have fallen consistently each year while those on further mathematics have risen consistently.

Table 10 STEM A level entries: 2010/11 to 2014/15

Academic Year	2010/11	2011/12	2012/13	2013/14	2014/15	Change 2010/11 - 2014-15	% change 2010/11 - 2014-15
Biological Sciences	6,001	6,118	6,218	5,888	5,723	-278	-5%
Chemistry	4,341	4,491	4,751	4,706	4,418	77	2%
Physics	3,129	3,306	3,404	3,337	3,379	250	8%
Other Science	918	864	918	962	986	68	7%
Mathematics	7,212	7,549	7,822	7,707	7,742	530	7%
Further Mathematics	627	716	772	796	827	200	32%
Design and Technology	2,130	1,758	1,600	1,561	1,467	-663	-31%
Computing	273	264	233	254	358	85	31%
ICT	2,093	1,822	1,646	1,275	1,396	-697	-33%
STEM Total	26,724	26,888	27,364	26,486	26,296	-428	-2%

Sources:England - DfE SFR03/2016 and equivalent SFRs for earlier years https://www.gov.uk/government/statistics/a-level-and-other-level-3-results-2014-to-2015-revised: Wales – StatsWales https://statswales.gov.wales/Catalogue/Education-and-Skills/Schools-and-Teachers/Examinations-and-Assessments/Advanced-Level-and-Equivalent/alevelentriesandresultspupilsaged17only-by-subjectgroup

4.3. Apprenticeships

Almost 8,200 apprenticeships were completed in STEM related frameworks in 2014/15. These were mostly in engineering and manufacturing technologies but also in information and communication technology. There is no clear trend in patterns of achievements – with the number of STEM related frameworks falling between 2012/13 and 2013/14 and then rising between 2014/14 and 2014/15/

Table 11 Apprenticeship Framework Achievements by Sector Subject Area, South West and SE Wales (2012/13 to 2014/15)

Sector Subject Area	2012/13	2013/14	2014/15	Change	% change
Agriculture, Horticulture and Animal Care	660	765	865	205	31%
Arts, Media and Publishing	125	125	130	5	4%
Business, Administration and Law	12,290	13,645	12,570	280	2%
Construction, Planning and the Built Environment	3,070	2,980	3,140	70	2%
Education and Training	260	270	280	20	8%
Engineering and Manufacturing Technologies	6,510	6,490	6,835	325	5%
Health, Public Services and Care	14,075	16,790	15,285	1,210	9%
Information and Communication Technology	1,200	1,160	1,340	140	12%
Languages, Literature and Culture					
Leisure, Travel and Tourism	2,190	2,665	2,335	145	7%
Preparation for Life and Work					
Retail and Commercial Enterprise	9,745	9,430	8,720	-1,025	-11%
Science and Mathematics	10	20		-10	
Unknown					
Total	50,135	54,340	51,500	1,365	3%
SIA Sector Frameworks	7,720	7,670	8,175	455	6%
SIA Frameworks as % of total	15%	14%	16%	0.5%	

Source: South West - FE Data Library (Skills Funding Agency)
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/520539/apprenticeships-achievements-by-geography-and-sector-subject-area.xls Wales – StatsWales
https://statswales.gov.wales/Catalogue/Education-and-Skills/Post-16-Education-and-Training/Further-Education-and-Work-Based-Learning/Learners/Work-Based-Learning/learningprogrammesapprenticeships

4.4. Further education

The number of learning aims delivered in sector subject areas relevant to the SIA themes has fallen in line with the contraction in aims delivered across the board. Within this, only science and mathematics has bucked the general trend with year-on-year growth. Around one in six learning aims delivered across the consortium area are in sector subject areas that relate to the SIA themes.

Table 12 FE and skills learning aims delivered by Sector Subject Area, South West and South East Wales, 2012/13 - 2014/15

Sector Subject Area	2012/13	2013/14	2014/15	Change	% change
Agriculture, Horticulture and Animal Care	15,580	14,430	12,785	-2,795	-18%
Arts, Media and Publishing	69,435	60,115	47,205	-22,230	-32%
Business, Administration and Law	60,155	55,580	41,730	-18,425	-31%
Construction, Planning and the Built Environment	20,345	21,135	22,375	2,030	10%
Education and Training	12,505	8,815	6,155	-6,350	-51%
Engineering and Manufacturing Technologies	33,085	29,510	23,975	-9,110	-28%
Health, Public Services and Care	83,625	79,790	71,495	-12,130	-15%
History, Philosophy and Theology	17,720	18,005	15,660	-2,060	-12%
Information and Communication Technology	52,290	47,205	31,080	-21,210	-41%
Languages, Literature and Culture	49,010	49,115	46,045	-2,965	-6%
Leisure, Travel and Tourism	40,585	33,610	31,045	-9,540	-24%
Preparation for Life and Work	336,540	351,195	300,680	-35,860	-11%
Retail and Commercial Enterprise	54,280	46,455	38,640	-15,640	-29%
Science and Mathematics	57,175	63,730	66,435	9,260	16%
Social Sciences	13,940	15,100	15,600	1,660	12%
Unknown	240	3,410	5,435	5,195	2165%
Total	916,510	897,200	776,340	-140,170	-15%
SIA Sectors	142,550	140,445	121,490	-21,060	-15%
SIA Sectors as % of total	16%	16%	16%		

Sources: England - derived from National Achievement Rate Tables - Institution level data https://www.gov.uk/government/statistics/sfa-national-achievement-rates-tables-2014-to-2015-open-data-csv-files Wales – StatsWales https://statswales.gov.wales/Catalogue/Education-and-Skills/Post-16-Education-and-Training/Further-Education-and-Work-Based-Learning/Learners/Further-Education/learningactivitiesfurthereducationinstitutions-by-sectorsubjectarea-domicile

4.5. Higher education

Notes to tables: The Local Education Partnership reported here include data from the HE providers listed below. England & Wales includes data for all HE providers (inclusive of the listed LEPs). Providers in Scotland and Northern Ireland have been excluded from all tables.

LEP	Institute name	Campus name
Cornwall & IOS	Falmouth University	Entire institution
	University of Exeter	Cornwall campus
Gloucestershire	The Royal Agricultural University	Entire institution
	University of Gloucestershire	Main campus
Heart of the South West	Plymouth College of Art	Entire institution
	University of Exeter	Main campus
	University of Plymouth	Entire institution
	University of St Mark & St John	Entire institution
West of England	Bath Spa University	Entire institution
	The Conservatoire for Dance and Drama	BOVTS
	The University of Bath	Entire institution
	University of Bristol	Entire institution
	University of the West of England, Bristol	Entire institution
South East Wales	Cardiff University	Entire institution
	Cardiff Metropolitan University	Entire institution
	Newport (merged with Uni. Of South Wales April 2013)	Entire institution
	University of South Wales	Entire institution
	University of Wales	Entire institution

Undergraduates

Table 13 Number of undergraduate students by subject and provider location: 2014/15

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	West of England	Consortia area (total)	England & Wales (total)
(1) Medicine and dentistry			1,305	1,920	1,615	4,840	38,245
(2) Subjects allied to medicine		70	4,845	5,970	6,505	17,390	186,705
(3) Biological sciences	520	1,345	4,970	7,350	4,655	18,840	157,300
(4) Veterinary science					680	680	3,675
(5) Agriculture and related subjects		540	450	240	140	1,370	13,470
(6) Physical sciences	290	110	2,330	2,370	3,455	8,555	64,800
(7) Mathematical sciences			795	695	2,285	3,775	32,765
(8) Computer science	50	345	1,205	1,915	1,680	5,195	65,200
(9) Engineering and technology	245	10	2,515	4,210	5,765	12,745	104,385
(A) Architecture, building and planning	20	275	545	1,085	1,710	3,635	28,360
Non-STEM subjects	4,500	4,790	21,340	27,485	25,155	83,270	826,435
All subjects	**5,620**	**7,480**	**40,295**	**53,235**	**53,645**	**160,275**	**1,521,335**
Percentage STEM subjects	***20.0%***	***36.0%***	***47.0%***	***48.4%***	***53.1%***	***48.1%***	***45.7%***

Source: HESA 2014/15 Student Return

1. Data is full person equivalent (FPE).
2. Data is based on First Degree and Other Undergraduate students within the standard registration population who studied at an English or Welsh HE provider.
3. Data has been rounded up or down to the nearest multiple of 5.

Table 14 Percentage change in number of undergraduate students: 2012/3 to 2014/15

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	West of England	Consortia area (total)	England & Wales (total)
(1) Medicine and dentistry			0.4%	-5.2%	-3.6%	-3.2%	-2.40%
(2) Subjects allied to medicine		-39.1%	15.2%	-5.5%	5.8%	3.6%	-4.22%
(3) Biological sciences	44.4%	4.7%	8.3%	32.4%	3.3%	15.7%	4.54%
(4) Veterinary science					4.6%	4.6%	5.60%
(5) Agriculture and related subjects		5.9%	-27.4%	60.0%	-76.3%	-26.7%	-7.01%
(6) Physical sciences	70.6%		-2.7%	5.1%	5.7%	4.3%	-0.47%
(7) Mathematical sciences			0.6%	9.4%	22.8%	14.9%	-1.61%
(8) Computer science		-2.8%	15.9%	4.6%	0.3%	6.0%	2.93%
(9) Engineering and technology	4.3%		-1.9%	-17.0%	11.3%	-2.4%	1.16%
(A) Architecture, building and planning		-8.3%	-28.3%	-12.5%	-9.0%	-13.0%	-14.19%
Non-STEM subjects	2.6%	-6.9%	0.2%	-3.7%	1.3%	-1.1%	-7.78%
All subjects	**9.1%**	**-4.3%**	**1.9%**	**-0.7%**	**2.6%**	1.2%	**-4.72%**

Source: HESA 2012/13 and 2014/15 Student Returns

1. Data is full person equivalent (FPE).
2. Data is based on First Degree and Other Undergraduate students within the standard registration population who studied at an English or Welsh HE provider.
3. Data has been rounded up or down to the nearest multiple of 5.

Table 15 Percentage of undergraduate students on STEM courses: 2012/13 to 2014/15

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	West of England	Consortia area (total)	England & Wales (total)
2012/13	14.9%	34.2%	46.2%	46.8%	52.5%	46.9%	43.9%
2013/14	17.6%	36.0%	47.6%	47.0%	52.8%	47.6%	44.7%
2014/15	20.0%	36.0%	47.0%	48.4%	53.1%	48.0%	45.7%

Source: HESA 2012/13, 2013/14 and 2014/15 Student Returns

1. Data is full person equivalent (FPE).
2. Data is based on First Degree and Other Undergraduate students within the standard registration population who studied at an English or Welsh HE provider.
3. STEM courses are defined by JACS subject area 1-9 and subject area A.
4. Data has been rounded up or down to the nearest multiple of 5.

Postgraduates

Table 16 Number of postgraduate students: 2014/15

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	West of England	Consortia area (total)	England & Wales (total)
(1) Medicine and dentistry	5		170	1,610	540	2,325	17,965
(2) Subjects allied to medicine	10	25	635	2,125	2,500	5,295	53,225
(3) Biological sciences	160	290	755	1,055	970	3,230	30,675
(4) Veterinary science					45	45	670
(5) Agriculture and related subjects		80	40	75	95	290	3,245
(6) Physical sciences	65	25	275	405	780	1,550	16,750
(7) Mathematical sciences	5		80	95	140	320	5,670
(8) Computer science		35	115	485	360	995	14,575
(9) Engineering and technology	80		270	950	1,390	2,690	34,195
(A) Architecture, building and planning		165	25	490	850	1,530	12,775
Non-STEM subjects	325	735	4,280	10,825	8,925	25,090	256,325
All subjects	**655**	**1,355**	**6,655**	**18,120**	**16,605**	**43,390**	**446,100**
Percentage STEM subjects	***50.0 %***	***45.8 %***	***35.6 %***	***40.2 %***	***46.2 %***	***42.1 %***	***42.5 %***

Source: HESA 2014/15 Student Return

1. Data is full person equivalent (FPE).
2. Data is based on Postgraduate Taught and Postgraduate Research students within the standard registration population who studied at an English or Welsh HE provider.
3. Data has been rounded up or down to the nearest multiple of 5.

Table 17 Percentage change in number of postgraduate students: 2012/3 to 2014/15

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	West of England	Consortia area (total)	England & Wales (total)
(1) Medicine and dentistry			30.77%	-6.12%	-12.20%	-5.5%	0.17%
(2) Subjects allied to medicine		66.67%	25.74%	21.43%	30.21%	26.4%	8.10%
(3) Biological sciences	23.08%	70.59%	-10.12%	-3.65%	17.58%	5.6%	5.14%
(4) Veterinary science							-10.00%
(5) Agriculture and related subjects		45.45%	-52.94%	150.00%	35.71%	20.8%	41.39%
(6) Physical sciences		66.67%	-25.68%	5.19%	0.65%	-3.7%	2.29%
(7) Mathematical sciences				18.75%	-12.50%		8.40%
(8) Computer science		40.00%		1.04%	2.86%	2.6%	0.34%
(9) Engineering and technology	-11.11%		-25.00%	3.83%	-2.11%	-3.4%	1.12%
(A) Architecture, building and planning		6.45%	-58.33%	13.95%	24.09%	15.0%	1.96%
Non-STEM subjects	-17.72%	-19.23%	-15.33%	12.41%	-6.98%	-1.9%	-3.25%
All subjects	**-4.38%**	**0.74%**	**-12.55%**	**9.75%**	**0.85%**	**1.8%**	**-0.16%**

Source: HESA 2012/13 and 2014/15 Student Returns

1. Data is full person equivalent (FPE).
2. Data is based on Postgraduate Taught and Postgraduate Research students within the standard registration population who studied at an English or Welsh HE provider.
3. Data has been rounded up or down to the nearest multiple of 5.

Table 18 Percentage of postgraduate students on STEM courses: 2012/13 to 2014/15

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	West of England	Consortia area (total)	England & Wales (total)
2012/13	42.3%	32.1%	33.6%	41.7%	41.7%	40.0%	40.7%
2013/14	45.0%	38.2%	32.2%	40.1%	44.3%	40.4%	41.1%
2014/15	50.4%	45.8%	35.7%	40.3%	46.3%	42.2%	42.5%

Source: HESA 2012/13, 2013/14 and 2014/15 Student Returns

1. Data is full person equivalent (FPE).
2. Data is based on Postgraduate Taught and Postgraduate Research students within the standard registration population who studied at an English or Welsh HE provider.
3. STEM courses are defined by JACS subject area 1-9 and subject area A.
4. Data has been rounded up or down to the nearest multiple of 5.

Inflows and outflows of students

Table 19 Inflows and outflows: undergraduates

	Students domiciled in area			HEI in area		
	HEI inside area	HEI outside area	Total	Student domiciled outside area	Student domiciled inside area	Total
(1) Medicine and dentistry	1,255	2,740	3,995	3,580	1,255	4,835
(2) Subjects allied to medicine	11,740	7,165	18,905	5,650	11,740	17,390
(3) Biological sciences	8,415	8,595	17,005	10,425	8,415	18,840
(4) Veterinary science	130	345	475	550	130	680
(5) Agriculture and related subjects	685	1,220	1,910	680	685	1,365
(6) Physical sciences	2,885	4,490	7,370	5,670	2,885	8,550
(7) Mathematical sciences	1,025	1,785	2,810	2,750	1,025	3,775
(8) Computer science	2,970	3,235	6,205	2,220	2,970	5,190
(9) Engineering and technology	4,315	4,925	9,240	8,430	4,315	12,745
(A) Architecture, building and planning	1,540	795	2,335	2,095	1,540	3,635
Non-STEM subjects	36,085	43,015	79,100	47,185	36,085	83,270
All subjects	**71,045**	**78,305**	**149,350**	**89,235**	**71,045**	**160,275**

Source: HESA 2014/15 Student Return

1. Data is full person equivalent (FPE).
2. Data is based on First Degree and Other Undergraduate students within the standard registration population who studied at an English or Welsh HE provider.
3. Data has been rounded up or down to the nearest multiple of 5.

Progression

Table 20a Progression from STEM subjects into STEM occupations, Consortium area HEIs, 2014/15

	% of graduates moving into STEM occupations		
	Employed within area	Employed outside of area	**All graduates**
(1) Medicine and dentistry	9.8%	89.4%	99.2%
(2) Subjects allied to medicine	8.4%	81.0%	89.4%
(3) Biological sciences	2.3%	21.1%	23.3%
(4) Veterinary science	17.4%	78.3%	95.7%
(5) Agriculture and related subjects	2.3%	19.1%	21.7%
(6) Physical sciences	3.7%	35.7%	39.3%
(7) Mathematical sciences	3.2%	34.0%	37.2%
(8) Computer science	5.8%	59.1%	64.8%
(9) Engineering and technology	7.5%	57.0%	64.5%
(A) Architecture, building and planning	6.1%	66.1%	72.2%
Non-STEM subjects	1.4%	14.8%	16.2%
All subjects	**3.5%**	**33.8%**	**37.3%**

Source: HESA 2014/15 Student and DLHE Returns

1. Data is full person equivalent (FPE).
2. Data is based on First Degree and Other Undergraduate graduates who graduated from an English or Welsh HE provider.
3. STEM occupations are defined by SOC 2010 categories 21 - 'Science and Technology Professional', 22 - 'Health Professionals', 24 - 'Business and Public Services Professionals', 31 - 'Science and Technology Associate Professionals', 32 - 'Health and social Welfare Associate Professionals'.
4. Data has been rounded up or down to the nearest multiple of 5.

Table 20b As Table 20a, but the base population is of graduates from providers within the consortia area only who went into employment

	% of graduates moving into STEM occupations		
	Employed within area	Employed outside of area	**All graduates**
(1) Medicine and dentistry	33.33%	66.04%	99.37%
(2) Subjects allied to medicine	66.15%	22.57%	88.72%
(3) Biological sciences	11.04%	11.04%	22.08%
(4) Veterinary science	38.89%	55.56%	94.44%
(5) Agriculture and related subjects	10.20%	8.16%	18.37%
(6) Physical sciences	12.92%	22.97%	35.89%
(7) Mathematical sciences	12.22%	32.22%	44.44%
(8) Computer science	41.22%	27.48%	68.70%
(9) Engineering and technology	31.39%	34.30%	65.70%
(A) Architecture, building and planning	40.00%	33.64%	73.64%
Non-STEM subjects	7.27%	7.57%	14.85%
All subjects	**19.56%**	**16.40%**	**35.96%**

4.6. Retention of local skills

The graduate retention measures describes the percentage of students domiciled in each LEP area who are employed 6 months following graduation are working within their home region. The results suggest that students domiciled in Cornwall & the Isles of Scilly and Wales were most likely to remain within their local area to work upon graduation.

Table 21 Retention of local skills (2013/14) – English LEPs and Wales

LEP	% in London	Retention in HOME REGION (where known) SW	Rank of retention in HOME REGION
Cornwall and Isles of Scilly	9.6	74.9	9th
Gloucestershire	13.4	60.7	32nd
Heart of the South West	11.1	71.6	14th
Swindon and Wiltshire	14.5	61.3	31st
West of England	10.6	72.7	13th
Wales (all, calculated)	5.5%	73.6	

Source: Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015). Available at: https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths and HESA Destinations of Leavers from Higher Education 2013/14

Table 22 Employment destinations of STEM students: 2008/9 to 2013/14

	Total students that found employment in the LEP area	Total employed graduates that studied in the LEP area	Net flow out of the LEP area	Students that studied and found employment in the LEP area
Cornwall & the Isles of Scilly	6,295	8,795	-2,500	3,560
Gloucestershire	10,375	8,705	1,670	3,045
Heart of the South West	28,080	25,190	2,890	`13,255
Swindon & Wiltshire	2,845	9,995	-7,150	2,440
West of England	30,390	15,465	14,935	7,385

Source: http://www.hefce.ac.uk/analysis/maps/student/

4.7. General S&T staff

The BIS 'Mapping Comparative Advantage' report provides estimates of the proportion of residents in employment working in 'science, research, engineering and technology' professional and association professional occupations. However, these estimates are fairly dated – relating to July 2013 to June 2014 – and do not provide consortium level or UK benchmarks.

Table 23 General S&T staff - % workforce in 'science, research, engineering and technology' professions and associated professions (Jul 2013 - Jun 2014)

	Cornwall and Isles of Scilly	Gloucestershire	Heart of the South West	Swindon and Wiltshire	West of England	South East Wales
% workforce in 'science, research, engineering and technology' professions and associated professions (Jul 2013 - Jun 2014)	5.2%	7.5%	5.6%	9.1%	10.2%	5.8%
- % all in employment who are - 21: science, research, engineering and technology professions (SOC2010) (Jul 2013 - Jun 2014 English LEPs and Jan 2015 – Dec 2015 South East Wales)	3.2%	5.7%	4.0%	6.7%	8.2%	3.8%
% all in employment who are - 31: science, engineering and technology associate professions (SOC2010) (Jul 2013 - Jun 2014 English LEPs and Jan 2015 – Dec 2015 South East Wales)	2.0%	1.8%	1.6%	2.4%	2.0%	2.0%

Source: Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015). Available at: https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths; Welsh data calculated as an average of Local Authority Districts, taken from Annual Population Survey [Jul 2013-Jun 2014]. Available at: https://www.nomisweb.co.uk.

Updating the analysis for April 2015 to March 2016, reveals that overall the consortium area has a very similar proportion of these technical occupations to the UK average, comprising 7% of all residents in employment. Within the consortium area, the LEP areas of Swindon & Wiltshire and West of England had higher shares of employment in these occupations, ranking 5th and 7th respectively when ranked alongside all other LEP areas on this measure.

Table 24 Percentage of the workforce in 'science, research, engineering' professions and associate professions: Apr 2015-Mar 2016

	% residents in employment			Rank
Area	Science, engineering and technology associate professions	Science, research, engineering and technology professions	**Science, research, engineering and technology professions and associated professions**	Science, research, engineering and technology professions and associated professions
Swindon & Wiltshire	2.3	6.8	**9.1**	5th
West of England	1.5	7.4	**8.9**	7th
Heart of the South West	2.5	4.5	**7.0**	=18th
Gloucestershire	1.4	5.2	**6.6**	=21st
South East Wales	1.8	4.1	**5.9**	=30th
Cornwall & the IoS	1.0	2.4	**3.4**	40th
Consortium average	**1.9**	**5.1**	**7.0**	**-**
England & Wales	1.7	5.4	**7.1**	-
United Kingdom	1.7	5.4	**7.1**	-

Source: Annual Population Survey, ONS

4.8. Qualified working population

The estimates quoted in the 'Mapping local comparative advantages in innovation' report refer to the population aged 16 to 64[4] and related to the period January 2013 to December 2013.

Table 25 Qualified working population (2013) England LEPs and Wales Local Authorities in SIA Area

LEP / LA	% with no qualifications (NVQ) - aged 16-64	% with NVQ3 only - aged 16-64	% with NVQ4+ - aged 16-64
Cornwall and Isles of Scilly	6.8	19.3	32.1
Gloucestershire	7.3	20.5	35.0
Heart of the South West	6.5	20.5	31.0
Swindon and Wiltshire	7.5	17.6	34.9
West of England	6.2	18.7	38.1
South East Wales	6.5	18.5	38.1
Consortium area average	6.8	19.2	34.9

Source: Mapping local comparative advantages in innovation. Department for Business, Innovation & Skills (BIS) (2015). Available at: https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths; and ONS annual population survey [Jan 2015-Dec 2015] for Welsh Local Authorities. Available at: https://www.nomisweb.co.uk/. Note: the South East Wales figure is calculated as an average of each of the Local Authority areas in the area, drawn from the UK Annual Population Survey (12 months to June 2015). The consortium area average is calculated using the figures in the table.

[4] Note that the estimates do not relate, as suggested by the title of the Technopolis table, to the 'working population' which would normally be either the employed or the economically active population.

Updating this analysis for January 2015 to December 2015, reveals that qualification levels across the consortium area are broadly in line with the UK average but with notably higher percentages of the population qualified to degree level or above in the West of England (44%) and Gloucestershire (41%). When ranking with other LEP areas across England, the West of England and Gloucestershire rank 5th and 9th respectively. Notwithstanding this, more than ¼ million people aged 16 to 64 living in the consortium area do not have a formal qualification.

Table 26 Qualification levels of the population aged 16 to 64: Jan 2015 to Dec 2015

Area	% with no qualifications (NVQ) - aged 16-64			% with NVQ3 only - aged 16-64			% with NVQ4+ - aged 16-64		
	No.	%	Rank	No.	%	Rank	No.	%	Rank
West of England	35400	5	39	126900	17.9	22	309300	43.6	5
Gloucestershire	24000	6.4	29	63200	16.8	31	154900	41.2	9
Heart of the South West	53400	5.3	38	204000	20.2	3	365900	36.1	15
Swindon and Wiltshire	25300	5.9	34	83000	19.4	8	147700	34.6	18
South East Wales	102400	10.8	6	167900	17.7	24	324900	34.3	19
Cornwall and Isles of Scilly	19100	5.9	33	69800	21.7	1	94200	29.3	33
Consortium area	259500	6.8		714700	18.8		1396900	36.8	
United Kingdom	3579100	8.8		6928400	17		15022900	36.9	

Source: Annual Population Survey via NOMIS

Table 27 Percentage of residents aged 16 to 64 with qualifications at Level 4 or above: January to December 2015

	Number of residents	Percentage of residents	Confidence interval	Rank of percent
Bristol, City of	145,700	**47.9**	3.3	29
Bath and North East Somerset	55,300	**47.8**	2.8	30
Cardiff	104,200	**43.5**	3.0	46
Monmouthshire	22,800	**41.6**	3.1	58
Gloucestershire	154,900	**41.2**	3.0	61
The Vale of Glamorgan	31,100	**40.8**	3.3	62
Devon	183,100	**40.4**	3.1	65
South Gloucestershire	63,700	**37.7**	3.3	79
Wiltshire	107,100	**37.4**	2.8	83
North Somerset	44,500	**36.7**	3.5	90
Somerset	113,000	**35.7**	3.3	100
Newport	31,000	**34.0**	3.5	116
Bridgend	26,800	**31.0**	3.0	148
Plymouth	50,200	**29.9**	2.5	154
Rhondda, Cynon, Taff	44,000	**29.6**	2.8	156
Cornwall	94,200	**29.3**	2.9	158
Swindon	40,600	**28.8**	2.8	164
Caerphilly	31,600	**28.1**	2.8	168
Torfaen	15,600	**27.5**	3.0	172
Torbay	19,600	**26.3**	2.8	179
Merthyr Tydfil	9,400	**25.5**	3.3	186
Blaenau Gwent	8,300	**19.1**	2.7	205

Source: Annual Population Survey

4.9. Skills shortages

The UK Employer Skills Survey is the largest survey of its kind, examining the experiences and practices of over 91,000 employers in 2015. The large sample size generates reasonably robust estimates at the local level.

At the time of the last survey, there were an estimated 81,200 job vacancies in the consortium area of which almost one-quarter (24%) or 19,300 were proving hard-to-fill because of skill shortages. The density of skills-shortage vacancies (i.e. the proportion of vacancies that were hard-to-fill because of skill shortages) in the consortium area was marginally higher than in England & Wales as a whole (23%) and was highest in Swindon & Wiltshire (30%) and Heart of the South West (29%).

Within the consortium area skills shortage vacancies are broadly evenly distributed across the four categories of occupations: high skill (29%), middle-skill (25%), service-intensive (22%) and labour-intensive (25%). The distribution of skill shortage vacancies follows a similar pattern to that evident across England & Wales as a whole but with a notably smaller share within high-skill occupations (37%).

Table 28 Profile of skill-shortage vacancies by occupation - (all skills shortage vacancy base)

	West of England	Cornwall and the Isles of Scilly	Heart of the South West	Gloucestershire	Swindon and Wiltshire	South East Wales	Consortia Area	England & Wales
High skills	20.9%	12.4%	36.8%	25.4%	31.4%	21.6%	27.7%	36.6%
Middle-skill	39.1%	41.5%	17.9%	28.6%	19.7%	25.5%	25.3%	23.1%
Service-intensive	20.0%	27.5%	14.2%	14.7%	31.2%	30.6%	22.3%	19.7%
Labour intensive	20.0%	18.7%	31.1%	31.3%	17.7%	22.0%	24.7%	20.1%

Base: All skill-shortage vacancies (up to 6 occupations followed up)
Source: UK Employer Skills Survey

The UK summary report stated that[5]:

"Skill-shortage vacancies were caused by a number of people and personal skills and technical and practical skills lacking amongst applicants. Skills related to operational aspects of the role, as well as complex analytical skills, were the main technical and

[5] https://www.gov.uk/government/publications/ukces-employer-skills-survey-2015-uk-report

practical skills lacking. The main people and personal skills lacking pertained to time management, management and leadership, and sales and customer handling skills. Although the number of skill-shortage vacancies is relatively small, the impacts of skill-shortage vacancies continued to be significant for employers. Over two-thirds of employers that had difficulty filling their vacancies solely as a result of skill shortages had experienced a direct financial impact through either loss of business to competitors, or increased operating costs".

4.10. Skills gaps

In addition to skills shortages, the UK Employer Skills Survey also investigated the extent and nature of skills deficiencies within the existing workforce.

Around one in seven (15%) of employers across the consortium area reported skills gaps within their existing workforce. This is broadly on par with the national average (14%) but higher in South East Wales (16%), Cornwall & the Isles of Scilly (16%) and Gloucestershire (16%).

While most skills gaps are attributed to employees being new to a role or having yet to complete their training, a significant minority of gaps are also linked to the introduction of new products and services, working practices or technology.

Table 29 Selected causes of skills gaps in occupations followed up (prompted unless *) (skills gaps base)

	West of England	Cornwall and the Isles of Scilly	Heart of the South West	Gloucestershire	Swindon and Wiltshire	South East Wales	Consortia Area	England & Wales
The development of new products and services	15%	10%	15%	20%	14%	13%	13%	22%
The introduction of new working practices	24%	30%	21%	20%	29%	29%	24%	30%
The introduction of new technology	16%	14%	14%	10%	24%	35%	22%	21%

Base: All skills gaps followed up

Source: UK Employer Skills Survey

Almost half (47%) of local employers who had funded or arranged training for their employees had trained staff in using new technology.

4.11. Replacement demand

Working Futures is the government's detailed model of the UK labour market. It projects the future size and shape of the labour market by considering employment prospects by industry, occupation, qualification level, gender and employment status. The projections are compiled by the Institute of Employment Research at the University of Warwick. The latest set related to the period 2014 to 2024.

This section presents a summary of the combined results for the South West of England and Wales, focusing on the following sub-sectors:

Sector No.	Sector Description[6]	SIA theme
19	Motor vehicles etc	Aerospace & advanced engineering
20	Other transport equipment (includes aerospace)	
23	Repair and installation	
53	Architectural and engineering	
45	Computer programming, consultancy & related	Digital Living
46	Information services	
54	Scientific research & development	
16	Computer, electronic & optical	Microelectronics
24	Electricity, gas etc	New energy systems
25	Water	Resilience, environment & sustaintability
26	Sewerage	
27	Waste management	

[6] See Table A1.3 for definitions within https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/298512/working-futures-2012-2022-annexes-bound.pdf

Table 30 Total requirement for labour by sub-sector: South West & Wales: 2014 to 2024

Sub-sector	Base year employment (2014)	Expansion Demand	Replacement Demand	Net Requirement
Computer, electronic	29,800	-9,900	9,700	-200
Computing services	55,500	8,000	20,300	28,300
Information services	7,000	1,400	2,900	4,300
Scientific research & development	15,900	2,500	5,700	8,200
Motor vehicles etc	20,000	-1,700	6,500	4,800
Other transport equipment (includes aerospace)	43,200	-500	14,000	13,500
Repair and installation	18,500	3,100	6,900	10,000
Architectural and related	64,100	8,800	26,100	34,900
Electricity, gas, etc.	14,300	1,900	5,200	7,100
Water	6,200	600	2,300	2,900
Sewerage	3,600	200	1,200	1,400
Waste management	19,000	1,500	7,300	8,800
Microelectronics	29,800	-9,900	9,700	-200
Digital living platform	78,400	12,000	28,700	40,700
Aerospace & advanced	145,900	9,700	53,300	63,000
New energy systems	14,300	1,900	5,200	7,100
Resilience, environment	28,700	2,100	10,900	13,000
All SIA sectors	297,100	15,800	107,800	123,600

Source: Working Futures

The projections suggest a net requirement of an additional 123,600 workers in the South West and Wales within SIA related sectors between 2014 and 2024. Most of these will be required to replace workers leaving the industries (for example, through retirement or moving to other sectors) although an additional 15,800 will be required to accommodate growth in the sectors.

Table 31 and Table 32 show that most of the increase in demand for workers within these industries will be within professional, associate professional and technical or managerial occupations and will require qualification at QCF4 or above (degree level or above). The net requirement for workers with qualifications lower than QCF2 will fall.

Table 31 Total requirement for labour by occupation, 2014 - 2024

Occupation	Base year employment (2014)	Expansion Demand	Replacement Demand	Net Requirement
Managers, directors and senior officials	33,600	5,300	13,300	18,600
Professional occupations	81,600	10,800	29,000	39,800
Associate professional and technical	45,700	5,000	16,600	21,600
Administrative and secretarial	27,200	-800	12,000	11,200
Skilled trades occupations	46,100	-2,700	15,300	12,600
Caring, leisure and other service	3,800	1,300	1,700	3,000
Sales and customer service	8,900	700	3,000	3,700
Process, plant and machine operatives	37,300	-3,600	12,300	8,700
Elementary occupations	12,900	-200	4,600	4,400
Total	297,100	15,800	107,800	123,600

Source: Working Futures

Table 32 Total requirement for labour by qualification level required, 2014 - 2024

Qualification Level	Base year employment (2014)	Expansion Demand	Replacement Demand	Net Requirement
QCF4+	136,500	47,700	56,500	104,200
QCF3	63,100	-13,400	19,500	6,100
QCF2	50,400	0	18,000	18,000
QCF Below L2 / no quals	47,100	-18,600	14,000	-4,600
Total	297,100	15,700	108,000	123,700

Source: Working Futures

5. ESTABLISHED INDUSTRIAL CAPACITY AND GROWTH POINTS

The section summarises the detailed sectoral analysis that is presented in Appendices M1 to M6, based predominantly on Theme SIC codes detailed in Appendix M7.

5.1. Employee jobs

According to the BRES, 318,500 people were employed across the consortia area in 2014 in one of five thematic industrial sectors. These were:

- New energy systems (184,100)
- Resilience, environment & sustainability (153,100)
- Aerospace and advanced engineering (98,100)
- Digital Living Innovation Platform (93,800)
- Microelectronics (18,500)

Table 33 Employee jobs by sector: 2014

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area
Aerospace and advanced engineering	3,600	9,700	25,200	19,300	15,200	25,100	98,100
Digital Living Innovation Platform	3,000	15,100	16,500	20,600	13,000	25,600	93,800
Electronics	400	6,000	2,700	6,900	1,100	1,600	18,500
New Energy Systems	9,200	26,900	39,100	45,600	24,300	38,900	184,100
Resilience, Environment & Sustainability	7,200	16,100	31,500	30,100	23,900	44,300	153,100
All SIA themes	14,900	40,200	72,600	73.300	42,300	75,300	318,500
All industries (ex. Farms)	197,400	276,600	680,400	594,700	303,800	559,300	2,612,100

Some SICs are attributed to more than one theme

Source: BRES via NOMIS

The thematic sectors account for around one in eight employee jobs across the consortia area (12.2%). The proportion is on par with the Great Britain average (11.9%) but is highest in Gloucestershire (14.5%), Swindon and Wiltshire (13.9%) and West of England (13.5%). It is lowest in Cornwall and the Isles of Scilly (7.5%).

Table 34 Share of employee jobs by sector: 2014

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area	Great Britain
Aerospace and advanced engineering	1.8	3.5	3.7	3.3	5.0	4.5	3.8	2.9
Digital Living Innovation Platform	1.5	5.5	2.4	3.5	4.3	4.6	3.6	4.1
Microelectronics	0.2	2.2	0.4	1.2	0.4	0.3	0.7	0.4
New Energy Systems	4.7	9.7	5.7	7.7	8.0	7.0	7.0	6.9
Resilience, Environment & Sustainability	3.6	5.8	4.6	5.1	7.9	7.9	5.9	6.3
All SIA themes	7.5	14.5	10.7	12.3	13.9	13.5	12.2	11.9
All industries (ex. Farms)	100	100	100	100	100	100	100	100.0

Source: BRES via NOMIS

Location quotients relate a sectors share of employee jobs in any one area to that sectors share of employee jobs nationally. A result greater than one means that the area has a greater share of employee jobs in that sector than the national average. Table 3 shows that compared to the national average the consortia has particularly high shares of employee jobs in:

- Aerospace and advanced engineering in Swindon & Wiltshire (1.71), West of England (1.53), Heart of the South West (1.27) and Gloucestershire (1.20).
- Digital Living Innovation Platform in Gloucestershire (1.33)
- Microelectronics in Gloucestershire (5.48) and South East Wales (2.95)
- New energy systems in Gloucestershire (1.41)
- Resilience, environment and sustainability in Swindon and Wiltshire (1.25) and West of England (1.26)

Table 35 Location Quotient by sector: 2014

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area
Aerospace and advanced engineering	0.62	1.20	1.27	1.11	1.71	1.53	1.28
Digital Living Innovation Platform	0.37	1.33	0.59	0.84	1.04	1.12	0.88
Microelectronics	0.46	5.48	0.99	2.95	0.88	0.72	1.80
New Energy Systems	0.68	1.41	0.83	1.11	1.16	1.01	1.02
Resilience, Environment & Sustainability	0.58	0.93	0.74	0.81	1.25	1.26	0.93
All SIA themes	**0.63**	**1.23**	**0.90**	**1.04**	**1.17**	**1.14**	**1.03**

Source: BRES via NOMIS

Ranking the LQs of the 206 local authority areas across Great Britain reveals particularly high national rankings for:

- Aerospace and advanced engineering in South Gloucestershire (6th), Plymouth (9th), Swindon (12th)
- Digital living innovation platform in South Gloucestershire (18th)
- Microelectronics in Torfaen (1st), Caerphilly (2nd), Gloucestershire (3rd), Monmouthshire (5th), Rhondaa, Cynon, Taff (7th), Newport (9th) and Blaenau Gwent (12th)
- New energy systems in Gloucestershire (21st), Rhonddam, Cynon, Taff (27th) and South Gloucestershire (30th)
- Resilience, environment and sustainability in South Gloucestershire (19th) and Bath & North East Somerset (31st).

Table 36 Ranking of Location Quotients by sector and local authority area in Great Britain (ranking out of 206): 2014

	Aerospace and advanced engineering	Digital Living Innovation Platform	Micro-electronics	New Energy Systems	Resilience, Environment & Sustainability	All SIA themes
South Gloucestershire	6	18	44	30	19	12
Swindon	12	46	150	56	42	23
Torfaen	21	39	1	57	139	25
Bridgend	16	58	34	36	64	33
Gloucestershire	43	33	3	21	76	34
Blaenau Gwent	23	156	12	122	113	39
Plymouth	9	159	54	167	184	43
Caerphilly	45	80	2	37	102	50
Rhondda, Cynon, Taff	54	106	7	27	163	60
Wiltshire	40	70	58	44	39	61
Monmouthshire	47	68	5	60	100	64
The Vale of Glamorgan	20	116	33	48	164	69
North Somerset	68	84	114	84	51	82
Bath & North East Somerset	74	83	176	97	31	80
Cardiff	116	103	70	85	62	85
Newport	190	69	9	43	135	86
Bristol, City of	75	79	122	115	48	88
Somerset	35	137	72	126	120	100
Devon	103	108	75	96	88	102
Merthyr Tydfil	89	49	205	99	205	155
Cornwall	125	173	117	171	166	174
Torbay	163	169	59	193	172	202
Isles of Scilly	-	-	204	206	206	206

Source: BRES via NOMIS

5.2. Enterprises

There were 37,870 enterprises operating within the thematic areas across the consortium areas in 2015. These were:

- Resilience, environment and sustainability (25,295)
- New energy systems (22,815)
- Digital living innovation platform (14,870)
- Aerospace and advanced engineering (7,775)
- Microelectronics (505)

Table 37 Enterprises by sector: 2015

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area
Aerospace and advanced engineering	590	1,005	1,945	1,330	1,060	1,840	7,775
Digital Living Innovation Platform	720	2,290	2,950	2,170	2,680	4,055	14,870
Microelectronics	40	80	130	85	75	90	505
New Energy Systems	1,945	2,985	6,065	4,060	2,975	4,785	22,815
Resilience, Environment & Sustainability	1,605	3,650	5,700	3,975	4,030	6,335	25,295
All SIA themes	**2,825**	**5,160**	**9,215**	**6,330**	**5,505**	**8,830**	**37,870**
All industries	23,145	27,540	69,185	38,875	28,175	42,210	229,125

Some SICs are attributed to more than one theme

Source: BRES via NOMIS

The thematic sectors account for around one in six enterprises in the area (16.5%), rising to one in five in the West of England (20.9%) and Swindon & Wiltshire (19.5%).

Table 38 Share of enterprises by sector: 2015

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area	Great Britain
Aerospace and advanced engineering	2.5	3.6	2.8	3.4	3.8	4.4	3.4	3.7
Digital Living Innovation Platform	3.1	8.3	4.3	5.6	9.5	9.6	6.5	8.0
Microelectronics	0.2	0.3	0.2	0.2	0.3	0.2	0.2	0.2
New Energy Systems	8.4	10.8	8.8	10.4	10.6	11.3	10.0	10.3
Resilience, Environment & Sustainability	6.9	13.3	8.2	10.2	14.3	15.0	11.0	13.0
All themes	12.2	18.7	13.3	16.3	19.5	20.9	16.5	18.4
All industries	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: BRES via NOMIS

The location quotient analysis suggests particular concentrations of specialised activity in the following:

- Aerospace and advanced engineering in West of England (1.17)
- Digital living innovation platform in West of England (1.20) and Swindon & Wiltshire (1.19)
- Microelectronics in Swindon & Wiltshire (1.30) and West of England (1.18)
- New energy systems in West of England (1.10)
- Resilience, environment and sustainability in West of England (1.16) and Swindon & Wiltshire (1.10).

Table 39 Location Quotient by sector: 2014

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area
Aerospace and advanced engineering	0.69	0.98	0.76	0.92	1.01	1.17	0.91
Digital Living Innovation Platform	0.39	1.04	0.53	0.70	1.19	1.20	0.81
Microelectronics	0.78	1.31	0.85	0.99	1.20	0.96	0.99
New Energy Systems	0.82	1.05	0.85	1.02	1.03	1.10	0.97
Resilience, Environment & Sustainability	0.53	1.02	0.64	0.79	1.10	1.16	0.85
All themes	0.66	1.02	0.72	0.88	1.06	1.13	0.90

Source: BRES via NOMIS

Table 40 Ranking of Location Quotients by sector and local authority area in Great Britain (ranking out of 232): 2014

	Aerospace and advanced engineering	Digital Living Innovation Platform	Microelectronics	New Energy Systems	Resilience, Environment & Sustainability	All SIA themes
Swindon	56	14	86	41	21	15
South Gloucestershire	24	43	67	18	39	26
Bristol, City of	71	42	123	112	47	50
Bath and North East Somerset	115	56	114	117	58	64
North Somerset	58	63	80	69	77	70
Gloucestershire	94	65	55	85	81	86
Bridgend	47	151	158	28	153	102
Wiltshire	99	69	50	115	88	105
Torfaen	110	110	4	35	144	110
The Vale of Glamorgan	45	130	174	89	125	119
Plymouth	64	153	65	60	138	123
Cardiff	152	99	156	138	113	126
Newport	158	109	62	128	126	136
Monmouthshire	106	111	83	136	121	138
Caerphilly	123	168	68	71	175	144
Rhondda, Cynon, Taff	133	177	17	84	183	163
Somerset	120	154	100	126	167	168
Merthyr Tydfil	111	191	=205	120	200	189
Torbay	184	170	22	168	196	192
Blaenau Gwent	196	198	10	146	205	193
Cornwall	173	195	127	170	198	198
Devon	185	185	148	185	194	199
Isles of Scilly	178	232	=205	232	226	232

Replacement demand

Table 41 Change in employment by occupation, Aerospace & advanced engineering, 2014 - 2024

Occupation	2014	%	2024	%
1. Managers, directors and senior officials	15,300	10%	18,500	12%
2. Professional occupations	34,600	24%	40,100	26%
3. Associate professional and technical	21,200	15%	24,800	16%
4. Administrative and secretarial	15,000	10%	15,100	10%
5. Skilled trades occupations	29,800	20%	28,400	18%
6. Caring, leisure and other service	900	1%	1,100	1%
7. Sales and customer service	3,200	2%	3,500	2%
8. Process, plant and machine operatives	21,700	15%	19,900	13%
9. Elementary occupations	4,200	3%	4,200	3%
Total	**145,900**	**100%**	**155,600**	**100%**
Higher level occupations	**71,100**	**49%**	**83,400**	**54%**

Source: Working Futures

Table 42 Change in employment by sub-sector, Aerospace & advanced engineering, 2014 - 2024

	Sub-sector	2014	%	2024	%
19	Motor vehicles etc	20,000	13.7%	18,200	11.7%
20	Other transport equipment (includes aerospace)	43,200	29.6%	42,700	27.4%
23	Repair and installation	18,500	12.7%	21,800	14.0%
53	Architectural and related	64,100	43.9%	72,900	46.9%
	Total	**145,900**	**99.9%**	**155,600**	**100.0%**

Source: Working Futures

Table 43 Change in employment by qualification level required, Aerospace & advanced engineering, 2014 - 2024

Qualification Level	2014	%	2024	%
QCF4+	63,100	43%	87,200	56%
QCF3	34,300	24%	28,300	18%
QCF2	25,700	18%	26,900	17%
QCF Below L2 / no quals	22,800	16%	13,100	8%
Total	**145,900**	**100%**	**155,600**	**100%**

Source: Working Futures

Table 44 Total requirement for labour by occupation, Aerospace & advanced engineering, 2014 - 2024

Occupation	Base year employment (2014)	Expansion Demand	Replacement Demand	Net Requirement
Managers, directors and senior officials	15,300	3,200	6,200	9,400
Professional occupations	34,600	5,500	13,000	18,500
Associate professional and technical	21,200	3,600	8,000	11,600
Administrative and secretarial	15,000	100	6,700	6,800
Skilled trades occupations	29,800	-1,500	9,500	8,000
Caring, leisure and other service	900	300	400	700
Sales and customer service	3,200	300	1,100	1,400
Process, plant and machine operatives	21,700	-1,800	6,800	5,000
Elementary occupations	4,200	0	1,600	1,600
Total	**145,900**	**9,700**	**53,300**	**63,000**

Source: Working Futures

Table 45 Total requirement for labour by qualification level required, Aerospace & advanced engineering, 2014 - 2024

Qualification Level	Base year employment (2014)	Expansion Demand	Replacement Demand	Net Requirement
QCF4+	63,100	24,100	27,300	51,400
QCF3	34,300	-6,000	10,000	4,000
QCF2	25,700	1,200	9,400	10,600
QCF Below L2 / no quals	22,800	-9,600	6,700	-2,900
Total	**145,900**	**9,700**	**53,400**	**63,100**

Source: Working Futures

Table 46 Total requirement for labour by sub-sector, Aerospace & advanced engineering, 2014 - 2024

	Sub-sector	Base year employment (2014)	Expansion Demand	Replacement Demand	Net Requirement
19	Motor vehicles etc	20,000	-1,700	6,500	4,800
20	Other transport equipment (includes aerospace)	43,200	-500	14,000	13,500
23	Repair and installation	18,500	3,100	6,900	10,000
53	Architectural and related	64,100	8,800	26,100	34,900
	Total	**145,900**	**9,700**	**53,300**	**63,000**

Source: Working Futures

Employment

The aerospace and advanced engineering theme accounts for 98,100 employee jobs across the consortia area. The largest sectors are: other engineering activities (24,600) and manufacture of air and space craft and related machinery (19,700) (Table 47). Taken as whole, the sector accounts for a higher share of employee jobs (3.8%) to the Great Britain average (2.9%) with higher concentrations – as demonstrated by the highest location quotients – within (Table 48):

- Building of pleasure and sporting boats in Heart of the South West (13.31) and Cornwall & the IoS (5.36)
- Building of ships and floating structures in Heart of the South Wes (10.16) and Cornwall & the IoS (2.46)
- Repair and maintenance of aircraft and spacecraft in Sout East Wales (7.16), Cornwall & the IOS (3.25) and Gloucestershire (2.29)
- Manufacture of air and spacecraft and related machinery in West of England (4.76), Gloucestershire (3.18) and Heart of the South West (2.90)
- Other research and experimental development on natural sciences and engineering in Swindon & Wiltshire (4.20)
- Manufacture of bearings, gears, gearing and driving elements in Gloucestershire (3.45)
- Manufacture of other transport equipment not else classified in Swindon & Wiltshire (3.35)
- Engineering design activities for industrial process and production in West of England (2.86)
- Manufacture of other parts and accessories for motor vehicles in South East Wales and Swindon & Wiltshire (2.55).

Table 47 Employee jobs in the aerospace and advanced engineering sector; consortium sub-area: 2014

	C&IOS	Glos	HoSW	SEW	S&W	WoE	SIA area	Great Britain
Repair and maintenance of aircraft and spacecraft	400	400	400	2,800	100	300	4,500	18,300
Manufacture of motor vehicles	0	200	100	!	!	100	6,000	70,600
Manufacture of electrical and electronic equipment for motor vehicles	!	!	!	0	!	0	100	2,500
Manufacture of other parts and accessories for motor vehicles	0	500	300	3,000	1,500	600	5,800	52,900
Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	0	!	!	!	!	0	500	16,900
Manufacture of bearings, gears, gearing and driving elements	!	300	!	100	!	300	1,400	8,600
Building of ships and floating structures	400	0	5,500	0	!	0	5,900	21,900
Building of pleasure and sporting boats	300	0	2,800	!	100	100	3,400	8,600
Manufacture of air and spacecraft and related machinery	0	2,700	6,100	2,600	100	8,200	19,700	85,500
Manufacture of military fighting vehicles	0	!	0	0	!	!	400	3,400
Manufacture of other transport equipment nec	!	!	!	0	0	0	100	1,000
Engineering design activities for industrial process and production	200	500	1,100	800	800	3,200	6,600	55,900
Engineering related scientific and technical consulting activities	800	800	2,500	1,400	800	1,500	7,900	73,400
Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)	800	3,100	4,300	5,300	2,900	8,100	24,600	234,300
Technical testing and analysis	200	300	600	300	600	1,100	3,000	51,800
Other research and experimental development on natural sciences and engineering	400	600	600	600	4,900	1,300	8,300	107,000
Aerospace and advanced engineering	3,600	9,700	25,200	19,300	15,200	25,100	98,100	812,600

Source: BRES via NOMIS

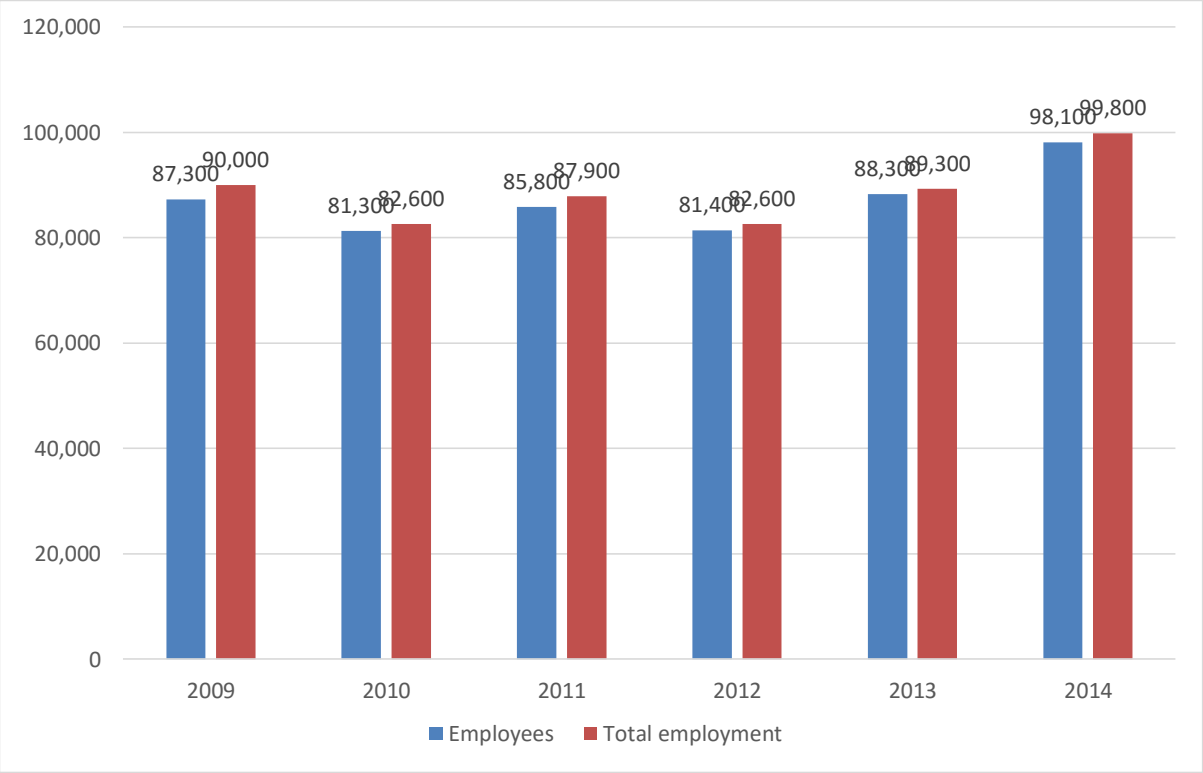
Table 48 Location quotients of employee jobs in the aerospace and advanced engineering sector; consortium sub-area: 2014

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area
Repair and maintenance of aircraft and spacecraft	3.25	2.29	1.00	7.16	0.36	0.92	2.62
Manufacture of motor vehicles	0.03	0.28	0.05	!	!	0.10	0.90
Manufacture of electrical and electronic equipment for motor vehicles	!	!	!	0.00	!	0.12	0.39
Manufacture of other parts and accessories for motor vehicles	0.04	0.93	0.21	2.62	2.55	0.52	1.16
Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	0.10	!	!	!	!	0.07	0.34
Manufacture of bearings, gears, gearing and driving elements	!	3.45	!	0.33	!	1.88	1.69
Building of ships and floating structures	2.46	0.05	10.16	0.01	!	0.10	2.87
Building of pleasure and sporting boats	5.36	0.20	13.31	!	0.58	0.81	4.15
Manufacture of air and spacecraft and related machinery	0.05	3.18	2.90	1.40	0.10	4.76	2.45
Manufacture of military fighting vehicles	0.00	!	0.00	0.00	!	!	1.39
Manufacture of other transport equipment nec	!	!	!	0.00	3.35	0.89	0.98
Engineering design activities for industrial process and production	0.43	0.93	0.83	0.68	1.24	2.86	1.26
Engineering related scientific and technical consulting activities	1.60	1.09	1.38	0.90	1.00	1.03	1.14
Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)	0.51	1.35	0.75	1.05	1.14	1.72	1.11
Technical testing and analysis	0.41	0.64	0.43	0.30	1.01	1.06	0.63
Other research and experimental development on natural sciences and engineering	0.46	0.52	0.24	0.26	4.20	0.59	0.83
Aerospace and advanced engineering	0.62	1.20	1.27	1.11	1.71	1.53	1.28

Source: BRES via NOMIS

Employment in the sector has risen locally and in 2014, was 9,800 (10.9%) higher than it was in 2009. This is a much larger percentage increase than employment across all sectors (0.6%) and is higher than the industry average across Great Britain (6.6%).

Figure 3 Total employment in the aerospace and advanced engineering sector; consortium area: 2009 to 2014



Source: BRES, ONS via NOMIS

Table 49 Employment indicators for the aerospace and advanced engineering sector by LEP areas and South East Wales: 2009 and 2014

Rank of %	LEP area	%, 2014	Change, 2009 to 2014	
			Number	%
1	Coventry and Warwickshire	6.9	5,400	22
2	Oxfordshire	5.1	2,000	12
3	Swindon and Wiltshire	4.9	700	5
4	Greater Cambridge and Greater Peterborough	4.9	1,200	4
5	Cheshire and Warrington	4.4	700	3
6	West of England	4.4	3,500	16
7	Enterprise M3	4.4	1,700	5
8	Derby, Derbyshire, Nottingham and Nottinghamshire	4.2	5,900	18
9	Cumbria	4.2	1,300	16
10	Tees Valley	4.0	1,000	10
11	Greater Birmingham and Solihull	3.9	1,000	3
12	Heart of the South West	3.6	1,300	5
13	Lancashire	3.5	-7,700	-26
14	Gloucestershire	3.5	1,200	14
15	Solent	3.4	-2,000	-12
16	Thames Valley Berkshire	3.4	2,500	18
17	South East Wales	3.2	2,700	16
18	Northamptonshire	3.2	1,900	22
19	South East Midlands	3.1	5,400	26
20	North Eastern	3.1	-500	-2
21	Worcestershire	3.0	-2,200	-24
22	The Marches	2.9	500	7
23	Buckinghamshire Thames Valley	2.9	600	10
24	Dorset	2.8	800	10
25	Coast to Capital	2.8	2,200	11
26	Liverpool City Region	2.7	3,800	30
27	Hertfordshire	2.6	100	1
28	Leicester and Leicestershire	2.6	1,900	20
29	York, North Yorkshire and East Riding	2.5	600	5
30	Stoke-on-Trent and Staffordshire	2.3	100	1
31	Greater Lincolnshire	2.2	4,000	76
32	New Anglia	2.2	0	0
33	South East	2.2	-500	-1
34	Leeds City Region	2.1	1,500	6
35	Black Country	2.0	-200	-2
36	Sheffield City Region	1.9	1,800	15
37	Cornwall and Isles of Scilly	1.8	300	9
38	Greater Manchester	1.8	-400	-2
39	Humber	1.6	-500	-8
40	London	1.5	2,600	4

Source: BRES, 2014 via NOMIS

Enterprises

In 2015, there were 7,775 enterprises operating within the aerospace and advanced engineering sector across the consortium area (Table 50). The largest number of enterprises were in:

- Other engineering activities (3,805)
- Engineering related scientific and technical consulting activities (1,385)
- Engineering design activities for industrial process and production (1,015)

When expressed as location quotients, the consortium area has particularly high concentrations of enterprises in

- Repair and maintenance of aircraft and spacecraft (2.62) particularly in South East Wales (6.83)
- Building of pleasure and sporting boats in Cornwall & the IoS (5.15) and Heart of the South West (2.75)
- Manufacture of other transport equipment nec in Swindon & Wiltshire (4.23) and West of England (2.82)
- Manufacture of engineers and turbines, except aircraft, vehicle and cycle engineers in Cornwall & the IoS (4.20)
- Building of ships and floating structures in Cornwall & the IoS (3.51) and Heart of the South West (2.35)
- Manufacture of air and spacecraft and related machinery in South East Wales (2.96) and West of England (2.34)
- Manufacture of electrical and electronic equipment for motor vehicles in Swindon & Wiltshire (2.64)

Table 50 Number of enterprises in the aerospace and advanced engineering sector; consortium sub-area: 2015

	C& IOS	Glos	HoS W	SEW	S&W	WoE	SIA area	Great Britain
Repair and maintenance of aircraft and spacecraft	25	20	70	150	30	45	340	1,345
Manufacture of motor vehicles	5	10	15	10	10	15	65	805
Manufacture of electrical and electronic equipment for motor vehicles	0	0	0	0	5	5	10	160
Manufacture of other parts and accessories for motor vehicles	5	10	20	20	20	15	95	1,070
Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	10	0	10	5	0	0	25	245
Manufacture of bearings, gears, gearing and driving elements	0	5	5	5	0	5	20	225
Building of ships and floating structures	15	5	30	5	0	5	60	440
Building of pleasure and sporting boats	25	5	40	0	5	15	90	500
Manufacture of air and spacecraft and related machinery	5	15	35	35	15	30	135	725
Manufacture of military fighting vehicles	0	0	0	0	0	0	0	10
Manufacture of other transport equipment nec	0	0	0	0	5	5	10	100
Engineering design activities for industrial process and production	65	135	225	145	155	295	1,015	12,395
Engineering related scientific and technical consulting activities	120	175	360	240	185	305	1,385	15,860
Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)	245	540	945	585	535	960	3,805	45,480
Technical testing and analysis	30	50	120	90	60	75	425	5,680
Other research and experimental development on natural sciences and engineering	25	40	65	50	40	65	290	3,500
Aerospace and advanced engineering	590	1,005	1,945	1,330	1,060	1,840	7,775	88,535

Source: ONS Business Counts, NOMIS

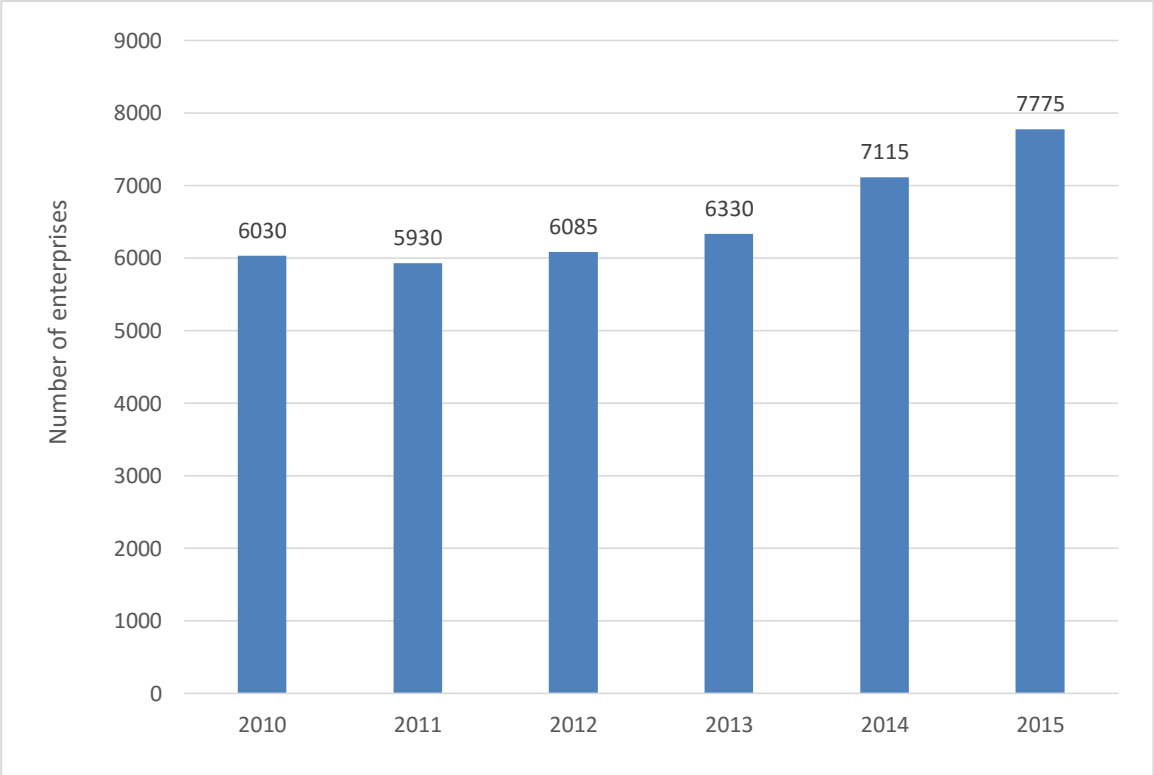
Table 51 Location quotients for share of enterprises in the aerospace and advanced engineering sector; consortium sub-area: 2015

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area
Repair and maintenance of aircraft and spacecraft	1.91	1.29	1.79	6.83	1.89	1.89	2.63
Manufacture of motor vehicles	0.64	1.07	0.64	0.76	1.05	1.05	0.84
Manufacture of electrical and electronic equipment for motor vehicles	0.00	0.00	0.00	0.00	2.64	1.76	0.65
Manufacture of other parts and accessories for motor vehicles	0.48	0.81	0.64	1.15	1.58	0.79	0.92
Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	4.20	0.00	1.41	1.25	0.00	0.00	1.06
Manufacture of bearings, gears, gearing and driving elements	0.00	1.92	0.77	1.36	0.00	1.25	0.92
Building of ships and floating structures	3.51	0.98	2.35	0.70	0.00	0.64	1.42
Building of pleasure and sporting boats	5.15	0.87	2.75	0.00	0.85	1.69	1.87
Manufacture of air and spacecraft and related machinery	0.71	1.79	1.66	2.96	1.75	2.34	1.94
Manufacture of military fighting vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manufacture of other transport equipment nec	0.00	0.00	0.00	0.00	4.23	2.82	1.04
Engineering design activities for industrial process and production	0.54	0.94	0.63	0.72	1.06	1.34	0.85
Engineering related scientific and technical consulting activities	0.78	0.95	0.78	0.93	0.99	1.09	0.91
Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)	0.55	1.03	0.72	0.79	0.99	1.19	0.87
Technical testing and analysis	0.54	0.76	0.73	0.97	0.89	0.75	0.78
Other research and experimental development on natural sciences and engineering	0.74	0.99	0.64	0.88	0.97	1.05	0.86
Aerospace and advanced engineering	0.69	0.98	0.76	0.92	1.01	1.17	0.91

Source: ONS Business Counts, NOMIS

The number of enterprises has grown strongly over the last 5 years (Figure 4) albeit at a marginally slower rate than the Great Britain average (29% compared to 33%). This is more twice the rate of business growth than average across industries in the consortium area (13%).

Figure 4 Number of enterprises within the aerospace and advanced engineering sector; consortium area: 2010 to 2015



Source: ONS Business Counts, NOMIS

Table 52 Change in number of enterprises within the aerospace and advanced engineering sector; consortium area and Great Britain: 2010 to 2015

	Consortium area		Great Britain
	Change in number of enterprises	% change in enterprises	**% change in enterprises**
Repair and maintenance of aircraft and spacecraft	275	423	249
Manufacture of motor vehicles	-5	-7	18
Manufacture of electrical and electronic equipment for motor vehicles	0	0	10
Manufacture of other parts and accessories for motor vehicles	-5	-5	-11
Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	0	0	23
Manufacture of bearings, gears, gearing and driving elements	-5	-20	-12
Building of ships and floating structures	-20	-25	-4
Building of pleasure and sporting boats	-25	-22	-19
Manufacture of air and spacecraft and related machinery	70	108	56
Manufacture of military fighting vehicles	0	#DIV/0!	100
Manufacture of other transport equipment nec	-5	-33	-9
Engineering design activities for industrial process and production	495	95	88
Engineering related scientific and technical consulting activities	530	62	68
Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)	370	11	17
Technical testing and analysis	80	23	48
Other research and experimental development on natural sciences and engineering	-10	-3	15
Aerospace and advanced engineering	1,745	29	33

Source: ONS Business Counts, NOMIS

Table 53 Enterprise indicators for the aerospace and advanced engineering sector by LEP areas and South East Wales: 2010 and 2015

Rank of %	LEP area	%, 2015	Change, 2010 to 2015	
			Number	%
1	Tees Valley	13.3	935	74
2	Coventry and Warwickshire	6.5	825	59
3	Cumbria	5.8	410	43
4	Cheshire and Warrington	5.3	450	28
5	Solent	4.8	320	21
6	North Eastern	4.8	760	47
7	West of England	4.4	460	33
8	Humber	4.2	300	33
9	Liverpool City Region	4.2	495	46
10	Enterprise M3	4.1	675	28
11	Greater Manchester	4.0	710	25
12	Oxfordshire	3.9	250	27
13	Thames Valley Berkshire	3.9	435	37
14	New Anglia	3.8	495	28
15	Swindon and Wiltshire	3.8	270	34
16	South East Midlands	3.7	640	31
17	Greater Cambridge and Greater Peterborough	3.7	315	17
18	Gloucestershire	3.6	195	24
19	Derby, Derbyshire, Nottingham and Nottinghamshire	3.6	430	21
20	Greater Lincolnshire	3.6	230	21
21	Lancashire	3.6	335	24
22	Coast to Capital	3.5	555	23
23	Stoke-on-Trent and Staffordshire	3.5	200	18
24	Northamptonshire	3.5	240	30
25	Worcestershire	3.5	105	15
26	South East	3.5	1,015	23
27	Buckinghamshire Thames Valley	3.4	160	19
28	South East Wales	3.4	400	43
29	Sheffield City Region	3.4	280	19
30	Dorset	3.4	165	19
31	Greater Birmingham and Solihull	3.4	410	25
32	Hertfordshire	3.2	345	24
33	York, North Yorkshire and East Riding	3.1	350	28
34	Leicester and Leicestershire	3.1	240	26
35	Black Country	3.0	130	17
36	Leeds City Region	3.0	680	30
37	Heart of the South West	2.8	280	17
38	The Marches	2.6	115	17
39	Cornwall and Isles of Scilly	2.5	135	30
40	London	2.2	2,905	41

Source: ONS Business Counts, NOMIS

Table 54 Enterprises by employment size band in the aerospace and advanced engineering sector; consortium area and Great Britain: 2015

Employment Size band	Consortium area			Great Britain
	No. aerospace & advanced engineering	% aerospace & advanced engineering	% all sectors	% aerospace & advanced engineering
0 to 4	6,710	86.3	75.2	87.4
5 to 9	525	6.8	13.3	5.8
10 to 19	270	3.5	6.4	3.3
20 to 49	145	1.9	3.3	1.8
50 to 99	45	0.6	1.0	0.7
100 to 249	45	0.6	0.5	0.5
250 to 499	20	0.3	0.2	0.2
500 to 999	10	0.1	0.1	0.1
1000+	10	0.1	0.1	0.1
Total	7,775	100.0	100.0	100.0

Source: ONS Business Counts, NOMIS

Table 55 Enterprises by legal status in the aerospace and advanced engineering sector: consortium area and Great Britain: 2015

Employment Size band	Consortium area			Great Britain
	No. aerospace & advanced engineering	% aerospace & advanced engineering	% all sectors	% aerospace & advanced engineering
Private sector total	**7,770**	**99.9**	**99.3**	**100.0**
Company (including building society)	6,870	88.4	58.3	91.1
Sole proprietor	680	8.7	23.6	6.5
Partnership	190	2.4	13.8	2.0
Non-profit body or mutual association	25	0.3	3.6	0.3
Public sector total	**5**	**0.1**	**0.7**	**0.0**
Public corporation	-	0.0	0.0	0.0
Central government	5	0.1	0.2	0.0
Local authority	-	0.0	0.5	0.0
Total	7,775	100.0	100.0	100.0

Source: ONS Business Counts, NOMIS

Replacement demand

Table 56 Change in employment by occupation, digital living innovation systems, 2014 - 2024

Occupation	2014	%	2024	%
1. Managers, directors and senior officials	9,800	13%	12,200	13%
2. Professional occupations	35,400	45%	40,900	45%
3. Associate professional and technical	15,300	19%	17,300	19%
4. Administrative and secretarial	6,100	8%	6,300	7%
5. Skilled trades occupations	4,400	6%	4,800	5%
6. Caring, leisure and other service	1,900	2%	2,700	3%
7. Sales and customer service	2,000	3%	2,400	3%
8. Process, plant and machine operatives	1,300	2%	1,500	2%
9. Elementary occupations	2,200	3%	2,500	3%
Total	78,400	100%	90,400	100%
Higher level occupations	60,500	77%	70,400	78%

Source: Working Futures

Table 57 Change in employment by sub-sector, digital living innovation systems, 2014 - 2024

	Sub-sector	2014	%	2024	%
45	Computing services	55,500	71%	63,500	70%
46	Information services	7,000	9%	8,600	10%
54	Scientific research & development	15,900	20%	18,400	20%
	Total	78,400	100%	90,400	100%

Source: Working Futures

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Table 58 Change in employment by qualification level required, digital living innovation systems, 2014 - 2024

Qualification Level	2014	%	2024	%
QCF4+	48,200	61%	66,600	74%
QCF3	11,600	15%	8,300	9%
QCF2	9,500	12%	9,000	10%
QCF Below L2 / no quals	9,200	12%	6,600	7%
Total	78,500	100%	90,400	100%

Source: Working Futures

Table 59 Total requirement for labour by occupation, digital living innovation systems, 2014 - 2024

Occupation	Base year employment (2014)	Expansion Demand	Replacement Demand	Net Requirement
Managers, directors and senior officials	9,800	2,300	3,900	6,200
Professional occupations	35,400	5,500	11,900	17,400
Associate professional and technical	15,300	2,000	5,500	7,500
Administrative and secretarial	6,100	200	2,700	2,900
Skilled trades occupations	4,400	400	1,700	2,100
Caring, leisure and other service	1,900	800	900	1,700
Sales and customer service	2,000	300	700	1,000
Process, plant and machine operatives	1,300	200	500	700
Elementary occupations	2,200	300	900	1,200
Total	78,400	12,000	28,700	40,700

Source: Working Futures

Table 60 Total requirement for labour by qualification level required, digital living innovation systems, 2014 – 2024

Occupation	Base year employment (2014)	Expansion Demand	Replacement Demand	Net Requirement
QCF4+	48,200	18,400	19,000	37,400
QCF3	11,600	-3,400	3,900	500
QCF2	9,500	-500	3,300	2,800
QCF Below L2 / no quals	9,200	-2,600	2,700	100
Total	78,500	11,900	28,900	40,800

Source: Working Futures

Table 61 Total requirement for labour by sub-sector, digital living innovation systems, 2014 – 2024

		Base year employment (2014)	Expansion Demand	Replacement Demand	Net Requirement
45	Computing services	55,500	8,000	20,300	28,300
46	Information services	7,000	1,400	2,900	4,300
54	Scientific research & development	15,900	2,500	5,700	8,200
	Total	78,400	12,000	28,700	40,700

Source: Working Futures

Employment

The digital living innovation platform theme accounts for 93,800 employee jobs across the consortia area. The largest sub-sectors are: computer consultancy activities (20,800), other telecommunications activities (15,000) and other information technology and computer service activities (10,000).

Taken as whole, the sector accounts for a similar share of employment (3.6%) to the Great Britain average (4.1%) but with higher concentrations – as demonstrated by the highest location quotients – within (Table 63)

- Manufacture of communication equipment in South East Wales (10.47) and Gloucestershire (2.23)
- Manufacture of electronic instruments and appliances for measuring, testing and navigation in Gloucestershire (9.92)
- Manufacture of other electronic and electric wires and cables in Swindon & Wiltshire (8.64) and Gloucestershire (2.17)
- Manufacture of loaded boards in Gloucestershire (7.29), South East Wales (4.58) and Swindon & Wiltshire (2.52)
- Manufacture of electronic components in South East Wales (6.51)
- Manufacture of fibre optic cables (2.97)
- Engineering design activities for industrial process and production in West of England (2.86)
- Manufacture of telegraph and telephone apparatus and equipment in South East Wales (2.79)
- Motion picture projection activities in Cornwall & the IoS (2.74
- Manufacture of electronic industrial process control equipment in South East Wales (2.68) and Heart of the South West (2.58)
- Data processing, hosting and related activities in West of England (2.29)
- Motion picture production activities in West of England (2.16)
- Video production activities in Cornwall & the IoS (2.03)

Table 62 Employee jobs in the digital living systems sector; consortium sub area: 2014

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area	Great Britain
Publishing of computer games	!	-	!	-	!	-	-	1,300
Other software publishing	-	200	200	-	100	200	700	10,400
Reproduction of sound recording	!	-	-	-	-	-	100	1,100
Reproduction of video recording	-	!	-	-	!	!	-	1,000
Reproduction of computer media	-	-	-	!	-	-	-	200
Manufacture of electronic components	!	-	600	2,100	300	-	3,100	14,700
Manufacture of loaded electronic boards	100	800	!	1,000	300	100	2,400	10,600
Manufacture of computers and peripheral equipment	-	!	-	100	-	!	1,100	8,300
Manufacture of telegraph and telephone apparatus and equipment	100	100	100	700	100	-	1,100	11,500
Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment)	!	100	100	1,100	-	!	1,300	5,000
Manufacture of consumer electronics	!	100	100	100	!	-	400	5,700
Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control equipment	100	4,400	1,300	700	200	700	7,400	44,100
Manufacture of electronic industrial process control equipment	-	100	300	300	!	!	700	4,800
Manufacture of optical precision instruments	!	-	!	!	!	!	400	4,100
Manufacture of photographic and cinematographic equipment	-	!	!	!	-	-	-	1,100
Manufacture of magnetic and optical media	-	-	-	-	!	-	!	200
Manufacture of fibre optic cables	-	-	!	!	!	-	300	1,200
Manufacture of other electronic	!	200	!	!	900	-	1,30	9,200

and electric wires and cables							0	
Manufacture of wiring devices	-	!	-	-	!	!	200	3,200
Motion picture production activities	-	200	200	300	-	1,000	1,800	21,900
Video production activities	100	-	100	100	100	100	400	3,800
Motion picture projection activities	300	100	500	500	200	500	2,200	17,900
Sound recording and music publishing activities	-	100	100	-	100	300	700	8,100
Wired telecommunications activities	-	-	-	100	100	100	400	7,000
Wireless telecommunications activities	-	100	300	100	100	100	700	16,200
Satellite telecommunications activities	!	!	!	!	100	-	300	9,400
Other telecommunications activities	700	1,400	3,900	3,800	2,300	3,000	15,000	166,700
Ready-made interactive leisure and entertainment software development	-	100	-	100	-	100	300	9,300
Business and domestic software development	200	1,200	1,200	1,500	900	3,500	8,600	138,400
Computer consultancy activities	600	2,800	3,400	3,300	4,100	6,700	20,800	333,300
Computer facilities management activities	-	-	-	-	-	-	100	1,900
Other information technology and computer service activities	300	1,800	1,500	2,400	1,100	2,800	10,000	122,100
Data processing, hosting and related activities	-	200	600	300	600	2,000	3,700	42,700
Web portals	-	!	-	-	-	-	200	7,400
News agency activities	-	-	-	-	!	!	100	9,500
Engineering design activities for industrial process and production	200	500	1,100	800	800	3,200	6,600	55,900
Repair of computers and peripheral equipment	!	500	100	400	200	100	1,400	31,100
Digital Living Innovation Platform"	3,000	15,100	16,500	20,600	13,000	25,600	93,800	1,140,300
All (excluding Farms)	197,400	276,600	680,400	594,700	303,800	559,300	2,612,100	27,777,800

Source: BRES, ONS via NOMIS

Table 63 Location quotients for employee jobs in the digital living systems sector; consortium sub-area: 2014

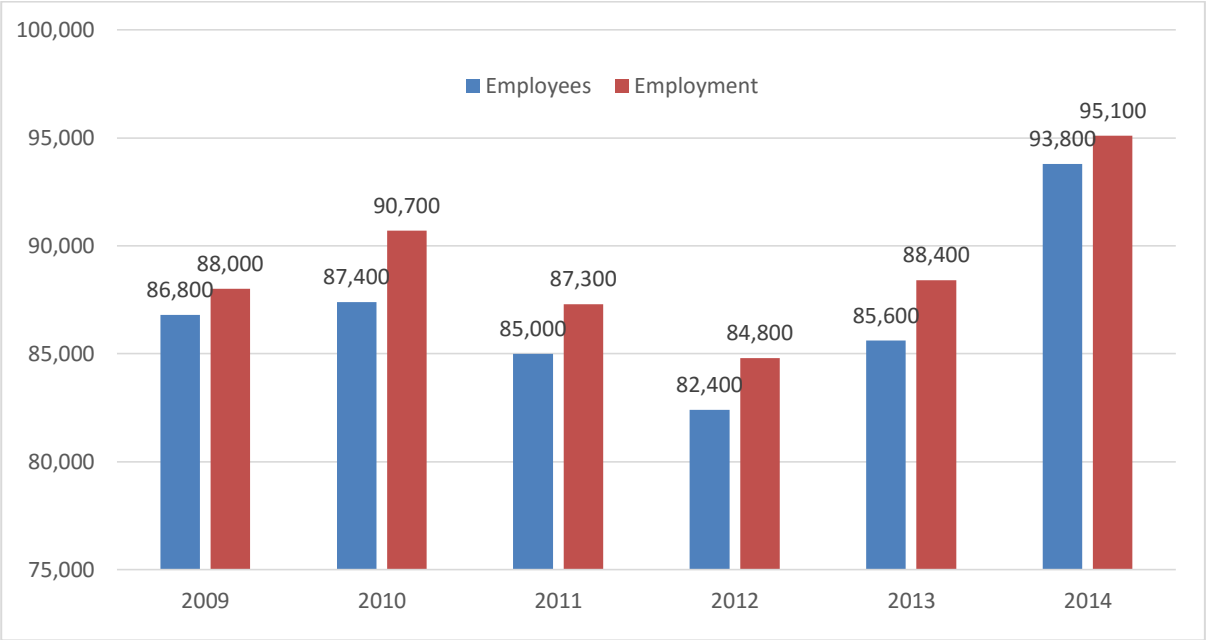
	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area
Publishing of computer games	!	0.47	!	0.22	!	0.39	0.26
Other software publishing	0.43	1.64	0.61	0.22	0.88	0.79	0.69
Reproduction of sound recording	!	0.71	0.22	0.41	0.73	0.84	0.50
Reproduction of video recording	0.00	!	0.25	0.00	!	!	0.12
Reproduction of computer media	0.00	0.00	0.83	!	0.00	1.21	0.56
Manufacture of electronic components	!	0.27	1.67	6.51	1.87	0.08	2.22
Manufacture of loaded electronic boards	1.14	7.29	!	4.58	2.52	0.25	2.45
Manufacture of computers and peripheral equipment	0.12	!	0.17	0.53	0.53	!	1.40
Manufacture of telegraph and telephone apparatus and equipment	1.39	0.85	0.38	2.79	0.61	0.20	1.04
Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment)	!	2.23	0.41	10.47	0.11	!	2.74
Manufacture of consumer electronics	!	1.15	0.45	0.73	!	0.25	0.81
Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control equipment	0.22	9.92	1.22	0.73	0.51	0.80	1.78
Manufacture of electronic industrial process control equipment	0.00	1.28	2.58	2.68	!	!	1.54
Manufacture of optical precision instruments	!	0.00	!	!	!	!	1.11
Manufacture of photographic and cinematographic equipment	0.00	!	!	!	0.00	0.00	0.30
Manufacture of magnetic and optical media	0.00	0.00	0.00	0.00	!	0.00	!
Manufacture of fibre optic cables	0.00	0.00	!	!	!	0.00	2.97
Manufacture of other electronic and electric wires and cables	!	2.17	!	!	8.64	0.02	1.46
Manufacture of wiring devices	0.00	!	0.00	0.00	!	!	0.52
Motion picture production activities	0.29	0.93	0.44	0.72	0.18	2.16	0.88
Video production activities	2.03	0.76	0.93	0.83	1.39	1.94	1.24
Motion picture projection activities	2.74	0.81	1.12	1.34	1.01	1.49	1.32
Sound recording and music publishing activities	0.38	0.79	0.53	0.28	1.26	2.00	0.89

Wired telecommunications activities	0.08	0.29	0.28	0.97	0.72	0.83	0.59
Wireless telecommunications activities	0.03	0.44	0.78	0.39	0.28	0.46	0.47
Satellite telecommunications activities	!	!	!	!	1.19	0.05	0.32
Other telecommunications activities	0.58	0.84	0.95	1.05	1.26	0.88	0.95
Ready-made interactive leisure and entertainment software development	0.17	0.76	0.14	0.45	0.17	0.43	0.34
Business and domestic software development	0.21	0.87	0.35	0.52	0.61	1.27	0.66
Computer consultancy activities	0.23	0.84	0.42	0.47	1.12	1.00	0.66
Computer facilities management activities	0.00	0.43	0.15	0.52	0.24	0.37	0.32
Other information technology and computer service activities	0.38	1.45	0.50	0.94	0.82	1.15	0.87
Data processing, hosting and related activities	0.07	0.39	0.60	0.29	1.29	2.29	0.91
Web portals	0.08	!	0.09	0.26	0.05	0.22	0.25
News agency activities	0.03	0.04	0.15	0.02	!	!	0.14
Engineering design activities for industrial process and production	0.43	0.93	0.83	0.68	1.24	2.86	1.26
Repair of computers and peripheral equipment	!	1.45	0.19	0.54	0.73	0.24	0.49
Digital Living Innovation Platform"	0.37	1.33	0.59	0.84	1.04	1.12	0.88

Source: BRES via NOMIS

Employment in the sector increased by 7,100 across the consortium area between 2009 and 2014. When expressed as a percentage, this change is slower than the growth rate recorded for this sector across Great Britain as whole over the same period (8% compared to 14%) but compares favourably to the 1% recorded across all industries in the consortium area.

Figure 5 Employees and total employment in the digital living systems sector; consortium area: 2009 to 2014



Source: BRES, ONS via NOMIS

Table 64 Employment indicators for digital living systems sector by LEP areas and South East Wales: 2009 and 2004

Rank of %	LEP area	%, 2014	Change, 2009 to 2014	
			Number	%
1	Thames Valley Berkshire	14.3	9,400	16
2	Enterprise M3	7.3	5,100	9
3	Buckinghamshire Thames Valley	6.7	2,000	15
4	Hertfordshire	6.6	9,900	35
5	London	5.7	73,900	36
6	Greater Cambridge and Greater Peterborough	5.4	9,400	36
7	Gloucestershire	5.3	1,700	13
8	Solent	4.9	1,700	8
9	West of England	4.5	2,700	12
10	Coast to Capital	4.4	3,700	11
11	South East Midlands	4.4	2,300	6
12	Oxfordshire	4.4	0	0
13	Swindon and Wiltshire	4.2	-700	-5
14	Coventry and Warwickshire	4.1	-2,300	-12
15	Cheshire and Warrington	3.8	-300	-2
16	Worcestershire	3.7	700	9
17	South East	3.5	13,200	33
18	South East Wales	3.4	4,500	28
19	The Marches	3.4	400	4
20	Greater Manchester	3.2	-600	-2
21	North Eastern	3.2	0	0
22	Dorset	3.0	600	6
23	Derby, Derbyshire, Nottingham and Nottinghamshire	3.0	100	0
24	Leicester and Leicestershire	2.9	1,000	8
25	Greater Birmingham and Solihull	2.9	-700	-3
26	Leeds City Region	2.9	4,200	12
27	Sheffield City Region	2.8	2,100	11
28	New Anglia	2.8	2,700	16
29	Northamptonshire	2.7	600	7
30	Stoke-on-Trent and Staffordshire	2.6	-1,400	-11
31	Tees Valley	2.5	-600	-9
32	York, North Yorkshire and East Riding	2.5	1,200	11
33	Lancashire	2.4	200	1
34	Heart of the South West	2.4	-1,100	-6
35	Liverpool City Region	2.2	-900	-6
36	Humber	1.8	600	10
37	Black Country	1.6	-1,300	-15
38	Greater Lincolnshire	1.6	400	6
39	Cornwall and Isles of Scilly	1.5	-100	-2
40	Cumbria	1.3	-400	-10

Source: BRES, 2014 via NOMIS

Enterprises

In 2015, there were 14,870 enterprises operating within the digital living systems sector across the consortium area (Table 50). The largest number of enterprises were engaged in:

- Computer consultancy activities (6,610)
- Business and domestic software development (2,170)
- Other information technology and computer service activities (1,960)
- Engineering design activities for industrial process and control (1.015)

When expressed as location quotients, the consortium area has particularly high concentrations of enterprises in (Table 66

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area
Repair and maintenance of aircraft and spacecraft	1.91	1.29	1.79	6.83	1.89	1.89	2.63
Manufacture of motor vehicles	0.64	1.07	0.64	0.76	1.05	1.05	0.84
Manufacture of electrical and electronic equipment for motor vehicles	0.00	0.00	0.00	0.00	2.64	1.76	0.65
Manufacture of other parts and accessories for motor vehicles	0.48	0.81	0.64	1.15	1.58	0.79	0.92
Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	4.20	0.00	1.41	1.25	0.00	0.00	1.06
Manufacture of bearings, gears, gearing and driving elements	0.00	1.92	0.77	1.36	0.00	1.25	0.92
Building of ships and floating structures	3.51	0.98	2.35	0.70	0.00	0.64	1.42
Building of pleasure and sporting boats	5.15	0.87	2.75	0.00	0.85	1.69	1.87
Manufacture of air and spacecraft and related machinery	0.71	1.79	1.66	2.96	1.75	2.34	1.94
Manufacture of military fighting vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manufacture of other transport equipment nec	0.00	0.00	0.00	0.00	4.23	2.82	1.04
Engineering design activities for industrial process and production	0.54	0.94	0.63	0.72	1.06	1.34	0.85
Engineering related scientific and technical consulting activities	0.78	0.95	0.78	0.93	0.99	1.09	0.91

Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)	0.55	1.03	0.72	0.79	0.99	1.19	0.87
Technical testing and analysis	0.54	0.76	0.73	0.97	0.89	0.75	0.78
Other research and experimental development on natural sciences and engineering	0.74	0.99	0.64	0.88	0.97	1.05	0.86
Aerospace and advanced engineering	0.69	0.98	0.76	0.92	1.01	1.17	0.91

):

- Reproduction of computer media in West of England (3.32)
- Reproduction of video recording in Gloucestershire (2.98) and Swindon & Wiltshire (2.92)
- Manufacture of optical precision instruments in Cornwall & the IoS (2.94)
- Satellite telecommunications activities in Swindon & Wiltshire (2.92)
- Manufacture of loaded electronic boards in Gloucestershire (2.62)
- Manufacture of electronic industrial process control equipment in South East Wales (2.45)
- Publishing of computer games in Gloucestershire (2.40)
- Motion picture projection activities in Cornwall & the IoS (2.34)

Table 65 Number of enterprises in the digital living systems sector; consortium sub-area: 2015

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area	Great Britain
Publishing of computer games	0	5	5	0	0	5	15	180
Other software publishing	10	25	40	20	25	35	160	1,990
Reproduction of sound recording	5	5	10	5	5	20	55	710
Reproduction of video recording	0	5	0	0	5	0	10	145
Reproduction of computer media	0	0	0	0	0	5	5	85
Manufacture of electronic components	5	5	20	10	10	15	65	595
Manufacture of loaded electronic boards	5	10	0	10	5	5	35	330
Manufacture of computers and peripheral equipment	5	15	20	10	15	20	85	895
Manufacture of telegraph and telephone apparatus and equipment	5	15	25	15	15	10	85	940
Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment)	5	5	5	10	5	0	25	320
Manufacture of consumer electronics	5	10	10	5	5	5	40	515
Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control equipment	10	20	50	15	20	30	145	1,490
Manufacture of electronic industrial process control equipment	0	5	5	10	0	5	25	250
Manufacture of optical precision instruments	5	0	5	5	0	0	15	175
Manufacture of photographic and cinematographic equipment	0	0	5	0	0	0	10	95
Manufacture of magnetic and optical media	0	0	0	0	0	0	0	30
Manufacture of fibre optic cables	0	0	0	0	0	0	0	40
Manufacture of other electronic	0	5	5	5	5	5	25	250

and electric wires and cables								
Manufacture of wiring devices	0	0	0	0	0	0	5	65
Motion picture production activities	20	35	80	80	20	175	410	6,755
Video production activities	20	20	45	45	25	55	205	2,530
Motion picture projection activities	5	5	5	5	0	5	25	220
Sound recording and music publishing activities	15	15	35	30	30	70	200	2,930
Wired telecommunications activities	5	15	25	20	20	30	110	1,345
Wireless telecommunications activities	5	15	30	20	20	25	110	1,210
Satellite telecommunications activities	0	0	0	0	5	5	15	145
Other telecommunications activities	25	55	85	75	95	75	410	5,130
Ready-made interactive leisure and entertainment software development	5	15	15	20	10	25	80	1,330
Business and domestic software development	105	330	410	350	370	605	2,170	28,900
Computer consultancy activities	240	1,080	1,180	885	1,380	1,845	6,610	90,055
Computer facilities management activities	0	5	10	10	10	10	45	605
Other information technology and computer service activities	110	345	440	265	310	495	1,960	19,265
Data processing, hosting and related activities	15	35	50	30	45	65	240	3,080
Web portals	5	10	25	15	10	20	90	1,215
News agency activities	5	5	15	10	0	10	45	665
Engineering design activities for industrial process and production	65	135	225	145	155	295	1,015	12,395
Repair of computers and peripheral equipment	20	40	65	60	50	85	320	3,990
Digital Living Innovation Platform"	720	2,290	2,950	2,170	2,680	4,055	14,870	190,865
All industries	23,145	27,540	69,185	38,875	28,175	42,210	229,125	2,382,370

Source: ONS Business Counts, NOMIS

Table 66 Location quotients for share of enterprises in the digital living system sector; consortium sub-area: 2015

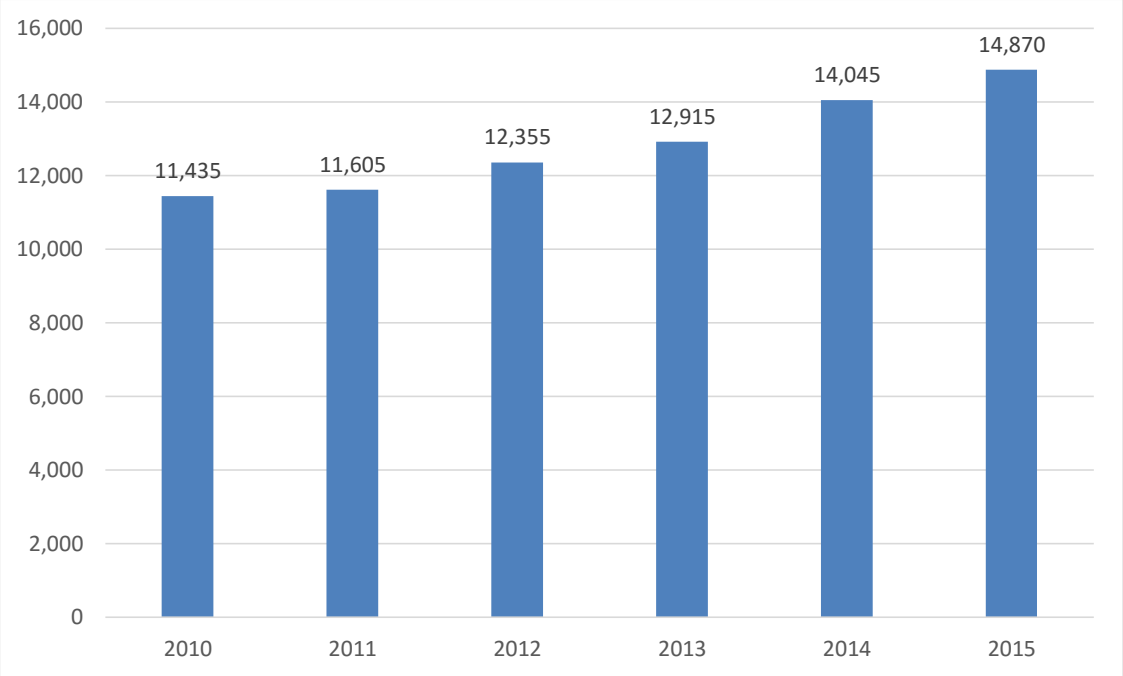
	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area
Publishing of computer games	0.00	2.40	0.96	0.00	0.00	1.57	0.87
Other software publishing	0.52	1.09	0.69	0.62	1.06	0.99	0.84
Reproduction of sound recording	0.72	0.61	0.48	0.43	0.60	1.59	0.81
Reproduction of video recording	0.00	2.98	0.00	0.00	2.92	0.00	0.72
Reproduction of computer media	0.00	0.00	0.00	0.00	0.00	3.32	0.61
Manufacture of electronic components	0.86	0.73	1.16	1.03	1.42	1.42	1.14
Manufacture of loaded electronic boards	1.56	2.62	0.00	1.86	1.28	0.86	1.10
Manufacture of computers and peripheral equipment	0.58	1.45	0.77	0.68	1.42	1.26	0.99
Manufacture of telegraph and telephone apparatus and equipment	0.55	1.38	0.92	0.98	1.35	0.60	0.94
Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment)	1.61	1.35	0.54	1.92	1.32	0.00	0.81
Manufacture of consumer electronics	1.00	1.68	0.67	0.59	0.82	0.55	0.81
Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control equipment	0.69	1.16	1.16	0.62	1.13	1.14	1.01
Manufacture of electronic industrial process control equipment	0.00	1.73	0.69	2.45	0.00	1.13	1.04
Manufacture of optical precision instruments	2.94	0.00	0.98	1.75	0.00	0.00	0.89
Manufacture of photographic and cinematographic equipment	0.00	0.00	1.81	0.00	0.00	0.00	1.09
Manufacture of magnetic and optical media	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manufacture of fibre optic cables	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manufacture of other electronic and electric wires and cables	0.00	1.73	0.69	1.23	1.69	1.13	1.04
Manufacture of wiring devices	0.00	0.00	0.00	0.00	0.00	0.00	0.80
Motion picture production activities	0.30	0.45	0.41	0.73	0.25	1.46	0.63
Video production activities	0.81	0.68	0.61	1.09	0.84	1.23	0.84
Motion picture projection activities	2.34	1.97	0.78	1.39	0.00	1.28	1.18
Sound recording and music publishing activities	0.53	0.44	0.41	0.63	0.87	1.35	0.71

Wired telecommunications activities	0.38	0.96	0.64	0.91	1.26	1.26	0.85
Wireless telecommunications activities	0.43	1.07	0.85	1.01	1.40	1.17	0.95
Satellite telecommunications activities	0.00	0.00	0.00	0.00	2.92	1.95	1.08
Other telecommunications activities	0.50	0.93	0.57	0.90	1.57	0.83	0.83
Ready-made interactive leisure and entertainment software development	0.39	0.98	0.39	0.92	0.64	1.06	0.63
Business and domestic software development	0.37	0.99	0.49	0.74	1.08	1.18	0.78
Computer consultancy activities	0.27	1.04	0.45	0.60	1.30	1.16	0.76
Computer facilities management activities	0.00	0.71	0.57	1.01	1.40	0.93	0.77
Other information technology and computer service activities	0.59	1.55	0.79	0.84	1.36	1.45	1.06
Data processing, hosting and related activities	0.50	0.98	0.56	0.60	1.24	1.19	0.81
Web portals	0.42	0.71	0.71	0.76	0.70	0.93	0.77
News agency activities	0.77	0.65	0.78	0.92	0.00	0.85	0.70
Engineering design activities for industrial process and production	0.54	0.94	0.63	0.72	1.06	1.34	0.85
Repair of computers and peripheral equipment	0.52	0.87	0.56	0.92	1.06	1.20	0.83
Digital Living Innovation Platform"	0.39	1.04	0.53	0.70	1.19	1.20	0.81

Source: ONS Business Counts, NOMIS

The number of enterprises within the digital living systems sector has increased strongly locally (30%) and across Great Britain as a whole (35%). Growth exceeded the all sector average within the consortium area (13%).

Figure 6 Number of enterprises within the digital living systems sector; consortium area: 2010 to 2015



Source: ONS Business Counts, NOMIS

Table 67 Change in number of enterprises within the digital living systems sector; consortium area and England & Wales: 2010 to 2015

	Consortium area		Great Britain
	Change in number of enterprises	% change in enterprises	**% change in enterprises**
Publishing of computer games	5	50	89
Other software publishing	0	0	6
Reproduction of sound recording	-15	-21	-27
Reproduction of video recording	-10	-50	-36
Reproduction of computer media	-10	-67	-19
Manufacture of electronic components	0	0	-1
Manufacture of loaded electronic boards	0	0	-3
Manufacture of computers and peripheral equipment	15	21	1
Manufacture of telegraph and telephone apparatus and equipment	-50	-37	-35
Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment)	10	67	88
Manufacture of consumer electronics	-10	-20	-21
Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control equipment	-5	-3	-7
Manufacture of electronic industrial process control equipment	0	0	-7
Manufacture of optical precision instruments	5	50	40
Manufacture of photographic and cinematographic equipment	0	0	0
Manufacture of magnetic and optical media	-5	-100	-14
Manufacture of fibre optic cables	0	#DIV/0!	-11
Manufacture of other electronic and electric wires and cables	10	67	19
Manufacture of wiring devices	0	0	18
Motion picture production activities	110	37	42
Video production activities	150	273	199
Motion picture projection activities	5	25	5
Sound recording and music publishing activities	70	54	43
Wired telecommunications activities	55	100	140
Wireless telecommunications activities	75	214	144
Satellite telecommunications activities	5	50	38
Other telecommunications activities	40	11	3
Ready-made interactive leisure and entertainment software development	55	220	186
Business and domestic software development	1,270	141	135

Computer consultancy activities	1,540	30	36
Computer facilities management activities	35	350	210
Other information technology and computer service activities	-535	-21	-21
Data processing, hosting and related activities	30	14	16
Web portals	25	38	35
News agency activities	-15	-25	-22
Engineering design activities for industrial process and production	495	95	88
Repair of computers and peripheral equipment	85	36	25
Digital Living Innovation Platform"	3,435	30	35
All enterprises	25,700	13	17

Source: ONS Business Counts, NOMIS

Table 68 Enterprise indicators for the digital living systems sector by LEP areas and South East Wales: 2010 and 2015

Rank of %	LEP area	%, 2015	Change, 2010 to 2015	
			Number	%
1	Thames Valley Berkshire	17.0	1,775	34
2	Enterprise M3	12.2	1,870	25
3	London	11.7	18,260	54
4	Hertfordshire	11.6	1,630	34
5	Buckinghamshire Thames Valley	10.8	580	23
6	Coast to Capital	10.4	1,955	29
7	South East Midlands	9.6	1,760	33
8	West of England	9.6	1,115	38
9	Swindon and Wiltshire	9.5	545	26
10	Coventry and Warwickshire	9.4	920	40
11	Oxfordshire	9.0	365	16
12	Greater Cambridge and Greater Peterborough	8.4	825	20
13	Gloucestershire	8.3	555	32
14	Cheshire and Warrington	8.2	675	27
15	Solent	8.2	595	24
16	South East	7.3	2,585	29
17	Greater Birmingham and Solihull	7.1	1,025	31
18	Greater Manchester	7.0	1,485	32
19	Dorset	7.0	295	16
20	Worcestershire	6.7	180	13
21	Northamptonshire	6.6	470	31
22	Leeds City Region	6.1	1,520	33
23	Derby, Derbyshire, Nottingham and Nottinghamshire	6.0	760	23
24	Liverpool City Region	5.9	495	29
25	Tees Valley	5.9	280	41
26	Leicester and Leicestershire	5.8	500	29
27	South East Wales	5.6	535	33
28	Stoke-on-Trent and Staffordshire	5.4	390	25

29	Sheffield City Region	5.2	555	26
30	Lancashire	5.2	465	22
31	Black Country	5.2	295	23
32	North Eastern	5.2	570	29
33	New Anglia	5.0	255	9
34	The Marches	4.8	240	20
35	York, North Yorkshire and East Riding	4.5	460	25
36	Heart of the South West	4.3	555	23
37	Humber	3.9	215	24
38	Greater Lincolnshire	3.5	105	9
39	Cumbria	3.2	120	19
40	Cornwall and Isles of Scilly	3.1	130	22

Source: ONS Business Counts, NOMIS

Table 69 Enterprises by employment size band in the digital living systems sector; consortium area and Great Britain: 2015

Employment Size band	Consortium area			Great Britain
	No. digital living	% digital living	% all sectors	% digital living
0 to 4	13,225	88.9	75.2	89.3
5 to 9	795	5.3	13.3	5.0
10 to 19	435	2.9	6.4	2.8
20 to 49	255	1.7	3.3	1.7
50 to 99	90	0.6	1.0	0.6
100 to 249	45	0.3	0.5	0.3
250 to 499	10	0.1	0.2	0.1
500 to 999	5	0.0	0.1	0.0
1000+	5	0.0	0.1	0.0
Total	14,870	100.0	100.0	100.0

Source: ONS Business Counts, NOMIS

Table 70 Enterprises by legal status in the digital living systems sector: consortium area and Great Britain: 2015

Employment Size band	Consortium area			Great Britain
	No. digital living	% digital living	% all sectors	% digital living
Private sector total	14,870	100.0	99.3	100.0
Company (including building society)	13,810	92.9	58.3	94.7
Sole proprietor	835	5.6	23.6	4.2
Partnership	190	1.3	13.8	0.9
Non-profit body or mutual association	30	0.2	3.6	0.1
Public sector total	0	0.0	0.7	0.0
Public corporation	0	0.0	0.0	0.0
Central government	0	0.0	0.2	0.0
Local authority	0	0.0	0.5	0.0
Total	14,870	100.0	100.0	100.0

Replacement demand

Table 71 Change in employment by occupation, resilience, environment and sustainability, 2014 - 2024

Occupation	2014	%	2024	%
1. Managers, directors and senior officials	3,000	10%	3,500	11%
2. Professional occupations	3,300	11%	4,100	13%
3. Associate professional and technical	3,000	10%	3,200	10%
4. Administrative and secretarial	2,400	8%	2,000	6%
5. Skilled trades occupations	3,000	11%	3,600	12%
6. Caring, leisure and other service	500	2%	500	2%
7. Sales and customer service	900	3%	1,000	3%
8. Process, plant and machine operatives	7,700	27%	8,200	26%
9. Elementary occupations	4,900	17%	4,800	16%
Total	28,700	100%	30,900	100%
Higher level occupations	9,300	32%	10,800	35%

Source: Working Futures

Table 72 Change in employment by sub-sector, resilience, environment and sustainability, 2014 - 2024

	Sub-sector	2014	%	2024	%
25	Water	6,200	21.6%	6,600	21.4%
26	Sewerage	3,600	12.5%	3,800	12.3%
27	Waste management	19,000	66.2%	20,500	66.3%
	Total	28,700	100.3%	30,900	100.0%

Source: Working Futures

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Table 73 Change in employment by qualification level required, resilience, environment and sustainability, 2014 - 2024

Qualification Level	2014	%	2024	%
QCF4+	8,800	31%	12,500	41%
QCF3	5,400	19%	5,300	17%
QCF2	6,700	23%	7,800	25%
QCF Below L2 / no quals	7,800	27%	5,200	17%
Total	28,700	100%	30,900	100%

Source: Working Futures

Table 74 and Total requirement for labour by occupation, resilience, environment sustainability, 2014 - 2024

Occupation	Base year employment (2014)	Expansion Demand	Replacement Demand	Net Requirement
Managers, directors and senior officials	3,000	500	1,200	1,700
Professional occupations	3,300	800	1,400	2,200
Associate professional and technical	3,000	200	1,100	1,300
Administrative and secretarial	2,400	-400	1,000	600
Skilled trades occupations	3,000	500	1,200	1,700
Caring, leisure and other service	500	100	200	300
Sales and customer service	900	100	300	400
Process, plant and machine operatives	7,700	400	2,900	3,300
Elementary occupations	4,900	-100	1,600	1,500
Total	28,700	2,100	10,900	13,000

Source: Working Futures

Table 75 Total requirement for labour by qualification level required, resilience, environment and sustainability, 2014 – 2024

Occupation	Base year employment (2014)	Expansion Demand	Replacement Demand	Net Requirement
QCF4+	8,800	3,800	3,600	7,400
QCF3	5,400	-100	2,500	2,400
QCF2	6,700	1,200	2,500	3,700
QCF Below L2 / no quals	7,800	-2,600	2,300	-300
Total	28,700	2,300	10,900	13,200

Source: Working Futures

Table 76 Total requirement for labour by sub-sector, resilience, environment and sustainability, 2014 – 2024

		Base year employment (2014)	Expansion Demand	Replacement Demand	Net Requirement
25	Water	6,200	600	2,300	2,900
26	Sewerage	3,600	200	1,200	1,400
27	Waste management	19,000	1,500	7,300	8,800
	Total	28,700	2,100	10,900	13,000

Source: Working Futures

Employment

The resilience, environment and sustainability theme accounts for 153,100 jobs across the consortia area. The largest sectors are: other engineering activities (24,600), computer consultancy activities (20,800), other information technology and computer service activities (10,000) and business and domestic software development (8,600) (Table 47).

Taken as whole, the sector accounts for a similar share of employee jobs (5.9%) to the Great Britain average (6.3%) but with higher concentrations – as demonstrated by the highest location quotients – within (Table 78):

- Sewerage in Swindon & Wiltshire (4.17)
- Other research and experimental development on natural sciences and engineering in Swindon & Wiltshire (4.20)
- Botanical and zoological gardens and nature reserve activities in Cornwall & the IoS (3.77)
- Engineering design activities for industrial process and production in West of England (2.86)
- Manufacture of pharmaceutical preparations in Swindon & Wiltshire (2.79)
- Urban planning and landscape architectural activities in West of England (2.36)
- Data processing, hosting and related activities in West of England (2.29)
- Treatment and disposal of hazardous waste across consortium area (2.21)
- Non-life insurance in South East Wales (2.2)
- Dismantling of wrecks in Heart of the South West (2.03)
- Recovery of sorted materials in South East Wales (2.02)
- Water collection, treatment and supply in Heart of the South West (1.9)
- Collection of non-hazardous waste in Cornwall & the IoS (1.9)

Table 77 Employee jobs in the resilience, environment and sustainability sector; consortium sub-area: 2014

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area	Great Britain
Botanical and zoological gardens and nature reserve activities	500	300	700	100	100	400	2,200	19,400
Water collection, treatment and supply	200	200	1,500	800	100	1,400	4,300	32,400
Sewerage	100	200	900	500	900	600	3,300	20,400
Collection of non-hazardous waste	800	300	1,500	1,700	300	1,600	6,200	58,400
Collection of hazardous waste	!	!	0	0	!	!	100	800
Treatment and disposal of non-hazardous waste	300	200	1,300	900	600	600	3,900	32,200
Treatment and disposal of hazardous waste	!	!	!	100	!	!	1,500	7,400
Dismantling of wrecks	0	!	0	!	0	0	0	200
Recovery of sorted materials	100	300	500	1,100	200	300	2,500	24,800
Remediation activities and other waste management services	!	0	100	100	!	0	200	4,900
Passenger rail transport, interurban	!	!	1,100	!	900	!	4,200	46,800
Satellite telecommunications activities	!	!	!	!	100	0	300	9,400
Data processing, hosting and related activities	0	200	600	300	600	2,000	3,700	42,700
Non-life insurance	100	!	1,000	3,200	!	2,600	7,500	67,200
Non-life reinsurance	0	0	0	!	0	0	!	700
Research and experimental development on biotechnology	0	0	0	0	!	!	1,200	7,700
Other research and experimental development on natural sciences and engineering	400	600	600	600	4,900	1,300	8,300	107,000
Manufacture of other inorganic basic chemicals	!	!	0	!	0	0	!	4,700

Manufacture of other organic basic chemicals	0	0	!	300	0	!	300	9,600
Manufacture of basic pharmaceutical products	0	!	0	!	!	0	100	4,600
Manufacture of pharmaceutical preparations	!	!	1,200	1,100	1,000	!	3,900	32,300
Business and domestic software development	200	1,200	1,200	1,500	900	3,500	8,600	138,400
Computer consultancy activities	600	2,800	3,400	3,300	4,100	6,700	20,800	333,300
Computer facilities management activities	0	0	0	0	0	0	100	1,900
Other information technology and computer service activities	300	1,800	1,500	2,400	1,100	2,800	10,000	122,100
Architectural activities	400	700	1,500	1,200	500	1,800	6,000	61,200
Urban planning and landscape architectural activities	100	100	100	200	100	400	1,000	9,300
Engineering design activities for industrial process and production	200	500	1,100	800	800	3,200	6,600	55,900
Engineering related scientific and technical consulting activities	800	800	2,500	1,400	800	1,500	7,900	73,400
Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)	800	3,100	4,300	5,300	2,900	8,100	24,600	234,300
Technical testing and analysis	200	300	600	300	600	1,100	3,000	51,800
Specialised design activities	200	400	700	500	300	1,000	3,200	47,800
Environmental consulting activities	100	100	300	300	100	200	1,000	9,600
Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying)	300	500	2,900	700	600	1,300	6,300	73,000
Resilience, Environment & Sustainability	7,200	16,100	31,500	30,100	23,900	44,300	153,100	1,745,400
All industries (excluding	197,	276,	680,	594,	303,	559,	2,61	27,777

farms)	400	600	400	700	800	300	2,100	,800

Source: BRES via NOMIS

Table 78 Location Quotients for employee jobs in resilience, environment and sustainability sector; consortium sub-area: 2014

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area
Botanical and zoological gardens and nature reserve activities	3.77	1.46	1.56	0.27	0.54	1.06	1.20
Water collection, treatment and supply	1.05	0.51	1.92	1.20	0.25	2.19	1.41
Sewerage	0.96	0.89	1.79	1.16	4.17	1.46	1.69
Collection of non-hazardous waste	1.88	0.47	1.02	1.39	0.51	1.39	1.13
Collection of hazardous waste	!	!	0.20	0.97	!	!	0.96
Treatment and disposal of non-hazardous waste	1.20	0.74	1.63	1.34	1.60	0.93	1.28
Treatment and disposal of hazardous waste	!	!	!	0.88	!	!	2.21
Dismantling of wrecks	0.00	!	2.03	!	0.00	0.00	1.00
Recovery of sorted materials	0.68	1.04	0.79	2.02	0.87	0.64	1.07
Remediation activities and other waste management services	!	0.04	1.04	0.61	!	0.10	0.49
Passenger rail transport, interurban	!	!	0.95	!	1.80	!	0.96
Satellite telecommunications activities	!	!	!	!	1.19	0.05	0.32
Data processing, hosting and related activities	0.07	0.39	0.60	0.29	1.29	2.29	0.91
Non-life insurance	0.17	!	0.62	2.20	!	1.92	1.19
Non-life reinsurance	0.00	0.00	0.00	!	0.00	0.00	!
Research and experimental development on biotechnology	0.55	0.17	0.03	0.16	!	!	1.70
Other research and experimental development on natural sciences and engineering	0.46	0.52	0.24	0.26	4.20	0.59	0.83
Manufacture of other inorganic basic chemicals	!	!	0.00	!	0.00	0.00	!
Manufacture of other organic	0.00	0.00	!	1.22	0.00	!	0.31

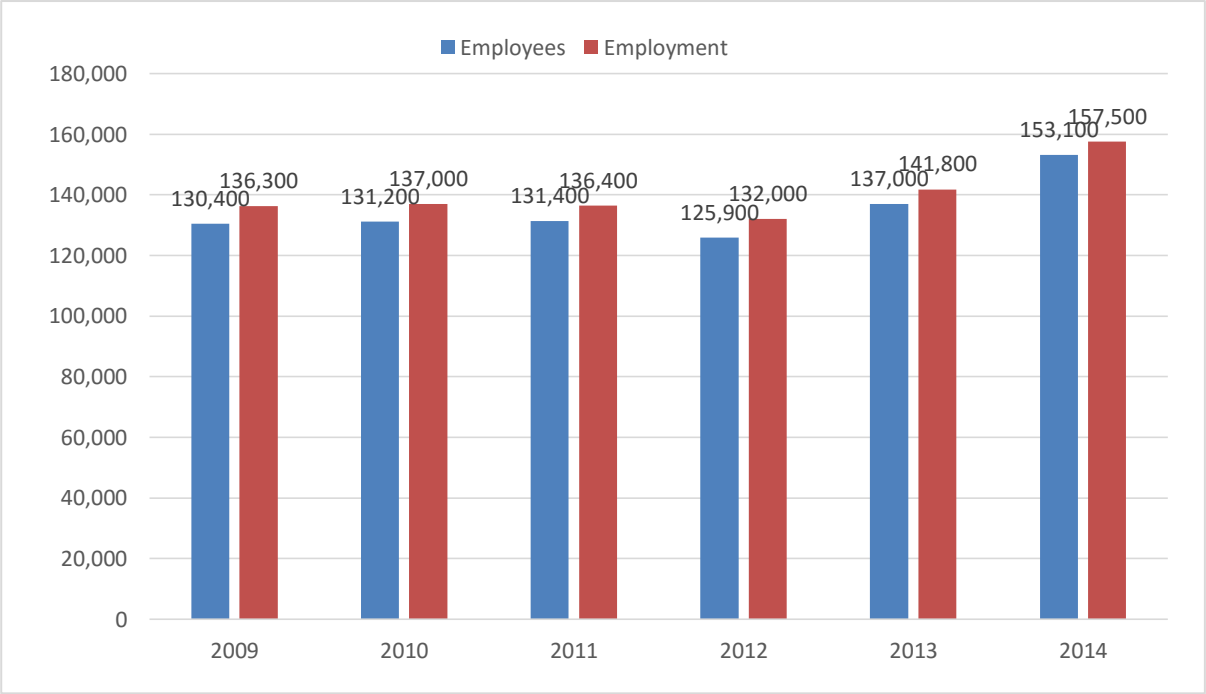
basic chemicals							
Manufacture of basic pharmaceutical products	0.00	!	0.05	!	!	0.10	0.33
Manufacture of pharmaceutical preparations	!	!	1.57	1.66	2.79	!	1.30
Business and domestic software development	0.21	0.87	0.35	0.52	0.61	1.27	0.66
Computer consultancy activities	0.23	0.84	0.42	0.47	1.12	1.00	0.66
Computer facilities management activities	0.00	0.43	0.15	0.52	0.24	0.37	0.32
Other information technology and computer service activities	0.38	1.45	0.50	0.94	0.82	1.15	0.87
Architectural activities	0.97	1.10	0.98	0.94	0.73	1.43	1.05
Urban planning and landscape architectural activities	0.94	1.48	0.62	0.96	0.76	2.36	1.20
Engineering design activities for industrial process and production	0.43	0.93	0.83	0.68	1.24	2.86	1.26
Engineering related scientific and technical consulting activities	1.60	1.09	1.38	0.90	1.00	1.03	1.14
Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)	0.51	1.35	0.75	1.05	1.14	1.72	1.11
Technical testing and analysis	0.41	0.64	0.43	0.30	1.01	1.06	0.63
Specialised design activities	0.72	0.88	0.59	0.47	0.66	1.02	0.70
Environmental consulting activities	0.94	0.55	1.21	1.69	0.88	0.98	1.14
Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying)	0.58	0.73	1.61	0.43	0.78	0.85	0.91
Reslience, Environment & Sustainability	0.58	0.93	0.74	0.81	1.25	1.26	0.93

Source: BRES via NOMIS

Employment in the sector has grown strongly over the last 5 years, with total employment increasing by 16% across the consortium area between 2009 and 2014.Employment in the sector has risen locally and in 2014, was 9,800 (10.9%) higher than it was in 2009. This is a much larger percentage increase than employment across all sectors (0.6%) and is higher than the industry average across Great Britain (6.6%).

Figure 3). While this is marginally less growth than that evident across the sector nationwide (17%) it is substantially more than the 1% growth recorded across all sectors locally.

Figure 7 Total employment and employee jobs in the resilience, environment and sustainability sector; consortium area: 2009 to 2014



Source: BRES, ONS via NOMIS

Table 79 Employment indicators for the resilience, environment and sustainability sector by LEP areas and South East Wales: 2009-14

Rank of %	LEP area	%, 2014	Change, 2009 to 2014	
			Number	%
1	Thames Valley Berkshire	14.9	13,300	22
2	Enterprise M3	10.7	8,200	11
3	Greater Cambridge and Greater Peterborough	9.3	11,500	23
4	Oxfordshire	8.2	2,500	9
5	Hertfordshire	8.2	8,800	23
6	Cheshire and Warrington	8.1	7,200	23
7	Buckinghamshire Thames Valley	7.9	2,300	15
8	West of England	7.9	8,700	24
9	Swindon and Wiltshire	7.8	1,300	6
10	Coast to Capital	7.6	8,300	15
11	London	7.2	72,500	26
12	Coventry and Warwickshire	7.0	2,500	9
13	York, North Yorkshire and East Riding	6.3	6,300	26
14	Tees Valley	6.1	3,500	27
15	Solent	6.0	-200	-1
16	South East	6.0	14,100	18
17	Gloucestershire	5.9	600	4
18	South East Midlands	5.8	7,400	18
19	Derby, Derbyshire, Nottingham and Nottinghamshire	5.7	9,000	21
20	Leeds City Region	5.6	16,800	29
21	Leicester and Leicestershire	5.4	6,500	36
22	Greater Manchester	5.3	11,600	22
23	Worcestershire	5.2	-900	-7
24	South East Wales	5.1	5,400	21
25	Liverpool City Region	5.0	4,600	18
26	Dorset	5.0	2,400	17
27	The Marches	4.9	500	4
28	New Anglia	4.8	4,200	15
29	Heart of the South West	4.6	4,600	16
30	Greater Birmingham and Solihull	4.6	-4,200	-9
31	North Eastern	4.5	500	1
32	Sheffield City Region	4.5	7,600	30
33	Northamptonshire	4.4	3,900	36
34	Greater Lincolnshire	4.1	4,600	36
35	Humber	4.1	2,900	23
36	Lancashire	4.0	3,100	14
37	Cumbria	3.8	1,600	22
38	Stoke-on-Trent and Staffordshire	3.7	-500	-3
39	Cornwall and Isles of Scilly	3.6	600	9
40	Black Country	3.2	-2,300	-14

Source: BRES, 2014 via NOMIS

Enterprises

In 2015, there were 25,295 enterprises operating within the resilience, environment and sustainability sector across the consortium area (Table 50). The largest numbers of enterprises in:

- Computer consultancy activities (6,610)
- Other engineering activities (3,805)
- Other professional scientific and technical activities (3,125)
- Business and domestic software development (2,170).
- Other information technology and computer service activities (1,960)
- Specialised design activities (1,710)

When expressed as location quotients, the consortium area has particularly high concentrations of enterprises in (

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area
Repair and maintenance of aircraft and spacecraft	1.91	1.29	1.79	6.83	1.89	1.89	2.63
Manufacture of motor vehicles	0.64	1.07	0.64	0.76	1.05	1.05	0.84
Manufacture of electrical and electronic equipment for motor vehicles	0.00	0.00	0.00	0.00	2.64	1.76	0.65
Manufacture of other parts and accessories for motor vehicles	0.48	0.81	0.64	1.15	1.58	0.79	0.92
Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	4.20	0.00	1.41	1.25	0.00	0.00	1.06
Manufacture of bearings, gears, gearing and driving elements	0.00	1.92	0.77	1.36	0.00	1.25	0.92
Building of ships and floating structures	3.51	0.98	2.35	0.70	0.00	0.64	1.42
Building of pleasure and sporting boats	5.15	0.87	2.75	0.00	0.85	1.69	1.87
Manufacture of air and spacecraft and related machinery	0.71	1.79	1.66	2.96	1.75	2.34	1.94
Manufacture of military fighting vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manufacture of other transport equipment nec	0.00	0.00	0.00	0.00	4.23	2.82	1.04
Engineering design activities for industrial process and production	0.54	0.94	0.63	0.72	1.06	1.34	0.85

Engineering related scientific and technical consulting activities	0.78	0.95	0.78	0.93	0.99	1.09	0.91
Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)	0.55	1.03	0.72	0.79	0.99	1.19	0.87
Technical testing and analysis	0.54	0.76	0.73	0.97	0.89	0.75	0.78
Other research and experimental development on natural sciences and engineering	0.74	0.99	0.64	0.88	0.97	1.05	0.86
Aerospace and advanced engineering	0.69	0.98	0.76	0.92	1.01	1.17	0.91

- Collection of hazardous waste in South East Wales (5.57)
- Manufacture of other inorganic basic chemicals in South East Wales (3.23)
- Treatment and disposal of hazardous waste in the Heart of the South West (3.44) and South East Wales (3.06)
- Water collection, treatment and supply in West of England (3.32) and Heart of the South West (2.03)
- Biological and zoological gardens and nature reserve activities in Cornwall and the IoS (2.90), Gloucestershire (2.44) and Heart of the South West (2.42)
- Satellite telecommunication activities in Swindon & Wiltshire (2.92) and West of England (1.95).
- Dismantling of wrecks in Heart of the South West (2.87)
- Passenger rail transport, interurban in Heart of the South West (2.87)
- Manufacture of other organic basic chemicals in South East Wales (2.45)

Table 80 Number of enterprises in the resilience, environment and sustainability sector; consortium sub-area: 2015

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area	Great Britain
Botanical and zoological gardens and nature reserve activities	10	10	25	5	5	5	60	355
Water collection, treatment and supply	0	0	5	0	0	5	10	85
Sewerage	10	10	30	20	10	20	100	915
Collection of non-hazardous waste	15	20	50	50	25	45	205	2,235
Collection of hazardous waste	0	0	5	10	0	0	15	110
Treatment and disposal of non-hazardous waste	5	5	30	20	15	15	90	920
Treatment and disposal of hazardous waste	0	0	10	5	0	0	15	100
Dismantling of wrecks	0	0	5	0	0	0	5	60
Recovery of sorted materials	10	20	45	55	25	35	190	1,785
Remediation activities and other waste management services	5	5	10	20	0	10	50	745
Passenger rail transport, interurban	0	0	5	0	0	0	5	60
Satellite telecommunications activities	0	0	0	0	5	5	15	145
Data processing, hosting and related activities	15	35	50	30	45	65	240	3,080
Non-life insurance	5	5	5	10	5	10	35	630
Non-life reinsurance	0	0	0	0	0	0	0	15
Research and experimental development on biotechnology	5	5	5	10	5	10	40	640
Other research and experimental development on natural sciences and engineering	25	40	65	50	40	65	290	3,500
Manufacture of other inorganic basic chemicals	0	0	0	5	0	0	10	95
Manufacture of other organic basic chemicals	0	0	0	5	0	0	10	125
Manufacture of basic pharmaceutical products	0	0	5	0	5	0	10	170

Manufacture of pharmaceutical preparations	0	5	10	5	0	5	30	385
Business and domestic software development	105	330	410	350	370	605	2,170	28,900
Computer consultancy activities	240	1,080	1,180	885	1,380	1,845	6,610	90,055
Computer facilities management activities	0	5	10	10	10	10	45	605
Other information technology and computer service activities	110	345	440	265	310	495	1,960	19,265
Architectural activities	95	140	305	160	135	235	1,075	12,425
Urban planning and landscape architectural activities	15	30	50	25	30	60	205	1,905
Engineering design activities for industrial process and production	65	135	225	145	155	295	1,015	12,395
Engineering related scientific and technical consulting activities	120	175	360	240	185	305	1,385	15,860
Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)	245	540	945	585	535	960	3,805	45,480
Technical testing and analysis	30	50	120	90	60	75	425	5,680
Specialised design activities	160	235	390	240	215	470	1,710	21,190
Environmental consulting activities	30	40	100	65	50	45	335	3,040
Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying)	275	375	800	625	415	640	3,125	35,945
Resilience, Environment & Sustainability	1,605	3,650	5,700	3,975	4,030	6,335	25,295	308,915
All enterprises	23,145	27,540	69,185	38,875	28,175	42,210	229,125	2,382,370

Source: ONS Business Counts, NOMIS

Table 81 Location quotients for share of enterprises in the resilience, environment and sustainability sector; consortium sub-area: 2015

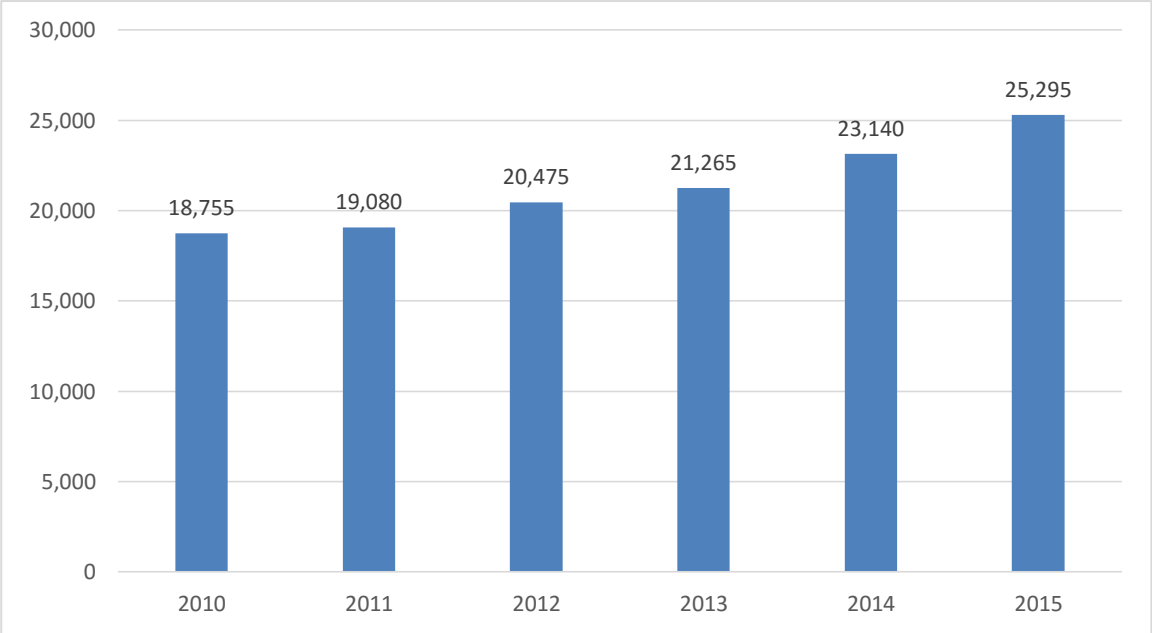
	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area
Botanical and zoological gardens and nature reserve activities	2.90	2.44	2.42	0.86	1.19	0.79	1.76
Water collection, treatment and supply	0.00	0.00	2.03	0.00	0.00	3.32	1.22
Sewerage	1.12	0.95	1.13	1.34	0.92	1.23	1.14
Collection of non-hazardous waste	0.69	0.77	0.77	1.37	0.95	1.14	0.95
Collection of hazardous waste	0.00	0.00	1.57	5.57	0.00	0.00	1.42
Treatment and disposal of non-hazardous waste	0.56	0.47	1.12	1.33	1.38	0.92	1.02
Treatment and disposal of hazardous waste	0.00	0.00	3.44	3.06	0.00	0.00	1.56
Dismantling of wrecks	0.00	0.00	2.87	0.00	0.00	0.00	0.87
Recovery of sorted materials	0.58	0.97	0.87	1.89	1.18	1.11	1.11
Remediation activities and other waste management services	0.69	0.58	0.46	1.65	0.00	0.76	0.70
Passenger rail transport, interurban	0.00	0.00	2.87	0.00	0.00	0.00	0.87
Satellite telecommunications activities	0.00	0.00	0.00	0.00	2.92	1.95	1.08
Data processing, hosting and related activities	0.50	0.98	0.56	0.60	1.24	1.19	0.81
Non-life insurance	0.82	0.69	0.27	0.97	0.67	0.90	0.58
Non-life reinsurance	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Research and experimental development on biotechnology	0.80	0.68	0.27	0.96	0.66	0.88	0.65
Other research and experimental development on natural sciences and engineering	0.74	0.99	0.64	0.88	0.97	1.05	0.86
Manufacture of other inorganic basic chemicals	0.00	0.00	0.00	3.23	0.00	0.00	1.09
Manufacture of other organic basic chemicals	0.00	0.00	0.00	2.45	0.00	0.00	0.83
Manufacture of basic pharmaceutical products	0.00	0.00	1.01	0.00	2.49	0.00	0.61
Manufacture of	0.00	1.12	0.89	0.80	0.00	0.73	0.81

pharmaceutical preparations							
Business and domestic software development	0.37	0.99	0.49	0.74	1.08	1.18	0.78
Computer consultancy activities	0.27	1.04	0.45	0.60	1.30	1.16	0.76
Computer facilities management activities	0.00	0.71	0.57	1.01	1.40	0.93	0.77
Other information technology and computer service activities	0.59	1.55	0.79	0.84	1.36	1.45	1.06
Architectural activities	0.79	0.97	0.85	0.79	0.92	1.07	0.90
Urban planning and landscape architectural activities	0.81	1.36	0.90	0.80	1.33	1.78	1.12
Engineering design activities for industrial process and production	0.54	0.94	0.63	0.72	1.06	1.34	0.85
Engineering related scientific and technical consulting activities	0.78	0.95	0.78	0.93	0.99	1.09	0.91
Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)	0.55	1.03	0.72	0.79	0.99	1.19	0.87
Technical testing and analysis	0.54	0.76	0.73	0.97	0.89	0.75	0.78
Specialised design activities	0.78	0.96	0.63	0.69	0.86	1.25	0.84
Environmental consulting activities	1.02	1.14	1.13	1.31	1.39	0.84	1.15
Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying)	0.79	0.90	0.77	1.07	0.98	1.00	0.90
Resilience, Environment & Sustainability	0.53	1.02	0.64	0.79	1.10	1.16	0.85

Source: ONS Business Counts, NOMIS

As with employment, the number of enterprises has grown strongly over the last 5 years (Figure 4) albeit at a slightly slower rate than the Great Britain average (35% compared to 40%).

Figure 8 Number of enterprises within the resilience, environment and sustainability sector; consortium area: 2010 to 2015



Source: ONS Business Counts, NOMIS

Table 82 Change in number of enterprises within the resilience, environment and sustainability sector; consortium area and Great Britain: 2010 to 2015

Sub-sector	Consortium area		Great Britain
	Change in number of enterprises	% change in enterprises	% change in enterprises
Botanical and zoological gardens and nature reserve activities	10	20	15
Water collection, treatment and supply	-10	-50	-32
Sewerage	-15	-13	0
Collection of non-hazardous waste	20	11	20
Collection of hazardous waste	10	200	120
Treatment and disposal of non-hazardous waste	30	50	48
Treatment and disposal of hazardous waste	10	200	186
Dismantling of wrecks	0	0	200
Recovery of sorted materials	-15	-7	1
Remediation activities and other waste management services	30	150	176
Passenger rail transport, interurban	-5	-50	-29
Satellite telecommunications activities	5	50	38
Data processing, hosting and related activities	30	14	16
Non-life insurance	-35	-50	-44
Non-life reinsurance	0	-	50
Research and experimental development on biotechnology	25	167	178
Other research and experimental development on natural sciences and engineering	-10	-3	15
Manufacture of other inorganic basic chemicals	0	0	-5
Manufacture of other organic basic chemicals	0	0	-11
Manufacture of basic pharmaceutical products	5	100	62
Manufacture of pharmaceutical preparations	5	20	18
Business and domestic software development	1,270	141	135
Computer consultancy activities	1,540	30	36
Computer facilities management activities	35	350	210
Other information technology and computer service activities	-535	-21	-21
Architectural activities	225	26	34
Urban planning and landscape architectural activities	100	95	72
Engineering design activities for industrial process and production	495	95	88
Engineering related scientific and technical consulting activities	530	62	68

Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)	370	11	17
Technical testing and analysis	80	23	48
Specialised design activities	425	33	36
Environmental consulting activities	225	205	212
Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying)	1,695	119	99
Resilience, Environment & Sustainability	6,540	35	40
All industries	25,700	13	17

Source: ONS Business Counts, NOMIS

Table 83 Enterprise indicators for the resilience, environment and sustainability sector by LEP areas and South East Wales: 2010-15

Rank of %	LEP area	%, 2015	Change, 2010 to 2015	
			Number	%
1	Thames Valley Berkshire	21.7	2,495	39
2	Tees Valley	20.1	1,330	67
3	Enterprise M3	17.3	3,115	31
4	Hertfordshire	15.8	2,265	35
5	Coventry and Warwickshire	15.7	1,630	43
6	London	15.5	25,420	58
7	Coast to Capital	15.3	3,095	32
8	West of England	15.0	1,780	39
9	Cheshire and Warrington	14.9	1,430	33
10	Buckinghamshire Thames Valley	14.8	880	26
11	Oxfordshire	14.4	845	24
12	Swindon and Wiltshire	14.3	1,035	35
13	South East Midlands	14.1	2,800	37
14	Solent	13.3	1,055	27
15	Gloucestershire	13.3	875	32
16	Greater Cambridge and Greater Peterborough	13.2	1,565	26
17	South East	12.2	4,745	33
18	Greater Manchester	12.0	2,610	34
19	Liverpool City Region	11.9	1,360	44
20	Greater Birmingham and Solihull	11.5	1,670	31
21	North Eastern	11.3	1,695	44
22	Worcestershire	11.2	395	17
23	Dorset	11.1	635	23
24	Northamptonshire	11.1	880	36
25	Derby, Derbyshire, Nottingham and Nottinghamshire	10.9	1,665	29
26	Leeds City Region	10.8	3,310	45
27	Leicester and Leicestershire	10.3	1,115	40
28	South East Wales	10.2	1,155	41
29	Cumbria	10.0	590	34
30	New Anglia	9.9	1,160	24
31	Lancashire	9.9	945	24
32	Sheffield City Region	9.8	1,160	29
33	Stoke-on-Trent and Staffordshire	9.7	770	28
34	Humber	9.3	660	33
35	York, North Yorkshire and East Riding	9.3	1,195	34
36	Black Country	9.2	545	24
37	The Marches	8.7	565	28
38	Greater Lincolnshire	8.5	555	22
39	Heart of the South West	8.2	1,200	27
40	Cornwall and Isles of Scilly	6.9	490	44

Source: ONS Business Counts, NOMIS

Table 84 Enterprises by employment size band; consortium area and Great Britain: 2015

Employment Size band	Consortium area			Great Britain
	No. environment	% environment	% all sectors	% environment
0 to 4	22,160	87.6	75.2	88.5
5 to 9	1,690	6.7	13.3	5.9
10 to 19	815	3.2	6.4	3.0
20 to 49	390	1.5	3.3	1.6
50 to 99	125	0.5	1.0	0.5
100 to 249	65	0.3	0.5	0.3
250 to 499	20	0.1	0.2	0.1
500 to 999	15	0.1	0.1	0.0
1000+	15	0.1	0.1	0.0
Total	25,295	100.0	100.0	100.0

Source: ONS Business Counts, NOMIS

Table 85 Enterprises by legal status: consortium area and Great Britain: 2015

Employment Size band	Consortium area			England & Wales
	No. environment	% environment	% all sectors	% environment
Private sector total	25,270	99.9	99.3	100.0
Company (including building society)	21,935	86.7	58.3	90.1
Sole proprietor	2,595	10.3	23.6	7.8
Partnership	590	2.3	13.8	1.6
Non-profit body or mutual association	150	0.6	3.6	0.5
Public sector total	25	0.1	0.7	0.0
Public corporation	5	0.0	0.0	0.0
Central government	5	0.0	0.2	0.0
Local authority	15	0.1	0.5	0.0
Total	25,295	100.0	100.0	100.0

Replacement demand

Table 86 Change in employment by occupation, microelectronics, 2014 - 2024

Occupation	**2014**	**%**	**2024**	**%**
1. Managers, directors and senior officials	4,200	14%	3,100	16%
2. Professional occupations	5,900	20%	4,300	22%
3. Associate professional and technical	4,200	14%	3,000	15%
4. Administrative and secretarial	1,900	6%	1,300	7%
5. Skilled trades occupations	5,900	20%	3,700	18%
6. Caring, leisure and other service	200	1%	100	1%
7. Sales and customer service	900	3%	600	3%
8. Process, plant and machine operatives	5,300	18%	2,800	14%
9. Elementary occupations	1,300	4%	800	4%
Total	29,800	100%	19,800	100%
Higher level occupations	14,300	48%	10,400	53%

Source: Working Futures

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Table 87 Change in employment by qualification level required, microelectronics, 2014 - 2024

Qualification Level	2014	%	2024	%
QCF4+	10,600	36%	9,400	47%
QCF3	8,100	27%	4,800	24%
QCF2	5,900	20%	3,900	19%
QCF Below L2 / no quals	5,200	17%	1,800	9%
Total	29,800	100%	19,800	100%

Source: Working Futures

Table 88 Total requirement for labour by occupation, microelectronics, 2014 - 2024

Occupation	Base year employment (2014)	Expansion Demand	Replacement Demand	Net Requirement
Managers, directors and senior officials	4,200	-1,100	1,400	300
Professional occupations	5,900	-1,600	1,800	200
Associate professional and technical	4,200	-1,200	1,300	100
Administrative and secretarial	1,900	-600	800	200
Skilled trades occupations	5,900	-2,300	1,900	-400
Caring, leisure and other service	200	0	100	100
Sales and customer service	900	-200	300	100
Process, plant and machine operatives	5,300	-2,500	1,700	-800
Elementary occupations	1,300	-400	400	0
Total	29,800	-9,900	9,700	-200

Source: Working Futures

Table 89 Total requirement for labour by qualification level required, microelectronics, 2014 – 2024

Occupation	Base year employment (2014)	Expansion Demand	Replacement Demand	Net Requirement
QCF4+	10,600	-1,200	4,000	2,800
QCF3	8,100	-3,300	2,200	-1,100
QCF2	5,900	-2,000	2,100	100
QCF Below L2 / no quals	5,200	-3,400	1,300	-2,100
Total	29,800	-9,900	9,600	-300

Source: Working Futures

Employment

The microelectronics theme accounts for 18,500 employee jobs across the consortia area. The largest sectors are: manufacture of electronic instruments and appliances for measuring, testing, and navigation, expect for industrial process control equipment (7,400), manufacture of electronic components (3,100) and manufacture of loaded electronic boards (2,400).

Taken as whole, the sector accounts for a larger share of employee jobs (0.71%) to the Great Britain average (0.39%) with higher concentrations – as demonstrated by the highest location quotients within:

- Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment in South East Wales (10.47) and Gloucestershire (2.23)
- Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control equipment in Gloucestershire (9.92)
- Manufacture of loaded electronic boards in Gloucestershire (7.29), South East Wales (4.58) and Swindon & Wiltshire (2.52)
- Manufacture of electronic components in South East Wales (6.51)
- Manufacture of irradiation, electro medical and electrotherapeutic equipment in South East Wales (5.54)
- Repair of electronic and optical equipment in South East Wales (3.07)
- Manufacture of telegraph and telephone apparatus and equipment in South East Wales (2.79)
- Manufacture of electronic industrial process control equipment in South East Wales (2.68) and Heart of the South West (2.58).

Table 90 Employee jobs in the microelectronics sector; consortium sub-area: 2014

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area	Great Britain
Repair of electronic and optical equipment	!	!	-	300	!	-	700	4,800
Manufacture of electronic components	!	-	600	2,100	300	-	3,100	14,700
Manufacture of loaded electronic boards	100	800	!	1,000	300	100	2,400	10,600
Manufacture of computers and peripheral equipment	-	!	-	100	-	!	1,100	8,300
Manufacture of telegraph and telephone apparatus and equipment	100	100	100	700	100	-	1,100	11,500
Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment)	!	100	100	1,100	-	!	1,300	5,000
Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control equipment	100	4,400	1,300	700	200	700	7,400	44,100
Manufacture of electronic industrial process control equipment	-	100	300	300	!	!	700	4,800
Manufacture of irradiation, electromedical and electrotherapeutic equipment	!	!	!	600	!	-	700	5,100
Microelectronics	400	6,000	2,700	6,900	1,100	1,600	18,500	109,000
All excluding farms	197,400	276,600	680,400	594,700	303,800	559,300	2,612,100	27,777,800

Source: BRES via NOMIS

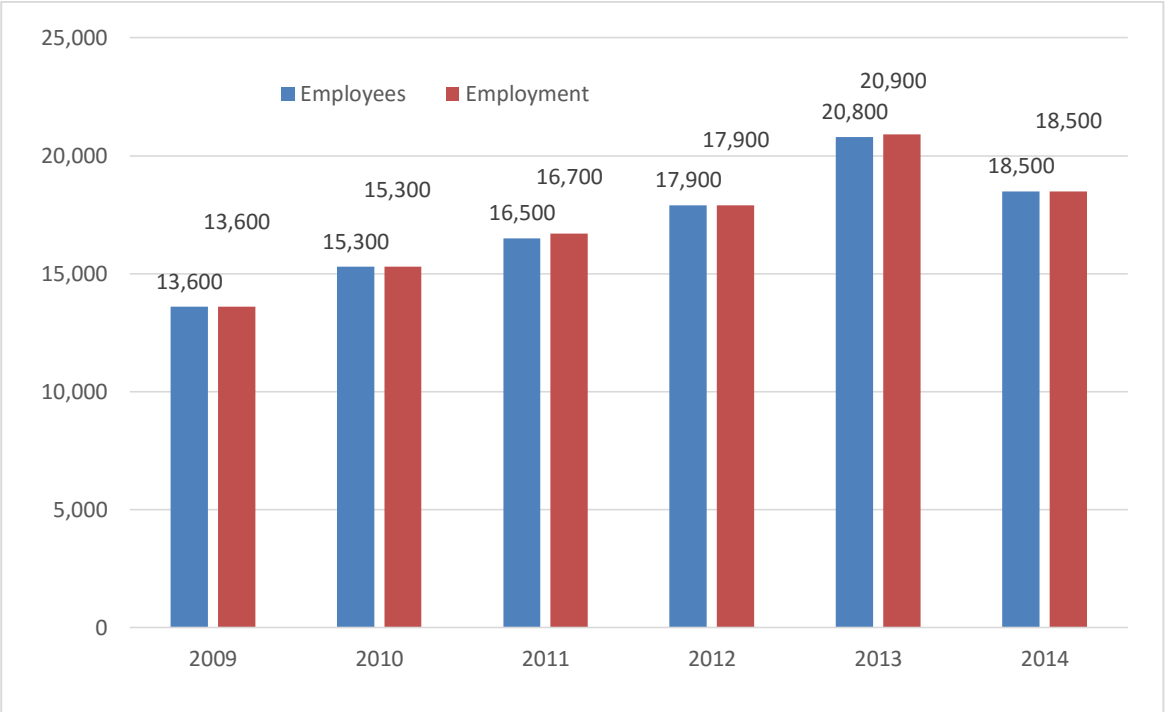
Table 91 Location Quotients for employee jobs in the microelectronics sector; consortium area: 2014

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area
Repair of electronic and optical equipment	!	!	0.32	3.07	!	0.37	1.47
Manufacture of electronic components	!	0.27	1.67	6.51	1.87	0.08	2.22
Manufacture of loaded electronic boards	1.14	7.29	!	4.58	2.52	0.25	2.45
Manufacture of computers and peripheral equipment	0.12	!	0.17	0.53	0.53	!	1.40
Manufacture of telegraph and telephone apparatus and equipment	1.39	0.85	0.38	2.79	0.61	0.20	1.04
Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment)	!	2.23	0.41	10.47	0.11	!	2.74
Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control equipment	0.22	9.92	1.22	0.73	0.51	0.80	1.78
Manufacture of electronic industrial process control equipment	0.00	1.28	2.58	2.68	!	!	1.54
Manufacture of irradiation, electromedical and electrotherapeutic equipment	!	!	!	5.54	!	0.00	1.44
Microelectronics	0.46	5.48	0.99	2.95	0.88	0.72	1.80

Source: BRES via NOMIS

Employment levels within microelectronics have increased most years since 2009. Total employment in the sector in 2014 was more than one-third (36%) than in 2009. This growth is substantially higher than that recorded across the sector nationally (2%) and the expansion in employment opportunities across all sectors locally (1%).

Figure 9 Total employment and employee jobs in the microelectronics sector; consortium area: 2009 to 2014



Source: BRES, ONS via NOMIS

Table 92 Employment indicators for the microelectronics sector by LEP areas and South East Wales: 2009 and 2004

Rank of %	LEP area	%, 2014	Change, 2009 to 2014	
			Number	%
1	Gloucestershire	2.08	1,100	22
2	South East Wales	1.13	3,600	108
3	Solent	1.00	400	11
4	Oxfordshire	0.85	0	0
5	Buckinghamshire Thames Valley	0.81	-300	-13
6	Worcestershire	0.79	400	26
7	Greater Cambridge and Greater Peterborough	0.76	-100	-3
8	Coast to Capital	0.73	1,300	28
9	South East	0.67	1,700	19
10	Enterprise M3	0.60	700	16
11	Hertfordshire	0.59	900	33
12	Dorset	0.56	200	11
13	Stoke-on-Trent and Staffordshire	0.53	100	2
14	South East Midlands	0.52	-1,300	-23
15	Leicester and Leicestershire	0.47	-400	-15
16	The Marches	0.40	300	35
17	Thames Valley Berkshire	0.39	-100	-4
18	Heart of the South West	0.37	-200	-6
19	Northamptonshire	0.37	300	30
20	Cheshire and Warrington	0.34	300	24
21	Swindon and Wiltshire	0.34	0	-1
22	Greater Manchester	0.31	-800	-17
23	Coventry and Warwickshire	0.31	300	24
24	Cumbria	0.31	-100	-11
25	New Anglia	0.30	-200	-9
26	Greater Lincolnshire	0.29	-200	-15
27	West of England	0.27	300	23
28	Lancashire	0.25	-200	-12
29	Greater Birmingham and Solihull	0.23	700	48
30	North Eastern	0.22	-2,600	-60
31	Derby, Derbyshire, Nottingham and Nottinghamshire	0.21	-100	-3
32	Black Country	0.18	200	23
33	Cornwall and Isles of Scilly	0.17	200	86
34	York, North Yorkshire and East Riding	0.16	-700	-46
35	Sheffield City Region	0.14	-800	-43
36	Tees Valley	0.14	-300	-41
37	Liverpool City Region	0.14	0	2
38	Leeds City Region	0.12	-1,200	-43
39	London	0.07	-2,100	-37
40	Humber	0.04	-200	-60

Source: BRES, 2014 via NOMIS

Enterprises

In 2015, there were 505 enterprises operating within the microelectronics sector across the consortium area (Table 50). The largest numbers of enterprises in:

- Manufacture of electronic instruments and appliances for measuring, testing, and navigation (145)
- Manufacture of telegraph and telephone apparatus and equipment (85)
- Manufacture of computers and peripheral equipment

The sector accounted for 0.2% of enterprises across the consortium area, the same as the Great Britain average but with particularly high concentrations in the following sub-sectors:

- Manufacture of irradiation, electromedical and electrotherapeutic equipment in South East Wales (2.79)
- Manufacture of loaded electronic boards in Gloucestershire (2.62)
- Manufacture of electronic industrial and process control equipment in South East Wales (2.45).

Table 93 Number of enterprises in the microelectronics sector; consortium sub area: 2015

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area	Great Britain
Repair of electronic and optical equipment	5	5	5	5	5	5	30	350
Manufacture of electronic components	5	5	20	10	10	15	65	595
Manufacture of loaded electronic boards	5	10	0	10	5	5	35	330
Manufacture of computers and peripheral equipment	5	15	20	10	15	20	85	895
Manufacture of telegraph and telephone apparatus and equipment	5	15	25	15	15	10	85	940
Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment)	5	5	5	10	5	0	25	320
Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control equipment	10	20	50	15	20	30	145	1,490
Manufacture of electronic industrial process control equipment	0	5	5	10	0	5	25	250
Manufacture of irradiation, electromedical and electrotherapeutic equipment	0	0	0	5	0	0	10	110
Microelectronics	40	80	130	85	75	90	505	5,280
All industries	23,145	27,540	69,185	38,875	28,175	42,210	229,125	2,382,370

Source: ONS Business Counts, NOMIS

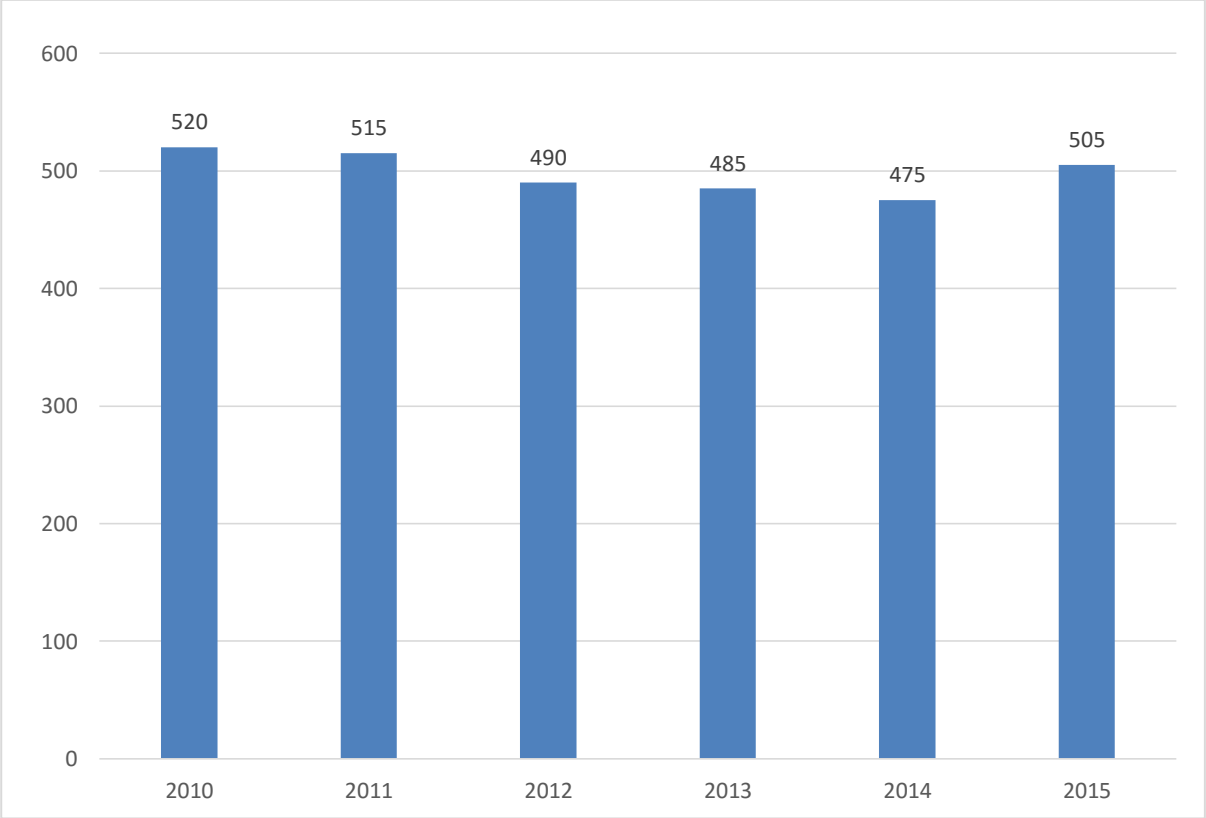
Table 94 Location quotients for share of enterprises in the microelectronics sector; consortium sub-area: 2015

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area
Repair of electronic and optical equipment	1.47	1.24	0.49	0.88	1.21	0.81	0.89
Manufacture of electronic components	0.86	0.73	1.16	1.03	1.42	1.42	1.14
Manufacture of loaded electronic boards	1.56	2.62	0.00	1.86	1.28	0.86	1.10
Manufacture of computers and peripheral equipment	0.58	1.45	0.77	0.68	1.42	1.26	0.99
Manufacture of telegraph and telephone apparatus and equipment	0.55	1.38	0.92	0.98	1.35	0.60	0.94
Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment)	1.61	1.35	0.54	1.92	1.32	0.00	0.81
Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control equipment	0.69	1.16	1.16	0.62	1.13	1.14	1.01
Manufacture of electronic industrial process control equipment	0.00	1.73	0.69	2.45	0.00	1.13	1.04
Manufacture of irradiation, electromedical and electrotherapeutic equipment	0.00	0.00	0.00	2.79	0.00	0.00	0.95
Microelectronics	0.78	1.31	0.85	0.99	1.20	0.96	0.99

Source: ONS Business Counts, NOMIS

The number of microelectronics enterprises in the consortium decreased by 3% between 2009 and 2015 and while this is a smaller decline than average for the sector across Great Britain (4%) it compared to growth of 13% across all industries within the consortium area.

Figure 10 Number of enterprises within the microelectronics sector; consortium area: 2010 to 2015



Source: ONS Business Counts, NOMIS

Table 95 Change in number of enterprises within the microelectronics sector; consortium area and Great Britain: 2010 to 2015

Sub-sector	Consortium area		Great Britain
	Change in number of enterprises	% change in enterprises	% change in enterprises
Repair of electronic and optical equipment	20	200	60
Manufacture of electronic components	0	0	-1
Manufacture of loaded electronic boards	0	0	-3
Manufacture of computers and peripheral equipment	15	21	1
Manufacture of telegraph and telephone apparatus and equipment	-50	-37	-54
Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment)	10	67	47
Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control equipment	-5	-3	-7
Manufacture of electronic industrial process control equipment	0	0	-8
Manufacture of irradiation, electromedical and electrotherapeutic equipment	-5	-33	32
Microelectronics	-15	-3	-5
All industries	25,700	13	15

Source: ONS Business Counts, NOMIS

Table 96 Enterprise indicators for the microelectronics sector by LEP areas and South East Wales: 2010 and 2015

Rank of %	LEP area	%, 2015	Change, 2010 to 2015	
			Number	%
1	Greater Cambridge and Greater Peterborough	0.46	-20	-7
2	Thames Valley Berkshire	0.38	5	3
3	Solent	0.36	-20	-13
4	Oxfordshire	0.35	5	5
5	South East Midlands	0.33	-30	-11
6	Buckinghamshire Thames Valley	0.33	-5	-5
7	Hertfordshire	0.32	0	0
8	Worcestershire	0.32	-15	-17
9	Dorset	0.31	-15	-14
10	Enterprise M3	0.30	-35	-13
11	Coast to Capital	0.29	-20	-8
12	Gloucestershire	0.29	5	7
13	Stoke-on-Trent and Staffordshire	0.27	-5	-5
14	Tees Valley	0.27	10	29
15	Greater Manchester	0.27	15	7
16	Northamptonshire	0.27	10	14
17	Swindon and Wiltshire	0.27	-25	-25
18	Leicester and Leicestershire	0.26	-10	-9
19	New Anglia	0.25	-15	-9
20	South East	0.25	-30	-7
21	Cheshire and Warrington	0.24	-5	-5
22	Derby, Derbyshire, Nottingham and Nottinghamshire	0.24	-20	-11
23	Coventry and Warwickshire	0.23	-5	-6
24	North Eastern	0.23	-10	-8
25	Sheffield City Region	0.23	-10	-8
26	South East Wales	0.22	-10	-11
27	The Marches	0.22	5	8
28	West of England	0.21	10	13
29	Greater Birmingham and Solihull	0.21	-5	-4
30	Leeds City Region	0.20	-25	-11
31	Lancashire	0.19	0	0
32	Heart of the South West	0.19	0	0
33	Black Country	0.18	-10	-15
34	York, North Yorkshire and East Riding	0.18	0	0
35	Cornwall and Isles of Scilly	0.17	0	0
36	Liverpool City Region	0.16	-5	-8
37	Humber	0.16	0	0
38	Cumbria	0.15	-5	-13
39	Greater Lincolnshire	0.14	-15	-23
40	London	0.11	-20	-4

Source: ONS Business Counts, NOMIS

Table 97 Enterprises by employment size band; consortium area and Great Britain: 2015

Employment Size band	Consortium area			Great Britain
	No. Microelectronic	% microelectronic	% all sectors	% microelectronic
0 to 4	300	59.4	75.2	62.0
5 to 9	75	14.9	13.3	14.0
10 to 19	55	10.9	6.4	9.4
20 to 49	35	6.9	3.3	7.7
50 to 99	15	3.0	1.0	3.4
100 to 249	15	3.0	0.5	2.3
250 to 499	5	1.0	0.2	0.8
500 to 999	0	0.0	0.1	0.3
1000+	0	0.0	0.1	0.2
Total	505	100.0	100.0	100.0

Source: ONS Business Counts, NOMIS

Table 98 Enterprises by legal status: consortium area and Great Britain: 2015

Employment Size band	Consortium area			England & Wales
	No. Microelectronic	% microelectronic	% all sectors	% microelectronic
Private sector total	505	100.0	99.3	100.0
Company (including building society)	435	86.1	58.3	87.0
Sole proprietor	55	10.9	23.6	9.3
Partnership	15	3.0	13.8	3.5
Non-profit body or mutual association	0	0.0	3.6	0.2
Public sector total	0	0.0	0.7	0.0
Public corporation	0	0.0	0.0	0.0
Central government	0	0.0	0.2	0.0
Local authority	0	0.0	0.5	0.0
Total	505	100.0	100.0	100.0

Source: ONS Business Counts, NOMIS

Replacement demand

Table 99 Change in employment by occupation, new energy systems, 2014 - 2024

Occupation	2014	%	2024	%
1. Managers, directors and senior officials	1,300	9%	1,700	11%
2. Professional occupations	2,400	17%	3,000	19%
3. Associate professional and technical	2,000	14%	2,400	15%
4. Administrative and secretarial	1,800	13%	1,700	10%
5. Skilled trades occupations	3,000	21%	3,200	20%
6. Caring, leisure and other service	300	2%	400	2%
7. Sales and customer service	1,900	13%	2,100	13%
8. Process, plant and machine operatives	1,300	9%	1,300	8%
9. Elementary occupations	300	2%	300	2%
Total	14,300	100%	16,100	100%
Higher level occupations	5,700	40%	7,100	44%

Source: Working Futures

Table 100 Change in employment by qualification level required, new energy systems, 2014 - 2024

Qualification Level	2014	%	2024	%
QCF4+	5,800	41%	8,500	53%
QCF3	3,700	26%	3,100	19%
QCF2	2,600	18%	2,800	17%
QCF Below L2 / no quals	2,100	15%	1,700	11%
Total	**14,200**	**100%**	**16,100**	**100%**

Source: Working Futures

Table 101 Total requirement for labour by occupation, new energy systems, 2014 -2024

Occupation	Base year employment (2014)	Expansion Demand	Replacement Demand	Net Requirement
Managers, directors and senior officials	1,300	400	600	1,000
Professional occupations	2,400	600	900	1,500
Associate professional and technical	2,000	400	700	1,100
Administrative and secretarial	1,800	-100	800	700
Skilled trades occupations	3,000	200	1,000	1,200
Caring, leisure and other service	300	100	100	200
Sales and customer service	1,900	200	600	800
Process, plant and machine operatives	1,300	100	400	500
Elementary occupations	300	0	100	100
Total	14,300	1,900	5,200	7,100

Source: Working Futures

Table 102 Total requirement for labour by qualification level required, new energy systems, 2014 – 2024

Occupation	Base year employment (2014)	Expansion Demand	Replacement Demand	Net Requirement
QCF4+	5,800	2,600	2,600	5,200
QCF3	3,700	-600	900	300
QCF2	2,600	100	700	800
QCF Below L2 / no quals	2,100	-400	1,000	600
Total	14,200	1,700	5,200	6,900

Source: Working Futures

Employment

The new energy systems theme accounts for 184,100 employee jobs across the consortia area. The largest sectors are: other engineering activities (24,600), electrical installation (23,200) and other telecommunications activities (15,000) Table 47).

Taken as whole, the sector accounts for the same share of employee jobs (7%) to the Great Britain average (7%) but with notably higher concentrations of employee jobs (Table 104) in

- Manufacture of batteries and accumulators (4.66)
- Manufacture of fibre optic cables (2.97)

- Manufacture of communication equipment (2.74) particularly in South East Wales (10.47)
- Repair and maintenance of aircraft and space craft (2.62) particularly in South East Wales (7.16).
- Manufacture of other taps and valves (2.60) particularly in Gloucestershire (15.38)
- Manufacture of loaded electronic boards (2.45) especially in Gloucestershire (7.29)
- Manufacture of electronic components (2.22) especially in South East Wales (6.51).

Table 103 Employee jobs in the new energy sector; consortium sub-area: 2014

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortium area	Great Britain
Other research and experimental development on natural sciences and engineering	400	600	600	600	4,900	1,300	8,300	107,000
Other information technology and computer service activities	300	1,800	1,500	2,400	1,100	2,800	10,000	122,100
Wired telecommunications activities	0	0	0	100	100	100	400	7,000
Wireless telecommunications activities	0	100	300	100	100	100	700	16,200
Satellite telecommunications activities	!	!	!	!	100	0	300	9,400
Other telecommunications activities	700	1,400	3,900	3,800	2,300	3,000	15,000	166,700
Wholesale of electronic and telecommunications equipment and parts	0	200	300	200	300	400	1,400	34,900
Wholesale of mining, construction and civil engineering machinery	0	0	100	200	0	100	600	8,100
Electrical installation	1,600	2,900	5,700	4,900	3,000	5,100	23,200	197,000
Other construction installation	200	400	800	1,000	400	700	3,500	38,500
Construction of utility projects for fluids	!	0	100	100	0	0	200	5,300
Construction of utility projects for electricity and telecommunications	!	0	!	0	!	0	200	10,200
Construction of other civil engineering projects nec	600	700	2,200	1,900	500	1,500	7,400	119,900
Production of electricity	200	1,600	1,000	500	100	200	3,500	28,100
Transmission of electricity	!	!	!	!	!	!	!	2,600
Distribution of electricity	!	!	900	2,100	400	600	4,700	37,100
Trade of electricity	!	!	0	0	!	0	400	1,900
Manufacture of gas	0	!	!	!	0	!	!	5,800
Distribution of gaseous fuels through mains	0	!	!	1,700	!	0	2,000	33,100
Trade of gas through mains	!	0	!	0	!	!	!	1,20

								0
Steam and air conditioning supply	0	!	0	0	0	!	!	400
Repair of fabricated metal products	0	0	100	500	0	100	700	7,600
Repair of machinery	100	200	500	1,100	100	400	2,400	34,200
Repair of electronic and optical equipment	!	!	0	300	!	0	700	4,800
Repair of electrical equipment	100	100	100	200	0	200	600	6,200
Repair and maintenance of ships and boats	500	0	200	100	0	0	1,000	7,600
Repair and maintenance of aircraft and spacecraft	400	400	400	2,800	100	300	4,500	18,300
Repair and maintenance of other transport equipment	0	0	100	700	0	100	900	9,800
Repair of other equipment	0	0	100	200	0	200	500	5,300
Installation of industrial machinery and equipment	100	200	300	300	100	1,500	2,400	20,400
Manufacture of electrical and electronic equipment for motor vehicles	!	!	!	0	!	0	100	2,500
Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	0	!	!	!	!	0	500	16,900
Manufacture of fluid power equipment	!	100	400	0	!	!	1,000	7,100
Manufacture of pumps	300	1,000	100	100	!	100	1,600	9,200
Manufacture of compressors	0	0	!	0	!	!	100	3,200
Manufacture of other taps and valves	!	1,300	200	300	100	!	2,100	8,800
Manufacture of bearings, gears, gearing and driving elements	!	300	!	100	!	300	1,400	8,600
Manufacture of ovens, furnaces and furnace burners	!	!	0	!	!	!	100	2,100
Manufacture of lifting and handling equipment	100	100	200	300	200	400	1,200	17,100
Manufacture of office machinery and equipment (except computers and peripheral equipment)	0	!	100	0	!	!	300	4,300
Manufacture of power-driven hand tools	0	0	0	0	0	0	0	600
Manufacture of non-domestic cooling and ventilation equipment	0	100	800	500	200	100	1,800	18,700
Manufacture of other general-purpose machinery nec	100	100	500	200	400	300	1,600	22,200
Manufacture of other special-purpose	!	0	300	500	!	200	1,00	8,30

machinery nec								0	0
Manufacture of electric motors, generators and transformers	!		0	700	!	!	!	1,300	12,300
Manufacture of electricity distribution and control apparatus		0	100	200	300	200	200	1,100	15,400
Manufacture of batteries and accumulators		0	0	100	!	!	0	800	1,700
Manufacture of fibre optic cables		0	0	!	!	!	0	300	1,200
Manufacture of other electronic and electric wires and cables	!		200	!	!	900	0	1,300	9,200
Manufacture of wiring devices		0	!	0	0	!	!	200	3,200
Manufacture of electric lighting equipment	!		!	100	0	!	!	400	13,900
Manufacture of other electrical equipment	!		200	200	0	200	0	800	8,700
Manufacture of electronic components	!		0	600	2,100	300	0	3,100	14,700
Manufacture of loaded electronic boards		100	800	!	1,000	300	100	2,400	10,600
Manufacture of computers and peripheral equipment		0	!	0	100	0	!	1,100	8,300
Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment)	!		100	100	1,100	0	!	1,300	5,000
Manufacture of consumer electronics	!		100	100	100	!	0	400	5,700
Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control equipment		100	4,400	1,300	700	200	700	7,400	44,100
Manufacture of electronic industrial process control equipment		0	100	300	300	!	!	700	4,800
Manufacture of non-electronic instruments and appliances for measuring, testing and navigation, except industrial process control equipment	!		0	!	200	!	100	400	5,000
Manufacture of non-electronic industrial process control equipment	!		!	!	!	!	!	300	1,700
Manufacture of irradiation, electromedical and electrotherapeutic equipment	!		!	!	600	!	0	700	5,100
Manufacture of optical precision instruments	!		0	!	!	!	!	400	4,100
Manufacture of photographic and cinematographic equipment		0	!	!	!	0	0	0	1,100
Manufacture of magnetic and optical media		0	0	0	0	!	0	!	200

Manufacture of central heating radiators and boilers	0	!	0	!	!	!	!	4,800
Manufacture of other tanks, reservoirs and containers of metal	0	!	0	100	!	100	200	4,700
Manufacture of steam generators, except central heating hot water boilers	0	0	!	100	0	!	200	1,900
Manufacture of wire products, chain and springs	!	!	!	100	0	0	300	7,500
Support activities for petroleum and natural gas extraction	!	0	0	!	!	!	0	25,100
Engineering design activities for industrial process and production	200	500	1,100	800	800	3,200	6,600	55,900
Engineering related scientific and technical consulting activities	800	800	2,500	1,400	800	1,500	7,900	73,400
Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)	800	3,100	4,300	5,300	2,900	8,100	24,600	234,300
Technical testing and analysis	200	300	600	300	600	1,100	3,000	51,800
Environmental consulting activities	100	100	300	300	100	200	1,000	9,600
Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying)	300	500	2,900	700	600	1,300	6,300	73,000
New Energy Systems	9,200	26,900	39,100	45,600	24,300	38,900	184,100	1,914,400
All (excluding Farms)	197,400	276,600	680,400	594,700	303,800	559,300	2,612,100	27,777,800

Table 104 Location quotients of employee jobs in the new energy sector; consortium sub-area: 2014

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortium area
Other research and experimental development on natural sciences and engineering	0.46	0.52	0.24	0.26	4.20	0.59	0.83
Other information technology and computer service activities	0.38	1.45	0.50	0.94	0.82	1.15	0.87
Wired telecommunications activities	0.08	0.29	0.28	0.97	0.72	0.83	0.59
Wireless telecommunications activities	0.03	0.44	0.78	0.39	0.28	0.46	0.47
Satellite telecommunications activities	!	!	!	!	1.19	0.05	0.32
Other telecommunications activities	0.58	0.84	0.95	1.05	1.26	0.88	0.95
Wholesale of electronic & telecommunications equipment and parts	0.06	0.45	0.30	0.33	0.83	0.55	0.42
Wholesale of mining, construction and civil engineering machinery	0.61	0.58	0.56	1.29	0.42	0.83	0.77
Electrical installation	1.14	1.48	1.19	1.17	1.39	1.27	1.25
Other construction installation	0.63	1.10	0.86	1.16	1.05	0.94	0.98
Construction of utility projects for fluids	!	0.04	0.59	0.58	0.07	0.03	0.31
Construction of utility projects for electricity and telecommunications	!	0.21	!	0.13	!	0.15	0.23
Construction of other civil engineering projects nec	0.71	0.59	0.73	0.76	0.40	0.63	0.66
Production of electricity	0.90	5.69	1.45	0.80	0.38	0.29	1.34
Transmission of electricity	!	!	!	!	!	!	!
Distribution of electricity	!	!	0.99	2.67	1.06	0.87	1.34
Trade of electricity	!	!	0.38	0.49	!	0.13	1.98
Manufacture of gas	0.00	!	!	!	0.00	!	!
Distribution of gaseous fuels through mains	0.00	!	!	2.45	!	0.00	0.66
Trade of gas through mains	!	0.00	!	0.00	!	!	!
Steam and air conditioning supply	0.00	!	0.00	0.00	0.00	!	!
Repair of fabricated metal products	0.26	0.50	0.62	2.90	0.45	0.45	1.04
Repair of machinery	0.46	0.63	0.55	1.43	0.30	0.62	0.74
Repair of electronic and optical equipment	!	!	0.32	3.07	!	0.37	1.47
Repair of electrical equipment	1.36	0.84	0.36	1.39	0.65	1.48	1.00
Repair and maintenance of ships and boats	10.12	0.55	1.23	0.75	0.00	0.13	1.34
Repair and maintenance of aircraft and spacecraft	3.25	2.29	1.00	7.16	0.36	0.92	2.62
Repair and maintenance of other transport equipment	0.47	0.11	0.38	3.30	0.25	0.41	1.02
Repair of other equipment	0.58	0.36	0.60	1.96	0.65	1.55	1.10

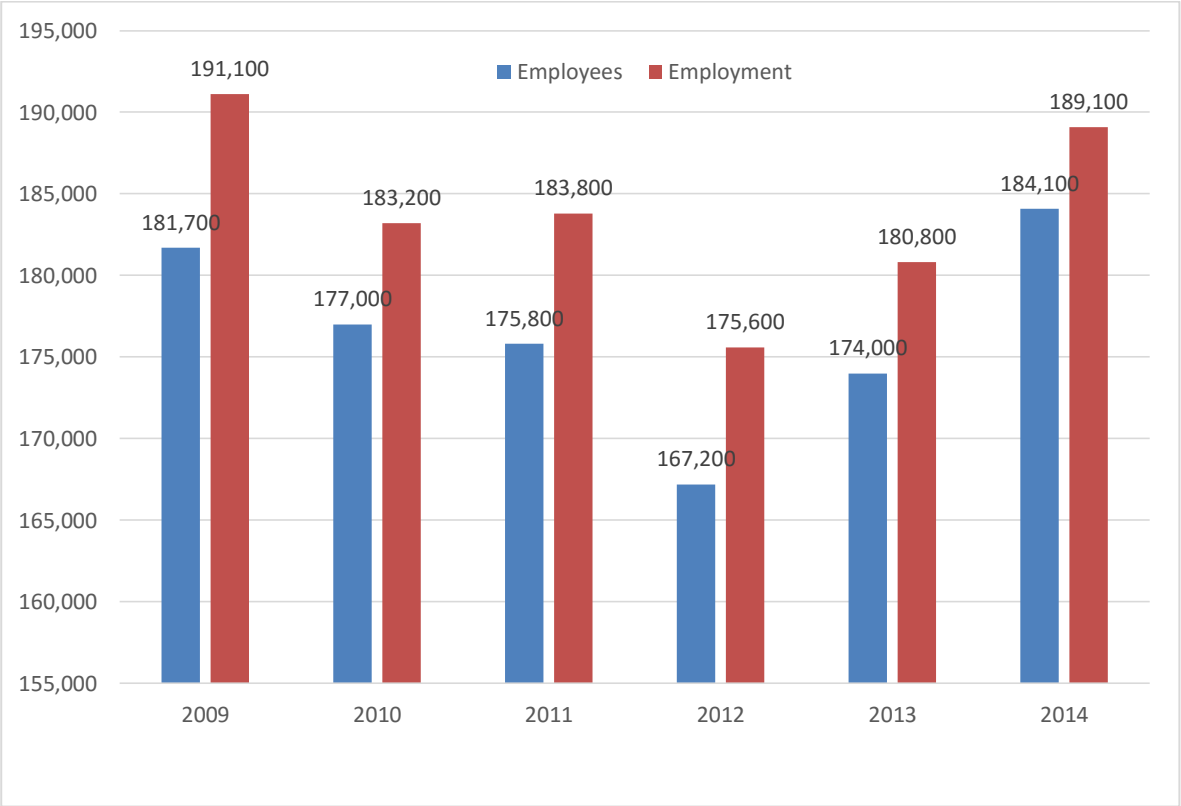
Installation of industrial machinery and equipment	0.37	0.82	0.57	0.60	0.63	3.65	1.25
Manufacture of electrical & electronic equipment for motor vehicles	!	!	!	0.00	!	0.12	0.39
Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	0.10	!	!	!	!	0.07	0.34
Manufacture of fluid power equipment	!	1.91	2.22	0.04	!	!	1.47
Manufacture of pumps	4.71	11.41	0.32	0.40	!	0.39	1.83
Manufacture of compressors	0.00	0.41	!	0.00	!	!	0.19
Manufacture of other taps and valves	!	15.38	1.03	1.51	1.15	!	2.60
Manufacture of bearings, gears, gearing and driving elements	!	3.45	!	0.33	!	1.88	1.69
Manufacture of ovens, furnaces and furnace burners	!	!	0.00	!	!	!	0.46
Manufacture of lifting and handling equipment	0.55	0.77	0.45	0.73	0.87	1.24	0.77
Manufacture of office machinery and equipment (except computers and peripheral equipment)	0.00	!	1.32	0.00	!	!	0.85
Manufacture of power-driven hand tools	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manufacture of non-domestic cooling and ventilation equipment	0.18	0.62	1.71	1.33	1.20	0.28	1.03
Manufacture of other general-purpose machinery nec	0.46	0.65	0.91	0.47	1.52	0.63	0.76
Manufacture of other special-purpose machinery nec	!	0.45	1.30	2.85	!	0.90	1.27
Manufacture of electric motors, generators and transformers	!	0.22	2.30	!	!	!	1.14
Manufacture of electricity distribution and control apparatus	0.08	0.78	0.58	1.04	1.15	0.77	0.78
Manufacture of batteries and accumulators	0.00	0.00	2.14	!	!	0.00	4.66
Manufacture of fibre optic cables	0.00	0.00	!	!	!	0.00	2.97
Manufacture of other electronic and electric wires and cables	!	2.17	!	!	8.64	0.02	1.46
Manufacture of wiring devices	0.00	!	0.00	0.00	!	!	0.52
Manufacture of electric lighting equipment	!	!	0.15	0.07	!	!	0.29
Manufacture of other electrical equipment	!	2.48	1.10	0.23	1.96	0.24	1.02
Manufacture of electronic components	!	0.27	1.67	6.51	1.87	0.08	2.22
Manufacture of loaded electronic boards	1.14	7.29	!	4.58	2.52	0.25	2.45
Manufacture of computers and peripheral equipment	0.12	!	0.17	0.53	0.53	!	1.40
Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment)	!	2.23	0.41	10.47	0.11	!	2.74
Manufacture of consumer electronics	!	1.15	0.45	0.73	!	0.25	0.81
Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control	0.22	9.92	1.22	0.73	0.51	0.80	1.78

equipment							
Manufacture of electronic industrial process control equipment	0.00	1.28	2.58	2.68	!	!	1.54
Manufacture of non-electronic instruments and appliances for measuring, testing and navigation, except industrial process control equipment	!	0.90	!	2.05	!	0.50	0.94
Manufacture of non-electronic industrial process control equipment	!	!	!	!	!	!	1.75
Manufacture of irradiation, electromedical and electrotherapeutic equipment	!	!	!	5.54	!	0.00	1.44
Manufacture of optical precision instruments	!	0.00	!	!	!	!	1.11
Manufacture of photographic and cinematographic equipment	0.00	!	!	!	0.00	0.00	0.30
Manufacture of magnetic and optical media	0.00	0.00	0.00	0.00	!	0.00	!
Manufacture of central heating radiators and boilers	0.00	!	0.00	!	!	!	!
Manufacture of other tanks, reservoirs and containers of metal	0.00	!	0.16	0.98	!	0.80	0.52
Manufacture of steam generators, except central heating hot water boilers	0.00	0.00	!	2.30	0.24	!	0.94
Manufacture of wire products, chain and springs	!	!	!	0.84	0.26	0.13	0.43
Support activities for petroleum and natural gas extraction	!	0.00	0.00	!	!	!	0.02
Engineering design activities for industrial process and production	0.43	0.93	0.83	0.68	1.24	2.86	1.26
Engineering related scientific and technical consulting activities	1.60	1.09	1.38	0.90	1.00	1.03	1.14
Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)	0.51	1.35	0.75	1.05	1.14	1.72	1.11
Technical testing and analysis	0.41	0.64	0.43	0.30	1.01	1.06	0.63
Environmental consulting activities	0.94	0.55	1.21	1.69	0.88	0.98	1.14
Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying)	0.58	0.73	1.61	0.43	0.78	0.85	0.91
New Energy Systems	0.68	1.41	0.83	1.11	1.16	1.01	1.02

Source: BRES via NOMIS

Total employment in the sector in the sector fell by 1% between 2009 and 2014. This compares to 1% growth across the sector nationally and 1% growth across all sectors locally.

Figure 11 Total employment and employee jobs in the new energy sector; consortium area: 2009 to 2014



Source: BRES, ONS via NOMIS

Table 105 Employment indicators for the new energy sector by LEP areas and South East Wales: 2009 and 2004

Rank of %	LEP area	%, 2014	Change, 2009 to 2014	
			Number	%
1	Thames Valley Berkshire	11.5	-2,800	-4.8
2	Enterprise M3	10.8	4,900	6.0
3	Greater Cambridge and Greater Peterborough	9.8	4,600	7.7
4	Gloucestershire	9.6	3,000	12.0
5	Hertfordshire	8.8	-400	-0.7
6	Solent	8.4	-1,300	-3.3
7	Tees Valley	8.4	-600	-2.6
8	Oxfordshire	8.3	0	-0.1
9	Swindon and Wiltshire	7.9	-3,800	-13.2
10	Worcestershire	7.9	-700	-3.8
11	Leicester and Leicestershire	7.8	2,900	9.0
12	Cheshire and Warrington	7.6	-600	-1.6
13	Coventry and Warwickshire	7.6	-1,900	-5.4
14	South East Wales	7.6	1,400	3.2
15	Buckinghamshire Thames Valley	7.5	-1,200	-6.6
16	Coast to Capital	7.2	-1,500	-2.5
17	South East Midlands	7.2	600	1.0
18	West of England	6.9	2,100	5.6
19	Dorset	6.9	1,600	7.7
20	Stoke-on-Trent and Staffordshire	6.9	-1,500	-4.5
21	South East	6.9	-5,200	-4.7
22	New Anglia	6.8	-2,100	-4.3
23	Derby, Derbyshire, Nottingham and Nottinghamshire	6.7	1,000	1.7
24	Black Country	6.7	-2,800	-8.5
25	North Eastern	6.6	-8,900	-14.7
26	Greater Lincolnshire	6.5	3,200	13.0
27	Northamptonshire	6.5	1,300	6.4
28	Sheffield City Region	6.5	4,000	9.3
29	Lancashire	6.4	3,200	8.6
30	The Marches	6.4	0	0.1
31	Leeds City Region	6.3	-1,600	-1.9
32	Greater Manchester	6.2	-2,200	-2.7
33	York, North Yorkshire and East Riding	5.9	400	1.3
34	Heart of the South West	5.8	-3,500	-7.9
35	Humber	5.8	2,900	15.2
36	Greater Birmingham and Solihull	5.6	-5,100	-9.4
37	Cumbria	5.5	-100	-0.9
38	Liverpool City Region	4.8	-1,000	-3.2
39	London	4.8	17,300	8.0
40	Cornwall and Isles of Scilly	4.7	-1,200	-11.3

Source: BRES, 2014 via NOMIS

Enterprises

In 2015, there were 22,815 enterprises operating within the new energy systems sector across the consortium area (Table 50). The largest number of enterprises were engaged in:

- Electrical installation (3,940)
- Other engineering activities (3,805)
- Other professional scientific and technical activities (3.125)

When expressed as location quotients, the consortium area has particularly high concentrations of enterprises in (Table 107)

- Repair and maintenance of aircraft and spacecraft (2.63) particularly in South East Wales (6.83)
- Manufacture of steam generators, except central heating (1.83) particularly in Swindon & Wiltshire (4.97), South East Wales (3.60) and Heart of the South West (2.03)
- Manufacture of compressors in Gloucestershire (5.77)
- Manufacture of engines and turbines in Cornwall & the IoS (4.20)
- Production of electricity in Cornwall & the IoS (4.14)
- Repair and maintenance of ships and boats in Cornwall & the IoS (4.00)
- Manufacture of optical precision instruments in Cornwall & the IoS (2.94)
- Satellite telecommunications activities in Swindon & Wiltshire (2.92)
- Manufacture of batteries and accumulators in Heart of the South West (2.87)
- Manufacture of irradiation, electromedical and electrotherapeutic equipment in South East Wales (2.79)
- Manufacture of electrical and electronic equipment for motor vehicles in Swindon & Wiltshire (2.64)
- Manufacture of loaded electronic boards in Gloucestershire (2.62)
- Manufacture of other taps and valves in Gloucestershire (2.62) and Swindon & Wiltshire (2.56)
- Manufacture of electronic industrial process control equipment in South East Wales (2.45)
- Manufacture of central heating radiators and boilers in South East Wales (2.36)
- Manufacture of other tanks, reservoirs and containers of steel in West of England (2.17)
- Manufacture of non-electronic instruments and appliances for measuring, testing and navigation in Swindon & Wiltshire (2.06)

Table 106 Number of enterprises in the new energy sector; consortium sub-area: 2015

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortium area	Great Britain
Other research and experimental development on natural sciences and engineering	25	40	65	50	40	65	290	3,500
Other information technology and computer service activities	110	345	440	265	310	495	1,960	19,265
Wired telecommunications activities	5	15	25	20	20	30	110	1,345
Wireless telecommunications activities	5	15	30	20	20	25	110	1,210
Satellite telecommunications activities	0	0	0	0	5	5	15	145
Other telecommunications activities	25	55	85	75	95	75	410	5,130
Wholesale of electronic and telecommunications equipment and parts	5	25	40	40	40	40	190	2,945
Wholesale of mining, construction and civil engineering machinery	5	5	20	20	5	5	60	715
Electrical installation	380	480	1,180	710	410	775	3,940	39,310
Other construction installation	45	80	195	150	75	135	680	7,650
Construction of utility projects for fluids	0	5	10	10	5	5	35	400
Construction of utility projects for electricity and telecommunications	0	5	5	10	0	10	35	480
Construction of other civil engineering projects nec	215	210	590	310	220	270	1,815	15,615
Production of electricity	110	50	115	45	35	70	425	2,735
Transmission of electricity	0	0	0	0	0	0	0	10
Distribution of electricity	0	0	0	0	0	0	5	55
Trade of electricity	0	5	10	5	5	5	30	425
Manufacture of gas	0	0	0	0	0	0	0	5
Distribution of gaseous fuels through mains	0	0	0	0	0	0	0	25
Trade of gas through mains	0	0	0	0	0	0	0	70
Steam and air conditioning supply	0	0	0	0	0	0	0	10
Repair of fabricated metal products	5	10	25	20	5	15	80	855

Repair of machinery	40	50	130	75	35	50	380	3,610
Repair of electronic and optical equipment	5	5	5	5	5	5	30	350
Repair of electrical equipment	10	5	20	15	5	20	80	935
Repair and maintenance of ships and boats	20	5	25	10	0	5	70	515
Repair and maintenance of aircraft and spacecraft	25	20	70	150	30	45	340	1,345
Repair and maintenance of other transport equipment	5	5	20	15	10	10	75	970
Repair of other equipment	10	15	30	35	15	30	130	1,255
Installation of industrial machinery and equipment	10	20	35	30	15	45	160	1,765
Manufacture of electrical and electronic equipment for motor vehicles	0	0	0	0	5	5	10	160
Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	10	0	10	5	0	0	25	245
Manufacture of fluid power equipment	0	0	5	0	0	0	15	145
Manufacture of pumps	5	5	5	5	0	5	25	220
Manufacture of compressors	0	5	0	0	0	0	5	75
Manufacture of other taps and valves	0	5	0	5	5	0	15	165
Manufacture of bearings, gears, gearing and driving elements	0	5	5	5	0	5	20	225
Manufacture of ovens, furnaces and furnace burners	0	0	0	5	5	0	15	180
Manufacture of lifting and handling equipment	5	15	15	15	5	20	80	840
Manufacture of office machinery and equipment (except computers and peripheral equipment)	0	0	5	0	0	0	10	125
Manufacture of power-driven hand tools	0	0	0	0	0	0	0	15
Manufacture of non-domestic cooling and ventilation equipment	5	10	20	10	15	10	70	825
Manufacture of other general-purpose machinery nec	10	15	40	20	20	25	130	1,405
Manufacture of other special-purpose machinery nec	5	5	15	15	0	10	50	475
Manufacture of electric motors, generators and transformers	0	5	15	5	5	5	35	295
Manufacture of electricity distribution and control apparatus	0	10	20	10	10	10	60	615
Manufacture of batteries and accumulators	0	0	5	0	0	0	10	60

Manufacture of fibre optic cables	0	0	0	0	0	0	0	40
Manufacture of other electronic and electric wires and cables	0	5	5	5	5	5	25	250
Manufacture of wiring devices	0	0	0	0	0	0	5	65
Manufacture of electric lighting equipment	5	5	15	10	5	5	40	690
Manufacture of other electrical equipment	5	10	15	15	15	10	65	675
Manufacture of electronic components	5	5	20	10	10	15	65	595
Manufacture of loaded electronic boards	5	10	0	10	5	5	35	330
Manufacture of computers and peripheral equipment	5	15	20	10	15	20	85	895
Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment)	5	5	5	10	5	0	25	320
Manufacture of consumer electronics	5	10	10	5	5	5	40	515
Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control equipment	10	20	50	15	20	30	145	1,490
Manufacture of electronic industrial process control equipment	0	5	5	10	0	5	25	250
Manufacture of non-electronic instruments and appliances for measuring, testing and navigation, except industrial process control equipment	0	5	5	5	5	5	25	205
Manufacture of non-electronic industrial process control equipment	0	0	0	0	0	5	10	60
Manufacture of irradiation, electromedical and electrotherapeutic equipment	0	0	0	5	0	0	10	110
Manufacture of optical precision instruments	5	0	5	5	0	0	15	175
Manufacture of photographic and cinematographic equipment	0	0	5	0	0	0	10	95
Manufacture of magnetic and optical media	0	0	0	0	0	0	0	30
Manufacture of central heating radiators and boilers	0	0	0	5	0	0	10	130
Manufacture of other tanks, reservoirs and containers of metal	0	0	0	0	0	5	10	130
Manufacture of steam generators, except central heating hot water	0	0	5	5	5	0	15	85

boilers								
Manufacture of wire products, chain and springs	0	5	5	5	5	5	25	400
Support activities for petroleum and natural gas extraction	0	0	0	0	0	0	5	225
Engineering design activities for industrial process and production	65	135	225	145	155	295	1,015	12,395
Engineering related scientific and technical consulting activities	120	175	360	240	185	305	1,385	15,860
Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)	245	540	945	585	535	960	3,805	45,480
Technical testing and analysis	30	50	120	90	60	75	425	5,680
Environmental consulting activities	30	40	100	65	50	45	335	3,040
Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying)	275	375	800	625	415	640	3,125	35,945
New Energy Systems	1,945	2,985	6,065	4,060	2,975	4,785	22,815	244,870
All industries	23,145	27,540	69,185	38,875	28,175	42,210	229,125	2,382,370

Source: ONS Business Counts, NOMIS

Table 107 Location quotients for share of enterprises in the new energy sector; consortium sub-area: 2015

	C&I OS	Glos	HoS W	SEW	S& W	WoE	SIA
Other research and experimental development on natural sciences and engineering	0.74	0.99	0.64	0.88	0.97	1.05	0.86
Other information technology and computer service activities	0.59	1.55	0.79	0.84	1.36	1.45	1.06
Wired telecommunications activities	0.38	0.96	0.64	0.91	1.26	1.26	0.85
Wireless telecommunications activities	0.43	1.07	0.85	1.01	1.40	1.17	0.95
Satellite telecommunications activities	0.00	0.00	0.00	0.00	2.92	1.95	1.08
Other telecommunications activities	0.50	0.93	0.57	0.90	1.57	0.83	0.83
Wholesale of electronic and telecommunications equipment and parts	0.17	0.73	0.47	0.83	1.15	0.77	0.67
Wholesale of mining, construction and civil engineering machinery	0.72	0.60	0.96	1.71	0.59	0.39	0.87
Electrical installation	1.00	1.06	1.03	1.11	0.88	1.11	1.04
Other construction installation	0.61	0.90	0.88	1.20	0.83	1.00	0.92
Construction of utility projects for fluids	0.00	1.08	0.86	1.53	1.06	0.71	0.91
Construction of utility projects for electricity and telecommunications	0.00	0.90	0.36	1.28	0.00	1.18	0.76
Construction of other civil engineering projects nec	1.42	1.16	1.30	1.22	1.19	0.98	1.21
Production of electricity	4.14	1.58	1.45	1.01	1.08	1.44	1.62
Transmission of electricity	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distribution of electricity	0.00	0.00	0.00	0.00	0.00	0.00	0.95
Trade of electricity	0.00	1.02	0.81	0.72	0.99	0.66	0.73
Manufacture of gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distribution of gaseous fuels through mains	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trade of gas through mains	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Steam and air conditioning supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Repair of fabricated metal products	0.60	1.01	1.01	1.43	0.49	0.99	0.97
Repair of machinery	1.14	1.20	1.24	1.27	0.82	0.78	1.09
Repair of electronic and optical equipment	1.47	1.24	0.49	0.88	1.21	0.81	0.89
Repair of electrical equipment	1.10	0.46	0.74	0.98	0.45	1.21	0.89
Repair and maintenance of ships and boats	4.00	0.84	1.67	1.19	0.00	0.55	1.41
Repair and maintenance of aircraft and spacecraft	1.91	1.29	1.79	6.83	1.89	1.89	2.63
Repair and maintenance of other transport equipment	0.53	0.45	0.71	0.95	0.87	0.58	0.80
Repair of other equipment	0.82	1.03	0.82	1.71	1.01	1.35	1.08
Installation of industrial machinery and	0.58	0.98	0.68	1.04	0.72	1.44	0.94

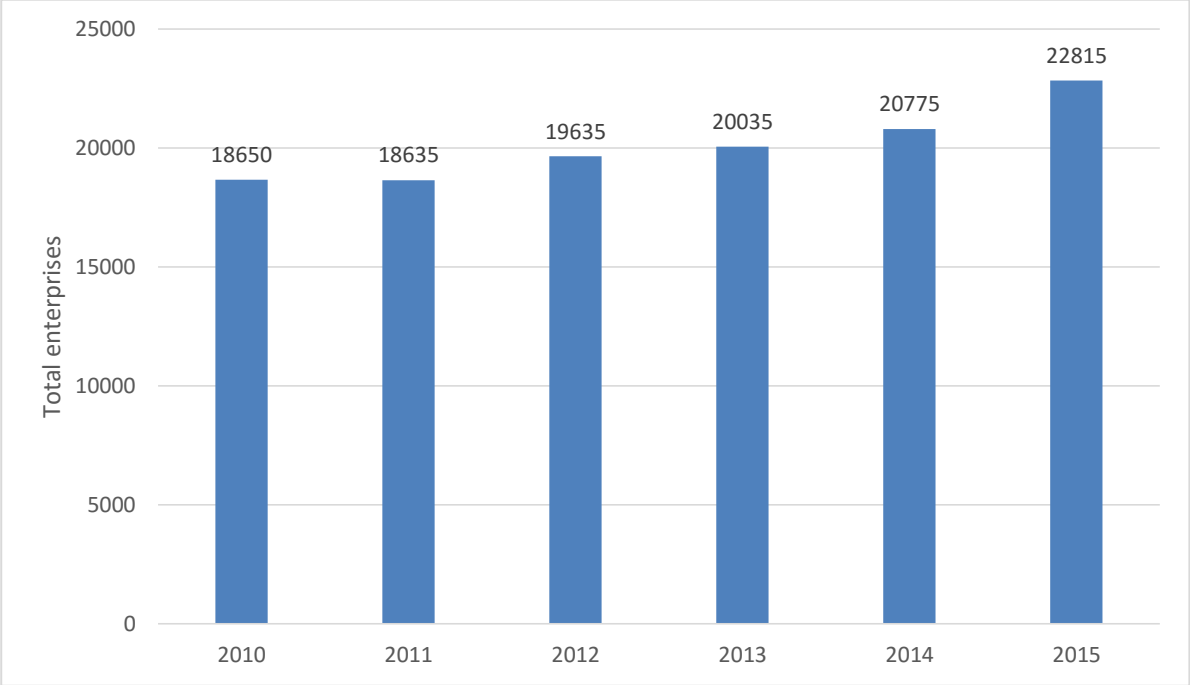
equipment							
Manufacture of electrical and electronic equipment for motor vehicles	0.00	0.00	0.00	0.00	2.64	1.76	0.65
Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	4.20	0.00	1.41	1.25	0.00	0.00	1.06
Manufacture of fluid power equipment	0.00	0.00	1.19	0.00	0.00	0.00	1.08
Manufacture of pumps	2.34	1.97	0.78	1.39	0.00	1.28	1.18
Manufacture of compressors	0.00	5.77	0.00	0.00	0.00	0.00	0.69
Manufacture of other taps and valves	0.00	2.62	0.00	1.86	2.56	0.00	0.95
Manufacture of bearings, gears, gearing and driving elements	0.00	1.92	0.77	1.36	0.00	1.25	0.92
Manufacture of ovens, furnaces and furnace burners	0.00	0.00	0.00	1.70	2.35	0.00	0.87
Manufacture of lifting and handling equipment	0.61	1.54	0.61	1.09	0.50	1.34	0.99
Manufacture of office machinery and equipment (except computers and peripheral equipment)	0.00	0.00	1.38	0.00	0.00	0.00	0.83
Manufacture of power-driven hand tools	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manufacture of non-domestic cooling and ventilation equipment	0.62	1.05	0.83	0.74	1.54	0.68	0.88
Manufacture of other general-purpose machinery nec	0.73	0.92	0.98	0.87	1.20	1.00	0.96
Manufacture of other special-purpose machinery nec	1.08	0.91	1.09	1.94	0.00	1.19	1.09
Manufacture of electric motors, generators and transformers	0.00	1.47	1.75	1.04	1.43	0.96	1.23
Manufacture of electricity distribution and control apparatus	0.00	1.41	1.12	1.00	1.37	0.92	1.01
Manufacture of batteries and accumulators	0.00	0.00	2.87	0.00	0.00	0.00	1.73
Manufacture of fibre optic cables	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manufacture of other electronic and electric wires and cables	0.00	1.73	0.69	1.23	1.69	1.13	1.04
Manufacture of wiring devices	0.00	0.00	0.00	0.00	0.00	0.00	0.80
Manufacture of electric lighting equipment	0.75	0.63	0.75	0.89	0.61	0.41	0.60
Manufacture of other electrical equipment	0.76	1.28	0.77	1.36	1.88	0.84	1.00
Manufacture of electronic components	0.86	0.73	1.16	1.03	1.42	1.42	1.14
Manufacture of loaded electronic boards	1.56	2.62	0.00	1.86	1.28	0.86	1.10
Manufacture of computers and peripheral equipment	0.58	1.45	0.77	0.68	1.42	1.26	0.99
Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment)	1.61	1.35	0.54	1.92	1.32	0.00	0.81
Manufacture of consumer electronics	1.00	1.68	0.67	0.59	0.82	0.55	0.81

Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control equipment	0.69	1.16	1.16	0.62	1.13	1.14	1.01
Manufacture of electronic industrial process control equipment	0.00	1.73	0.69	2.45	0.00	1.13	1.04
Manufacture of non-electronic instruments and appliances for measuring, testing and navigation, except industrial process control equipment	0.00	2.11	0.84	1.49	2.06	1.38	1.27
Manufacture of non-electronic industrial process control equipment	0.00	0.00	0.00	0.00	0.00	4.70	1.73
Manufacture of irradiation, electromedical and electrotherapeutic equipment	0.00	0.00	0.00	2.79	0.00	0.00	0.95
Manufacture of optical precision instruments	2.94	0.00	0.98	1.75	0.00	0.00	0.89
Manufacture of photographic and cinematographic equipment	0.00	0.00	1.81	0.00	0.00	0.00	1.09
Manufacture of magnetic and optical media	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manufacture of central heating radiators and boilers	0.00	0.00	0.00	2.36	0.00	0.00	0.80
Manufacture of other tanks, reservoirs and containers of metal	0.00	0.00	0.00	0.00	0.00	2.17	0.80
Manufacture of steam generators, except central heating hot water boilers	0.00	0.00	2.03	3.60	4.97	0.00	1.83
Manufacture of wire products, chain and springs	0.00	1.08	0.43	0.77	1.06	0.71	0.65
Support activities for petroleum and natural gas extraction	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Engineering design activities for industrial process and production	0.54	0.94	0.63	0.72	1.06	1.34	0.85
Engineering related scientific and technical consulting activities	0.78	0.95	0.78	0.93	0.99	1.09	0.91
Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)	0.55	1.03	0.72	0.79	0.99	1.19	0.87
Technical testing and analysis	0.54	0.76	0.73	0.97	0.89	0.75	0.78
Environmental consulting activities	1.02	1.14	1.13	1.31	1.39	0.84	1.15
Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying)	0.79	0.90	0.77	1.07	0.98	1.00	0.90
New Energy Systems	0.82	1.05	0.85	1.02	1.03	1.10	0.97

Source: ONS Business Counts, NOMIS

The number of enterprises has grown strongly over the last 5 years (Figure 4) albeit at a marginally slower rate than the Great Britain average (22% compared to 25%). This is almost twice the rate of business growth than average across industries in the consortium area (13%).

Figure 12 Number of enterprises within the new energy sector; consortium area: 2010 to 2015



Source: ONS Business Counts, NOMIS

Table 108 Change in number of enterprises within the new energy sector; consortium area and Great Britain: 2010 to 2015

	Consortium area		Great Britain
	Change in number of enterprises	% change in enterprises	% change in enterprises
Other research and experimental development on natural sciences and engineering	-10	-3	15
Other information technology and computer service activities	-535	-21	-21
Wired telecommunications activities	55	100	140
Wireless telecommunications activities	75	214	144
Satellite telecommunications activities	5	50	38
Other telecommunications activities	40	11	3
Wholesale of electronic and telecommunications equipment and parts	0	0	8
Wholesale of mining, construction and civil engineering machinery	0	0	14
Electrical installation	205	5	4
Other construction installation	225	49	60
Construction of utility projects for fluids	25	250	248
Construction of utility projects for electricity and telecommunications	20	133	405
Construction of other civil engineering projects nec	-510	-22	-16
Production of electricity	365	608	681
Transmission of electricity	0	#DIV/0!	100
Distribution of electricity	-5	-50	-15
Trade of electricity	30	#DIV/0!	1114
Manufacture of gas	0	#DIV/0!	-50
Distribution of gaseous fuels through mains	-5	-100	-29
Trade of gas through mains	0	#DIV/0!	600
Steam and air conditioning supply	0	#DIV/0!	0
Repair of fabricated metal products	55	220	138
Repair of machinery	190	100	95
Repair of electronic and optical equipment	20	200	150
Repair of electrical equipment	20	33	43
Repair and maintenance of ships and boats	30	75	43
Repair and maintenance of aircraft and spacecraft	275	423	249
Repair and maintenance of other transport equipment	55	275	223
Repair of other equipment	70	117	128
Installation of industrial machinery and equipment	65	68	122

Manufacture of electrical and electronic equipment for motor vehicles	0	0	10
Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	0	0	23
Manufacture of fluid power equipment	-5	-25	12
Manufacture of pumps	-5	-17	-15
Manufacture of compressors	-5	-50	-25
Manufacture of other taps and valves	0	0	-11
Manufacture of bearings, gears, gearing and driving elements	-5	-20	-12
Manufacture of ovens, furnaces and furnace burners	5	50	13
Manufacture of lifting and handling equipment	-5	-6	-7
Manufacture of office machinery and equipment (except computers and peripheral equipment)	0	0	9
Manufacture of power-driven hand tools	0	#DIV/0!	-25
Manufacture of non-domestic cooling and ventilation equipment	-15	-18	-17
Manufacture of other general-purpose machinery nec	0	0	-7
Manufacture of other special-purpose machinery nec	15	43	10
Manufacture of electric motors, generators and transformers	10	40	23
Manufacture of electricity distribution and control apparatus	-10	-14	-17
Manufacture of batteries and accumulators	0	0	-14
Manufacture of fibre optic cables	0	#DIV/0!	-11
Manufacture of other electronic and electric wires and cables	10	67	19
Manufacture of wiring devices	0	0	18
Manufacture of electric lighting equipment	0	0	5
Manufacture of other electrical equipment	10	18	32
Manufacture of electronic components	0	0	-1
Manufacture of loaded electronic boards	0	0	-3
Manufacture of computers and peripheral equipment	15	21	1
Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment)	10	67	88
Manufacture of consumer electronics	-10	-20	-21
Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control equipment	-5	-3	-7
Manufacture of electronic industrial process control equipment	0	0	-7
Manufacture of non-electronic instruments and appliances for measuring, testing and navigation, except industrial process control equipment	5	25	11
Manufacture of non-electronic industrial process control equipment	0	0	-37
Manufacture of irradiation, electromedical and electrotherapeutic equipment	-5	-33	47

Manufacture of optical precision instruments	5	50	40
Manufacture of photographic and cinematographic equipment	0	0	0
Manufacture of magnetic and optical media	-5	-100	-14
Manufacture of central heating radiators and boilers	0	0	-26
Manufacture of other tanks, reservoirs and containers of metal	-5	-33	-16
Manufacture of steam generators, except central heating hot water boilers	5	50	-6
Manufacture of wire products, chain and springs	0	0	-10
Support activities for petroleum and natural gas extraction	0	0	-27
Engineering design activities for industrial process and production	495	95	88
Engineering related scientific and technical consulting activities	530	62	68
Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)	370	11	17
Technical testing and analysis	80	23	48
Environmental consulting activities	225	205	212
Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying)	1,695	119	99
"SIA New Energy Systems"	4,165	22	25
All industries	25,700	13	17

Employment

Table 109 Employee jobs in the iron and steel manufacturing sector; consortium sub-area: 2014

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area	Great Britain
Manufacture of basic iron and steel and of ferro-alloys	!	-	-	2,000	-	!	2,200	23,600
Manufacture of tubes, pipes, hollow profiles and related fittings, of steel	-	!	!	200	-	!	600	7,800
Manufacture: iron and steel	!	-	500	2,200	-	!	2,800	31,400
All sectors (excluding farms)	197,400	276,600	680,400	594,700	303,800	559,300	2,612,100	27,777,800

Source: BRES via NOMIS

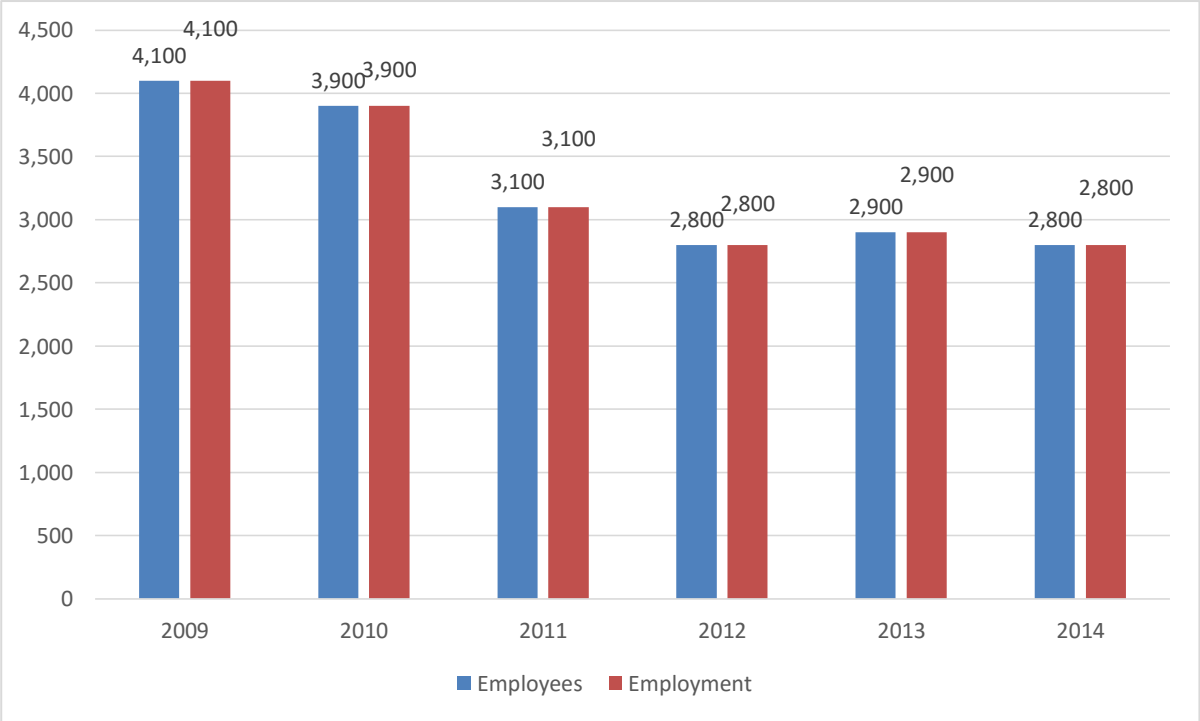
Table 110 Location Quotients for employee jobs in the iron and steel manufacturing sector; consortium area: 2014

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area
Manufacture of basic iron and steel and of ferro-alloys	!	0.05	0.01	3.94	0.13	!	0.98
Manufacture of tubes, pipes, hollow profiles and related fittings, of steel	0.09	!	!	1.00	0.00	!	0.88
Manufacture: iron and steel	!	0.12	0.60	3.21	0.10	!	0.96

Source: BRES via NOMIS

Employment within the iron and steel manufacturing sector has fallen by one-third (32%) since 2009. This compares with very modest growth within the sector nationally (0.2%) and across all sectors locally (0.6%).

Figure 13 Total employment and employee jobs in the iron and steel sector; consortium area: 2009 to 2014



Source: BRES, ONS via NOMIS

Enterprises

Table 111 Number of enterprises in the iron and steel sector; consortium sub area: 2015

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area	Great Britain
Manufacture of basic iron and steel and of ferro-alloys	0	5	10	20	5	5	45	445
Manufacture of tubes, pipes, hollow profiles and related fittings, of steel	5	5	5	5	0	0	20	280
Manufacture: iron and steel	5	10	20	20	5	10	65	720
All industries	23,145	27,540	69,185	38,875	28,175	42,210	229,125	2,382,370

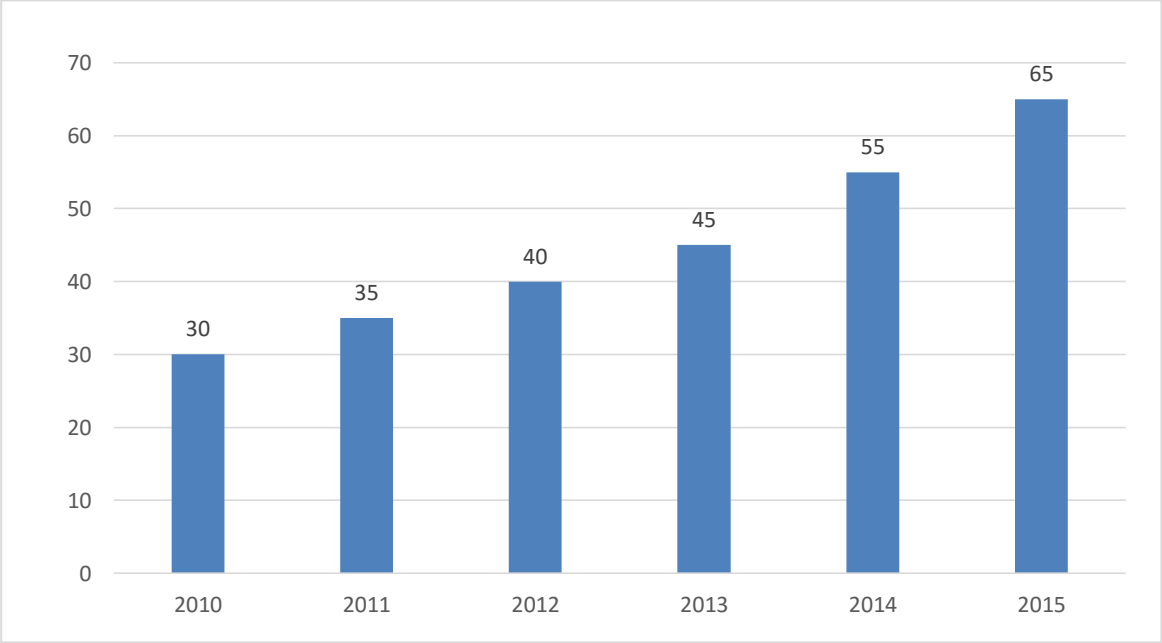
Source: ONS Business Counts, NOMIS

Table 112 Location quotients for share of enterprises in the iron and steel sector; consortium sub-area: 2015

	Cornwall & IOS	Gloucestershire	Heart of the South West	South East Wales	Swindon & Wiltshire	West of England	Consortia area
Manufacture of basic iron and steel and of ferro-alloys	0.00	0.97	0.77	2.75	0.95	0.63	1.05
Manufacture of tubes, pipes, hollow profiles and related fittings, of steel	1.84	1.54	0.61	1.09	0.00	0.00	0.74
Manufacture: iron and steel	0.71	1.20	0.96	1.70	0.59	0.78	0.94

Source: ONS Business Counts, NOMIS

Figure 14 Number of enterprises within the iron and steel sector; consortium area: 2010 to 2015



Source: ONS Business Counts, NOMIS

Table 113 Change in number of enterprises within the iron and steel sector; consortium area and Great Britain: 2010 to 2015

Sub-sector	Consortium area		Great Britain
	Change in number of enterprises	% change in enterprises	% change in enterprises
Manufacture of basic iron and steel and of ferro-alloys	35	350	305
Manufacture of tubes, pipes, hollow profiles and related fittings, of steel	0	0	12
Manufacture: iron and steel	35	117	103
All industries	25,700	13	17

Source: ONS Business Counts, NOMIS

Table 114 Enterprise indicators for the iron and steel sector by LEP areas and South East Wales: 2010 and 2015

Rank of %	LEP area	%, 2015	Change, 2010 to 2015	
			Number	%
1	Black Country	0.182	10	22
2	Sheffield City Region	0.096	30	150
3	Tees Valley	0.091	10	200
4	Cumbria	0.086	15	300
5	Humber	0.070	10	100
6	Stoke-on-Trent and Staffordshire	0.055	10	100
7	South East Wales	0.051	10	100
8	North Eastern	0.051	15	150
9	Greater Manchester	0.046	20	100
10	Leeds City Region	0.045	25	125
11	Worcestershire	0.042	0	0
12	Greater Lincolnshire	0.041	5	50
13	Lancashire	0.040	10	100
14	Greater Birmingham and Solihull	0.040	5	25
15	Leicester and Leicestershire	0.040	10	200
16	Derby, Derbyshire, Nottingham and Nottinghamshire	0.037	15	150
17	Gloucestershire	0.036	10	#DIV/0!
18	Northamptonshire	0.034	5	100
19	The Marches	0.034	10	
20	New Anglia	0.033	10	100
21	Dorset	0.033	5	100
22	Coventry and Warwickshire	0.029	5	100
23	York, North Yorkshire and East Riding	0.029	10	200
24	Heart of the South West	0.029	10	100
25	South East	0.029	25	125
26	Liverpool City Region	0.027	0	0
27	Solent	0.026	5	100
28	Cheshire and Warrington	0.026	5	100
29	West of England	0.024	10	
30	Cornwall and Isles of Scilly	0.022	0	0
31	South East Midlands	0.021	10	200
32	Swindon and Wiltshire	0.018	0	0
33	Greater Cambridge and Greater Peterborough	0.017	0	0
34	Buckinghamshire Thames Valley	0.017	5	#DIV/0!
35	Thames Valley Berkshire	0.012	0	0
36	Coast to Capital	0.012	5	100
37	Hertfordshire	0.009	0	0
38	London	0.008	15	75
39	Enterprise M3	0.007	5	#DIV/0!
40	Oxfordshire	0.000	-5	-100

Source: ONS Business Counts, NOMIS

Table 115 Enterprises by employment size band; consortium area and Great Britain: 2015

Employment Size band	Consortium area			Great Britain
	No. Iron & Steel	% Iron & Steel	% all sectors	% Iron & Steel
0 to 4	40	61.5	75.2	58.3
5 to 9	5	7.7	13.3	11.8
10 to 19	5	7.7	6.4	9.0
20 to 49	10	15.4	3.3	11.8
50 to 99	5	7.7	1.0	4.9
100 to 249	5	7.7	0.5	2.8
250 to 499	0	0.0	0.2	0.7
500 to 999	0	0.0	0.1	0.7
1000+	0	0.0	0.1	0.7
Total	65	100.0	100.0	100.0

Source: ONS Business Counts, NOMIS

Table 116 Enterprises by legal status: consortium area and Great Britain: 2015

Legal Status	Consortium area			Great Britain
	No. Iron & Steel	Iron & Steel %	% all sectors	% Iron & Steel
Private sector total	65	100.0	99.3	100.0
Company (including building society)	55	84.6	58.3	88.2
Sole proprietor	10	15.4	23.6	9.7
Partnership	0	0.0	13.8	2.1
Non-profit body or mutual association	0	0.0	3.6	0.0
Public sector total	0	0.0	0.7	0.0
Public corporation	0	0.0	0.0	0.0
Central government	0	0.0	0.2	0.0
Local authority	0	0.0	0.5	0.0
Total	65	100.0	100.0	100.0

Source: ONS Business Counts, NOMIS

APPENDIX M7: SIC CODES USED TO DEFINE SWW-SIA THEMES

SIA Aerospace and advanced engineering
33160 : Repair and maintenance of aircraft and spacecraft
29100 : Manufacture of motor vehicles
29310 : Manufacture of electrical and electronic equipment for motor vehicles
29320 : Manufacture of other parts and accessories for motor vehicles
28110 : Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
28150 : Manufacture of bearings, gears, gearing and driving elements
30110 : Building of ships and floating structures
30120 : Building of pleasure and sporting boats
30300 : Manufacture of air and spacecraft and related machinery
30400 : Manufacture of military fighting vehicles
30990 : Manufacture of other transport equipment nec
71121 : Engineering design activities for industrial process and production
71122 : Engineering related scientific and technical consulting activities
71129 : Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)
71200 : Technical testing and analysis
72190 : Other research & experimental development on natural sciences and engineering

SIA Digital Living Innovation
58210 : Publishing of computer games
58290 : Other software publishing
18201 : Reproduction of sound recording
18202 : Reproduction of video recording
18203 : Reproduction of computer media
26110 : Manufacture of electronic components
26120 : Manufacture of loaded electronic boards
26200 : Manufacture of computers and peripheral equipment
26301 : Manufacture of telegraph and telephone apparatus and equipment
26309 : Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment)
26400 : Manufacture of consumer electronics
26511 : Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control equipment
26512 : Manufacture of electronic industrial process control equipment
26701 : Manufacture of optical precision instruments
26702 : Manufacture of photographic and cinematographic equipment
26800 : Manufacture of magnetic and optical media
27310 : Manufacture of fibre optic cables
27320 : Manufacture of other electronic and electric wires and cables
27330 : Manufacture of wiring devices
59111 : Motion picture production activities
59112 : Video production activities
59140 : Motion picture projection activities
59200 : Sound recording and music publishing activities
61100 : Wired telecommunications activities
61200 : Wireless telecommunications activities

61300 : Satellite telecommunications activities
61900 : Other telecommunications activities
62011 : Ready-made interactive leisure and entertainment software development
62012 : Business and domestic software development
62020 : Computer consultancy activities
62030 : Computer facilities management activities
62090 : Other information technology and computer service activities
63110 : Data processing, hosting and related activities
63120 : Web portals
63910 : News agency activities
71121 : Engineering design activities for industrial process and production
95110 : Repair of computers and peripheral equipment

SIA Next Generation Microelectronics
Individual selections:
SIC 2007 subclass (5 digit)
33130 : Repair of electronic and optical equipment
26110 : Manufacture of electronic components
26120 : Manufacture of loaded electronic boards
26200 : Manufacture of computers and peripheral equipment
26301 : Manufacture of telegraph and telephone apparatus and equipment
26309 : Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment)
26511 : Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control equipment
26512 : Manufacture of electronic industrial process control equipment
26600 : Manufacture of irradiation, electromedical and electrotherapeutic equipment

SIA New Energy Systems
72190 : Other research & experimental development on natural sciences and engineering
62090 : Other information technology and computer service activities
61100 : Wired telecommunications activities
61200 : Wireless telecommunications activities
61300 : Satellite telecommunications activities
61900 : Other telecommunications activities
46520 : Wholesale of electronic and telecommunications equipment and parts
46630 : Wholesale of mining, construction and civil engineering machinery
43210 : Electrical installation
43290 : Other construction installation
42210 : Construction of utility projects for fluids
42220 : Construction of utility projects for electricity and telecommunications
42990 : Construction of other civil engineering projects nec
35110 : Production of electricity
35120 : Transmission of electricity
35130 : Distribution of electricity
35140 : Trade of electricity
35210 : Manufacture of gas
35220 : Distribution of gaseous fuels through mains
35230 : Trade of gas through mains
35300 : Steam and air conditioning supply

33110 : Repair of fabricated metal products
33120 : Repair of machinery
33130 : Repair of electronic and optical equipment
33140 : Repair of electrical equipment
33150 : Repair and maintenance of ships and boats
33160 : Repair and maintenance of aircraft and spacecraft
33170 : Repair and maintenance of other transport equipment
33190 : Repair of other equipment
33200 : Installation of industrial machinery and equipment
29310 : Manufacture of electrical and electronic equipment for motor vehicles
28110 : Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
28120 : Manufacture of fluid power equipment
28131 : Manufacture of pumps
28132 : Manufacture of compressors
28140 : Manufacture of other taps and valves
28150 : Manufacture of bearings, gears, gearing and driving elements
28210 : Manufacture of ovens, furnaces and furnace burners
28220 : Manufacture of lifting and handling equipment
28230 : Manufacture of office machinery and equipment (except computers and peripheral equipment)
28240 : Manufacture of power-driven hand tools
28250 : Manufacture of non-domestic cooling and ventilation equipment
28290 : Manufacture of other general-purpose machinery nec
28990 : Manufacture of other special-purpose machinery nec
27110 : Manufacture of electric motors, generators and transformers
27120 : Manufacture of electricity distribution and control apparatus
27200 : Manufacture of batteries and accumulators
27310 : Manufacture of fibre optic cables
27320 : Manufacture of other electronic and electric wires and cables
27330 : Manufacture of wiring devices
27400 : Manufacture of electric lighting equipment
27900 : Manufacture of other electrical equipment
26110 : Manufacture of electronic components
26120 : Manufacture of loaded electronic boards
26200 : Manufacture of computers and peripheral equipment
26309 : Manufacture of communication equipment (other than telegraph and telephone apparatus and equipment)
26400 : Manufacture of consumer electronics
26511 : Manufacture of electronic instruments and appliances for measuring, testing, and navigation, except industrial process control equipment
26512 : Manufacture of electronic industrial process control equipment
26513 : Manufacture of non-electronic instruments and appliances for measuring, testing and navigation, except industrial process control equipment
26514 : Manufacture of non-electronic industrial process control equipment
26600 : Manufacture of irradiation, electromedical and electrotherapeutic equipment
26701 : Manufacture of optical precision instruments
26702 : Manufacture of photographic and cinematographic equipment
26800 : Manufacture of magnetic and optical media
25210 : Manufacture of central heating radiators and boilers
25290 : Manufacture of other tanks, reservoirs and containers of metal

25300 : Manufacture of steam generators, except central heating hot water boilers
25930 : Manufacture of wire products, chain and springs
09100 : Support activities for petroleum and natural gas extraction
71121 : Engineering design activities for industrial process and production
71122 : Engineering related scientific and technical consulting activities
71129 : Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)
71200 : Technical testing and analysis
74901 : Environmental consulting activities
74909 : Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying)

SIA Resilience, Environment & Sustainability
91040 : Botanical and zoological gardens and nature reserve activities
36000 : Water collection, treatment and supply
37000 : Sewerage
38110 : Collection of non-hazardous waste
38120 : Collection of hazardous waste
38210 : Treatment and disposal of non-hazardous waste
38220 : Treatment and disposal of hazardous waste
38310 : Dismantling of wrecks
38320 : Recovery of sorted materials
39000 : Remediation activities and other waste management services
49100 : Passenger rail transport, interurban
61300 : Satellite telecommunications activities
63110 : Data processing, hosting and related activities
65120 : Non-life insurance
65202 : Non-life reinsurance
72110 : Research and experimental development on biotechnology
72190 : Other research & experimental development on natural sciences and engineering
20130 : Manufacture of other inorganic basic chemicals
20140 : Manufacture of other organic basic chemicals
21100 : Manufacture of basic pharmaceutical products
21200 : Manufacture of pharmaceutical preparations
62012 : Business and domestic software development
62020 : Computer consultancy activities
62030 : Computer facilities management activities
62090 : Other information technology and computer service activities
71111 : Architectural activities
71112 : Urban planning and landscape architectural activities
71121 : Engineering design activities for industrial process and production
71122 : Engineering related scientific and technical consulting activities
71129 : Other engineering activities (not including engineering design for industrial process and production or engineering related scientific and technical consulting activities)
71200 : Technical testing and analysis
74100 : Specialised design activities
74901 : Environmental consulting activities
74909 : Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying)

Department for
Business, Energy
& Industrial Strategy

South West England and South East Wales Science and Innovation Audit

Annex N: Business Cases

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

N

Annex N: Business Cases

Our planned investments cover a timeline of projects currently in the bidding process, those that are under development and opportunities emerging from our audit that are the new opportunities. The following projects have a 2-page project profile in this Annex:

New proposals at Outline Business Case stage:

- High Value Engineering Design & Systems Integration Capabilities (Bristol)
- Digital Innovation Hub (Bristol)
- Digital Innovation Specialist Centre: Institute for Environmental Risk (Exeter)

Projects under development:

- National Composites Materials Centre (Bristol)
- Oceansgate Marine Industries Production Campus (Plymouth)
- Compound Semiconductor Cluster (Cardiff)
- Institute for Sustainable Technology Innovation (Wiltshire)
- Berkeley Science and Technology Park (Gloucestershire)

Bids in progress:

- Institute for Advanced Automotive Propulsion Systems (GD3 & RPIF) (Bristol)

New proposals at Outline Business Case stage

Project Title: Securing excellence in High Value Design (HVD)
Current Status: The Challenge: The UK aerospace sector is the 2nd largest in the world, with proven experience in the design and manufacture of complex major components and systems. However, a number of factors have contributed to a situation where the UK aircraft design capability has suffered decline for a number of years and this now threatens the future of the UK Aerospace Industry. Notably, the extended period between new aircraft development programmes, combined with retirement of experienced Engineers, is leading to a growing “capability gap”. **The Solution:** Continued success depends on retaining excellence in design in the face of growing international competition. “High Value Design” is the intellectually-intensive activity associated with architectural definition and integration of a complex product, its major components and systems. Engineers and designers involved in the conceptual / architectural design phase have the greatest influence on overall product specification and thus the subsequent selection and optimisation of technologies and systems. Other industrial sectors face similar challenges, and opportunities for cross-sectorial support and benefits have been identified. Urgent action is needed to ensure future competitiveness of HVD in the UK, and to demonstrate this to the global market. Investment in improving the “design productivity” of UK-based engineering teams is essential. Proposals include the formation of a “High Value Design Institute” (HVDI), dedicated to

delivering the next generation of engineering design capability in the region as part of a national HVD capability initiative. This project is at a formative stage but has support from some of the UK's largest aerospace companies. A number of OEM's and first tier suppliers have independently identified the need for urgent action to support the UK's vital HVD capability. This was confirmed when aerospace stakeholders met to discuss the SIA. The UK Aerospace strategy has identified this as an area of importance. The Aerospace Technology Institute[1] is currently carrying out a strategic review of the topic.

Partners: Currently: Airbus, Rolls-Royce, Leonardo Helicopters, GKN, Dowty Propellers, together with West of England Aerospace Forum, regional universities and the National Composites Centre. It will ultimately form part of a national programme and links to other organisations, other sectors across the UK and beyond are being established.

Strategic Case: The market for civil aircraft over the next 20 years is forecast to be worth over $5tn. New market opportunities for low earth orbit vehicles and unmanned air vehicles continue to emerge. We must be positioned to maximise the exploitation of this growing sector. Strength in HVD will have the greatest influence on productivity and competitiveness acting as critical backbone to stimulate growth in the UK's aerospace industry. The extended period between new aircraft development programmes, combined with retirement of experienced Engineers, is leading to a growing "capability gap". Developing Engineers can no longer gather experience in delivering all-new products as manufacturers focus on derivatives to existing products. Overseas investment in HVD capability is increasing in response to recognition of the need for action, threatening to improve local competitiveness to the detriment of the UK. Without immediate action, there is a real danger that vital HVD capabilities will be lost making it difficult, if not impossible, for the UK to bid for future high value design and manufacturing opportunities. With appropriate support, the UK aerospace industry has the opportunity to take a global leadership position on the "digitalisation" agenda (the design process and digital services).

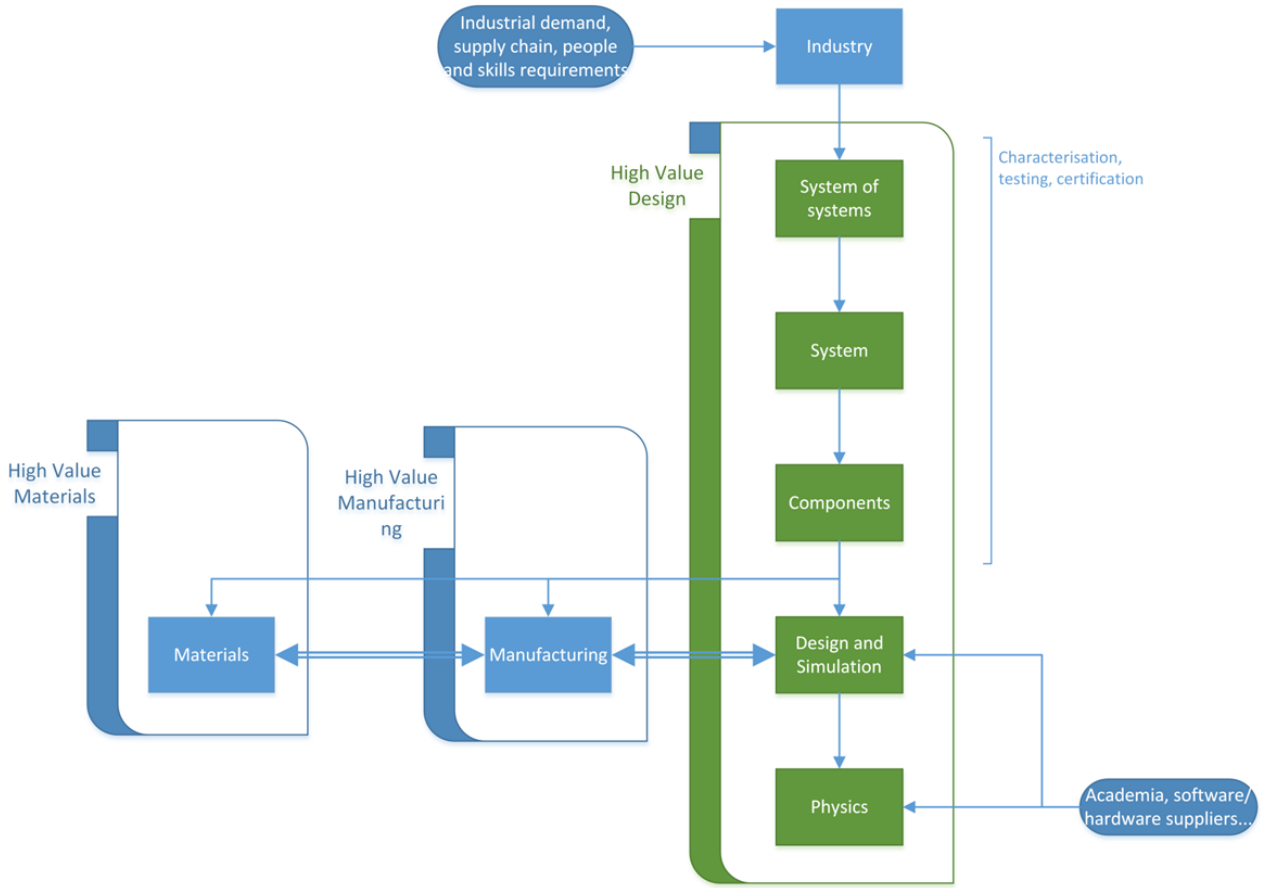
This proposal seeks to address some of the fundamental challenge articulated in the Aerospace Growth Partnership's Means of Ascent, Industrial Strategy for UK Aerospace 2016 which states that 'HVD is essential to high value manufacturing'. Current indications are that a HVDI would be an effective means to co-ordinate a programme of capability development and demonstration. Such an environment would give the "next generation" chance to learn from experienced practitioners, but also allow them the opportunity to explore innovative ideas that can form the basis for future products and services relevant to evolving market demands. The UK must also proudly demonstrate its proven capability if it is to influence the investment and procurement decisions of international stakeholders. Our audit areas is well positioned to host elements of such an Institute as it is home to significant capabilities within leading aerospace OEM's and supply chain companies, leading universities, HPC capabilities and the National Composites Centre (part of HVMC).

Economic Case: The case for investing in HVD is robust. c128,000 people are employed within UK aerospace, with 154,000 jobs in associated businesses. Within aerospace itself,

[1] Technology Strategy & Portfolio Update (July 2016) http://www.ati.org.uk/strategy/publications/

at least 26,000 people are engaged in design and Engineering-related activity. Aerospace generates over £31bn pa T/O, with £27bn exports pa. BIS figures (Growth is our business - Professional and business services strategy (2113)) showed Engineering Consultancy (a key provider and user of HVD-related activities) accounted for 14% of GVA delivered by the Professional and Business Services sector. Without developing and retaining vital capability, there is a danger the UK's competitive strength in advanced engineering design will be eroded with the consequential loss of high quality jobs, GVA and tax revenues. Many of the companies in aerospace are transnational with headquarters / shareholders globally. Excellence in HVD capability and productivity is essential if the UK is to retain competitiveness and the accountability for the design (and thus manufacture) of complex systems and products in the face of growing competition from overseas providers. Similar issues are faced by other sectors including automotive, nuclear and renewables. It therefore follows that the benefits of investing in the UK's HVD capability would be felt across many sectors other than just aerospace, benefiting the wider UK economy.
Commercial Case: The project is at a conceptual phase and relevant stakeholders are engaged in defining it. Means of addressing the challenges facing those engaged in HVD are being developed. There is a need to bring people together and develop innovative solutions to complex challenges. Whilst there could be a need for new premises, the aim will be to make use of existing infrastructure where possible.
Financial Case: Work is underway to define the financial model associated with this project. These studies are drawing in experience from similar initiatives to ensure that best practice is adopted and that any solution is financially robust.
Management Case: Whilst many businesses have significant order books, many engaged in HVD are facing a reduced workload while future market drivers evolve. Consensus amongst our aerospace community of the need to develop this into a firm proposal which could be undertaken within 3 months if this business case is accepted by BEIS.

Figure N1: The importance of High Value Design in retaining System of Systems capability within the UK



Project Title: Digital Innovation Hub
Current Status: An Outline Business Case, based on the Five Case model, has been developed for the **Digital Innovation Hub** (DIH) addressing the research, innovation and skills needs of the region's world leading digital companies.
Partners: University of Bristol is the lead organisation. Partners include Bristol City Council, a range of private sector partners such as Oracle, Nokia, IBM, BAE, Airbus, Axa, and other public and third sector partners such as GCHQ and Bristol Health Partners.
Strategic Case: University of Bristol is proposing a major new facility within Bristol city centre, radically different from a conventional university. Rather than re-implement the traditional organisational structure and operational practices of a UK research intensive university, it will be an innovative new style of higher education facility, designed from the ground up to be suited to the needs of the 21st Century. Referred to by the working title Digital Innovation Hub, it will be a major generator of the skilled graduates, underpinning technologies and innovative applications needed for the modern knowledge economy of digital goods and services. Initially, it will house researchers with world class specialisms in core technologies such as data analytics, cybersecurity, communications and networks and in applications areas including digital

health, smart cities, transport & autonomous systems and creative digital technologies. Over the life of the facility these will change to remain at the leading edge of digital innovation.

Staff and students of the University will be co-located with, and working alongside, partners from a variety of relevant industries ranging in size from start-ups, through SMEs, to major multinationals, on an annual cycle that rejects the traditional notion of an "academic year". The activities of the students, staff, and industry partners will be focused on challenge-based research and education, co-created, co-developed and co-delivered by the University and its corporate collaborators, developing graduates with sought-after skills in technology research and development in a commercial context, in innovation, and in entrepreneurship. The intended location of DIH places it at the core of the Bristol & Bath technology cluster and it will have strong and supporting links with specialist digital centres regionally (such as the Institute for Environmental Risk proposed elsewhere in the Science and Innovation Audit and regional incubators for digital start-ups), nationally including the Digital, Transport, Energy Systems and Future Cities Catapults and internationally.

Policy supports the development of the Digital Innovation Hub at a national, local and university level. Four principal objectives for development of research, innovation and the digital economy have been identified from a review of UK policy documents: *growing the digital economy*; *providing skills for the digital economy*; *maintaining world class research*; and *enabling collaborative research*. These are supplemented by local support for the digital economy, innovation, inward investment, and collaboration between industry, the public sector and academia. The University of Bristol Strategy (2016) has clear recognition of, and desire to build upon a close relationship to the wider city, particularly with reference to the 'city as a testbed' for digital innovation, and also sets out to explore the development of a new campus.

Economic Case: The Economic Case demonstrates that the Digital Innovation Hub represents good value for money, generating approximately £153m in present-value GVA benefits through additional employment in the local economy. This monetised benefit represents only the impacts of direct employment in the building itself, plus the knock-on income effects of these jobs and student expenditure within the economy. This is expected to be a relatively small benefit in comparison to the wider economic impacts of the project, that will extend to the national economy as a result of:

- Research itself
- Research becoming innovation
- Talent generation (employees)
- Talent generation (entrepreneurs)
- Collaborative research and networks (inc. SMES)
- Inward investment and retention
- New business creation & scale up
- Cluster impact

The above benefits have been assessed qualitatively and mapped to the set of market and systems failures that lead to their under provision in the absence of public support. Although challenging to measure quantitatively, current evidence suggests their scale is significant, contributing both to the success of the local economy and in maintaining UK competitiveness by driving productivity and economic growth.

The Economic Case has discounted alternative options, such as the "Do nothing" option, an option to develop a new building at the current Clifton Campus and another option for a site outside the city centre, on the basis that they do not meet the strategic objectives of

the University, city or wider economy. The preferred option taken forward to appraisal is the **DIH** at the Temple Quarter Enterprise Zone (TQEZ). The location in the Enterprise Zone, adjacent to a major transport hub and in the centre of the Bristol and Bath digital cluster has many benefits. This is compared against a low cost "Do Minimum" alternative of extending the existing Merchant Venturers Building, which in comparison delivers just over £2m in GVA benefit and very little in terms of wider economic benefits, representing only a marginal increase in the scale of activity, with little prospect for in-house collaboration with industry.

Commercial Case: A range of procurement options are still being considered for a building for the DIH activity, the most likely being that the University will design and build a new building that it would own, maintain and operate. To this end, available land has been identified in the TQEZ, and an acquisition strategy is being developed. Procurement will be compliant with OJEU processes. The contribution of the private sector will be crucial, and early engagement has been positive.

Financial Case: An outline project budget has been developed based on the best available assumptions at this stage, which for the medium scenario (18,000m^2) is an estimated £107m. Finance will need to be secured, and a possible breakdown is set out:

Source of Finance	Capital/Recurrent	£m
University of Bristol	Capital	**17**
Business and private sector	Capital + Recurrent	**40**
West of England LEP LGF	Capital	**15**
UKRPIF	Capital	**20**
UK Government	Capital	**15**
TOTAL funding required		**107**

Note: This table represents a possible breakdown of costs, based on University of Bristol experience and early discussions with stakeholders / funders.

Management Case: An initial timeline has been developed, targeting a completion date of summer 2021. The University has a range of experience in major capital project delivery, including the National Composite Centre. Ongoing management of the DIH building and programmes will fall within existing established faculty structures.
Major risks have been identified at this early stage and mitigation measures outlined. The approach the University and partners take to active risk management will specify the roles and specific responsibilities in managing risk, as well as how risks are identified, assessed, addressed and escalated through the projects governance framework.

Project Title: Institute for Environmental Risk & Innovation (IERI)

Current Status:
Concept Development – further detail and business case in development.

Partners:
Jointly led by Met Office and University of Exeter. Partners from across public, private and academic sectors – in particular the re/insurance, disaster risk reduction, disaster risk financing sectors and infrastructure sectors. It is expected that the Institute would have

global impact, and involve international governments and UN agencies.

Strategic Case:

We propose an Institute of Environmental Risk & Innovation to drive the development of services that will enable society to become more resilient to Environmental Risk. We estimate that a £60m public investment could deliver a 5-year return of over £500m, with public sector leverage having potential to more than double this.

Society's exposure to extreme weather and climate events threatens to derail the sustainability of economic development and social welfare across the globe, and to threaten the securities on which we rely for our health and wellbeing. Extreme events and severe weather conditions are becoming more frequent, with costs of adapting to these conditions expected to rise to $70-100bn globally by 2030. In the UK the impacts of such events have been brought into sharp focus winter 2013-14 flooding, with estimates putting the insurance costs at £500m and the damage to the UK economy at £630m. The 2015 flooding in North West England again emphasised how exposed and potentially unprepared we are. Delivery of greater economic and societal resilience to environmental risk requires translation of huge, complex and diverse sets of knowledge and information, into actionable intelligence that can be ingested quickly and implemented with confidence. There is now an urgent need, and indeed critical opportunity in the context of international developments such as the Sendai Framework for Disaster Risk Reduction, the Sustainable Development Goals and the United Nations Climate Resilience Initiative, to deliver step changes in modelling, communicating and responding to risk to address future environmental hazards in the context of our changing climate and vulnerability.

Traditional approaches to modelling risk have relied primarily on isolation of each major component of the system, and utilised empirical/statistical techniques based on observed hazards. But the world is changing and past observations are no longer a reliable measure of future risks, especially in the context of environmental change. In recent years, efforts have been made to integrate adjacent components; however, a step change is now required to deliver a more interdisciplinary and innovative approach. Importantly, a new approach will need to combine scientifically intensive techniques with innovative communication methods and new business models. Scientific innovation will be required, for example, to integrate key feedback loops into models, ensure formal propagation of uncertainty down the whole information chain, and incorporate new approaches to modelling socio-economic impact. Innovation in the technical infrastructure, communication of outputs, and associated business models will also be required – for example, innovation in data streaming across the Cloud will be integral to the success of IERI; increased digital connectivity will be required in engaging communities globally; and business models and services will need to drive data transparency and enable rapid communication and action from the synthesis of complex information.

Addressing these challenges requires a critical mass of knowledge, infrastructure and resources that cannot be readily accessed by entrepreneurs, innovators and SMEs; this is evidenced by the dominance of three global companies - RMS, AIR Worldwide and CoreLogic - within the commercial catastrophe modelling market. An Institute for Environmental Risk & Innovation would catalyse the development of a new generation of integrated risk models that are global in reach and open to all through delivery of a directed, interdisciplinary research programme and targeted innovation and translation

programme. The planned, co-located, “Environmental Futures & Big Data Impact Lab” would facilitate the development of both physical and virtual communities focussed on generating commercial and socio-economic growth from associated innovation activities. Through close partnership, shared staffing and common objectives the Institute for Environmental Risk & Innovation and the Environmental Future & Big Data Impact Lab would support the existing catastrophe modelling community, whilst addressing the issues associated with critical mass and enabling growth of a complementary industry focussed on communicating environmental risk and possible responses to a wider audience. This in turn would enable the world, and UK in particular, to be better prepared and more resilient to environmental hazards through a range of research, policy, business and societal responses that are formally costed and evaluated. Ultimately, development of an Institute for Environmental Risk & Innovation, in partnership with the private sector, offers opportunity for the UK to further cement its position as a nation that is seeking to address the global challenges associated with climate change. In addition, IERI will require the continued development of essential technical infrastructure such as high speed, high capacity wireless networks, high performance computing for complex simulations, advanced data storage and manipulation capabilities, and an associated skills and knowledge economy. These developments, alongside the entrepreneurship and innovation facilities afforded by the Impact Lab, will be used as leverage in driving growth in other environmentally related sectors and in achieving a common vision for a smarter city.
Economic Case: Detailed options are in development in line with Green Book guidance; however, it is anticipated that a public investment of £60m could deliver a 5 year return in excess of £250m, with private sector leverage having potential to double this figure.
Commercial Case: Initial components of IERI could be housed immediately in the Met Office collaborative building, with a permanent location and technical infrastructure for being built as part of ongoing development of the Global Environmental Futures Campus at Exeter Science Park. Development of a full Commercial Case is being undertaken as part of detailed scoping, with all strategies expected to comply with public sector procurement guidelines.
Financial Case: Development of a full Financial Case is being undertaken as part of detailed scoping; including identification of up-front investment, ongoing business model, and potential funding sources. Up-front capital investment will be required to cover development of appropriate accommodation and technical infrastructure. Initial revenue investment will be required to cover early stage operations; detailed scoping will aim for a self-sustaining model within 5 years.
Management Case: Strategic Outline Case (SOC) by end of Oct16; with an Outline Business Case (OBC), contingent on SOC, by end Dec16; a Full Business Case (FBC), contingent on SOC & OBC, by end Mar17. Implementation of a seed-corn to IERI could begin Apr17.

Projects under development

Project Title: Composites Excellence Programme – with National Composites Materials Centre
Current Status: Our area is the centre of the UK composites industry. It is home to all of the major aerospace companies whose composites technology & product is world-leading, & a strong maritime supply-chain. It houses the UK's National Composites Centre (NCC), the internationally renowned ACCIS centre (University of Bristol), coupled with academic specialists in composite recycling in Exeter, non-destructive test and metrology at Bath University, and maritime composites at the University of Plymouth. The NCC, ACCIS, & the wider University of Bristol have declared aspirations to develop the capability, with the inclusions of the wider industrial and academic base in the region, into the "Global Go To Place for Composites". The aspirations are currently in formation & different elements are at different stages of development but would include: • Development of the National Composite Materials Centre (NCMC) for research into future composite materials e.g. fibres, textiles and resins. Proposals are currently with Innovate UK & BEIS, with support from OEMS, Tier 1's & materials manufactures. • Extension of the already world-class NCC capability in composites for transport vehicles, in particular for aerospace and increasingly for automotive. ATI proposals for advanced, innovative equipment are in process to develop this capability. Further funds will be needed to address some specific automotive and rail technologies • A Smart Structures capability, drawing on technology from the University of Bristol, University of Cardiff, the Semi-conductors Catapult in Cardiff, and 'Bristol is Open'. • A multi-materials "Beyond Carbon Fibre Programme". The use of carbon and/or glass fibre alone will not be the solution, ultimate the use of multiple materials will be required. The proposed Global Centre of Excellence in the SW must be able to advice in this area. Work on this has begun & is at an early stage with High Value Manufacturing Catapult funding fuelling early work. • With a world focused on sustainability, reducing waste & recyclability, a "Composites & Multi-Materials Sustainability Centre" is in early planning, & would form a critical piece of the overall capability. This would build on the University of Exeter's knowledge of recycling & recyclable materials, bio materials, the NCC's waste-free manufacturing plans (the data-driven factory) & through-life knowledge (Uni of Bath). • A Large Structure Centre. The proposal has been reviewed by BEIS. & is still under consideration for future funding. • Critical is the extension of knowledge, training & skills for the future work force, potentially through a National College, coupled with higher education provision. • Cutting across these, there is a need to develop the industrial composites supply-chain. Data shows huge gaps in the supply-chain, and a need for new/transitioned companies.
Partners: The lead organisation will be NCC with the support of the University of Bristol & South-west academic sector. HVMC-CPI will support NCMC to deliver this.
Strategic Case: Composite materials are enabling a paradigm shift in a number of sectors

such as aerospace, defence, automotive & maritime. The UK market is predicted to grow from current £2.3B to £12.5B by 2030 (UKTI), with the majority of the growth coming from transport sectors such as aerospace & automotive. This indicates a significant opportunity to make the UK, led from the SW, great in Composites. Other nations & global companies can see this trend & the race is beginning to secure the future fibre/matrix supply chains & continued product & process activity. With appropriate & timely investment, the UK can win a significant portion of the projected growth in revenue, increase the UK GVA content & better anchor existing product manufacture. In terms of product development the UK is already excellently placed with the NCC which, with associated academic support, is in place to provide the research, development & scale-up expertise & facilities required. Integration of new & other materials (multi-material solutions) & digital & 'smart' (Smart Structures) elements to production & product must be considered to keep the UK & SW at the leading edge globally. Diversity into new sectors such as Oil & Gas, Energy, among others are key opportunities for the region.
Economic Case: The opportunity is to capture additional UK content on future composites products including the value associated with the materials. The UK Composite Strategy 2016 details market growth figures with the current UK product market estimated to be £2.3b, that by 2020 will have grown to £5b & by 2030 the total composite products market value is forecasted at £12.5b. NCC cost modelling studies show that material content of a typical composite product could be 60% to 80% of product value by 2030, most of which will be imported. The opportunity for the UK to complete the supply chain is worth between £7b & £10b whilst also anchoring product production. There is an opportunity for the UK to export the materials to overseas manufacturers, worth a further £2-3b by 2030. The set-up of the NCMC & the SW 'Composite Excellence' programme of R&D in processes & products will enable UK companies to innovate & grow, capturing a significant share of the extensive global markets.
Commercial Case: The "Composite Excellence – with NCMC Programme" envisages a phased 7 year programme of major projects to bring to reality the aspirations outlined above, with public funding to support the infrastructure, equipment, and associated industrial research and developments being put in place, supported by a comprehensive and integrated academic programme. Some of this is directly South-West focused, some to provide national-serving assets and expertise in the region as the 'go to place for composite excellence' for the UK, generating economic benefit and jobs in our area.
Financial Case: The overall costs for the programme are still in definition. The NCMC proposal is for **£114m** over 5 years (2017-2021), to provide open-access facilities to industry. Details are available. Other projects are likely to be of smaller scale, & the funding profiles will differ in relation to project needs.
Management Case: The University of Bristol is the owner of NCC Operations Ltd. Overall management of the programme will be undertaken by the NCC with their support. The proposal is phased & details for the NCMC are available. Major risks include: Lack of Government appetite to support and grow the current composites product sector, and to generate a new foundation materials sector; and Lack of skilled people, and inability to

‘create’ them fast enough to meet industrial demand, and demand in the NCC and associated academic community, to deal with growth.

Project Title: Refurbishment of Dock 4 in Oceansgate Enterprise Zone to create a facility to increase levels of innovation and commercialisation of prototypes

Current Status:

Oceansgate Enterprise Zone is the flagship project in the Plymouth and South West Peninsula City Deal. The aim is to transform an under- utilised part of Devonport Dockyard into a major marine hub of national and international standing. Through City Deal negotiations 7.5ha of the 35ha site will be transferred to Plymouth City Council from the MoD. A consented masterplan estimates that up to 1200 jobs and 25,000m2 will be created. Through the City Deal £25.5m of funding has been raised to invest in infrastructure works and Phase 1 construction so far.

An important strand of Oceansgate is to develop a Marine Technology Centre to enable marine businesses to launch and test prototype devices, including autonomous vehicles, in waters in and around Plymouth Sound and provide research institutes with more accessible facilities to undertake marine research. The Marine Technology Centre is a unique partnership between Plymouth University, Exeter University, Plymouth Marine Laboratory, Sir Alister Hardy Foundation for Ocean Science and Plymouth City Council. The aim of the Marine Technology Centre is to increase levels of innovation and R&D. These onshore and offshore facilities will be the first of their kind in the UK and will link to other marine innovation facilities along the south coast. A crucial part of the Marine Technology Centre offer is access to the water to enable testing to take place. A dock in Oceansgate (Dock 4) has been earmarked for boats and devices to be moored and launched or for devices to be tested within the confines of the dock. However, a programme of works needs to be undertaken before the dock can become operational again. An £2.7m ERDF bid has been submitted to develop the Centre but additional funding is required to refurbish Dock 4.

Partners:

- Plymouth City Council
- Plymouth University
- Exeter University
- Plymouth Marine Laboratory
- Sit Alister Hardy Foundation for Ocean Science

Strategic Case:

The marine sector is one of the largest and most productive sectors in the South West with strong growth prospects. However, there are no commercial marine sites available in region for the sector to grow. Through City Deal negotiations land at Devonport Dockyard has been made available by the MoD to redevelop as a major marine hub. At the same time a gap in innovation assets enabling businesses and research institutes to undertake trials and tests of devices in real life marine environments was a real barrier to

commercialisation and research.

Economic Case:

There are very few marine sites with available docks space in the UK and none in the South West. There are two other docks in Phase 3 but these are considerably larger and will need more investment. They also lend themselves to more competing commercial uses.

Commercial Case:

Phase 3 which includes Dock 4 will be transferred to Plymouth City Council from the MoD in April 2018 on a 299yr lease. The Council is currently inviting expressions of interest from the market to invest in Phase 3 but has earmarked Dock 4 as an innovation asset for prototype testing and research. Surveys of Dock 4 have already been carried out and have generally found the Dock to be in good condition. However, the Docks are over 100 years old and do require some refurbishment and reinstallation of infrastructure such as gates and craneage if its use is to be maximised. Items for investment are listed below:

Minimum requirements are:

- Potential pontoon and mooring infrastructure within the dock would require additional minor investment
- De-silting and cleansing of the dock
- Craneage is likely to be provided by on an site mobile crane and would require additional minor investment.
- Additional dockside surface remediation and health and safety work is also likely to be required.
- Initial estimates for these works are around £300k.

Additional options include;

- To construct a new tidal sill and provide a boat hoist would cost in the region of £1.16m.
- To construct new radial gates around £2.06m.

Financial Case:

Currently there is no project budget assigned to the refurbishment of Dock 4. Plymouth City Council as owner of the site will in the first instance invest up to £8m in infrastructure works such as provision of utilities to enable investment to take place. The Council will then work with partners to seek investment in the Dock as well as private sector investment.

Source of Finance	**Capital/Recurrent; Cash/In-kind**	**£m**
DCLG	Capital – cash grant	8.0 secured
Plymouth City Council	Capital – cash grant	5.0 secured
MoD	Loan	1.0 secured
LEP Growth Deal	Capital – cash grant	6.5 awaiting govt approval
LEP	Loan	5.0 secured
ERDF	Revenue/capital grant	2.7 EoI submitted
TOTAL funding for project		28.2

(to date,

Notes: In order to complete Oceansgate Phase 1 to 3 we estimate we require another £17m of public sector investment and £30m of private sector investment.

Management Case:

- Infrastructure works undertaken in Phase 3 - 2017-18
- Detailed survey of Dock 4 conducted - 2017
- Phase 3 transferred to Plymouth City Council – April 2017
- Refurbishment works commence – July 2018
- Refurbishment works complete – May 2019

Project Title: Developing a globally relevant Compound Semiconductor Cluster

Current Status:

Concept Development – further detail and business case in development.

Partners:

There is a diverse, complimentary portfolio of Compound Semiconductor (CS) research in the region's universities (particularly Cardiff, Bristol and Bath) with research areas ranging from CS device physics through to novel component device fabrication, characterisation and system integration in applications such as Optoelectronics, Power electronics, RF communications and Quantum science. In addition, there is a concentration of well-established CS technology suppliers in the region: IQE (Cardiff), Infineon, SPTS (both Newport), Oclaro, II-VI (both Paignton), Plessey (Plymouth) and a wide range of end-users such as Airbus, Bae Systems, General Dynamics, Rolls Royce, Renishaw, Microsemi, Qinetiq, Tata and Sony.

Strategic Case:

The importance of Compound Semiconductor (CS) materials technology cannot be understated. It has underpinned the operation of the internet and enabled emerging megatrends such as Smart Phone and tablet usage, satellite communications/GPS, Direct Broadcast TV, energy efficient solid state lighting, efficient solar power generation, consumer electronics, high capacity communications networks and data storage, advanced healthcare and ground-breaking biotechnology. The demands of next generation electronic technologies are driving the integration and replacement of silicon based electronics with advanced CS materials, creating a truly enormous, once in a generation, market opportunity. Wales and the South West is already home to globally significant activities in the CS technology boom.

In 2015, Cardiff University, IQE Plc and The Welsh Assembly Government aligned their visions for Compound Semiconductor Innovation with the announcement of a collective investment of over £125M in order to seed the ambition to create the world's first Compound Semiconductor Technology Cluster in South Wales. This is embodied in a ~£77M investment in a new Institute for Compound Semiconductor Research at Cardiff University over the next 3 years (including £17.5M from the prestigious UK Research Partnership Investment Fund), and ~£48M for the establishment of a 50:50 Cardiff

University-IQE Joint Venture to drive commercialisation of CS Research and Innovation - the Compound Semiconductor Centre. The vision has been strengthened significantly by a recent vote of confidence from the UK Government by George Osborne's announcement in January 2016 of an intention to create a Catapult Centre focusing on Compound Semiconductor Applications located in South Wales.
The next critical elements of the Cluster focus on energising the industrial supply chain in the South Wales and South West England to leverage the Innovation investment, and upscaling the existing CS manufacturing infrastructure to provide a unique, large scale regional Foundry capability. The scale of the vision requires a long term investment of the order of ~£100M in order to unlock a target economic impact of 4,400 new high skilled manufacturing jobs in the full supply chain.

Economic Case:
The argument for investment in the cluster was underlined by a recent study by Cardiff Business school, which concluded that the GVA per employee in the technology sector including Compound Semiconductors is well above the Welsh average, as are the average earnings in the sector. For example, IQE average gross salaries are an estimated £53,000 across the Welsh operation and close to £40,000 across the whole IQE UK group. Estimated gross value added per employee across the UK group employing an estimated 479 people was over £86,000 in 2013 (greater than twice the Welsh average on both measures). The Compound Semiconductor Cluster will be a catalyst in creating high value jobs in Wales and the South West built on existing expertise and critical mass already in the region, through the involvement of companies listed above. Our model predicts that the cluster would lead to a net increase in GVA of >£378M pa and additional payroll contribution in UK of >£230M pa. In addition, the international nature of the cluster demands that inward investment will be key to measuring global relevance. Our analysis concludes that an inward investment target of £150M is a reasonable target.

Commercial Case:
Commitments to date include:
Institute of Compound Semiconductors: £77M committed to a new Translational Research Facility due to open in 2019 to house 116 CS researchers at Cardiff University's Compound Semiconductor Centre: £24M committed by Welsh Government and WEFO, £24M by IQE to establish the CSC in 2015 (the CSC has 73 staff, August 2016).
CS Applications Catapult: £50M committed by Innovate UK in Jan 2016, along with £50M in R&D funding matched by £50M from industry in 2016-2021, expected 80+ innovation and engineering staff.

Financial Case:
Ongoing investment priorities for the medium term include: £50M capital commitment for build of European Epitaxy Foundry Pilot Line in South Wales under the Cardiff City Deal; £8M for 25% National budget support for UK participants in an £60M ECSEL pilot line project to develop the business model for the European Epitaxy Foundry, with 19 EU partners; and £12-15M operating costs for the cluster companies based in the Region to participate in a large scale Integrated Project of Common European Interest (IPCEI) based on establishing a global customer base and energising the persistence of the cluster.

Management Case:
Establishment of the Compound Semiconductor Company has generated important

momentum and paves the way for successful deployment of the Compound Semiconductor Applications Catapult. A critical step will be for the Catapult to formally adopt the establishment of the Pilot Line as a strategic commercial goal.

	Milestone	Target	Status
M1	Establishment of CSC	2016	Capacity expansion for R+D @ TRL 4+
M2	Development of CS Institute	2016+	Currently increasing research capacity @ TRL1-3
		2018	TRF facility completion@ Cardiff innovation campus
M3	CS Catapult	2016	First CS CRD call July 2016
		2017+	Management team +business plan in place
M4	Pilot Line	2016	Location identified
		2018	Phase 1 Capacity: Operational
M5	First Production	2018-2020	European Foundry Pilot line operational

Project Title: Institute for Sustainable Technology Innovation (ISTI)

Current Status: UoBath proposes to construct a world-leading, sustainable technologies research centre that will develop innovative, sustainable solutions to long-standing societal, economic and developmental issues in the areas of chemical, biological and materials technologies. This centre will be known as the Institute for Sustainable Technologies Innovation, an early-stage applied research and innovation facility that will collaborate with industry, Catapults & universities. It will develop the next generation of disruptive technologies to the appropriate level for Catapults and industry to take to commercialisation. Local Growth Deal and ESIF bids are currently being developed with Swindon & Wiltshire LEP and West of England LEP. A Strategic Outline Case (SOC) is being drafted[2] according to Green Book guidance.

Partners: A joint working group is being formalised (MoU) between the University of Bath and Swindon & Wiltshire LEP. A partnership with the Centre for Process Innovation (CPI) – the process arm of the High Value Manufacturing Catapult – has been established through a MoU. Industrial partners and collaborators of the Centre for Sustainable Chemical Technologies (CSCT), on which ISTI builds, include: AB Agri; Airbus Group; BioSyntha Technology; Bruker; CatSci; Corbion Purac; Croda; Green Biologics; GSK; Johnson Matthey; Kerry; LanzaTech; Mast; NNFCC; Novartis; PhosphonicS; Sasol; Sharp; SPECIFIC; Tetrapak; Unilever; Veolia; Wessex Water. ISTI will also build on partnerships established through leadership of regional, national and international research consortia such as GW4, EPSRC UK Catalysis Hub (Research Complex @ Harwell) and international partners of CSCT: NTU, Singapore; USP, Brazil; OSU, USA; and Monash, Australia.

Strategic Case: A new approach is required for exploring solutions to increasingly

[2] Deloitte MCS Limited, *Strategic Outline Case: Institute for Sustainable Technologies Innovation,* September 2016

important issues of sustainability, which will have innovation and creativity at its core, whilst also providing a vital link between fundamental research and its technical application in industry. ISTI offers a unique value proposition: a creative, innovative approach to collaborative research with industry and Catapults, exploiting its cross-sectoral and multidisciplinary nature. Research will focus on sustainable chemical technologies, in four themes: Renewable Resources; Smart Materials; Sustainable Manufacturing & Design; and Added Value & Transformation. Themes of research will include: polymers & plastics; industrial biotechnology; the circular economy; and critical raw materials. Themes will involve a broad range of High Value Manufacturers, particularly in the sectors of pharmaceuticals, chemical manufacturing, home & personal care and electronics & consumer devices. ISTI will be a creative, collaborative, industry-facing and reactive, facility that builds upon the current capabilities of CSCT, whilst complementing and further enhancing the offering of CPI, HVM Catapult. The Creative Hub at the core of the development will strengthen existing, and catalyse new, collaborative partnerships, thus building a strong, transformative, UK wide research capability at the leading edge of sustainable technologies. Key project objectives for ISTI, to be achieved by 2025, include: to be one of the top three centres for sustainable technologies globally; contributing to ten new sustainable solutions; and delivering growth for the UK economy through collaboration with HVMs, Catapults and SMEs in order to catalyse real disruptive change and sustainability via its technological output.

Economic Case: A long-list of the potential options has been developed and assessed against the project objectives and critical success factors, to determine a short-list of four options, including a 'do nothing' comparator. The economic, social and environmental costs and benefits of the short-listed options have then been analysed, alongside the potential risks and non-monetary benefits, in order to identify a preferred solution. This preferred way forward consists of two physical components:

- A new research building (approximately 5,000m^2; off-campus, industry-facing) – the Institute itself, incorporating a range of laboratories, offices and conference space, providing high-specification facilities for academics, industry partners and Catapults to collaborate, translate and commercialise research and ideas: and
- A Creative Hub and Academic Gateway (on-campus, close to academic critical mass) that will be a customised space comprising activity areas to stimulate a climate of creativity and awareness of the practical potential and relevance of new technology.

There are a range of benefits of ISTI for both the local region and the UK. The impact of the potential public investment in collaborative R&D on GVA return has been estimated as £200m, based on public investment of £30m over five years.[3] Further benefits include:

- Direct and broader job creation, including high-skilled jobs, through development of ISTI, attraction of industry to the region and support for organisations such as SMEs, start-ups, spin-in corporate projects and programmes;
- Enhanced reputation of the UK for innovative research in sustainable technologies;
- Increases in the competiveness of UK industry on a global scale through development of innovative sustainable technologies, having cross-sectoral implications; and

[3] Warwick Economics & Development. *University of Bath Institute for Sustainable Chemical Technologies – Outline and Rationale*, November 2015.

- Environmental and societal benefits due to faster development and implementation of innovative sustainable technologies, e.g. solutions for decarbonisation of UK industry.

Commercial Case: This is under development and will set out the procurement approach to the provision of the new research facilities, options for agreeing a commercial operating structure and contractual arrangements with potential industry partners. Scoping of locations for the Institute is ongoing with Swindon & Wiltshire LEP, and two possible sites have already been identified, as has a potential campus location for the Creative Hub.

Financial Case: Initial cost analysis suggests that over the next five years the **investment required would be c£50m** to cover capital and operational costs. As specifications and requirements are refined, further economic analysis of the potential benefits, and refinement of the costs is required at OBC stage. Potential sources of funding are shown in the table below. Discussions are ongoing to confirm partners and secure commitments.

Source of Finance	Capital/Recurrent; Cash/In-kind	£m
University of Bath	Capital – cash	10
University of Bath	Recurrent – in-kind	2
Swindon & Wiltshire LEP Growth Deal	Capital – cash	20
Additional grants	Capital - cash	10
Businesses – industrial partners	Recurrent – in-kind/cash	4
Research Council, Innovate UK grants	Recurrent – cash	4
TOTAL funding for project		**50**

Management Case: The Creative Hub and Academic Gateway, to be developed on campus, is anticipated to be operational by Sept 2018. Development of ISTI, once a site has been chosen and funding secured, is expected to start in 2018 and be completed by 2020. Prior to development, key milestones will include clarification of governance arrangements, completion of full design and contractual arrangements agreed.

Project Title: Berkeley Science and Technology Park

Current Status:

The Park is on the site of the former Berkeley Nuclear Laboratories, adjacent to the decommissioned Magnox nuclear power station on the banks of the River Severn. The development site is held on a long lease from the NDA by South Gloucestershire and Stroud College. The development partnership includes the College, the University of Gloucestershire and gfirst Local Enterprise Partnership. Thus far the components of this multi-project, multi-phase development programme are:

- SGS College relocation of engineering and construction training into a refurbished building, with a view to skills training for nuclear
- Due diligence completed, contracts in place and building work commenced to create a Computing and Cyber Centre in a refurbished building, operated by the University and offering advanced business support and training facilities for companies and other organisations
- Contracts in place to build a University Technical College, within the SGS Multi

Academy Trust and sponsored by the University of Gloucestershire, specialising in digital technologies and advanced manufacturing

- Continuing presence of Cavendish Nuclear Laboratories and Magnox
- Agreement under Growth Deal 1 to invest £4 million capital in a Renewable Energies Centre in one or more refurbished buildings, with funding scheduled for 2019/20 and subject to due diligence
- ESIF bid (£948k) for low carbon support programme in second-stage approval process
- Bid in train to Innovate UK to develop a business case for a SmartGrid project, The SmartGrid will reduce each occupier's energy costs via the harnessing and storing of both renewable and off-peak mains electricity. It will also enable occupiers and learners as well as Government, academic and industrial stakeholders to understand, train, innovate and evaluate the efficient capture of and/or purchase of electricity, efficient storage and use of the same. It will also take advantage of predictive behavioural and weather modelling, and explore both physical and commercial applications of smart energy to address National Grid harmonics and short falls in National Grid capacity.
- Marketing of the site in train for commercial tenants, including new location of Green Fuels Research

Partners:

- South Gloucestershire and Stroud College
- University of Gloucestershire
- Gfirst LEP
- Business tenants of the Science and Technology Park

Strategic Case:

The original rationale and policy context was about building up the capacity for nuclear rebuild, in a way which (i) supports economic development of Gloucestershire and the wider region through a focus on applied research, business services and innovation support and (ii) capitalises on the site's potential and the area's existing economic assets to develop applied research, innovation and training for the range of renewable energies. The project gives an excellent strategic fit with the Science and Innovation Audit, linking directly to its foci on new energy systems (including nuclear), digital innovation (including cyber) and resilience (including sustainability and renewable energy), as well as the underlying cross-cutting theme of supporting business innovation. The total area of the development site is 111 acres, of which 60 are within the bed of the River Severn

Economic Case:

The development of the Berkeley site as the Gloucestershire Science and Technology Park was one of three top priorities for investment stated in the Gloucestershire Strategic Economic Plan in order to drive high-skill, high-innovation economic growth. It was endorsed by the Government as part of Growth Deal 1. Since then, individual projects have done their own due diligence to demonstrate the robustness of the economic case

Commercial Case:

The site is fully secured and available on a 999 year lease from NDA. It is fully commercially feasible, with masterplanning, facilities management, and marketing in place

Financial Case:

Source of Finance	Capital/Recurrent; Cash/In-kind	£m
University of Gloucestershire	Each of the Growth Deal and ESIF projects led by UOG has match funding	
SGS College	The Growth Deal project led by SGS has match funding	
Growth Deal	Capital –construction/nuclear skills training	5.0
Growth Deal	Capital - cyber and computing	2.0
Growth Deal	Capital - renewable energies	4.0
ESIF low carbon	Recurrent	0.95 ESIF towards project value of 1.9m
Innovate UK SmartGrid	Recurrent/capital	Development of Stage 1 business case towards £4m project

Notes: The "ask" for this project is for timely support to integrate the various component projects in developing the Berkeley site, so that all components can complement and reinforce each other - and specifically early decisions on ESIF, Growth Deal Advanced Renewable Energy, and SmartGrid

Management Case:

Each project component has its own project plan, timeline and milestones:

- The construction and engineering training facility will be operational from AY 2016/17
- The Computing and Cyber facilities will be operational from January 2017
- The UTC is on track to open September 2017
- The funding for the Renewable Energy project is profiled for 2019/20
- Second round submission deadline for the ESIF bid is end September 2016, seeking funding for the period 2017 – 2019
- SmartGrid funding bid for business case preparation in train

Bids in progress

Project Title: Institute for Advanced Automotive Propulsion Systems (IAAPS)

Current Status: Two capital funding bids have been submitted – one to the HEFCE UK Research and Partnership Investment Fund (outcome known Spring 2017) and one to the West of England Local Enterprise Partnership (outcome expected September 2016). Over £60m of industry match funding is secured. A Business Case, following the Green Book 5 Case Model, has been completed.

Partners: Lead organisation: **University of Bath**. Partners: Industry co-investors - Ford,

McLaren, Jaguar Landrover, HiETA Technologies, Hofer Powertrain. Partners: Letters of support (industry) – Horiba-Mira, Airbus, GE Precision Engineering, AshWoods, BP, Shell, CFMS. Partners: Letters of support (Government, NGOs etc) - Automotive Council, Warwick Manufacturers Group, National Composite Centre, Society of Motor Manufacturers and Traders, Mayor of Bristol, University of Bristol, South Glos Council, Bath & North East Somerset Council, West of England LEP, Swindon & Wiltshire LEP.

Strategic Case: IAAPS is a new research and innovation facility for advanced propulsion systems, to deliver future generations of clean and efficient vehicles.

- IAAPS will contribute to a low carbon economy by 2050, developing new low carbon technologies for the automotive sector to help meet ongoing carbon reduction targets. It will establish the UK as a 'Propulsion Nation',a global leader in propulsion systems;
- The proposed facility will support industry with specialist academic, technological and commercial expertise, keeping research expenditure in the UK and expediting the development of new technologies, ensuring the UK leads the way on ultra-low emission vehicles' R&D;
- IAAPS will safeguard existing and create additional research and automotive manufacturing jobs. It will help build a comprehensive talent pipeline to address the current skills gap, via new apprenticeship, undergraduate, Masters and PhD;
- The development of IAAPS will help secure the long-term future of the automotive sector through the growth of the UK share of the value chain. The Institute will help local SMEs break into the market, strengthening the domestic supply chain and assisting in the re-shoring of manufacturing jobs;
- The University of Bath's Powertrain and Vehicle Research Centre (PVRC) has five decades of globally recognised research in the automotive sector. IAAPS will assist the University in delivering upon its strategic intent. The project aligns with the University's overall vision and strategy around delivering research excellence, and will build upon and enhance PVRC's current role.

IAAPS will address the West of England's intention to invest in areas of strength (advanced engineering), which has the greatest potential to create jobs and growth. It will create 1,900 new jobs and safeguard thousands more. The new jobs created will be more productive, leading to higher wages and a more prosperous regional economy. IAAPS will address skills gaps by developing 'skills pathways' from our local education institutions, alongside IAAPS being developed as a centre for world class training and skills development. IAAPS will be built at the Bristol & Bath Science Park, enabling the science and technology vision of the park to be achieved.

Economic Case: A long list of 7 options were assessed against economic, social and environmental costs and benefits, in order to determine the best value for money. Each option was scored against project objectives, as well as critical success factors (e.g. strategic fit and deliverability).

A short list of 3 (as well as the 'do nothing' baseline option) was taken forward and appraised on both a monetary and non-monetary basis. For each of these, the following was undertaken: A cost / benefit analysis to determine best value for money; Sensitivity analysis; Non-monetary benefits analysis, e.g. ability to collaborate and higher quality research; Key risks associated with the delivery of each option. The preferred option was a **new build with both essential & desirable facility requirements.**

Commercial Case: The University of Bath's procurement procedures comply with EU regulations and the Universities traditional procurement route will be appropriate for IAAPS. The University uses an electronic tendering system (Delta eSourcing) and commonly applies the restricted procedure with standard stages, including publication in the Official Journal of the European Union (OJEU), followed by a pre-qualification questionnaire (PQQ), Invitation to Tender (ITT) for shortlisted companies and subsequent tender evaluation, award and contract issue. Headline procurement:

- Architect appointment (PQQ – Oct 2016 / ITT – Feb 2017 / Appoint – April 2017)
- Architect completes building design (by Oct 2017)
- Construction (PQQ – Nov 2017 / ITT – Jan 2018 / Appoint – March 2018)
- Construction phase (April 2018 – Oct 2019).

A site has been identified at the Bristol and Bath Science Park. The outline planning permission and masterplan for the Science Park supports the development of IAAPS.

Financial Case:

Source of Finance	Capital/Recurrent; Cash/In-kind	£m
UK RPIF	Capital - cash	30 (applied)
WoE LEP	Capital - cash	10 (applied)
Industry co-investment	Recurrent - revenue	61.7 (secured)
TOTAL funding for project		101.7

Notes: The balance of capital monies is being sought from a variety of other sources, including the Advanced Propulsion Centre and via the West of England Devolution deal.

Management Case: The actions required for the successful delivery of IAAPS have been considered, including: Governance and commercial structuring – we have worked with specialist consultants to determine how IAAPS should be run and operated. A short list of two options (IAAPS as a department of the University vs IAAPS as a department of the University but operated by a SubCo) are both being considered. A cost benefit analysis on each option is underway. **Key milestones:**

- Completed: Economic impact modelling; Governance and structuring analysis; SME survey and cluster analysis; Development of Business Case
- September 2016: Marketing materials complete; WoE LEP funding announcement
- December 2016: Appoint Oversight Board
- Spring 2017: UK RPIF funding announcement
- April 2017: Appoint architect
- October 2017: Building design complete; Recruit Chief Executive Officer
- February 2018: Planning permission; March 2018: Appoint construction firm
- April 2018 – Oct 2019: Construction phase; Oct 2019: Complete and handover

- **Risk management** – a comprehensive risk assessment has been undertaken identifying any risks associated with funding, State Aid, demand for use of the facility, reputational risks, construction (delivery overrun) and planning. All risks have mitigation actions and the post mitigation RAG rating is green for all identified risks.