Upstream Space SIA
Greater East Midlands

1 Regional Overview 1
1.1 Territory 1
1.2 Scope 2
1.3 Socio-Economic Characteristics 4
1.4 Science and Innovation Capabilities 5
1.5 Context Within the UK 14
2 Strengths in Science and Innovation 16
2.1 Excellence in Science and Research 16
2.2 Innovation strengths and growth points 20
2.3 Knowledge Transfer, Skills and Training 23
3 Themes 25
3.1 Method 25
3.2 Access to Space (A2S) 28
3.3 Satellites and Vehicles (SAV) 31
3.4 Ground Systems (GS) 35
3.5 Exploration and Enabling Technologies (E&E) 37
3.6 Cross-Theme Developments 40
3.7 Coverage Summary 45
4 Conclusions 47
4.1 Gap Analysis 47
4.2 Targeted Opportunities 48
4.3 Next Steps 49
A Research Organisations A-1
A.1 Industrial and General A-1
A.2 Universities A-3
A.3 Secondary and Further Education A-4
A.4 Hospitals and Healthcare A-4
B JACS Codes for Upstream Space B-1
C Questionnaires C-1
C.1 HEI Questionnaire C-1
C.2 LEP Questionnaire C-2
C.3 Questions for Multinational Space Companies C-3
D Company List D-1
E HEIDI+ Data E-1
E.1 Graduate Numbers per Subject E-1
E.2 Retention Numbers E-7
F European Framework Programme Participation F-1
F.1 H2020 Regional Participation F-1
F.2 FP7 Regional Participation F-4

List of Tables

Table 1-1: Footprint LEPs 1
Table 1-2: Summary Economic Characteristics 4
Table 1-3: Estimate of regionally retained upstream space ´technical group´ graduates 9
Table 2-1: Engineering publications 16
Table 2-2: Computing science publications 17
Table 2-3: Materials science publications 17
Table 2-4: Physics publications 17
Table 2-5: HEI ranking for citation impact in key topics 18
Table 2-6: REF2014 Results for Regional HEIs 18
Table 2-7: Overview of European framework programme regional engagement 20
Table 3-1: Example company table 27
Table 3-2: Occupation codes for workforce survey 29
Table 3-3: Summary of regional NSTP projects (public support) 40
Table 3-4: Space investments and projects with LLEP support 41
Table 3-5: Start-up support centres 44
Table 3-6: Product tree coverage summary 45
Table 4-1: Gap Summary 48
Table D-1: Example company table D-1

List of Figures

Figure 1-1: Proposed East Midlands Hub for HS2 connectivity 2
Figure 1-2: Greater East Midlands (LEP outlines) 3
Figure 1-3: Space industry overview 5
Figure 1-4: Student figures and retention 8
Figure 1-5: Classifying regional research organisations 10
Figure 1-6: Qualifications compared to national average 10
Figure 3-1: Organisations and data sources 25
Figure 3-2: Top-level upstream product tree 26
Figure 3-3: Company Check Process 26
Figure 3-4: Regional employment in selected occupations 29
Figure 3-5: Timeline of SRC space mission involvement 31
Figure 3-6: MIRI CAD model 31
Figure 3-7: Beagle-2 LOCC at switch-on 36

Sources

CORDIS	Community Research and Development Information Service [https://cordis.europa.eu/]
ESTAT	Eurostat [http://ec.europa.eu/eurostat/]
EUA2S	European Commission: Study on the competitiveness of the European sector in the domain of access to space, PWC, Nov. 2016 Published 2018: doi: 10.2873/795019
GRID	Global Research Identifier Database [https://www.digital-science.com/products/grid]
GTR	Gateway to Research [http://gtr.rcuk.ac.uk]
HEIQ	HEI Questionnaire (see Annex C)
HESA	Higher Education Statistics Agency [https://www.hesa.ac.uk]
HESA18	Student statistics, HESA [https://www.hesa.ac.uk/news/11-01-2018/sfr247-higher-education-student-statistics/location]
HS2EH	HS2 Phase 2b: benefits of the East Midlands Hub [https://www.gov.uk/government/publications/east-midlands-hub]
LEPD	Documentation from LEPs (various)
LEPQ	LEP Questionnaire (see Annex C)
MESIA	Midlands Engine SIA Report, Nov. 2016 [https://www.midlandsengine.org/our-five-themes/innovation-enterprise/science-innovation-audit/]
NETW	Direct networking
NOMIS	Official labour market statistics [https://www.nomisweb.co.uk]
ONS	Office for National Statistics [https://www.ons.gov.uk]
REF	Research Excellence Framework [http://results.ref.ac.uk/Results]
SH16	Size and Health Report, 2016 [https://www.gov.uk/government/publications/uk-space-industry-size-and-health-report-2016]
SOC2010	Current standard occupational classification for the UK [http://bit.ly/soc2010v2]
SSAL	Space & Satellite Applications UK Landscape [http://space.ktnlandscapes.com]
ST10	ECSS-M-ST-10C Rev.1, 6 March 2009, Space project management: Project planning and implementation [bit.ly/ecssMST10c]
UKSA	Space Agency public documents (various)
UKSD	UK Space Directory [http://www.ukspacedirectory.com]

Abbreviations and Acronyms

CNC	Computer Numeric Control
D2N2	Derby, Derbyshire, Nottingham and Nottinghamshire LEP
DWDM	Deep Wavelength Division Multiplexing
ECSS	European Cooperation for Space Standardisation
EMC	Electromagnetic Compatibility
EMCOE	East Midlands Centre of Excellence
ERDF	European Regional Development Fund
ESF	European Science Foundation
FDI	Foreign Direct Investment
FPGA	Field Programmable Gate Array
GNSS	Global Navigation Satellite Systems
GVA	Gross Value Added
JACS	Joint Academic Coding System
KTN	Knowledge Transfer Network
KTP	Knowledge Transfer Partnership
LEP	Local Enterprise Partnership
LLEP	Leicester and Leicestershire LEP
LQ	Location Quotient
NDT	Non-Destructive Test
NSTP	National Space Technology Programme
PG	Postgraduate
PNT	Position, Navigation and Timing
REF	Research Excellence Framework
RTG	Radioisotope Thermal Generator
SEMLEP	South-East Midlands LEP
SPL	Space Park Leicester
SRP	Surrey Research Park
UG	Undergraduate
USR	Upstream Relevance

Introduction

This audit "**Upstream Space for Greater East Midlands region**" has been produced to gather local evidence in response to the 3rd wave of the Science & Innovation Audit, with the space component coordinated by the UK Space Agency. The Science and Innovation Audit is part of an effort to identify areas of potential global leadership and define routes for the UK to realise that potential.

The analysis extends to the Greater East Midlands Higher Education institutions and industries, a compilation that illustrates the role of Upstream Space technologies in developing skills, infrastructure, and research and innovation, and technology transfer into other sectors, especially from fields of advanced manufacturing and aerospace. This report is key to understanding the gaps and the key requirements to unlock more effective utilisation of highly globally relevant knowledge, facilities, technologies, and industrial capacity, on a commercial basis.

This report is structured in four chapters: 1. Regional Overview 2. Strengths in Science and Innovation 3. Upstream Space Themes and 4. Conclusions. The data and methods used to gather the evidence are available within 6 annexes.

As the outcome of a very constrained undertaking, our hope is that further iterations will ensue following this first draft, improving the both the depth and the scope of the information. This requires a consolidation of approaches with other regions and clusters, with focus, support, engagement and feedback provided by the UKSA and the broader community of people and organisations involved in preparing the SIA drafts.

SUMMARY

- The region has strong representation in research and commercial exploitation of transport technologies and advanced manufacturing and engineering. The East Midlands is often considered one of the 'hot spots' of national space activity, supported by growing interest in applications (downstream) research and exploitation of research outcomes. Space, and the broader aerospace industry, are one of the four market-led priorities identified by the Midlands Engine SIA.
- There is a very significant manufacturing, design and test capability present in the Greater East Midlands region which actively supports adjacent industries with comparable requirements (aerospace, automotive) that could be encouraged to scale and diversify to support space related actions.
- Recruitment of skilled workforce remains a challenge throughout the country. Particularly in upstream, at the scale required, supply of graduates seems adequate but skills, business knowledge and awareness are lacking. Vocational training, apprenticeships, and recruits with 3-5 years of experience are hard to identify and access.
- Universities in the region are essential to creating new knowledge. Spacecraft and payloads have been the core capability of the space group at the University of Leicester (UOL) since the first UK satellite, Ariel-1, was built with Leicester payload and discovered the first cosmic X-ray source. Another example of relevant internationally recognised research which provides the basis for innovation and technology development in engineering and manufacturing is found at Loughborough University, especially in High Value Manufacturing and Transport Technology.
- The high-profile space education facility and museum space in Leicester – the National Space Centre – is a millennium project pioneered by the University of Leicester that remains a growing attraction and facility for knowledge exchange and training, teaching, learning and entertainment.
- **Upstream Space** is a necessarily international endeavour. Specialist SMEs throughout the supply chain are as vital as, and more adaptable and responsive than, the 'system primes'.
- Part of the foundation for growth is the space technology sector, which builds on wider skills in manufacturing, transport and energy. Further supporting this is Midlands Innovation – a world-class university research and innovation partnership recognising that the region accounts for 20% of the UK manufacturing output.

OPPORTUNITIES

- The establishment and operations of the UKSA are considered very positively. However, it is not fully clear that the sector has a sense of national direction or prioritisation that allows industry to align multi-year strategies or commit to significant investment within a comfortable risk posture. A **stronger direction** from the government and agency would help the UK industry progress and compete.
- Access to opportunities, training, and cross-support with space methods and standards, can be provided through established actors in upstream space – especially the strong HEI groups experienced with delivery of flight projects.
- Upstream Space still operates largely as an artificial market driven by *technology push*, *competitive prestige*, and *international competition* rather than by end-user needs. This is changing, and 'new space' has realigned the downstream subsector to a predominantly market pull model. The Greater East Midlands presents strong downstream use cases, especially in agriculture. The rest of the space economy is generally associated with other clusters.
- Key attributes of the region also include extremely good connectivity via all forms of transport, low land costs and strong business support incentives from local enterprise groups.
- Strategic long-term projects already underway can be aligned to support rapid growth in upstream space through leveraging the networks, HEIs, and connectivity of the Greater East Midlands. For example, business access to a large cleanroom facility — with balanced connections to each possible space port site — could form a focal point for capability and skills development in upstream industry, while forming a relatively low-cost, low-risk, part of the overall industrial system needed to support the UK's ambitions in access to space.
- Skills training remains largely underserved nationally. The regional prototyping of the Higher National Apprenticeship in Space Engineering, the National Space Academy, nationally recognised FE colleges, and private companies, all form a good foundation for a dedicated space skills training facility.
- Invest further in a suite of national infrastructure projects to provide a balanced capability that meets the expanding needs of the space sector to support both upstream and downstream activities in business and academia and fuel economic growth.

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Region of study

Greater East Midlands and relevant nearby locations that would otherwise likely to be excluded from other audits. To the extent possible to date, this contribution strives to be a collective response covering LEP representatives, industrial partners, and all HEIs within the region. Responses and engagement have been limited as at the date of this draft.

1 Regional Overview

1.1 Territory

The UK space industry has enjoyed recent political and financial support based upon its strong track record and persistent growth, both of which are widely reported upon and used to justify numerous measures, schemes and interventions. In recent years such support has had a downstream (applied / applications / enabled) emphasis, recognising that this is the largest part of the broader space economy. With low barriers to entry, widespread availability of low-cost or free data at ever higher spatial, temporal and radiometric resolutions, and growing consistency and standardisation of software interfaces – there is no particular strategic advantage to exploiting downstream space markets in one location over another. The UK however has enjoyed globally acknowledged leadership in small spacecraft and instrumentation (payloads) for decades. The present SIA is understood as an opportunity to redress the balance with downstream support somewhat, and to understand the geographic, academic, logistic, industrial and business advantages the nation has in driving and benefitting from the upstream space economy.

This regional report contribution to the SIA for Upstream Space presents information, analysis and insights concerned with the Greater East Midlands. Specifically, the region of interest is defined as the area covered by the following Local Enterprise Partnerships. Hereinafter, 'the region' is used to mean the land, cities, towns and other settlements, people, organisations and economic activity within these combined counties.

LEP *(LA Authority Areas)*		Link
D2N2	**Derby, Derbyshire, Nottingham and Nottinghamshire**	www.d2n2lep.org
GL	**Greater Lincolnshire** *Lincolnshire; North Lincolnshire; North East Lincolnshire*	www.greaterlincolnshirelep.co.uk
LLEP	**Leicester and Leicestershire**	www.llep.org.uk
SEMLEP	**South-East Midlands LEP** *Bedford; Buckinghamshire (part: Aylesbury Vale); Central Bedfordshire; Luton; Milton Keynes; Northamptonshire; Oxfordshire (part: Cherwell)*	www.semlep.com

Table 1-1: Footprint LEPs

The Midlands (east and west) is home to 12 million people, 18% of the UK population, and contributes £230 billion to the UK economy, about 15% of the UK's Gross Value Added (GVA), but has below-average economic productivity [ONS]. The highly connected regional **manufacturing sector** exported £39.9bn worth of products to over 100 countries in 2015, delivering the largest increase in exports of any UK region (6.5%). Key areas of strength and capability in the region include Food Processing, Transport and Energy and Low Carbon [MESIA].

Although smaller in economic value, the East Midlands is typically referred to as a **cluster of space activity**. This is underpinned by broad expertise in diverse parts of the space economy at the universities of Leicester, Nottingham, and **Cranfield**. The **University of Leicester** enjoys worldwide recognition for its international research in space science, planetary exploration and earth observation science. The **University of Nottingham** is a world leader in space-based applications of PNT (position, navigation and timing), and hosts the UK national centre of excellence for GNSS. The **National Space Centre** is a £60M science visitor centre attracting over 200,000 visitors annually, with over 10,000 students and their science teachers participating in the **National Space Academy** programmes and other space education initiatives (some of which are globally exported).

While the research base is strong – with other Universities in the area also working on more applied aspects of technology in general, and the **British Geological Survey** being a key consumer and provider of 'big data' related to space applications, the industrial landscape in the combined D2N2/LLEP territory has relatively little space activity in it. Through the inclusion of Northamptonshire in October 2016, SEMLEP covers a number of established and new space companies.

While predominantly rural (roughly 88% by area, 70% by population), the main urban concentrations in the region (in size order) are: Leicester (555,000), Nottingham (321,500), Derby (254,500), Northampton (221,000) and Lincoln (98,000).

The regional strategic road and rail networks such as the M6, the M1, the East Coast Mainline and the Midlands Mainline are of national importance. The West Coast Mainline is nearby and well connected to the region, enabling access to the north-west, Scotland, and London. Proximity to Birmingham is valuable for south-west access both by road and rail, and for international air travel.

HS2, with Phase One providing a high-speed link between Birmingham and central London, and proposals for an additional station between Derby and Nottingham, will strengthen further our offer at the centre of the UK's strategic transport network. [MESIA]

Road

Logistics is the dominant regional industry. This is reflected in the regional location quotient (LQ) for transport technologies of 1.8: the highest of any thematic area.

M1 access to Northampton, Leicester, Loughborough, Nottingham, Chesterfield and Derby.

A1 access to agricultural centres, east coast ports, London and the north.

Good access to south via M40, and to the south-west via various fast connections through to the M5.

Rail

Two mainline railways serve the region: Midland Main Line and the East Coast Main Line each with frequent services throughout the day to London, and north to Sheffield, Leeds (Midland) and York, Newcastle, Edinburgh, Aberdeen (East Coast).

Air

East Midlands Airport (EMA) is within 20km of Derby, Loughborough and Nottingham. Hosts the air freight bases for DHL, UPS and TNT, and is the second largest freight airport in UK (~10%) after Heathrow (~60%).

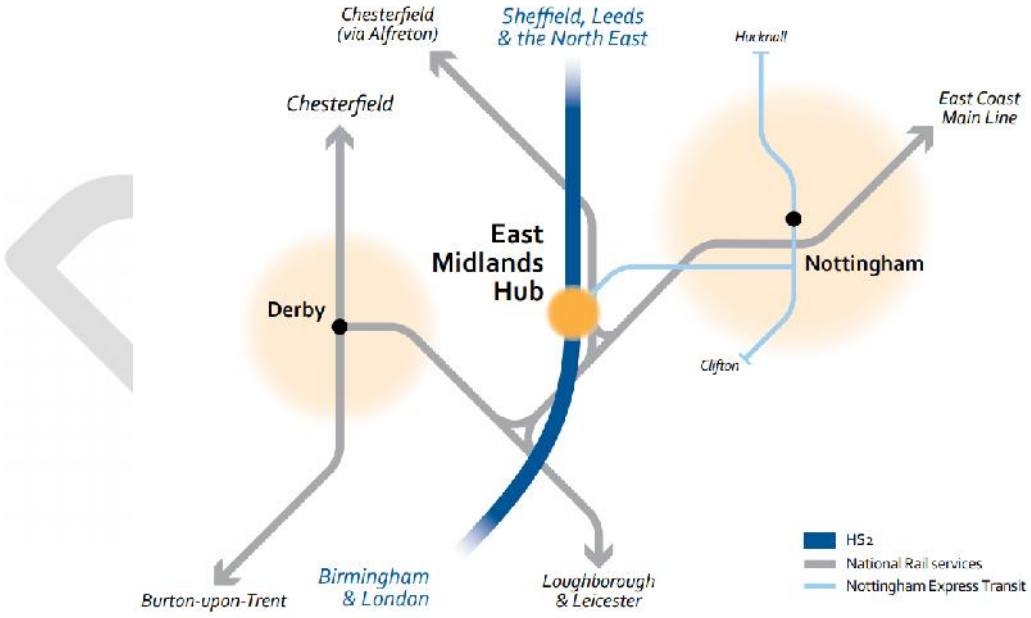


Figure 1-1: Proposed East Midlands Hub for HS2 connectivity

[HS2EH]

1.2 Scope

The scope of the Upstream Space subsector is adopted from the SIA remit:

Space Manufacturing: Design and/or manufacture of space equipment and subsystems Including: launch vehicles and subsystems, satellites/payloads/spacecraft and subsystems, ground segment systems and equipment

(control centres and telemetry), suppliers of materials and components, scientific and engineering support, fundamental and applied research.

Operations is excluded from scope since there is no identified regional facility or capability of appropriate significance.

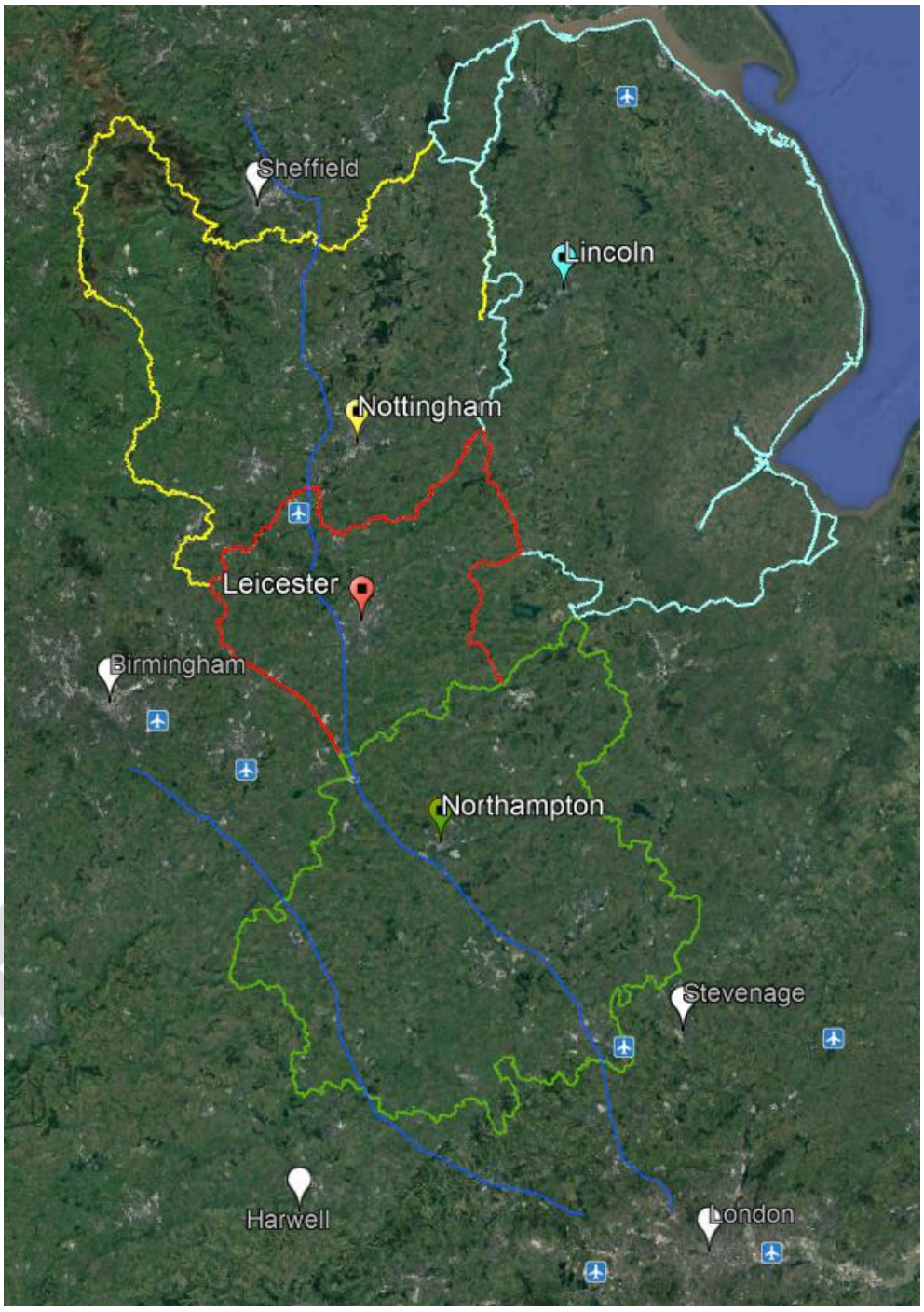


Figure 1-2: Greater East Midlands (LEP outlines)

1.3 Socio-Economic Characteristics

A summary table of top-level quantified characteristics for the Greater East Midlands.

	Parameter	*Value/Estimate*	*Source*
Economic output	GVA	£88b	
Population and Jobs	Population	~4.64 million (2014)	
	Population (16-64)	62% (~2.88 million) (2016)	NOMIS
	Area	15627 km^2	
	Population Density	300/km^2	
	Total Jobs		
	Jobs Density		
	Unemployment	2% (~97500)	NOMIS
Productivity	GVA per capita	£18965	
	Annual average gross earnings		
Science and Research Assets	Number of research organisations	240 (See ANNEX A)	GRID
General S&T Staff	Residents employed as science, research, engineering and technology professionals		
	Associate professionals		
Qualified working population	Percentage of working age population with NVQ4+ or NVQ3		
	Percentage of working age population with no qualifications		
Business Demography	Active enterprises per 1000 residents		
	Active enterprises		
	Net change		
R&D Expenditure of business	Business Enterprise R&D expenditure 2015		
New Businesses	3yr survival rate		
	High-growth firm incidence rate		
	Small high-growth firm incidence rate		
	Startup scaling		
	Number of startups per 10000 population		
	Survivor firms (older than 2013, scaling from £1-2m in 2013 to £3m+ in 2016)		
	Number of startups		
Digital Infrastructure	Percentage of premises with super-fast broadband availability		
	Average download/upload speeds		
Retention of local skills	Percentage of graduates retained in region 6 months after graduation	Technical – **44%** Business – **31%** (see §1.4.3, p.8)	HEIDI+
	Percentage of graduates in London 6 months after graduation	Technical + Business: **19%** (see §1.4.3, p.8)	HEIDI+
Student pop.	Numbers of students in relevant courses	**75335** (see Annex B)	HEIDI+

Economic data to be provided by Technopolis.

Table 1-2: Summary Economic Characteristics

1.4 Science and Innovation Capabilities

Figure 1-3 below divides the space industry into five main blocks, of which four are really business sub-sectors, and one relates to 'assets' (physical and virtual). The engineering, science, technology and related business of building and operating systems that travel to or in space, combined with the direct infrastructure involved in operating such systems. Satellites, launch vehicles (rockets), and all their associated subsystems, components, and operations are '**upstream'** elements. '**Launch'** is in dashed outline since it is not part of the UK sector at present, but launch is generally considered upstream. It is included to highlight the relevance to ongoing discussions about a proposed UK spaceport project. The **upstream subsector** is shown depending upon the **skills base** as an asset, and a wide assortment of supporting or enabling services.

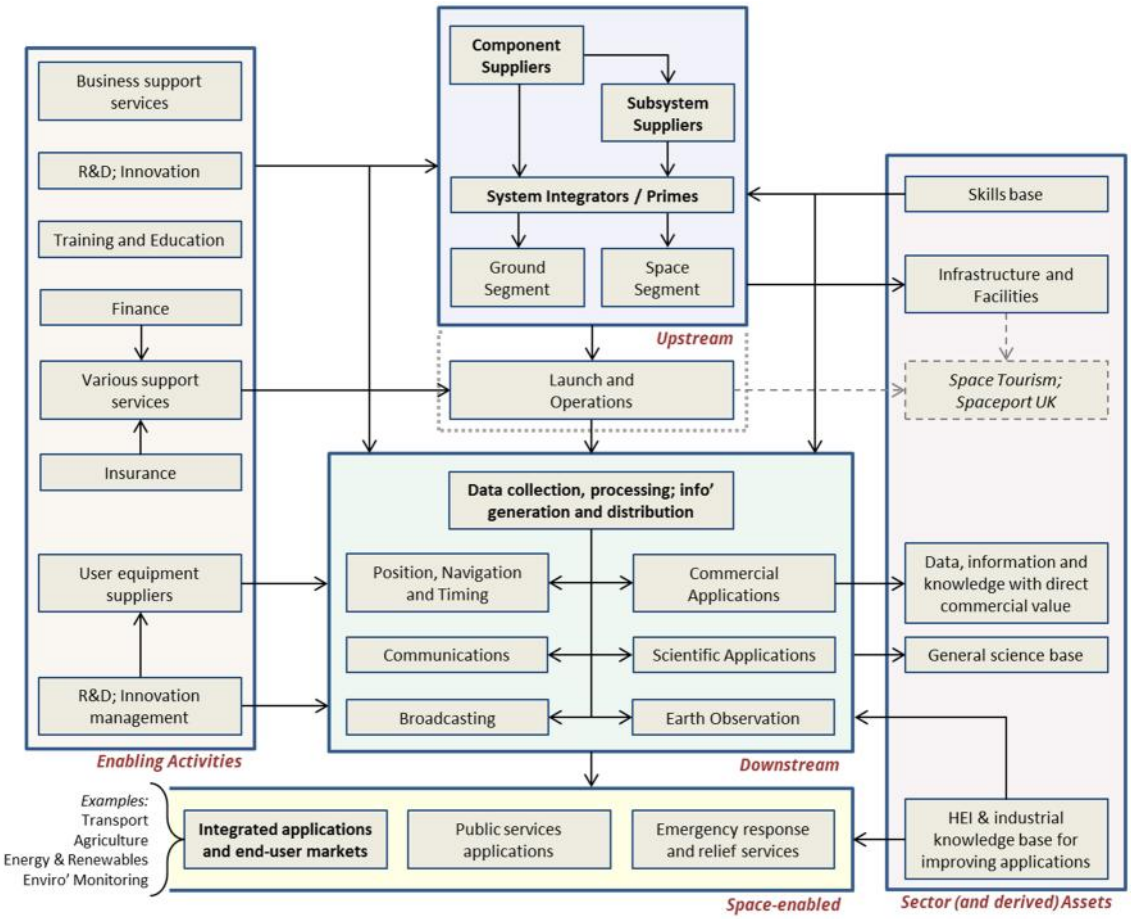


Figure 1-3: Space industry overview

1.4.1 Higher Education

The HEIs within the region are listed alphabetically with brief summary information about the size and priorities of each. The region has the lowest proportion of part-time students in England. The region has a higher influx of young people into the region at the university stage than out of the region into other regions' universities. Only 25% of the region's students undertaking a first degree are native to the region.

The relevance of the regional HEIs is examined in section 2. For the purposes of this overview section, for each institution, a summary table is given that attempts a broad classification of (separately) the **teaching relevance**, and **research relevance**, of the organisation to the **current and future upstream space sector**. 'Upstream Relevance' (**USR**) scores are assessed using public information about research groups and topics, and from coverage of subject teaching in each of the identified JACS codes applicable to upstream space. Student numbers are those available at [HESA18].

0 No thematic relevance at all

1 Foundation relevance (e.g. general engineering, mathematics, physics, materials)

2 Enabling relevance (i.e. directly relevant but not necessarily applied to space)

3 Engaged (i.e. direct upstream-relevant space sector teaching or research)

Bishop Grosseteste University

Location	**Lincoln**	Founded	**2006**
Full-time student numbers	**2,080**	USR Teaching	**0/1**
Part-time student numbers	**145**	USR Research	**0**
% postgraduates	**21%**	Collaborative visibility	**Low**
Principal relevant research groups	None		
Notes	Included for regional completeness; no relevant links for this SIA found.		

De Montfort University

Location	**Leicester**	Founded	**1969**
Full-time student numbers	**19,730**	USR Teaching	**2**
Part-time student numbers	**3,475**	USR Research	**2**
% postgraduates	**18%**	Collaborative visibility	**High**
Principal relevant research groups	Software technology; industrial and product design; advanced manufacturing and mechatronics; electronic and communication engineering; computational intelligence; Centre for Engineering Science and Advance Systems; Nonlinear Flight Dynamics Research Group.		
Notes	The university has one of the largest numbers of Teacher Fellows of any UK university and was awarded Centre of Excellence status for its performance practice teaching and student support.		

Loughborough University

Location	**Loughborough**	Founded	**1909**
Full-time student numbers	**15,374**	USR Teaching	**3**
Part-time student numbers	**2,601**	USR Research	**2**
% postgraduates	**23%**	Collaborative visibility	**Very High**
Principal relevant research groups	Advanced materials; control engineering; advanced manufacturing; large volume metrology; robotic assembly; machine vision		
Notes	Loughborough university has established wide-ranging academic strengths and is particularly acknowledged in engineering, with the largest concentration of students of any UK university.		

Nottingham Trent University

Location	**Nottingham**	Founded	**1992**
Full-time student numbers	**25,410**	USR Teaching	**1**
Part-time student numbers	**3,960**	USR Research	**1**
% postgraduates	**20%**	Collaborative visibility	**Med**
Principal relevant research groups	Materials and Engineering		
Notes	THES University of the Year in 2017; awarded TEF gold for outstanding teaching and learning.		

University of Derby

Location	**Derby**	Founded	**1992**
Full-time student numbers	**12,190**	USR Teaching	**1**
Part-time student numbers	**5,390**	USR Research	**1**
% postgraduates	**19%**	Collaborative visibility	**High**
Principal relevant research groups	Advanced Materials, Manufacturing Techniques and Systems; Thermofluids; Mechanical Analysis by CFD and FEA; Manufacturing Management; Mechatronics.		
Notes	Derby University works closely with regional businesses via the ‘University Corporate programme’.		

University of Leicester

Location	**Leicester**	Founded	**1921**
Full-time student numbers	**14,635**	USR Teaching	**3**
Part-time student numbers	**2,165**	USR Research	**3**
% postgraduates	**28%**	Collaborative visibility	**Very High**
Principal relevant research groups	Radio & Space Plasma Physics; Space Research Centre; Earth Observation Science (includes upstream instrument design/build/fly); X-ray and Observational Astronomy (includes upstream instrument design/build/fly); Computational Engineering and Control; Mechanics of Materials.		
Notes	The university has established itself as a leading research-led university and has been named University of the Year of 2008 by the Times Higher Education. The University is most famous for the invention of genetic fingerprinting DNA, the discovery of the remains of King Richard III and space research. It is a founding partner of the National Space Centre.		

University of Lincoln

Location	**Lincoln**	Founded	**1861**
Full-time student numbers	**11,580**	USR Teaching	**1**
Part-time student numbers	**2,525**	USR Research	**1**
% postgraduates	**16%**	Collaborative visibility	**Low**
Principal relevant research groups	Intelligent Systems Research Group; Machine Learning Group; Power and Energy Group		
Notes	An English university founded in 1992, with origins tracing back to the foundation and association with the Hull School of Art 1861.		

University of Northampton

Location	**Northampton**	Founded	**1975**
Full-time student numbers	**9,855**	USR Teaching	**1**
Part-time student numbers	**2,995**	USR Research	**1**
% postgraduates	**18%**	Collaborative visibility	**Low**
Principal relevant research groups	Advanced Technologies Research Group (Networking and robotics)		
Notes	Awarded TEF gold for outstanding teaching and learning.		

University of Nottingham

Location	**Nottingham**	Founded	**1881**
Full-time student numbers	**29,230**	USR Teaching	**3**
Part-time student numbers	**3,285**	USR Research	**3**
% postgraduates	**26%**	Collaborative visibility	**Very High**
Principal relevant research groups	Advanced Manufacturing Technology; Nottingham Geospatial Institute; Optics and Photonics.		
Notes	The university is often ranked in the British top seven for research power. It is the only Russell Group university in the East Midlands.		

1.4.2 Research Excellence Framework

REF (2014) performance information is provided in section 2.

1.4.3 Students and Regional Retention

1.4.3.1 Method

- The full set of JACS codes (see Annex B) were sorted and aligned according to their relevance to upstream space. 89 of the full set of 1570 four-digit codes were retained. The selected codes were used to interrogate the HEIDI+ system for statistics pertaining to each of the HEIs introduced in section 1. The two-digit codes were grouped into 2 very broad groups:

Technical and related:	F G H I J
Business and related:	N W

- Data was collected for each HEI covering total students and destinations after graduating. 'Retention' means 'within the region 6 months after graduating'.

1.4.3.2 Limitations

A number of limitations must be applied to data and conclusions from HEIDI+ statistics.

- All values are based on full person equivalents.
- Data are only available at level 2 (i.e. the 'fine grained' classification selected in Annex B is not available). The impact of this is that the numbers for our interpretation of upstream space may be slightly higher than reality – but these are in closely allied subjects, so the relevance is still defensible. All data are rounded to the nearest 5. Numbers lower than 2.5 are rounded to 0; halves are rounded upwards.
- Data used are for 2016/2017 academic year. Retention is based upon leaver destination surveys and is limited to UK students. These numbers exclude foreign students (presumed to have returned home), and also exclude anyone for whom further study is a destination.

1.4.3.3 Data

Figure 1-4 shows approximate graduates within the technical and business groups above, with the solid part of each column giving the estimated number retained within the East Midlands after 6 months. A number of assumptions and caveats need to be associated with the data used here. The main limitations are given above (§1.4.3.2), but here to enable such an estimate we also apply the average retention across topics to the total subject group graduate cohort. The data obtained are provided in Annex E.2.

Observations about this illustration follow in section 1.4.3.4.

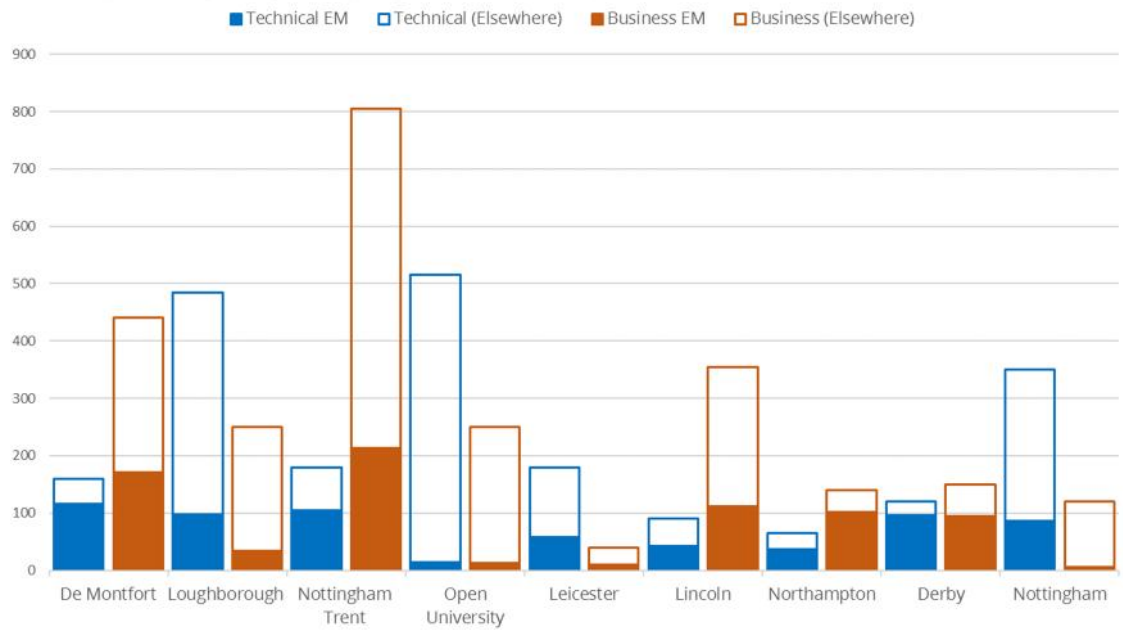


Figure 1-4: Student figures and retention

[Upstream space subjects, grouped into Technical (blue) and Business related (orange)]

1.4.3.4 Observations

- As expected, institutions with relatively high (or low) retention in one group have comparable high (or low) retention in the other group (technical vs. business).
- This is illustrated well by the Open University, with very low retention for both, since as a primarily distance learning institution we would not expect their students to be in the region after graduating.
- Most institutions have a marked emphasis upon one group over the other (technical vs business) and this is broadly as expected with regards to the research character of the institution, and the 1992 transition of vocational training organisations and FE colleges into 'new universities'.
- While it is not valid to directly compare data between institutions, broadly speaking the 'technical workforce contribution' (within the subject filters being considered) per year can be estimated by averaging the retention across all technical subjects per institution and multiplying it by the graduation rate. This tends to balance out the institution scale differences, and differences in thematic priority. This is summarised in the following table.

De Montfort University	115
Nottingham Trent University	104
Loughborough University	97
University of Derby	96
University of Nottingham	86
University of Leicester	58
University of Lincoln	42
University of Northampton	37
Open University	14

Table 1-3: Estimate of regionally retained upstream space ´technical group´ graduates

- This must be understood in the context of the limitations noted above (§1.4.3.2), and also the presumption that all subjects are equally valuable. That is, the order of magnitude is appropriate, but these values have wide error bounds (>10%, but probably not more than 20%).

1.4.4 Commercial Research

The following examples of R&D intensive commercial companies within the region are chosen *i)* to demonstrate the wide range of sectors represented and *ii)* because of their potential relevance to the upstream space subsector, despite none of these identifying as forming part of the space economy.

- Rolls-Royce
- Siemens
- ITP Engines
- Cytec Industries
- Cosworth
- Brush Electrical Machines
- HORIBA-MIRA
- Texas Instruments UK
- Oclaro UK

The research intensity values provided by Eurostat [ESTAT, dataset rd_e_gerdreg] place the East Midlands (NUTS2 definition UKF) show an intensity comparable with the national average. The per capita R&D expenditure by business within the East Midlands is €572, while the UK level figure is €671. This is skewed heavily by central London, Berkshire and Oxfordshire, East Anglia and the South East. Within the region, Derbyshire and Nottinghamshire are the highest-ranked locations outside the south-east for R&D intensity, with €855 per inhabitant.

Research-intensive organisations are listed in Annex A and discussed in the following subsection.

1.4.5 Science Assets and Talent

The GRID data, after removal of duplicates and out-of-date entries, identifies 240 research organisations within the region. Separating secondary and further education organisations, hospitals and healthcare units, universities and industrial research (including research support) highlights the significant R&D profile of the region. The organisations considered are listed in Annex A, and the proportions illustrated in Figure 1-5. This shows a strong engagement of industry with innovation support mechanisms.

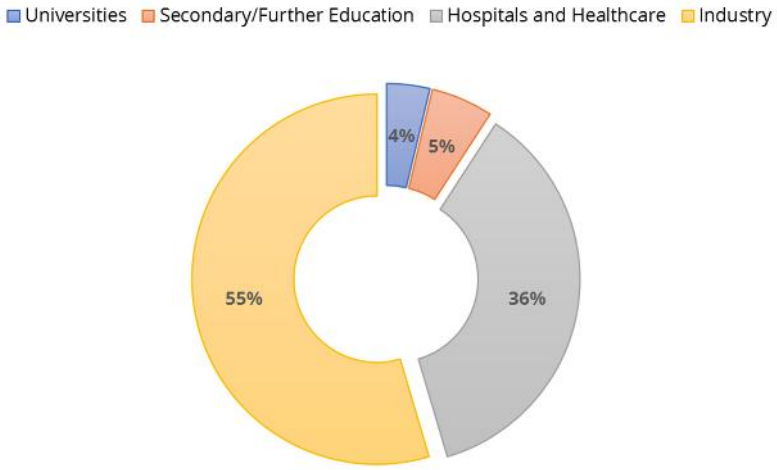


Figure 1-5: Classifying regional research organisations

In 2015, the total number of people employed in R&D roles (including researchers) was approximately 29,000 [ESTAT, rd_p_persreg database]. The geographic footprint for this population is not perfectly aligned with definition of the Greater East Midlands in this report: rather it covers the Eurostat level 2 NUTS areas UKF1 (Derbyshire and Nottinghamshire), UKF2 (Leicestershire, Rutland and Northamptonshire) and UKF3 (Lincolnshire). The discrepancy here is Rutland, and the parts of SEMLEP territory that spill into Oxfordshire and Buckinghamshire. Given the relative populations of Rutland and these other anomalies, this estimate is expected to be very conservative, with the real value somewhere a little above 30,000.

The level of qualification attainment is fairly consistent across the whole region, slightly below national averages for both NVQ3+ and NVQ4+ qualifications. The one exception is Leicestershire (excluding Leicester) exceeding the national average for NVQ3+.

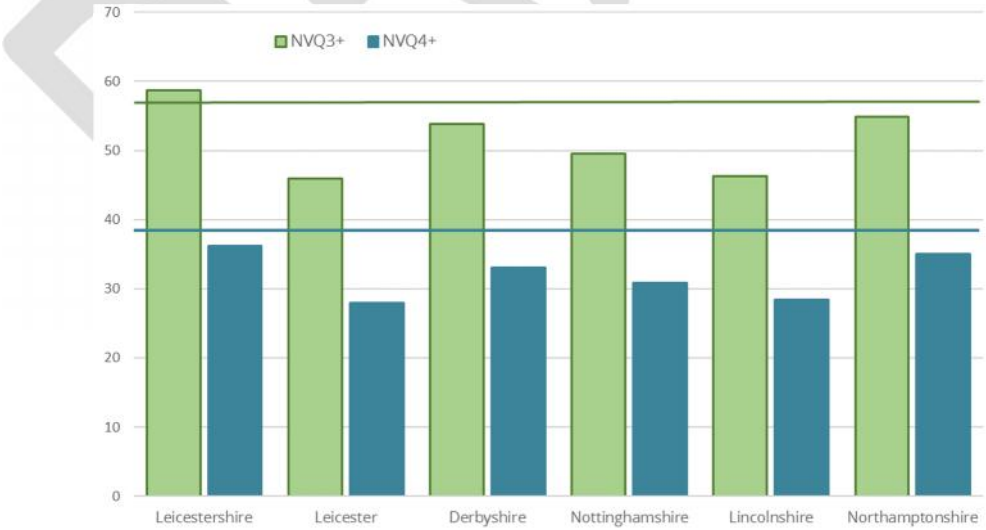


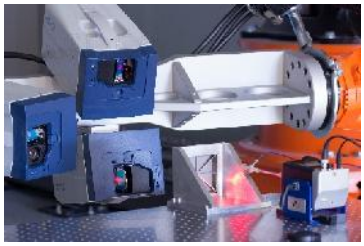
Figure 1-6: Qualifications compared to national average

Note: Leicester and Leicestershire are separated since they are separate local authority areas and source/census data is separated. [NOMIS].

1.4.6 Innovation Assets

The intention in this section is to provide summary profiles of innovation assets (centres, groups, facilities) that are nationally or internationally important. Relatively common facilities (for test, analysis, high performance computing, etc.) are not considered here, though all are present in the region.

1.4.6.1 Advanced Structural Dynamics Evaluation Centre (Leicester)



Advanced Structural Dynamics Evaluation Centre (ASDEC) was launched in July 2014. It is an autonomous testing facility associated with the University of Leicester. It was established to provide access to expertise for industry clients. It is based within the MIRA Technology Park, a hub of high-tech service providers for the automotive, defence, aerospace, and power generation industries. ASDEC is the UK's first commercial 3D vibration consultancy and modal analysis centre based upon advanced, non-contact laser Doppler vibrometry measurements.

It has been used for upstream space projects, especially in structural and vibration analysis of payload mechanical designs. 3D laser Doppler vibrometry (LDV) is ideal for measuring the structural dynamic properties of lightweight materials. Thin films used in detectors, optics and deployed arrays can only be tested using LDV.

[http://asdec.co/applications/space/]

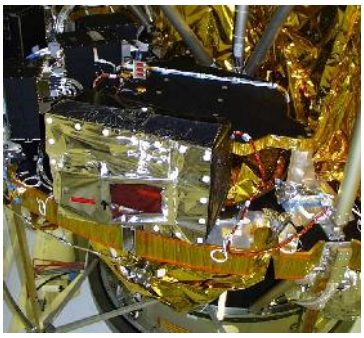
1.4.6.2 GNSS Centre of Excellence (Nottingham)

The core of the research activity at the Nottingham Geospatial Institute is focused on satellite navigation and positioning systems. Recently, this has expanded with R&D into ubiquitous positioning and navigation technologies using: different grades of inertial sensors; signals of opportunity (e.g. pseudolites, GSM/GPRS, Wi-Fi); and computer vision systems.

A unique feature of the roof-top laboratory of the Nottingham Geospatial Building is a fixed track designed for dynamic positioning system research and testing. Equipped with a custom designed remote-controlled locomotive that has been designed to carry a navigation grade POSRS inertial unit the track is a total of 120m in length. It provides a multi-sensor platform with the capability for sub-centimetre level accuracy for developing and testing integrated navigation and positioning solutions.

[https://www.nottingham.ac.uk/grace/]

1.4.6.3 Space Research Centre (Leicester)



GERB Instrument ©2002 RAL

The Space Research Centre (SRC) has a team of 80 academic and technical staff engaged in the research, design, engineering, build and testing of advanced sensors and instrumentation, and a number of well-equipped laboratories and workshops. The SRC annual research and development budget is valued at £4.5m and Leicester built devices are currently operating on six space missions and the Centre is involved in building sensor devices for a further six missions. The team combines specialist research expertise, technical engineering skills, and project management.

The SRC houses state of the art clean rooms, laboratories and workshops for testing and qualifying flight instrumentation, and a laboratory for the development of planetary exploration instrumentation. The room is currently being used for the ESA ExoMars mission. A CCD laboratory enables the group to qualify and test detector assemblies; the SRC has implemented the detectors for the GERB (Geostationary Earth Radiation Budget) instrument on board several generations of Europe's METEOSAT weather satellites.

[https://www2.le.ac.uk/departments/physics/research/src]

1.4.6.4 Aerospace Technology Institute (Cranfield)

The Aerospace Technology Institute (ATI) is responsible for developing and maintaining the UK's prominence in the aerospace sector. The ATI was established as a collaboration between Government and industry; to create the UK's aerospace technology strategy, advising and challenging the sector through £3.9 billion of secured R&T investment, to ensure the UK retains its global competitive position. The Institute's mission is to help the UK realise the opportunity available of capturing a valuable share of the growing global civil aviation market. ATI is headquartered in Cranfield, the ATI works with industry, government and academia to stimulate breakthroughs in technologies and manufacturing capabilities.

[http://www.ati.org.uk/]

1.4.6.5 SPRINT (Leicester, Cranfield and national)

SPRINT is a virtual innovation asset – a formal framework for collaborative sharing of expertise and facilities between the leading upstream space R&D groups in UK universities. Funded by HEFCE through the Connecting Capabilities Fund, SPRINT integrates a world-class blend of skills, capabilities and infrastructure to address the innovation needs of SMEs. The HEI partners are individually engaged in active strategic approaches to knowledge exchange and commercialisation within the space and space enabled sectors. They work with regional partners to develop investment in programmes, infrastructure and technology centres of excellence to secure facilities that support exploitation and growth (including Space Park Leicester, space and satellites in the Edinburgh City Deal, South Coast Satellite Applications Centre of Excellence, and plans for a national test facility for space propulsion in Buckinghamshire).

Working with the primary agencies, industry primes, science partners and the investor community, a core group of HEIs (Leicester, Open University, Southampton, Edinburgh and Surrey) will design and deliver a 'one stop shop' source of support for SMEs whose business growth is enabled by space technology/data. The geographic scope of the activity will be UK wide. It will draw on national partner infrastructure and programmes and blend them with regional infrastructure, skills and programmes.

[http://bit.ly/2JcHGi3]

1.4.6.6 Institute for Aerospace Technology (Nottingham)

The Institute for Aerospace Technology (IAT) is a major centre for aerospace research, linking global aerospace companies (including Rolls-Royce, GE Aviation, Airbus, Boeing, BAE Systems, Bombardier and GKN) with researchers and academics. IAT has over 70 externally-funded projects valued at over £75 million, being delivered by a team of 400 scientists and engineers.

[https://www.nottingham.ac.uk/aerospace]

1.4.6.7 Loughborough University Technology Centre

The Rolls-Royce University Technology Centre (UTC) at Loughborough University represents a strategic partnership between academia and industry set-up to investigate combustion and aerothermal processes. The Loughborough UTC is a world-leading research centre and focusses on the complex aerodynamic processes occurring within gas turbine combustion systems and other related engine components. It provides enhanced knowledge of the fundamental physics, the development of new and innovative methodologies and is supported by state-of-the-art computational and experimental facilities. Over 12 test facilities provide researchers with the opportunity to operate test rigs of various sizes and over a range of temperatures and pressures. In total the group has supervised in excess of 50 successful PhD candidates and the research activities have led to almost 200 journal publications, over 260 conference papers and the award of numerous worldwide patents.

[http://www.lboro.ac.uk/research/rolls-royce-utc]

1.4.6.8 Drop Tower (Northampton)

The National Lift Tower is a 127m research and development facility located in Northampton. Originally built to test lifts, the scope of work undertaken at the tower has increased considerably in recent years. The height of the building and its unique research-oriented features make it an unusual and valuable innovation asset for a wide variety of industries. Current projects span height safety and access equipment; escape systems for offshore platforms and vessels; novel systems for underwater cranage; lift engineer training; lift equipment development and marketing; drainage testing; telecommunications including long range high speed wireless broadband. There are six shafts of varying heights and speeds. A parallel vertical void is equipped with a sophisticated camera system used to track experiments in real time.

[http://www.nationallifttower.co.uk]

1.4.6.9 Advanced Manufacturing Research Centre (Sheffield)

The University of Sheffield Advanced Manufacturing Research Centre helps manufacturers of any size to become more competitive by introducing advanced techniques, technologies and processes. Industrial clients and partners include global leaders in aerospace and space: Boeing, Rolls-Royce, BAE Systems and Airbus. The centre employs about 500 researchers and engineers.

AMRC is part of the High Value Manufacturing Catapult and integrates with the other Catapult centres for pan-sector support to innovation. The principal key capabilities relevant to upstream space include: integrated manufacturing, composite development and machining, structural testing and metrology. AMRC has conducted upstream space design and prototyping studies, and won the overall UK Space Propulsion Innovation Award in 2015 for work on an innovative valve concept that removes the need for pyrotechnic activators.

AMRC falls outside the geographic boundary but has strong regional links and is more accessible than many places within the regional footprint (adjacent to the M1). Included to ensure represented within SIA.

1.4.6.10 Manufacturing Technology Centre (Coventry)

A related part of the HVM Catapult, the Manufacturing Technology Centre (MTC) develops and validates innovative manufacturing processes and technologies in an agile, low risk environment, in partnership with industry, academia and other institutions. MTC operates some of the most advanced manufacturing equipment in the world. This creates a high quality environment for the development and demonstration of new processes and technologies on an industrial scale.

The MTC's areas of expertise are directly relevant to industrial clients of all sizes and across a wide range of sectors. Partner organisations include global manufacturing companies, and research partners include 3 regional universities (Birmingham, Nottingham, Loughborough) and TWI Ltd.

MTC falls outside the geographic boundary but has strong regional links and is more accessible than many places within the regional footprint (off M6 junction2, and on the end of the M69, 20 miles from Leicester). Included to ensure represented within SIA.

1.5 Context Within the UK

Space, and the broader aerospace industry, are one of the **four market-led priorities** identified by the **Midlands Engine** SIA [MESIA]. The region has strong representation in research and commercial exploitation of *Transport Technologies* (LQ 1.8) and *Advanced Manufacturing and Engineering* (LQ 1.2). More directly linked with upstream space, the *Manufacture of air and spacecraft and related machinery* supports 25,000 employees with an LQ of 1.7, while '*Technical testing and analysis*' employs 12,500 people with an LQ of 1.4 [MESIA].

Regional Collaboration

The following regional-level initiatives and alliances create opportunities and deliver benefit to the Greater East Midlands.

- **Midlands Innovation** links 6 research-oriented universities, within which 3 regional HEIs (Leicester, Loughborough and Nottingham) collaborate with counterparts in the West Midlands (Aston, Birmingham, and Warwick) on innovation challenges.
- **SPRINT** is a recently launched national collaboration focussed on **upstream space and engagement with industry**. Six leading universities (University of Leicester, Open University, University of Surrey, Edinburgh University, University of Southampton) are formally sharing innovation resources and access to facilities and knowledge. Enabled through £4.8m funding through HEFCE CCF.
- **East Midlands Centre of Excellence in Satellite Applications** is focussed upon downstream benefits and opportunities, but in so doing raises the overall sector profile. The EMCOE represents regional collaboration in space, between UOL and the British Geological Survey, and provides an additional strong link to other regional clusters via the Satellite Applications Catapult (i.e. to Harwell Oxford, to Strathclyde, and to the South West). An important focus of this partnership is to engage with clients from organisations and sectors who do not currently use satellite technologies or data, and work with them to develop new applications of space-derived data.
- **Midlands Enterprise Universities** is a similar initiative focussed upon economic growth and less research-intensive (more vocational) HEIs (Birmingham City, Coventry, Nottingham Trent, Derby, Lincoln, Wolverhampton and De Montfort).
- The **Midlands Aerospace Alliance** (MAA) is an industry association linking around 300 members from the aerospace sector maintaining strong connections with the research base. Global players including Meggitt, Moog Aircraft Group, Rolls-Royce and UTC Aerospace Systems as well as small supply chain companies and key regional partner bodies all engage in networking, innovation support, and sector wide initiatives. MAA also curates a comprehensive database of member capabilities and distributes over 7000 copies a year throughout the industry. Midlands Aerospace magazine reaches >4000 readers. The main support pillars are Marketing and new business (e.g. for trade shows, supplier missions); Technology funding and support (e.g. NATEP); and improvements to supply chain performance, with a focus on Industry 4.0 techniques.

Space Sector Identity

The East Midlands is often considered one of the 'hot spots' of national space activity, primarily due to the activities of **University of Leicester** since the 1950s and strong track record in flight instrumentation and upstream space. The **Open University** conducts world-class planetary science research, and with the mission management and engineering support of University of Leicester led Europe's first Mars lander mission, the Beagle-2.

This has been supported by growing interest in applications (downstream) research and exploitation of research outcomes. While there is a strong overall engineering profile to the region, the commercial space industry organisations are generally found elsewhere in the country. This has not limited engagement or diminished the links between industry and the research base; space is a **necessarily international, necessarily collaborative** field of endeavour.

The high-profile space education facility and museum space in Leicester – the **National Space Centre** – is a millennium project pioneered by the University that remains a growing attraction and facility for knowledge exchange and training, teaching, learning and entertainment.

Compared to the *de facto* clusters of upstream space industrial activity around Guildford, Portsmouth, Harwell or Glasgow, the East Midlands is primarily considered as a concentration of academic space rather than an industrial- or supply-chain-relevant location. However, the strength of the research community, spanning multiple world-class HEIs, continues to generate new projects, new missions, and new opportunities. The University of Leicester has been involved in direct bilateral arrangements with **every major space agency**. The Space Research Centre at UOL operates a full life-cycle flight project business model: this is almost a unique capability for a university. See section 3.3.2.1.

2 Strengths in Science and Innovation

Traditional strengths in science and innovation within the region are found in manufacturing, engineering and materials and this is closely linked with the automotive sector. These areas of expertise have recently begun to be translated into new sectors, including upstream space, as it is recognised as a strategic priority and an economic opportunity for the region. This is demonstrated by the Midlands Engine – a coalition designed to increase competitiveness of the region. Part of the foundation for growth is the space technology sector, which builds on wider skills in manufacturing, transport and energy.

Further supporting this is Midlands Innovation – a world-class university research and innovation partnership recognising that the region accounts for 20% of UK manufacturing output and that there is opportunity to drive growth through building on these strengths.

Universities in the region are key to creating new knowledge. Examples of relevant internationally recognised research which provides the basis for innovation and technology development in engineering and manufacturing are found at Loughborough University, especially in High Value Manufacturing and Transport Technology. With regard to upstream space these assist in providing knowledge in processes, materials, manufacturing and automation – all essential for building a spacecraft – and in aerodynamics, structures, propulsion and control – relevant for Access to Space and in designing the vehicles.

Spacecraft and payloads have been the core capability of the space group at the University of Leicester (UOL) since the first UK satellite, Ariel-1, was built with Leicester payload and discovered the first cosmic X-ray source. In 1959, a group was formed dedicated to x-ray observation from space, responsible not only for the science, but the design and build of detectors and associated equipment forming the payload. Systems designed and built in UOL have been in continuous use in space ever since, in a wide variety of missions.

2.1 Excellence in Science and Research

2.1.1 Scientific production

The publication outputs from HEIs in the region were collated from Scopus SciVal looking at the years 2016, 2017 and 2018. There is no search category for upstream space so the following relevant disciplines were chosen because of their potential applicability to upstream space, although it is acknowledged that not all publications will be relevant. The regional totals deliver a higher percentage of outputs compared to the UK totals than would be expected compared to mean numbers.

- Engineering
- Computing Science
- Materials
- Physics and Astronomy

Engineering

Institution	2016	2017	2018 (Q1 only)
Cranfield	503	571	133
De Montfort	91	92	34
Derby	50	53	13
Leicester	145	139	35
Lincoln	23	25	11
Loughborough	554	518	142
Nottingham	921	935	253
Nottingham Trent	72	81	19
TOTAL	2359	2414	5838
% of UK TOTAL	9.24%	9.57%	10.96%

Table 2-1: Engineering publications

Computing Science

Institution	2016	2017	2018 (Q1 only)
Cranfield	160	228	50
De Montfort	135	146	31
Derby	79	57	12
Leicester	141	123	29
Lincoln	17	8	2
Loughborough	264	239	58
Nottingham	472	423	75
Nottingham Trent	90	82	17
TOTAL	1360	1306	274
% of UK TOTAL	7.21%	6.90%	8.88%

Table 2-2: Computing science publications

Materials Science

Institution	2016	2017	2018 (Q1 only)
Cranfield	128	171	50
De Montfort	10	40	4
Derby	12	14	0
Leicester	100	95	22
Lincoln	1	1	0
Loughborough	199	230	58
Nottingham	408	401	137
Nottingham Trent	28	28	8
TOTAL	886	980	279
% of UK TOTAL	7.24%	7.61%	8.60%

Table 2-3: Materials science publications

Physics and Astronomy

Institution	2016	2017	2018 (Q1 only)
Cranfield	54	61	33
De Montfort	22	25	7
Derby	3	5	2
Leicester	243	267	44
Lincoln	2	5	2
Loughborough	168	191	43
Nottingham	438	429	121
Nottingham Trent	32	25	2
TOTAL	1253	1270	301
% of UK TOTAL	6.24%	6.47%	7.20%

Table 2-4: Physics publications

The absolute numbers for publications are supported by previous work undertaken by Midlands Engine in citation impact in the following areas. These institutions are ranked in the top 20 in the UK for their field weighted citation impact.

Sector	Institutions (ranking)
Aerospace	Nottingham (2) Leicester (11) Loughborough (13) Cranfield (14)
Automotive	Loughborough (9) Nottingham (15) Cranfield (20)
Satellites	Leicester (17)

Table 2-5: HEI ranking for citation impact in key topics

2.1.2 Scientific quality

The established metric for relative quality assessment of scientific output in the UK is the Research Excellence Framework. Institutions provide impact and output case studies grouped by 'Units of Assessment' (related topics). A result of 3* relates to work of international significance, while 4* represents world-class research. In Table 2-6 only institutions with REF submissions relevant to upstream space are included.

The most relevant Unit of Assessment (shown in *italics*) for each institution has been selected for upstream space as indicative of the scientific quality. This naturally may not correspond to the highest achieving Unit of Assessment for a given HEI.

HEI	% 3*	% 4*	3* or 4*	FTE Staff Submitted	Comments
De Montfort University *Computer Science and Informatics*	48%	9%	57%	24.7	
Loughborough University *Aeronautical, Mechanical, Chemical and Manufacturing Engineering*	57%	26%	83%	127.4	
Nottingham Trent University *General Engineering*	59%	25%	84%	14.4	Joint 7th (of 62) for overall quality (94.6% at 3* or 4*).
University of Derby *General Engineering*	20%	0%	20%	13.0	
University of Leicester *Physics*	60%	21%	81%	49.3	Many outputs in Astrophysics, X-ray and Observational Astronomy and Space Science Instrumentation were judged to be of internationally excellent quality or better.
University of Lincoln *General Engineering*	38%	9%	47%	12.0	
University of Northampton *Aeronautical, Mechanical, Chemical and Manufacturing Engineering*	18%	0%	18%	6.75	
University of Nottingham *General Engineering*	62%	27%	89%	149.1	

Table 2-6: REF2014 Results for Regional HEIs

2.1.3 Scientific specialisation

Additional world class expertise exists in the region and some subjects are listed below. The examples chosen reflect not only world class research, but also applicability to industry and existing collaborations supporting the sector.

Smart X-Ray Optics: A consortium of 7 UK Institutions investigating next generation x-ray optics. The consortium is in its 3rd year and is funded by EPSRC. The University of Leicester is part of this consortium. There is a large scale application for the project aimed towards the development of large scale x-ray telescopes.

Planetary science at Leicester forms part of the Space Research Centre. The research has a focus on designing instruments for sampling on planets, comets, meteorites and asteroids. Ina wider remit, it provides engineering capability for the space sector and combines laboratories, workshops and clean room space.

Radioisotope thermoelectric generators (RTG) and heater units (RHU) are being developed by the University of Leicester in collaboration with industry partners (including: Airbus, Lockheed Martin, European Thermodynamics Ltd, National Nuclear Laboratory) as part of a **European Space Agency** (ESA) funded programme. Aimed at enabling or significantly enhancing space science missions, these systems rely on the cost-effective production of americium-241 for the fuel. The use of an iterative approach and the application of lean methods for the development the systems have been the focus of this technology program.

At the small end of the scale, the RHU configuration is based on a 3 W thermal power output. The first version of this system has been designed and analysed. Electrically-heated and mechanical models have been produced and tested. The RTG heat source configuration is designed to deliver 200 W of thermal power output while minimizing the volume occupied by the fuel. A 5% total system conversion efficiency and a modular scalable design imply that electrical power output can range between 10 W and 50 W. Each RTG system could house up to 5 heat sources. An electrically-heated RTG system based on the 200 W heat source architecture has been designed, analysed and is currently in an assembly integration and test phase.

Loughborough University has well-established partnerships with business and industry and commercial potential is at the centre of much activity. High quality STEM research and teaching is highly applicable and transferable to upstream space. Loughborough areas of expertise that could be applied to space manufacturing include:

- **Large volume metrology** and NDT – To support manufacture and also thinking about efficient remanufacture of reusable launch vehicles e.g. check for cracks etc. under thermal barrier coatings similar to overhaul processes for jet engine parts. Associated with this would be repair processes, crack grinding and metal deposition then resurfacing.
- **Robotic assembly**/disassembly – with the aim to reduce the cost of vehicle manufacture/remanufacture.
- Machine vision and robotic assisted assembly of complex one-off **space vehicle build** – again with the aim to reduce build cost and time but also assure quality.
- In service monitoring and repair strategies for extended service life – autonomous inspection and repair robotics
- Manufacturing technologies – including additive manufacturing, joining, composites and advanced coatings
- Advanced materials innovation and characterisation
- The use of virtual / augmented reality to support manufacturing, including digital twin technology.

2.1.4 Strength and competitiveness in Research

Gateway to Research [GTR] provides data for funded R&D from all the public research funding bodies. This was used with the following filters applied:

- East Midlands only
- Funders EPSRC, InnovateUK, STFC
- Last 10 years only
- Search term 'space'

The results were then manually sorted for relevance to upstream space industry (excluding other meanings of 'space').

26 projects were identified for the region over the last decade from these funding sources, with a total grant value of about £12.8m. The recipients were University of Leicester (18), University of Nottingham (4), Loughborough University (2), the British Geological Survey (1), and Rolls-Royce Controls and Data Services (1).

In total, across all subject areas, Universities in the region received research funding of £163.5M (based on HEBCI survey 2015/16). This includes UK research council, government, EU and contract research funding.

2.1.5 European Frameworks

To date, over one hundred regional organisations have participated in **460 projects** spanning most themes of H2020. For brevity/clarity, the list of companies, number of projects, and grant values are given in Annex F. The total grant drawn down into these organisations exceeds **€168M**.

Framework	Organisations	Number of Projects	Grant Value
H2020 (to date)	106	460	€168M
FP7	189	1201	€387M

Table 2-7: Overview of European framework programme regional engagement

2.2 Innovation strengths and growth points

The region has had a strong connection with manufacturing and engineering and this has been supported for many years as the key contributor to economic growth. Although not specifically focused on upstream space, the investments in the industry and skills base for the last 10 years has allowed the application of the technology to be focused on existing sectors such as automotive, but also to be applied to emerging sectors such as space.

The East Midlands Development Agency strategic plan 2007 – 2010 identified priority sectors to receive innovation support and created East midlands Innovation to bring together businesses, universities and public support. The priority areas identified included:

- Materials
- Design, Engineering and Manufacturing
- Information and Communication Technologies

These priorities were developed in 2010 with four priority sectors supported by cross-cutting themes. While EMDA no longer exists, these priorities reflect the regional innovation strengths and they remain highly pertinent today. These cross-cutting themes show a recognition of the space sector emerging in the region and included:

- Global navigation satellite systems
- Digital technology
- Advanced materials

There is a recognition of the importance of manufacturing contributing 23% of regional GDP and a higher than average investment by business in research and development. The sectors and these were identified through having a strong presence in the region, good prospects for growth and strong productivity with high level jobs.

More recently, the themes have continued with the development of Local Enterprise Partnerships across the region who are working to support the natural clusters that contribute most to the economy and utilise the skills and expertise available. Strategic priorities reflecting the importance of upstream space are common across the four LEPs in the region.

- Engineering and Advanced Manufacturing (including **aero and satellites**) [LLEP]
- Transport Equipment Manufacturing – including **aerospace** [D2N2]
- High performance technologies; Manufacturing and **Advanced Technology** [SEMLEP]
- Manufacturing [Greater Lincs]

LLEP is developing its Local Industrial strategy and Space Technologies and digital is an identified core sector.

These priorities drive interventions that support infrastructure and knowledge exchange to develop the sectors and themes further. Examples from across the region include:

- Loughborough Science and Enterprise Park
- Bedford College Advanced Engineering Centre
- iWORX: bespoke engineering and workshop spaces
- University of Lincoln new Engineering school
- Lincoln Science and Engineering Park

2.2.1 Clustering

Cross regional clusters that contribute to supporting upstream space include:

- Midlands Engine: a coalition of councils, combined authorities, Local Enterprise Partnerships, Universities and Businesses working to present the Midlands as a competitive and compelling offer to drive the UK economy.
- Midlands Aerospace Alliance: more than 300 organisations from global players to SMEs making up the supply chain.
- Manufacturing Technology Centre: developing and proving innovative manufacturing processes and technologies applicable across a wide range of sectors and relevant to both large and small companies. Although the MTC is outside of the geographic scope of this audit, its close proximity and the excellent connections means that it is an important asset to support the sector growing within the region.

2.2.2 Links with other National Clusters

2.2.2.1 SPRINT

SPRINT is a consortium of HEIs (Leicester, OU, Southampton, Surrey, Edinburgh); SatApps COEs and other partners (CEOI, UKSA, STFC). It is focussed on delivering sustainable outcomes through the development of a novel partnership of Universities, businesses and innovation agencies with a shared interest in the growth of the UK space sector and sectors enabled by space data and technology.

SPRINT will become a beacon of excellence in terms of how HEI partners work together to develop and deliver sector specific KE and innovation support. SPRINT will create a demand led, responsive, shared commercialisation and knowledge exchange service offer to SMEs in the space & space enabled sectors:

- Create a space & space enabled SME high growth support offer underpinned by the range of skills & assets within the partnership. It will provide a structure for aligning the operation, organisation and delivery of innovation support to SMEs, reflecting the strengths, assets and capabilities of the partner organisations (HEIs, UK Space Agency, Satellite Applications Catapult, Centre for Earth Observation & Instrumentation, STFC and National Centre for Earth Observation) typically reflecting the sector specialisations and priorities of Local Enterprise Partnerships (LEPs), City Deals and Local Authorities.
- Create a whole life cycle support proposition from early stage idea to business scale up.
- SPRINT joins up the wider environment – incubators, new ESA Business Applications Ambassadors, Catapult CoEs, and has the ability to access a strong network to engage companies, giving those with real potential the intensive support they need to take them to the next level. It will create hitherto unseen levels of collaboration between partner universities, agencies and businesses to meet the innovation and growth needs of SMEs in the space and space enabled sectors.
- Act as a major enabler of national level policy objectives which seek to: develop further clusters around existing and new space assets in industry and academia; ensure that the growth benefits of the space industries are felt at local level as well as nationally; support Science & Innovation (excellent science, ESA missions & programmes, fundamental science, transfer of space tech to new sectors); address the economy (jobs growth, highly skilled jobs, GVA, targeting diverse new sectors, space as enabler, investing in skills, invest in disruptive techniques, support export and inward investment).
- Bring together private sector investors such as Seraphim (space VC fund, Satellite Finance Network, Space Technology Angels Network) and regional investment funds.

2.2.2.2 Harwell Oxford

The Harwell Space cluster is formed of 80 space organisations based on the Harwell campus in Oxfordshire. It is made up of private companies, public space organisations, Satellite Applications Catapult and the UK Space Agency. There is research infrastructure through STFC and RAL Space are located there.

A key link with the cluster is through the Catapult regional centre of excellence (EMCOE), and collaborations between the University of Leicester and RALspace.

2.2.2.3 Guildford Space Cluster

This is based around Surrey Space Centre at University of Surrey and Surrey Satellite Technology Ltd located nearby on the Surrey Research Park (SRP). Also based on the SRP is the SETsquared Incubator Hub which has developed a focus on space businesses in order to support the local industry needs. The Guildford Space Cluster can provide end to end space missions capability.

Surrey Space Centre has been established in building small satellites since 1979 and has world class expertise in small satellite and space system engineering. They have excellent facilities include air bearing systems and a VHF/UHF ground station.

Mullard Space Science Laboratory, part of the University of London has participated in more than 200 sounding rockets, over 35 satellites and space probes. The Surrey based facilities include vacuum chambers and other test equipment. The University of Leicester partners with MSSL in the Smart X-ray optics consortium

Surrey Space Incubator supports new businesses with expertise from Surrey Technology Incubator. This includes incubation and lab space, business support and mentoring and access to academic/research facilities. It is part of the SETSquared network.

The Surrey Research Park was established 30 years ago. There are opportunities to design and build appropriate business and development space and supporting infrastructure on site, as well as co-location with several space-related businesses.

Other companies that can be classified as part of the space cluster include Earth-i; BAE systems; EOsense; Dmc International Imaging; Isardsat.

2.2.2.4 Strathclyde Cluster

The Scottish space sector focuses around Glasgow which is home to the Strathclyde Space Institute; Scottish Space School (University of Strathclyde) and the Scottish Centre of Excellence in Satellite Applications. The NANOBED missions laboratory (based on experiences of UKube-1) is also located at Strathclyde.

Glasgow has built more satellites than any other city in Europe in recent years and has a particular specialism in small satellites. The skilled workforce and connectivity is an attractor to global companies who are looking to relocate or expand.

Space companies that form part of the space cluster include Clyde Space; Spire Global, Bright Ascension, Astrosat.

2.2.2.5 Westcott Venture Park

The new National Propulsion Test Facility will be a testing facility for propulsion for engines for space exploration and other spacecraft and satellites. It is being based at Westcott Venture Park, previously the site of the Rocket Propulsions Establishment.

Also on site is a Business Incubation Centre funded through ERDF and supported by SACatapult and BTVLEP, Rockspring Hanover Property Unit Trust and UKSA. This will provide support for up to 20 start-up companies.

Other space companies located at WVP include Reaction Engines, 5G step out centre, Airborne Engineering, Nammo Westcott.

2.3 Knowledge Transfer, Skills and Training

Skills requirements in the space sector are varied and at all levels. There is a need for better engagement with education providers (from school age through to degree level) to ensure that there is an adequate level of interest and flow of students in STEM subject areas. The collaboration between employers and education providers will ensure that graduates are industry ready and that the skills and knowledge being learnt match the needs of the current industry.

Retention of those skills within the sector is another challenge and this can be addressed through providing information and knowledge about the sector in local areas. By articulating that jobs (and careers) are available in the locality, science and innovation talent will be retained and be able to contribute to the economic impact of the sector. There are two common times for talent to leave the sector – firstly at first job, where other sectors (e.g. financial services) may seem more attractive, and secondly after 5–10 years when individuals consider setting up their own company or have an opportunity to live and work in other regions or countries.

There is an opportunity to attract experienced engineers into the sector, but often there is a lack of knowledge about the sector and the opportunities that exist, based on skills more commonly associated with adjacent sectors. For upstream space examples of these include software development, robotics, autonomy and energy. Professional training availability to introduce potential employees to the space sector will benefit the region particularly if it can demonstrate the overlap in knowledge between sectors.

All HEIs in the region delivered CPD courses (not specific to upstream space) to both organisations and individuals. In 2015/16 the value of CPD delivered in the region was £63,716K.

2.3.1 Knowledge Transfer Partnerships

Knowledge Transfer Partnerships (KTP) is a UK-wide programme that has been helping businesses for the past 40 years to improve their competitiveness and productivity through the better use of knowledge, technology and skills that reside within the UK Knowledge Base.

A Knowledge Transfer Partnership serves to meet a core strategic need and to identify innovative solutions to help that business grow. KTP often delivers significant increased profitability for business partners as a direct result of the partnership through improved quality and operations, increased sales and access to new markets.

A number of organisations have hosted KTPs within the region. In addition to the location of the company partner, KTPs that link a regional HEI with company partners that are based outside of the region have also been taken into account.

Of the 96 KTP projects that are currently being undertaken in the region (in all subject areas), 78 of these can be classified as relevant to the upstream space sector. That is not to say that all (or any) of the projects are applied to the upstream space sector, but that the technology, innovation and knowledge to grow relevant technologies is being practised in the focus area. The technology areas that have been considered are:

- Advanced manufacturing
- Electronics, photonics and electrical technologies
- Advanced materials
- Emerging and Enabling Technologies

2.3.2 National Space Academy

The National Space Academy programme of student masterclasses, teacher CPD and careers events is delivered by a network of outstanding teachers and project scientists that use the context of space to teach physics, chemistry, biology, mathematics, geography and applied science to GCSE, A-level and BTEC students and their teachers. Part of the objective of the National Space Academy is to improve the size and quality of the UK science and engineering skills pool.

2.3.3 Brooksby Melton College

Brooksby Melton College in Melton Mowbray is the highest ranked for achievement (NVQ3+) in the East Midlands, and ranked 4th nationally. Recognising the rapid emergence of electric and hybrid vehicles, they are modernising their automotive maintenance training to include advanced electronic systems, networked and autonomous functions, and electronic diagnostics.

A specific opportunity has been identified for upstream space: training in CANbus protocol and systems (CAN networks are popular for small spacecraft, as a spin-in from automotive). This may be cast as overall training for harness design, implementation, and test engineering, making a unique offering within the UK (and possibly Europe).

2.3.4 Space IDEAS Hub

Following from success with business-facing innovation projects for downstream space (the ERDF co-funded project ‘G-STEP’), the University of Leicester launched an engineering and upstream-focused project to facilitate engagement of regional businesses with the technology portfolio, capabilities and assets of the Space Research Centre (see §1.4.6.3).

The Space IDEAS Hub (for Innovative Design, Engineering, Analysis and Support) ran for 3 years and completed ‘project interventions’ with over 100 SMEs, supported the creation of 3 companies, and placed graduates into jobs.

The intention and capability behind this project is continued through the broader remit of SPRINT (§2.2.2.1).

3 Themes

This section is intended to capture the present capability across four subthemes: Access to Space (§3.2), Satellites and Vehicles (§3.3), Ground Systems (§3.3.4.1) and Exploration and Enabling Technologies (§3.5). For each subtheme, five 'aspect questions' were raised by UKSA.

3.1 Method

- Question 1: *'National and international trends and size of global markets'* is understood to be provided from analysis by UKSA, informed by the most recent sector Size and Health report [SH16] and economic consultancy.
- Question 2: *'Local science and innovation assets'* has been developed using a range of data sources and analysis of requirements for a hypothetical project (see below).
  - The academic groups and facilities of international importance have been identified through a targeted survey (see Annex C) and through direct personal contacts.
  - Private or other facilities of similar significance have been sought through a variety of source materials, including the Midlands Engine SIA, LEP strategy and growth reports.
  - The perennial challenge in analysing or building strategies for the space industry is that many organisations relevant (or even active in) the supply chain do not self-identify with the sector. Most discussions about space companies in the regional footprint of interest yield a very short list, made even shorter when purely downstream subsector actors are excluded. The approach of this part of the SIA undertaking is to prioritise organisations currently outside the recognised sector, and then to supplement this set with those entities that do self-identify and whose involvement appears in, for example, the Size and Health report [SH16] dataset or the UK Space Directory [UKSD]. The 'local assets' include HEIs, organisations and associates linked through collaboration or innovation, businesses both within and outwith the space sector.
  - A range of sources were used to identify organisations within the regional footprint for consideration against the upstream scope, as follows:

	Reference/Resource						
	UKSD	SSAL	HESA	HEIDI	MESIA	LEPD	GRID
Academic Facilities	■	■					
Private/Other Facilities	■	■			■	■	
Active space companies	■	■					
Active space HEIs	■	■				■	
Adjacent sector companies					■		■
R&D Intensive companies		■			■		■
Relevant teaching HEIs		■	■	■			

Figure 3-1: Organisations and data sources

  - The hypothetical project was chosen to be a challenging scenario: the production of a constellation (order 100) of spacecraft within the regional footprint within an aggressive timescale (2-5 years), using existing companies and know-how and their extant supply chains. That is — without relying upon significant outside experience or facilities. The spacecraft specification, number, capability or timescale is largely arbitrary, but the scenario is defined to be intentionally challenging to even very experienced, established system primes anywhere in the country.

- This approach allows us to ask: 'which companies are within the footprint, that have the skills and technical domain expertise, that are of sufficient scale, that they could form part of the solution?' (to the hypothetical challenge). Upstream space is not substantially any different to advanced manufacturing and engineering in diverse other sectors. With the goal of highlighting upstream space capability and capacity in the region, to retain focus we have also applied a top-level standard space mission product tree, defined by the ECSS for using in management of all space projects [ST10]. The adjacent technology sectors (Electronics, Photonics, Sensors; ICT; High Value Manufacturing; Advanced Materials) are directly pertinent, and businesses in these sectors greatly enhance the regional capability to contribute to upstream space economic growth.
- The product tree is the breakdown of the project into successive levels of hardware and software products or elements, which together perform the functions identified in a corresponding function tree. The product tree includes the development models, the GSE, the integration tools and test equipment, and external items necessary to validate the end product. The product tree forms the basis for the elaboration of the project work breakdown structure.
- The product tree used is shown in Figure 3-2, and summarised with coverage/gap indicators in §3.7 (p.45).

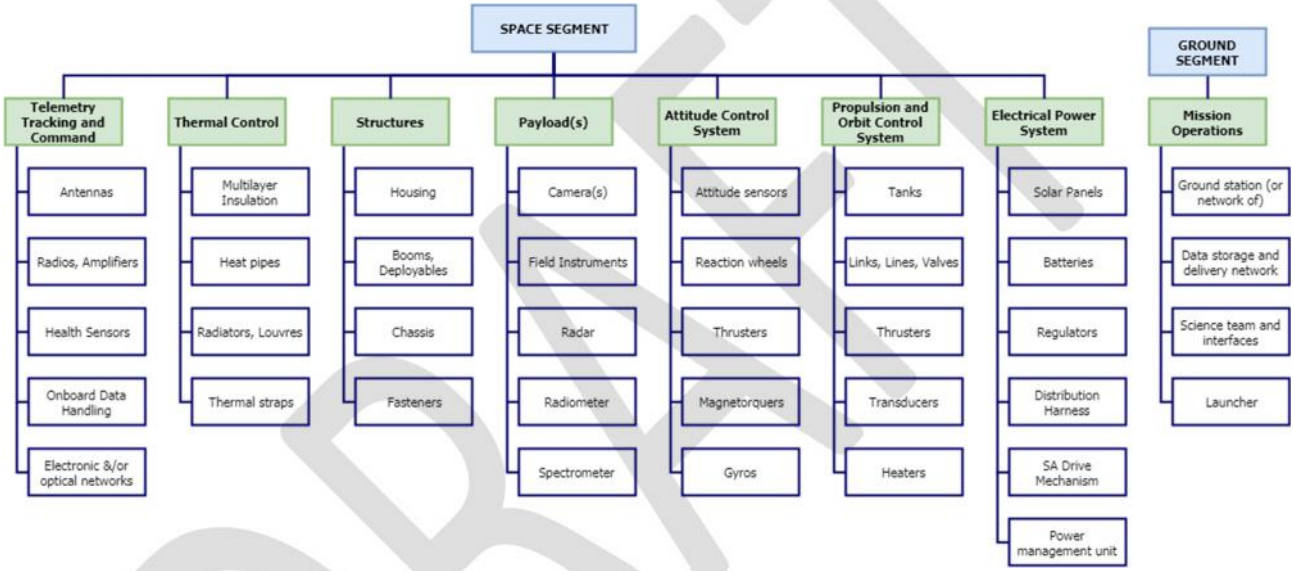


Figure 3-2: Top-level upstream product tree

- Each identified company is then associated with one or more blocks of the top-level product tree, showing their relevance to upstream space. A further benefit of this approach is that it supports the gap analysis work (see §4).
- For each identified company, the following process is used to check that it is appropriate to include them (principally addressing location and scale).

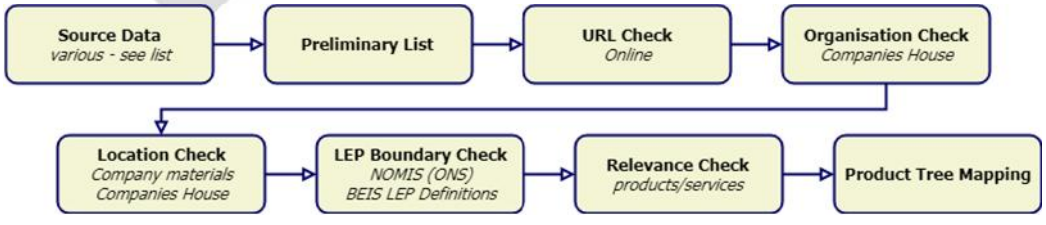


Figure 3-3: Company Check Process

- Finally, for each company in the final list, a short proforma table is completed; most fields in the table are self-explanatory (see example over). Product tree scope refers to specific aspects of the upstream product tree described above. Workforce estimates, where available, are rounded up to the nearest 10 for growth companies over the last 3 years and rounded down to the nearest 10 for companies with overall reduction in workforce.

- ‘Sector Score’ is a classification applied to describe current level of engagement with the space industry. This is akin to the scoring classifications used for HEIs in §2. The possible scores are:

  0 No engagement or relevance at all (should not then appear in SIA audit)
  1 Foundation relevance (e.g. general engineering services, parts, etc. for adjacent sector)
  2 Supply-chain relevance (i.e. directly relevant but not self-identified as space sector)
  3 In-sector (component, subsystem, service provider already in the space sector)

- ‘Innovation Score’ is a similar classification based upon evidence of the company having sought or obtained external funding or collaborative opportunities to pursue innovation-led projects beyond core business. The possible scores are:

  0 No obvious evidence for innovation culture
  1 Local innovation activities/support
  2 National-level innovation activities/support (e.g. InnovateUK, NSTP)
  3 International-level innovation activities/support (e.g. FP6, FP7, H2020)

Company	**The Company of Spaceship Builders**	*No.*	**01234567**
Location	**Place name**	*Postcode*	**LE0 0ZZ**
Established	**1900**	*Workforce*	**123**
Website	**www.thiscompany.com**	*Sector Score*	**2**
Product tree scope	**12, 34**	*Innovation Score*	**1**

Table 3-1: Example company table

- Each such table is followed by a brief justification for the company’s inclusion.
- The set of identified ‘upstream relevant’ companies within the region is given in Annex D.

- Question 3: *‘Local science and innovation talent’*
  - The full set of JACS codes were sorted and aligned according to their relevance to upstream space. 89 of the full set of 1570 four-digit codes were retained; this selection is provided in Annex B.
  - The selected codes were used to interrogate the HEIDI+ system for statistics pertaining to each of the HEIs introduced in section 1.
  - A survey sent to each HEI was used to improve the HEIDI+ dataset. The information is presented for each subtheme, while recognising that there is a lot of subject overlap and most data are repeated.
- Question 4: *‘National and international engagement’*
  - Project information from InnovateUK and UKSA NSTP is used to identify national level engagement and innovation. Data from the European Commission project database (CORDIS) and from ESA is used for European level engagement. Direct contacts are used to complement both sources, and to cover broader international activities.
- *Question 5*: *‘Developments in the wider funding landscape’.*
  - For the region under consideration, the developments in the wider funding landscape are not differentiated by subtheme. That is, the response is common to all themes, and so is addressed once (see §3.6). The primary sources are business and innovation managers in HEIs, and the strategic plans of the LEPs.

3.2 Access to Space (A2S)

3.2.1 A2S: National and international trends and size of global markets

This part to be addressed by UKSA.

3.2.2 A2S: Local science and innovation assets

3.2.2.1 ASDEC

The Advanced Structural Dynamics Evaluation Centre (ASDEC) is hosted by the HORIBO-MIRA facility near Nuneaton. ASDEC has state of the art 3D laser vibrometry equipment. This sophisticated measurement equipment is integrated with a robot control and positioning system. This enables tests involving large numbers of data points to be programmed and run at a fraction of the cost and time of traditional methods. Laser Doppler vibrometers have the ability to measure vibration at a distance and to study effects at high temperature making it powerful for engine applications, while the avoidance of transducer mass and the ability to measure huge numbers of data points is immensely valuable in wings and other large, light structures. The facility has been used for vibration and structural analysis of flight model designs of spacecraft payloads, including for ESA's Bepi-Columbo mission.

ASDEC is a world-class facility, one of only 3 in the world using this measurement equipment. It enables greater accuracy, resolution and speed in vibration testing and non-contact structural dynamics.

3.2.2.2 University of Loughborough

Three main research groups are highly relevant to the Access to Space subtheme:

- Propulsion and energy systems
  [http://www.lboro.ac.uk/departments/aae/research/propulsion-and-energy-systems/]
- Applied aerodynamics
  [http://www.lboro.ac.uk/departments/aae/research/applied-aerodynamics/]
- Structural dynamics and acoustics
  [http://www.lboro.ac.uk/departments/aae/research/dynamics-acoustics/]
- These groups have access to high quality research and innovation infrastructure, including:
  - Aeronautical Propulsion Test Cells
    Two test cells for high pressure (up to 8 bar) nozzle experiments
  - Dynamics and Control Laboratory
    - Fully instrumented 6-axis flight/car simulator
    - Small-scale servo-hydraulics rigs.
  - Low Speed Aerodynamics Laboratory
    - Three wind tunnels: a closed jet, a small low-turbulence wind tunnel, and a large wind tunnel, capable of reaching in excess of 100mph. All tunnels are state-of-the-art, including a six-component balance, high-speed pressure scanners, Particle Image Velocimetry (PIV) and hot wire anemometry.
  - Rolls-Royce UTC Laboratory
    - Comprising four purpose-built test cells for isothermal measurements on complex combustion chamber geometries and other gas-turbine engine components. Instrumentation comprises a range of advanced probe, hot wire and optical instrumentation used for flow-field surveys.

3.2.3 A2S: Local science and innovation talent

The number of graduates exiting regional HEIs, and the proportion retained in the region, are discussed in sections 1.4.3 and NVQ data in §1.4.5. Annex E provides the numbers for each institution and subject separately [HEIDI].

It has not (yet) been possible to establish the numbers of residents with STEM degrees (i.e. the intake of qualified personnel from outside the region). A good estimate is provided by the labour force survey [ONS]. We identify the most relevant employment codes [SOC2010] and filter the ONS data, as follows.

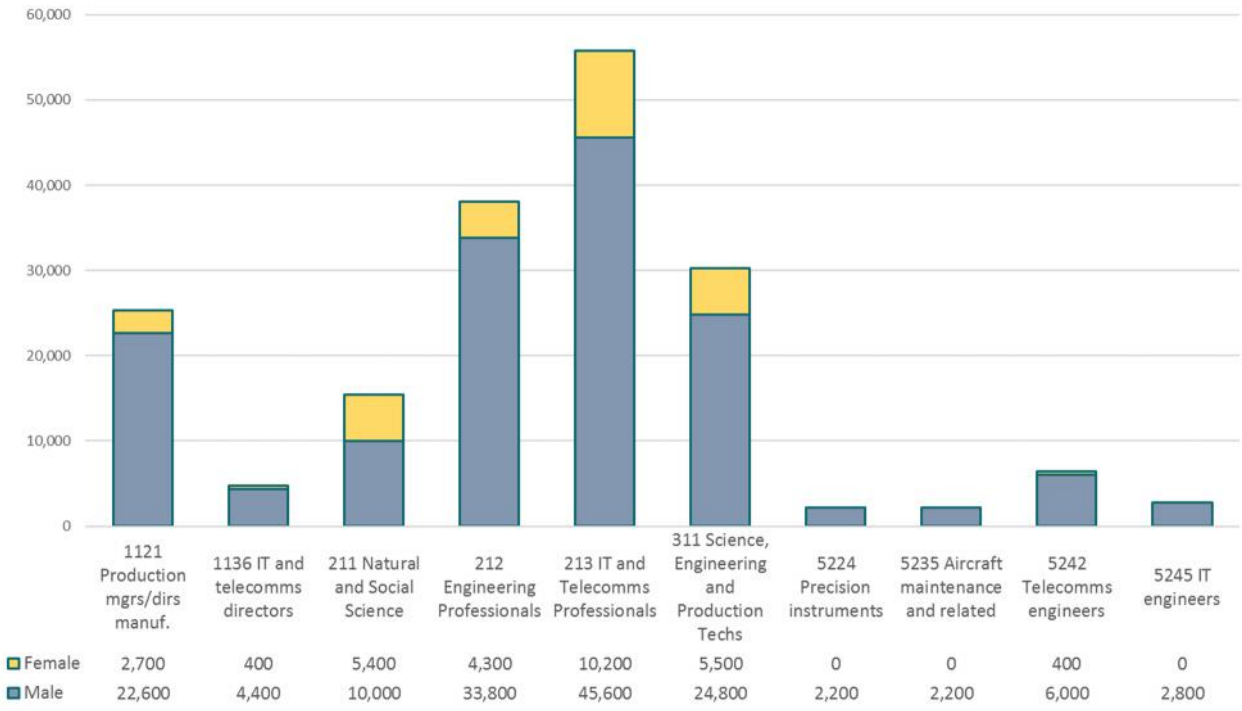


Figure 3-4: Regional employment in selected occupations

- The following occupation codes were selected:

Occupation Code	Description
1121	Production managers and directors in manufacturing
1136	Information technology and telecommunications directors
211	Natural and Social Science Professionals
212	Engineering Professionals
213	Information Technology and Telecommunications Professionals
311	Science, Engineering and Production Technicians
5224	Precision instrument makers and repairers
5235	Aircraft maintenance and related trades
5242	Telecommunications engineers
5245	IT engineers

Table 3-2: Occupation codes for workforce survey

Limitations of method

The qualified/experience labour force statistics obtained from ONS are based on the following limitations/settings:

- ONS data is structured by the usual definition of East Midlands (smaller than the footprint of this study)
- Latest figures (December 2017) are used, but a single time datum does not allow any trends to be identified. *This is possible in a future revision of this draft, if useful.*
- The granularity of employment classification makes this list as applicable to any of the other 3 SIA subthemes as to 'Access to Space'.
- Confidence value provided by ONS is 95%.
- Where '0' is indicated, this is very approximate since the estimate and confidence interval unreliable since the group sample size is small. For very small groups, data are not provided by ONS since it might be disclosive.
- Values less than 500 are approximate.
- It is also worth highlighting the strong gender imbalance in these occupations, with only Natural and Social Science (code 211) coming remotely close to balanced representation, but still with approximately 2:1 male:female employees.

Survey input

In response to the HEI survey [HEIQ], Loughborough University also highlight some specialist modules of study relevant to access to space:

- Ballistics and Rocket propulsion (69 undergraduates in 2017/18)
- Aerospace CFD (22 Masters students in 2017/18)

3.2.4 A2S: National and International Engagement

There are no clear examples to date of regional engagement on national or international level directly linked to Access to Space. However, the following brief observations are relevant to this question.

- Major aerospace upstream companies are active in the region. Lockheed Martin has active interest in small launch vehicle development, and some of this activity is expected to be supported by their UK operation.
- Space Park Leicester (see §4.2.1) is developing a strategy to exploit regional strengths in support of anticipated UK launch capability (both a launch facility, 'space port', and the vehicles that would use it).
- A 10-year collaboration between Loughborough University and Rolls-Royce on acoustic damping systems for aero gas turbine combustion systems continues to stimulate flight efficiency expertise, vehicle design, and aerothermal code development. [http://www.lboro.ac.uk/enterprise/case-studies/ads/]

3.3 Satellites and Vehicles (SAV)

3.3.1 SAV: National and international trends and size of global markets

This part to be addressed by UKSA.

3.3.2 SAV: Local science and innovation assets

3.3.2.1 University of Leicester Space Research Centre

The Space Research Centre (SRC) conducts its own R&D, enables projects in other research groups, and operates as a design-build-test-fly facility engaged in space missions with global partners. Since the early 1960s is has been a recognised centre of excellence for the design and production of spacecraft payloads and other subsystems. Recently, the SRC has contributed to NASA's James Webb Space Telescope project with the development of the payload structure for MIRI (Mid-Infrared Instrument).

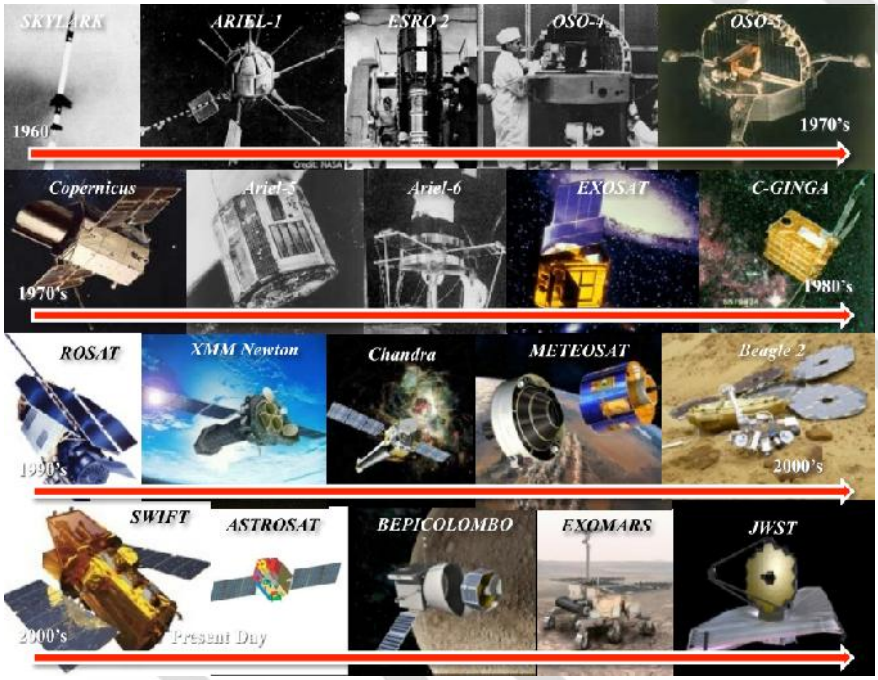


Figure 3-5: Timeline of SRC space mission involvement

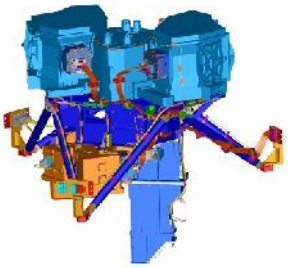


Figure 3-6: MIRI CAD model

The expertise and facilities at SRC are showcased through involvement in multiple international current flight projects:

- ESA: Bepi-Colombo - Mercury Imaging X-ray Spectrometer (launch 2017)
- ESA: ExoMars - Raman Spectrometer (launch 2018+)
- ESA: JMAG Jupiter Magnetometer for ESA JUICE Mission (launch 2022)
- NASA: MIRI James Webb Space Telescope (launch mid-2020)
- NASA Mars Science Laboratory (Curiosity) – operational; SRC involved in science analysis.
- Meteosat Second Generation – GERB instrument – operational

The SRC has state of the art clean rooms, laboratories and workshops for testing and qualifying flight instrumentation. The distinctive (some unique) capabilities include:

- MCP X-ray Optics
- Systems (Instrument) Engineering
    - Access to ASDEC facility as University partner for vibration and structural dynamics analysis. See section 1.4.6.1.
    - Complete instrumentation lifecycle
- Applications from EOS through to medical devices
- Space Nuclear Power Systems
- High End Electronics
- Clean Room
    - The SRC has on-site clean rooms which are used to meet the cleanliness requirements for flight instrumentation projects.
- Planetary Laboratory
    - This laboratory is set up for the development of planetary exploration instrumentation. The room is currently being used for the ESA ExoMars mission. Enabling technologies for access to and analysis of planetary environments and samples.
- CCD Laboratory
    - The CCD laboratory enables the group to qualify and test detector assemblies.
    - Photon detectors (focal plane assemblies)
    - High content multi-channel photon counting with picosecond timing
    - High spatial resolution optical/UV photon imaging
    - Scene-adaptive pulse processing electronics
- Vibration testing
    - The group is experienced in designing and testing hardware to survive the harsh dynamic environments during launch.
- Outgassing qualification
    - SRC benefits from an on-site outgassing facility capable of providing outgassing measurements. This facility has been used on numerous missions to prepare hardware for operation in space.
- Mission analysis and planning
    - The Department of Physics & Astronomy's Mission Modelling Unit undertakes a range of activities related to the design of space missions including trajectory analysis, observation planning, investigating the coordinated use of space assets, and a range of other topics concerned with the motion of spacecraft in low Earth orbit and beyond. The MMU uses tools including the latest version of AGI’s Systems Toolkit, complete with a suite of additional analytical modules for mission analysis and scenario development, along with NASA's SPICE and GMAT codes, and bespoke software.

The pipeline of satellite and space mission projects remains a focus for SRC, with involvement in CNES SVOM, ESA L2 Athena, ESA S2 SMILE, and diverse subsystem developments.

3.3.2.2 Loughborough University

The main research groups involved in the technologies and processes relevant to satellites and vehicles include:

- Structures and materials [http://www.lboro.ac.uk/departments/aae/research/structures-and-materials/]
- Advanced materials [http://www.lboro.ac.uk/departments/materials/research/advanced-materials/]
- Risk and reliability [http://www.lboro.ac.uk/departments/aae/research/risk-and-reliability/]
- Control [http://www.lboro.ac.uk/departments/aae/research/control/]
- Nano- and micro- scale engineering [http://www.lboro.ac.uk/departments/chemical/research/nano-micro-engineering/]

Loughborough's state-of-the art facilities for satellite development are principally suitable for structural elements and the incorporation of advanced materials.

- Additive Manufacturing Laboratories
    - Two research laboratories to support work from selective laser sintering to ultrasonic consolidation and a teaching laboratory fully equipped with 3D printers
- Loughborough Materials Characterisation Centre
    - LMCC is a facility within the Department of Materials that contains state of the art analytical instruments which can be used by students and external businesses. The centre currently contains over £6m of equipment, which can be used to characterise metals, ceramics and polymers. These facilities are supported by an experienced team of specialists. [http://www.lboro.ac.uk/research/lmcc/]
- Structures Laboratory
    - Including facilities for composite structures manufacture, dynamic drop testing and ultrasonic analysis.

3.3.2.3 HORIBA-MIRA

Mira is a centre of excellence for vehicle engineering design, test and development, whose experienced engineers have significant experience of working with automotive customers from all over the world on a wide range of programmes and projects. The company's knowledge base covers passenger cars through to heavy commercial vehicles and takes into account the requirements of differing vehicle usage profiles and manufacturing capabilities, enabling them to work closely with customers to optimise the design and manufacturing cost. Mira's Technology Park Enterprise Zone is a key site for technology related development.

3.3.3 SAV: Local science and innovation talent

See also section 3.2.3 (p. 29).

An early stage business case was endorsed the Leicester University Portfolio Management Group (UPMG) in March 2018 for a new space related Master's programme, MSc Satellite Data Science. The rationale for the introduction of this new programme is the alignment with the Space Park Leicester initiative (see §4.2.1).

The proposed MSc is timely given the development aims to strengthen industrial engagement with the university. The facility will boast new research and teaching facilities that could be exploited by the MSc, and critically it will bring students into contact with potential employers – a significant attraction for future applicants. It is envisaged that industry will actively engage within the research project element of the MSc.

3.3.4 SAV: National and international engagement

- SXO
  - The Smart X-ray Optics (SXO) consortium consists of 7 UK institutions investigating the next generation of X-ray optics. This collaboration is funded by an EPSRC basic technology grant and is currently in its 3rd year.
- NASA
  - SRC has a number of Technical Assistance Agreements in place to support work on JWST.
- CNES
  - The CNES (French Space Agency) SVOM satellite mission has placed a contract with SRC for the X-ray optics systems.
- Tencate, ADS, Airborne Aerospace and ESA
  - Airbus Defence and Space Netherlands, Airborne Aerospace, and TenCate Advanced Composites have developed and qualified the next generation, state-of-the-art substrate panel technology for satellite solar arrays. The panel design, materials, processes, and tooling were improved from previous panels with the main goals being increased process robustness, product performance, and cost efficiency.
  - The substrate panel features the next generation of space prepregs developed by TenCate Advanced Composites on areas including the facesheets, edge-members, and patches. TenCate RS36, an epoxy-based thermoset prepreg for structural composite applications was selected as the material solution.
  - In May 2017, TenCate and Airborne signed a long-term agreement for the supply of these materials, in unidirectional and fabric prepreg format from TenCate's European Centre of Excellence for thermoset systems in Langley Mill (Nottingham), UK.
  - A related composite development is baselined for inclusion within the panels for EDRS-C satellite, for ESA's Jupiter ICy moons Explorer (JUICE), and for MetOp-SG. [https://www.tencatecomposites.com/markets/space/space-and-satellite]

3.3.4.1 Thales and Elbit

The Watchkeeper WK450 UAV is built jointly by Thales and Elbit in Leicester. Further details are naturally difficult to obtain. The assembly, integration, validation expertise – especially with avionics and communication systems – is equally relevant to space platforms.

3.4 Ground Systems (GS)

3.4.1 GS: National and international trends and size of global markets

This part to be addressed by UKSA.

3.4.2 GS: Local science and innovation assets

3.4.2.1 GRACE, Nottingham University

The core of the research activity at the Nottingham Geospatial Institute is focused on satellite navigation and positioning systems. Recently, this has expanded with R&D into ubiquitous positioning and navigation technologies using: different grades of inertial sensors; signals of opportunity (e.g. pseudolites, GSM/GPRS, Wi-Fi); and computer vision systems.

A unique feature of the roof-top laboratory of the Nottingham Geospatial Building is a fixed track designed for dynamic positioning system research and testing. Equipped with a custom designed remote-controlled locomotive that has been designed to carry a navigation grade POSRS inertial unit the track is a total of 120m in length. It provides a multi-sensor platform with the capability for sub-centimetre level accuracy for developing and testing integrated navigation and positioning solutions.

[https://www.nottingham.ac.uk/grace/]

3.4.2.2 Loughborough University

Loughborough University's School of Mechanical, Electrical and Manufacturing Engineering has a Communications research theme, including three research groups considered most relevant for upstream space:

- Signal processing and networks [http://www.lboro.ac.uk/departments/meme/research/research-groups/signal-processing-networks/]
- Optical engineering [http://www.lboro.ac.uk/departments/meme/research/research-groups/optical-engineering/]
- Wireless Communications [http://www.lboro.ac.uk/departments/meme/research/research-groups/wireless-communications/]

3.4.2.3 3C Test Ltd

3C Test Ltd is a leading EMC testing company focused on reducing the impact of EM interference on all types of radio receivers. 3C Test helps manufacturers produce safe, reliable products that work together in harmony and meet the requirements of the correct EMC standards. Although not active in the space sector, the equipment, expertise and facilities are directly applicable.

[http://3ctest.co.uk/]

3.4.2.4 CST Ltd

CST offers accurate, efficient computational solutions for electromagnetic design and analysis.

[https://www.cst.com/]

3.4.2.5 Integrated Navigation Systems

iNS specialises in the design and manufacture of GNSS RF record and replay systems. These systems are used for validation of ground receivers and applications and in support for implementation of WAAS/EGNOS. Technical capability also reaches to processor porting and advanced management of embedded software.

[http://www.inavsystems.com/]

3.4.3 GS: Local science and innovation talent

See section 3.2.3 (p. 29). No specific additional information applies to this subtheme.

3.4.4 GS: National and international engagement

The University of Leicester has hosted or co-hosted ground data processing facilities in support of the following space missions:

- ESA XMM/Newton
  - UOL operated the XMM data archive.
- NASA SWIFT
  - Role in the SWIFT operations and data archiving, with a local portal.
- ESA Gaia
  - Members of the Gaia Data Processing and Analysis consortium.
- Beagle2
  - Europe's only Mars surface mission to date was conceived, developed, managed and controlled from the National Space Centre within facilities allocated to the University of Leicester. A ground monitoring and control facility was designed and implemented and **integrated with both NASA and ESA ground segments allowing cross-support from separate orbiter missions**.
  - Secure data handling, command sequence validation and science commissioning activities were all developed from scratch within an extremely constrained schedule and cost cap. The Lander Operations Control Centre operated in full view of the public visitors to the NSC gallery space.

Figure 3-7: Beagle-2 LOCC at switch-on

3.5 Exploration and Enabling Technologies (E&E)

3.5.1 E&E: National and international trends and size of global markets

This part to be addressed by UKSA.

3.5.2 E&E: Local science and innovation assets

3.5.2.1 University of Leicester

Planetary and AIV Laboratory

The Space Research Centre's Planetary and Assembly Integration and Verification (AIV) Laboratory provides a clean and controlled environment for tests of new instrument designs and experiments on planetary analogue materials. It also houses a small in-house thermal vacuum facility and a 3D microscope, and is adjacent to a cleanroom. This laboratory is for developing and testing instruments ranging from geotechnics (i.e. rock splitting and sampling) to organic detection instruments. The lab provides for the storage and handling of biological materials and rare specimens such as meteorites.

Cryogenic Laboratory

The laboratory floor has two "pits" to house low-temperature cryostats which require unusual overhead clearance and has multiple overhead crane access. The pits incorporate vibration isolation features to reduce the effects of micro phonic noise. One pit is circular, 1.0 m in diameter by 1.48 m deep and the second is rectangular, 1.38 m x 2.98 m x 0.49 m. The laboratory's safety features include an extraction fan system and multiple oxygen level sensors with suitable alarms.

The facility is currently being used to investigate graphene-based sensors.

RTG

Radioisotope thermoelectric generators (RTG) and heater units (RHU) are being developed by the University of Leicester in collaboration with industry partners (including: Airbus, Lockheed Martin, European Thermodynamics Ltd, National Nuclear Laboratory) as part of a European Space Agency (ESA) funded programme. Aimed at enabling or significantly enhancing space science missions, these systems rely on the cost-effective production of americium-241 for the fuel. The use of an iterative approach and the application of lean methodologies for the development of the systems have been the focus of this technology program. Isotope containment architectures and, in the case of RTG systems, bismuth telluride based thermoelectric generators were developed.

At the small end of the scale, the RHU configuration is based on a 3 W thermal power output. The first version of this system has been designed and analysed. Electrically-heated and mechanical models have been produced and tested. The RTG heat source configuration is designed to deliver 200 W of thermal power output while minimizing the volume occupied by the fuel. A 5% total system conversion efficiency and a modular scalable design imply that electrical power output can range between 10 W and 50 W. Each RTG system could house up to 5 heat sources. An electrically-heated RTG system based on the 200 W heat source architecture has been designed, analysed and is currently in an assembly integration and test phase.

3.5.2.2 Loughborough University

Research groups /centres include:

- Intelligent automation
  [http://www.lboro.ac.uk/departments/meme/research/research-groups/intelligent-automation/]
- Vision, autonomous and human-computer systems
  [http://www.lboro.ac.uk/departments/compsci/research/research-groups/vahc/]
- Autonomous systems
  [http://www.lucasresearch.co.uk/]
- Intelligent Automation Centre
  - 400m^2 dedicated lab space equipped with industrial robots, bespoke automation systems and state of the art test cells
    [https://www.intelligent-automation.org.uk/]

3.5.2.3 European Thermodynamics

European Thermodynamics is part of a wider group of companies whose markets span across the globe, dedicated to the design and supply of thermal management products. Regionally, this SME has nationally-important expertise in heat pipes, thermal design and management, and is already active in the space domain through international collaboration on a European RTG design (see above).

[http://www.europeanthermodynamics.com/]

3.5.2.4 Oclaro UK

Oclaro are one of the global leaders in integrated photonics for the data comms industry. The main product groups cover transponders, pluggable transceivers, and DWDM supporting technologies. ESA has recently undertaken a technical audit of capabilities and priorities for European industry to support the growing use of photonics in space. Onboard optical harnesses are key enablers for advanced payloads for both communications and SAR, and for any mission payloads that require very accurate clock distribution.

Optical solutions to intersatellite links are relevant to most emerging constellation designs. Space ground segment (still part of upstream) is increasingly migrating to RF-over-fibre solutions to integrate receiving stations with centralised data processing and archiving. This will become more of a challenge/opportunity as frequencies reach up to and beyond Ka band, and bandwidths exceed that which can be delivered over copper. Few photonics companies are active in space; a regional R&D facility for a global leader is a strong asset.

[https://www.oclaro.com/]

3.5.2.5 Magna Parva

Regional SME Magna Parva have been engaged in a variety of specialised engineering projects for upstream space. They have good familiarity with space processes and quality management, and could be expected to support future R&D and flight opportunities for exploration missions, especially with mechanical subsystem development.

[https://magnaparva.com/]

3.5.2.6 XCAM

The C3D CubeSat camera system is an imaging payload which can be used for a variety of applications including earth observation (EO) and CubeSat self-monitoring, and has proven success with both of these applications on real CubeSat missions in space.

[http://www.xcam.co.uk/]

3.5.3 E&E: Local science and innovation talent

See also section 3.2.3 (p. 29).

3.5.3.1 SEEDS MSc in Space Exploration Systems

Also offering various degrees in advanced technology, the University of Leicester has an international reputation in space technology which is evidenced by programmes such as G-STEP and the Satellite Applications Catapult node based at the University. 'The Guardian' newspaper ranked the University of Leicester in the top quartile of UK universities, where they are placed 27th out of 154 institutions. In terms of the REF, 75% of the University's research was judged to be internationally excellent. Leicester also demonstrated strong public impact of its research in the first year that this factor was measured. Some 65% of research in clinical medicine at Leicester was given the highest rating of 4-star – world leading – for its impact, thanks to work that the University's academics are doing to improve health in the local community. The public impact of Leicester's archaeological work, that included the internationally publicised archaeological dig for the remains of King Richard III, was judged to be 'internationally excellent' or better. In terms of manufacturing related technology, the University has developed a facility to house the UK's first commercial 3D laser measurement and modal analysis centre. The "Advanced Structural Dynamics Evaluation Collaborative (ASDEC) Research Centre", is an autonomous business unit within the University, created at the MIRA Technology Park near Nuneaton

http://www.le.ac.uk/space

3.5.3.2 DMU Advanced Technology

De Montfort University (DMU) offers a range of degrees in advanced technology. The University also has a growing reputation for research which benefits society, as confirmed in the REF 2014 results. Almost 60% of DMU's research activities were judged to be world-leading or internationally excellent and the University was earlier this year named the most-improved university in the UK according to the influential 'The Sunday Times League Table'. DMU has also seen an overall rise in research quality of 15 per cent compared to the last exercise in 2008.

The majority of case studies demonstrating the impact which the University's academics' work had on real-life issues were rated either 4-star (world-leading) or 3-star (internationally excellent). Key technology areas relevant to space include robotics, satellite mapping, aircraft manufacturing and safety, and mobile communication.

3.5.3.3 Loughborough University

Loughborough leads the £13.6M EPSRC Centre for Doctoral Training in Embedded Intelligence. This centre is the first of its kind in Europe and addresses high priority areas such as autonomous complex manufactured products and systems, functional materials with high performance systems, data-to-knowledge solutions (e.g. digital healthcare and digitally connected citizens), and engineering for industry, life and health.

[https://www.cdt-ei.com/]

3.5.4 E&E: National and international engagement

3.5.4.1 UK-RAS network

Loughborough is a founding partner of the EPSRC UK Robotics and Autonomous Systems Network (UK-RAS Network)

[http://hamlyn.doc.ic.ac.uk/uk-ras/about-us/facility

3.6 Cross-Theme Developments

This section captures developments in the wider funding landscape that are broadly applicable to each of the themes.

From the latest HE Business and Community Interaction (HEBCI) survey data publicly available (covering 2015/16) https://www.hesa.ac.uk/data-and-analysis/publications/hebci-2015-16 There is a good level of engagement of HEIs in the region with the development and implementation of regional economic strategies. All universities within the region reported some engagement, with the majority reporting that they are pro-actively engaged.

In addition to this strategic involvement the HEIs in the region reported that they monitor Labour Market Intelligence (LMI) in order to plan education provision within their institution. The range of responses fell between moderate and sophisticated monitoring of LMI.

This indicates that the strategic aims and science and innovation talent are interlinked and industry drivers will be supported by HEI provision to ensure that skills needs are met.

Across the region in focus, there was a total of £897M funding in collaborative research to HEIs we are considering in this study. This is not specific to upstream space but indicates that there is generally investment from public sources into generating new knowledge, and the infrastructure to support and manage this. A further £74M was invested for commercial research across all subject areas and all types of sponsor – from SMEs to corporates and other non-commercial organisations. Consultancy, including access to facilities and equipment added £21M to the regional economy.

3.6.1 National Space Technology Programme

A survey of the regional engagement with NSTP funding opportunities (filtered for upstream) has yielded the summary below in Table 3-3; it is not yet clear whether this is complete, but it shows a mix of small business, medium business, multinational, and HEI participation in strategic R&D.

Sub sector	Project Title	Organisation	Project Type
A2S/GS	Launch Authorisations System	Telespazio Vega (Luton)	Pathfinder
SAV/E&E	Critical assessment of the production and performance of a large format SWIR avalanche photodiode array	Leonardo MW Ltd. (Luton)	Fast Track
A2S/SAV	The Development of Advanced Composite Materials for Use in Non-Metallic Liquid and Gas Propellant Storage Tank Applications	Haydale Composites (Loughborough)	Fast track
E&E	Light-field photography: Technology development of bespoke multispectral optics for Earth, lunar and planetary observations	Dynamic Imaging Analytics (Milton Keynes)	Fast Track
SAV/E&E	TDI CMOS Capability Development	E2V (Lincoln)	Fast Track
SAV	In-orbit spacecraft health monitoring: Low-cost MEMS-based vibro-acoustic measurement of in-orbit spacecraft	Cranfield University	GEI
E&E	Microgravity & Space Environment Service – Market Assessment	Telespazio Vega (Luton)	GEI
SAV/E&E	An alternative material for radiation detectors	Cranfield University	GEI
	(Downstream)	University of Leicester	GEI

Table 3-3: Summary of regional NSTP projects (public support)

3.6.2 LLEP Advanced Manufacturing and Engineering Strategic Economic Plan

The LLEP recognises the importance of the manufacturing sector and within it, AME; not only in direct benefits such as jobs and fiscal benefits, but in the high value-added nature of the sector and the longer term benefits they bring in R&D, innovation and investment in skills. Two of the four 'Transformational Priorities' in the LLEP's Strategic Economic Plan18 are focused on these aspects;

Loughborough Science & Enterprise Parks are expected to provide up to 4,000 jobs and leverage private investment of up to £200M. The majority of STEM research funding at Loughborough University comes from the research councils (especially EPSRC). Loughborough also maintains a strong, successful profile within the EU H2020 Programme (see Annex F) and has received significant funding through industry-led InnovateUK competitions. Other public funders of STEM research include: DSTL, DfT, TfL, RAEng, Leverhulme, Royal Society, London Mathematical Society.

The following table captures UOL investment and development plans for the space sector, supported by LLEP.

Project	Investment	Status	Description
SPL Space Park Leicester Space	£12M HEI £14M Local Growth Funding	Confirmed	Global space hub and collaborative community which will facilitate and broker new markets and products drawing on space derived data.
SPRINT	£5M Research England £13M HEI and industry	Confirmed	Space sector focused SME high growth programme, engaging with 400 and supporting 150 businesses over 3 years
Leicester Innovation Hub	£1.25M Space & Data	Confirmed	A regional centre for to support the SMEs with R&D questions.
HEI Investment EO Talent		Under development	Higher Apprenticeship, University Foundation Degree, Undergraduate, Post Graduate and Professional Development Programmes

Table 3-4: Space investments and projects with LLEP support

3.6.3 Space Park Leicester

See also §4.2.1.

Space Park Leicester is a major strategic development led by University of Leicester. It is part of a strategic plan which articulates the ambition to deliver a new Space Innovation Campus at the Waterside Enterprise Zone in the city.

> "In collaboration with funding, business and local stakeholders, we will launch Space Park Leicester. Focusing on our world-class strengths in Space and Earth Observation Science, this national centre for undergraduate, postgraduate and apprenticeship training will provide a new anchor for a vital British industry. It will play a key part in realising the ambition that our cutting-edge translational research and enterprise enriches the local and regional economy and fuels the Midlands as an engine of future growth".
>
> *University of Leicester Strategic Plan 2015*

The Space Park's 4.4ha site will host the Leicester Institute of Space & Earth Observation, which will be the academic vehicle for delivering a transformation in scale and quality of the space and space-related research, teaching and enterprise activities of the University. It will drive research growth from a broad portfolio of activities. With a strong focus on emerging uses of satellite images, in a range of applications this will combine with the development of Earth Observation technologies as well as the leveraging of our research strength in mission design, technology and instrumentation. Space Park Leicester will drive applied research and development through industrial partner co-location and engagement.

Status

Core Hub

Seed investment of £23M (combination of Local Growth Fund and University capital), will enable the delivery of a core 400M2 Phase 1 facility focused on the exploitation and application of Earth observation data - planned to open in Spring 2020.

Phase 2 - Space Innovation Centre

The creation of a Space Innovation Centre – a further 4000m2 facility supporting the research developments necessary to underpin the commercial exploitation of space and deliver the anticipated economic growth for the UK. The Centre will constitute Phase 2 of the Space Park project, providing a significant enhancement of research and innovation facilities including Next Generation Space Engineering and Earth Observation Data AI laboratories.

The primary objectives of the Space Innovation Centre are to:

(1) Deliver research into space instrumentation and technology, driving the move from large, one-off satellites into low-cost constellations of smaller satellites amendable to production-line techniques.
(2) Apply Artificial Intelligence (AI) and Geographic Information System (GIS) techniques to merge complex and discontinuous data sets, supporting their exploitation as downstream services.
(3) Develop the pipeline of skills required by the UK space industry to support these paradigm changes.

Earth Observation Data AI Labs

In partnership with the National Centre for Earth Observation and industry partners, the Earth Observation Data AI Labs will drive research, innovation, skills, education to create innovative products, processes and services to address client needs in the UK economy from EO data. It will host equipment and hardware including visualization, cloud technologies, machine learning, data analytics, computing and interaction resources with graphics processors for image display and GIS systems. It will provide a focused interface between research methods and translation into the commercial EO world. The centre will undertake a 5-year programme of activity including a data platform shared with Centre partners, co-designed skills offerings and innovation services to promote market interaction and the development of novel services. Many partners will locate operations in an on-site in a specific business hosting area.

Next Generation Space Engineering

In the future, spacecraft will become a commodity for applications and services requiring constellations of satellites; value will be driven by end user requirements, payload function and performance. Next generation space engineering will lower the cost of access to space by introducing greater automation in spacecraft production, increase productivity and reduce spacecraft manufacturing and testing times by orders of magnitude using increased robotic assembly systems, standardisation and modularisation of subsystems. This centre will aim to address the market failure of the sector in developing advanced automated manufacturing and testing that meets high quality assurance requirements for the space sector.

Space Business Hosting

Space Park Leicester will be a fully serviced industrial/service Space and Space Enabled environment. With: excellent transport links; energy capacity of 4MVA; riverside landscaped environment; access to graduate and post graduate talent. It will be a critical enabling piece of infrastructure to support the forecast growth in the UK Space Sector and will work with upstream space businesses to address their technology, production and market development plans.

3.6.4 SPRINT (SPace Research & Innovation Network for Technology)

SPRINT is space sector focused SME high growth programme, engaging with 400 and supporting 150 businesses over 3 years - delivering a minimum £70M GVA and 500 jobs in support of the UK Space Sector Growth Strategy. The programme will allow SMEs to access the HEI Knowledge Base, interact with other support structures such as the Satellite Application Catapult, Regional SME growth projects and facilitate commercial deal flow to the investor community. It will optimise the scale up of successful growth businesses whose products and services are underpinned by space data and technology. The programme addresses both the Place and Sector policy focus and is strongly aligned with key pillars of the UK Government's Industrial Strategy.

3.6.5 STAR Project

The project provides engineering innovation to SMEs in the context of the development of a National Space Park within the Waterside Enterprise Zone. Delivered by the University of Leicester – it will provide an integrated prototype manufacturing and design facility, complementing research and education activities. The project will enable SMEs to use state of the art manufacturing facilities to develop unique (one-offs or a few offs) commercial prototypes of highly engineered, high value, in metal, plastic, composites and electronics. The facility will be aimed at mechanical components in the mm to 30-50cm size. It will enable rapid development of products to demonstrate optimal design for manufacture, functionality in operation, usability and price. The project will exploit the deep and applied capability in the design, development and manufacture of precision engineered, space-compliant equipment and also draw upon the materials expertise that exists at the University of Leicester. It will also act as demonstrator and workshop facility for companies in the LLEP region (and elsewhere) on the latest advanced manufacturing techniques.

The project will support businesses manufacturing in plastic, metal and composites, with rapid prototyping and out-of-the-autoclave composites. It will provide for the testing of electrical components via test stations and manufacturing of such components via processes such as coating and optical inspection. This equipment and capability is not normally available to SMEs and start-ups due to price and supply capacity. The facility will also provide a dedicated design or analysis capability to support the companies via its dedicated staff.

The project will locate all this equipment in one location and an open access “one stop” shop approach to prototyping and product development providing critical high-tech engineering infrastructure for the Enterprise Zone. It will be supported by specialist technicians and research engineers to address the weakness in absorptive capacity in SMEs. The facility will be capable of manufacturing prototype components for fields as diverse as medicine, transport, consumer goods, aerospace and space.

3.6.6 iNET (Loughborough)

Smart Innovation and Networking for Growth (SING) – for SMEs based in Leicester & Leicestershire (LLEP area) working on one of 6 priority sectors include Advanced Manufacturing and Engineering, Creative Industries (which include IT), Low Carbon Technologies and Logistics & Distribution. The project provides grant funding towards innovation, R&D projects that are aiming to develop a new product, service or process. The project also facilitates access to academic expertise by offering up to 5 days from an LU academic working on behalf of an SME on a knowledge transfer/innovation project and grant funding towards Collaborative R&D projects involving at least one SME and UK HEI.

Productivity and Capability Enhancement (PACE) – for SMEs based in Leicester & Leicestershire (LLEP area) working on one of 6 priority sectors. It provides grant funding towards projects leading to increase capacity, enhanced capabilities and business growth.

Catalysing Growth for Transport Equipment Manufacturing – for SME based in Derby, Derbyshire, Nottingham or Nottinghamshire (D2N2). University of Derby are the lead on this project, Loughborough University are delivery partners. The project provides grant funding towards innovation, R&D projects that are aiming to develop a new product, service or process. The project also facilitates access to academic expertise by offering up to 5 days from an LU academic working on behalf of an SME on a knowledge transfer/innovation project and grant funding towards Collaborative R&D projects involving at least one SME and UK HEI. University of Derby offer access to support from their academics.

3.6.7 Start-up Support

The main support centres for start-ups (identified to date) are listed in Table 3-5.

Name	Description
Loughborough University Space Incubator http://www.lusep.co.uk/space-incubator	Loughborough University Space Incubator programme to support new start-ups in the space and space-enabled sectors and existing businesses new to these sectors. This programme is supported by UKSA and is one of the incubators in the UK Space Incubator Network. It offers support, signposting and affordable accommodation at ATIC.
Space Technology Entrepreneurship (Space TEC) programme	A 2-day programme covering the essential elements of starting a business, aimed at high-tech space entrepreneurs. This is delivered by the SETSquared Partnership.
LCB Depot	Workshops, studios and business support for creative and technology entrepreneurs. Based in Leicester's cultural quarter this includes a business review, 1-2-1 coaching, strategic planning and networking events.
Innovation centre (DMU)	The Innovation Centre supports start up businesses, entrepreneurs and freelance workers. There is an events programme, flexible workspace and meeting space hire available in the centre of Leicester.
Downstream Dock http://www.dockleicester.co.uk	Dock is a new workspace and business development centre for the knowledge economy. There is a range of workspaces including offices, labs and workshops. There is a business growth programme and this is supported by an events programme. Dock Leicester hosts one of the UKSA funded business incubators.
Innovation Hub (U. Leicester)	Working to accelerate innovation by translating research and business ideas into products. There is incubation space, links to academic consultants, testing and analysis services and funding application support

Table 3-5: Start-up support centres

3.6.8 Supporting Initiatives

3.6.8.1 NEREUS

The Network of European Regions Using Space Technologies, NEREUS offers a dynamic platform to all regions aiming at making a better use of space applications for the delivery of efficient public policies benefiting citizens. The East Midlands has been a continuous member of NEREUS since its formation, and remains the only UK member.

[http://www.nereus-regions.eu/]

3.6.9 Policies and Roadmaps

No information on regional policy yet beyond the broad sector priorities highlighted from LEPs and [MESIA].

National policy form UKSA is the major driving force in the sector, with funding and business support programmes aligned to the growth roadmap.

3.7 Coverage Summary

The following table is equivalent to the product tree in Figure 3-2 (p.26). For each product group, the subtheme relevance is shown, followed by the number of companies identified within the region that have relevant expertise, products, or services. The final column indicates the presence of significant topical research groups in a regional HEI.

> 5 Good coverage/capability 2—5 Some coverage/capability 0—1 Low coverage/capability

ID	Product Tree		Access to Space	Satellites & Vehicles	Ground Systems	Explorn & Enabling	# Company	HEI R&D Focus
10	**Telemetry Tracking and Command**						6	
	11	Antennas	■	■	■	■	3	
	12	Radios, Amplifiers	■	■	■	■	4	
	13	Health Sensors	■	■		■	2	
	14	Onboard Data Handling	■	■		■	6	■
	15	Electronic &/or optical networks	■	■	■	■	8	
20	**Thermal Control**						1	
	21	Multilayer Insulation		■			1	
	22	Heat Pipes		■			2	■
	23	Radiators, Louvres		■			1	
	24	Thermal Straps		■			3	
30	**Structures**						8	
	31	Housing	■	■			3	
	32	Booms, Deployables		■			1	
	33	Chassis	■	■			3	
	34	Fasteners	■	■			-	
40	**Payload(s)**						3	
	41	Camera(s)		■		■	2	■
	42	Field Instruments		■			1	■
	43	Radar		■		■	1	
	44	Radiometer		■		■	1	■
	45	Spectrometer		■		■	-	■
50	**Attitude Control System**						7	
	51	Attitude Sensors	■	■			-	
	52	Reaction Wheels		■			-	
	53	Thrusters	■	■			-	
	54	Magnetorquers		■			1	
	55	Gyros	■	■			1	
60	**Propulsion and Orbit Control System**						-	
	61	Tanks	■	■			3	
	62	Links, Lines, Valves	■	■			1	
	63	Thrusters	■	■			1	
	64	Transducers	■	■			1	
	65	Heaters		■			-	
70	**Electrical Power System**						3	
	71	Solar Panels		■		■	-	
	72	Batteries		■		■	1	■
	73	Regulators		■			2	
	74	Distribution Harness		■			6	
	75	SA Drive Mechanism		■			-	
	76	Power management unit		■		■	6	
80	**Mission Operations**						1	
	81	Ground station (or network)	■	■	■		3	■
	82	Data Storage and Delivery		■	■	■	2	■
	83	Science team and interfaces		■	■		1	■
	84	Launcher*	■	■			1	

Table 3-6: Product tree coverage summary

The tally of coverage in Table 3-6 above allows some broad classification of regional strengths and gaps.

Relative Strengths

- Payloads and sensors
- Electrical power systems, especially power distribution and control
- Telemetry tracking and command, especially onboard data handling
- Structures and mechanical design
- Ground segment implementation, ground data processing

Capability Gaps

- Thermal design and subsystems
- Attitude control
- Propulsion and orbit control (unsurprising given lack of capability in attitude control)

4 Conclusions

4.1 Gap Analysis

The following table summarises gaps identified throughout this regional preparation exercise for the 'upstream space SIA'. '**Type**' attempts to categorise possible gaps; '**Level**' indicates whether the gap is local, regional, or national (estimated); and '**Imp**(ortance)' is a suggested scale of priority order in which that the gaps should be addressed (1=highest, 3=lowest).

Note that 'gaps' are also not necessarily all gaps – some are perceived (and/or real) shortcomings.

Type	Gap Description	Level	Imp.	Notes
Workforce	Identification and provision of appropriate technical training	National	1	35% of businesses struggle with this. Avoid theoretical IT-based training. [LLEP]
Workforce	Recruitment / Aging workforce profile	National	1	[LLEP]
Workforce	Retention	Regional	2	Area needs to compete with other regions: attract graduates from elsewhere and keep local graduates. [LLEP]
Workforce	Apprenticeships - Skills	National	1	Focus on the skills most in demand by employers rather than the preference of the apprentices or training bodies themselves. [LLEP]
Workforce	Apprenticeships - Support	National	3	Apprenticeship funding only for 2 rather; longer preferred; no funding for over 18s. [LLEP]
Business Support	Lack of clarity on which businesses are eligible for grant support	Local	1	[LLEP]
Business Support	Grant application processes taking too long to apply for and being slow to respond.	Regional	3	[LLEP]
Business Support	Funding gap for product development and 'upscaling' of businesses.	Regional	2	[LLEP]
Product Tree	Thermal design and subsystems (#20)	Regional	2	This is indicated as low capability in the product tree/company mapping, but in practice very strong capability exists in one
Product Tree	Attitude control (#50)	Regional	3	
Product Tree	Propulsion and orbit control	Regional	3	Unsurprising given ADCS gap above.
Funding	NSTP and CEOI funding and other technology funds such as Aurora CREST are oversubscribed by a large factor but provide mechanisms for Space technology development particularly at the concept proving stage where investment funding (company, angel etc.) is unlikely to contribute.	National	1	These mechanisms are essential for development of upstream capability and need to be consolidated onto an efficient, predictable, reliable funding platform that businesses can rely upon. This funding is exploited by both academia and industry separately and in partnership; this should be strengthened. 'Pump priming' for early development is essential if the IGS targets are to be met.

Type	Gap Description	Level	Imp.	Notes
Skills	Skilled workforce, and/or apprenticeships still largely unavailable for space sector.	National	1	Stronger apprenticeship support should be investigated and prioritised.
Skills	Training: Skills in machining, inspection, assembly, test and operations relevant to upstream are only acquired slowly through on-the-job training.	National	2	AMRC supports a pipeline of 300 engineering apprenticeships per year; not presently with any space engagement.
Skills	Business and process skills in technical recruits	National	2	From industry interviews.
Skills	Technical specialists	National	2	It is relatively straightforward to recruit internationally to technical roles from e.g. PT, ES, IT, FR. Identifying candidates harder, but UK candidates less available, less able.
Thematic test-beds	Much effort has been expended artificially separating upstream and downstream. Impactful test-beds for 'solutions' led by user needs should be the priority.	National	1	Examples could include e.g. precision automated agriculture; space assets in search and rescue or humanitarian relief.
Technical focus	UK does not apparently have a technical niche that it can prioritise.	National	2	Such a top-level steer would allow businesses and HEIs to build a strategy that can span years and really lift the sector. It is presently too ad hoc and too short term, leading to adverse risk postures from industry. Example focus could be SAR (full chain).

Table 4-1: Gap Summary

4.2 Targeted Opportunities

4.2.1 Space Park

The planned National Space Park in Leicester, which aims to become a global hub of a collaborative space and space-enabled community engaged in the development of new technologies and as such is fully in line with the national space policy, leveraging the location of the University of Leicester, National Space Centre, and industry partners at the UK's centre providing skills, training, education and research to meet the requirements of the space industry and space enabled businesses.

The University of Leicester is developing 'Space Park Leicester', and has secured seed investment of £23M (combination of Local Growth Fund and University capital) and are embarking upon the development of a core Phase 1 facility focused on the exploitation and application of Earth observation data planned to open early in 2020.

The second phase will realise the broader vision through the creation of a **Space Innovation Centre** (SIC) – a 4000m^2 facility supporting the research developments necessary to underpin the commercial exploitation of space and deliver the anticipated economic growth for the UK. The SIC will provide a significant enhancement of research and innovation facilities for **upstream space**, including next-generation space engineering and laboratories dedicated to EO and AI developments. The primary objectives of the **Space Innovation Centre** are to:

1. Deliver research into **space instrumentation and technology**, driving the move from large, one-off satellites into low-cost **constellations** of smaller satellites amendable to **production-line techniques**.
2. Apply Artificial Intelligence (AI) and Geographic Information System (GIS) techniques to merge complex and discontinuous data sets, supporting their exploitation as downstream **services**.
3. Develop the **pipeline of skills** required by the UK space industry to support these paradigm changes.

In the future, spacecraft will become a commodity for applications and services requiring constellations of satellites; value will be driven by end user requirements, payload function and performance. Next generation space engineering will lower the cost of access to space by introducing greater automation in spacecraft production, increase productivity and reduce spacecraft manufacturing and testing times by orders of magnitude using increased robotic assembly systems, standardisation and modularisation of subsystems. This centre will aim to address the market failure of the sector in developing advanced automated manufacturing and testing that meets high quality assurance requirements for the space sector.

The centre will be underpinned by a 5-year programme that will involve **working with multiple spacecraft manufacturing companies** to develop products designed for automated production alongside R&D into novel payload and space system technologies. The centre will work closely with global companies developing **launch services** to ensure spacecraft manufacturing and launch provision develop in tandem. The centre will be a focal point for innovation, research and development of advanced engineering, production and payload solutions for spacecraft that can meet the needs of incumbents and attract new entrants into the space sector.

The SIC can be aligned to **support rapid growth in upstream space** through leveraging the networks, HEIs, and connectivity of the Greater East Midlands. For example, business access to a large cleanroom facility — with balanced connections to each possible space port site — could form a focal point for capability and skills development in upstream industry, while forming a relatively low-cost, low-risk, part of the overall industrial system needed to support the UK's ambitions in access to space.

4.2.2 Dedicated Skills Training Centre

Skills training remains largely underserved nationally. The regional prototyping of the Higher National Apprenticeship in Space Engineering, the National Space Academy, nationally recognised FE colleges, and private companies, all form a good foundation for a dedicated space skills training facility. The scope and details of such an offer have not been elaborated as at the date of this draft.

4.3 Next Steps

Note: It has not yet been possible to present a standardised set of opportunities with costs, benefits, management cases and strategies in a consistent template.

The next steps in support of the regional SIA are:

1. Host a workshop day for stakeholders to discuss the findings so far, and gain broader understanding of the ways the 'adjacent' industry capabilities can be supported and integrated with space.
2. Develop an Opportunity Template and adapt outcomes of the workshop and this draft report to the template.
3. Present the opportunities to the LEPs, HEIs and industry partners for refinement and prioritisation.
4. Await the outcome of the space port funding decision and engage appropriately with key actors around leveraging a centralised AIV facility linked to R&D programmes.

A Research Organisations

A.1 Industrial and General

Organisation	*Place*
Aeristech (United Kingdom)	Kenilworth
Agriculture and Horticulture Development Board	Kenilworth
Ametek (United Kingdom)	Leicester
AOS Technology (United Kingdom)	Melton Mowbray
Applied Materials Technology (United Kingdom)	Lincoln
Beacon Energy (United Kingdom)	Loughborough
BHR Pharmaceuticals (United Kingdom)	Nuneaton
Blackstar Amplification (United Kingdom)	Northampton
BLC Leather Technology Centre	Northampton
Bluefrog Design (United Kingdom)	Leicester
Boots UK (United Kingdom)	Nottingham
British Geological Survey	Nottingham
British Steel (United Kingdom)	Scunthorpe
Britwind (United Kingdom)	Loughborough
Broadway	Nottingham
Building and Social Housing Foundation	Coalville
BYG Systems (United Kingdom)	Nottingham
Cambridge Weight Plan (United Kingdom)	Corby
Caterpillar (United Kingdom)	Leicester
CE Technologies (United Kingdom)	Nuneaton
Cenex (United Kingdom)	Loughborough
Chartered Institute of Ergonomics and Human Factors	Loughborough
Chartered Institute of Logistics and Transport	Corby
Chartered Institution of Wastes Management	Northampton
Codamotion (United Kingdom)	Leicester
Composites Evolution (United Kingdom)	Chesterfield
Critical Pharmaceuticals (United Kingdom)	Nottingham
Crown Packaging (United Kingdom)	Leicester
Derby City Council	Derby
Docobo (United Kingdom)	Great Bookham
Dynex Semiconductor (United Kingdom)	Lincoln
EMH Group	Coalville
Energy Technologies Institute	Leicester
Envirup (United Kingdom)	Nottingham
Euram (United Kingdom)	Nottingham
Euro Projects (United Kingdom)	Leicester
European Thermodynamics (United Kingdom)	Leicester
Experian (United Kingdom)	Nottingham
Experimental Psychology Society	Nottingham
Frontier Agriculture (United Kingdom)	Lincoln
Fully Distributed Systems (United Kingdom)	Loughborough
Fund for the Replacement of Animals in Medical Experiments	Nottingham
Fusion (United Kingdom)	Leicester
Galson Sciences	Oakham
Greenbank Group (United Kingdom)	Derby
Guidance (United Kingdom)	Leicester
Health & Safety Laboratory	Buxton

Organisation	*Place*
Heraeus (United Kingdom)	Chesterfield
HITEK Electronic Materials (United Kingdom)	Scunthorpe
Holscot Fluoroplastics (United Kingdom)	Grantham
Horiba (United Kingdom)	Northampton
Ibstock (United Kingdom)	Leicester
Icon Process Systems (United Kingdom)	Chesterfield
Industrial Control Solutions	Worksop
Intelligent Energy (United Kingdom)	Loughborough
International Alliance of ALS/MND Associations	Northampton
International Mining Consultants	Nottingham
Land Quality Management	Nottingham
Laser Expertise (United Kingdom)	Nottingham
Laser Optical Engineering (United Kingdom)	Donington
Legendary Games (United Kingdom)	Nottingham
Leicester City Council	Leicester
Lhoist (United Kingdom)	Buxton
Loake Shoemakers (United Kingdom)	Kettering
Luxfer Group (United Kingdom)	Nottingham
M Wright and Sons (United Kingdom)	Loughborough
Magna Parva (United Kingdom)	Leicester
Maltsters' Association of Great Britain (United Kingdom)	Newark on Trent
Mark Group (United Kingdom)	Leicester
Micropore Technologies (United Kingdom)	Derby
Mines Rescue Service	Mansfield
MIRA (United Kingdom)	Nuneaton
Monition (United Kingdom)	Nottingham
National Farmers Union	Kenilworth
National Space Centre	Leicester
Nemaura Pharma (United Kingdom)	Loughborough
NetComposites (United Kingdom)	Chesterfield
New Wave Innovation	Leicester
Nexor (United Kingdom)	Nottingham
Nickerson Ltd	Corby
Northamptonshire County Council	Northampton
Nottingham City Council	Nottingham
Nottingham Community Housing Association	Nottingham
Nottingham Express Transit (United Kingdom)	Nottingham
Nottingham Scientific (United Kingdom)	Nottingham
Nottingham Scientific Limited (United Kingdom)	Nottingham
Nottinghamshire County Council	Nottingham
Novozymes (United Kingdom)	Nottingham
Oclaro Technology (United Kingdom)	Towcester
Olberon (United Kingdom)	Nottingham
Orders of St John Care Trust	Lincoln
PCA Engineers	Lincoln
PepsiCo	Leicester
Pera (United Kingdom)	Melton Mowbray
Pharminox (United Kingdom)	Nottingham
Promethean Particles (United Kingdom)	Nottingham
PSP Association	Northampton
Quotient Clinical (United Kingdom)	Nottingham
Rail Vision (United Kingdom)	Castle Donington

Organisation	*Place*
RenaSci (United Kingdom)	Nottingham
Rolls-Royce (United Kingdom)	Derby
Romax Technology (United Kingdom)	Nottingham
Royal Agricultural Society of England	Kenilworth
RPC Bebo (United Kingdom)	Corby
Satra (United Kingdom)	Kettering
SCITEK Consultants (United Kingdom)	Derby
Semelab	Lutterworth
Shoe and Allied Trades Research Association	Kettering
Society for Renaissance Studies	Nottingham
Sonoco (United Kingdom)	Chesterfield
Source BioScience (United Kingdom)	Nottingham
Steris (United Kingdom)	Leicester
Tech4i2	Leicester
TerOpta (United Kingdom)	Nottingham
Texas Instruments (United Kingdom)	Northampton
ThyssenKrupp (United Kingdom)	Nottingham
Transport & Travel Research (United Kingdom)	Nottingham
Trelleborg (United Kingdom)	East Retford
UK Health and Environment Research Institute	Melton Mowbray
UK Intelligent Systems Research Institute	Melton Mowbray
UK Material Technology Research Institute	Melton Mowbray
Ulverscroft (United Kingdom)	Leicester
Uvasol (United Kingdom)	Leicester
VBC Group (United Kingdom)	Loughborough
Voicekey (United Kingdom)	Nottingham
Watershed Associates	Leighton Buzzard
Wildlife Trusts	Newark on Trent
William Ross (United Kingdom)	Northampton
Wilson Energy (United Kingdom)	Newark on Trent
Zachrome (United Kingdom)	Chesterfield
Zeeko (United Kingdom)	Coalville

A.2 Universities

Organisation	*Place*
Bishop Grosseteste University	Lincoln
De Montfort University	Leicester
Loughborough University	Loughborough
Nottingham Trent University	Nottingham
University of Derby	Derby
University of Leicester	Leicester
University of Lincoln	Lincoln
University of Northampton	Northampton
University of Nottingham	Nottingham

A.3 Secondary and Further Education

Organisation	*Place*
Bilborough Sixth Form College	Nottingham
Central College Nottingham	Nottingham
Chesterfield College	Chesterfield
Grantham College	Grantham
Irish Baptist College	Moira
Leicester College	Leicester
Loughborough College	Loughborough
Moulton College	Northampton
New College Nottingham	Nottingham
North Warwickshire and Hinckley College	Nuneaton
Northampton College	Northampton
Oakwood Academy	Nottingham
Vision West Nottinghamshire College	Mansfield

A.4 Hospitals and Healthcare

Organisation	*Place*
Arthritis Research UK	Chesterfield
Ashfield Community Hospital	Nottingham
Babington Hospital	Belper
Barton Under Needwood Cottage Hospital	Burton-on-Trent
Bassetlaw Hospital	Worksop
Berrywood Hospital	Northampton
Bolsover Hospital	Chesterfield
British Nuclear Medicine Society	Nottingham
British Psychological Society	Leicester
Buxton Hospital	Buxton
Caterham Dene Hospital	Caterham
Cavendish Hospital	Buxton
Chesterfield Royal Hospital	Chesterfield
Chesterfield Royal Hospital NHS Foundation Trust	Chesterfield
Children's Cancer and Leukaemia Group	Leicester
Clay Cross Hospital	Chesterfield
Coalville Community Hospital	Coalville
Corby Community Hospital	Corby
Derby Hospitals NHS Foundation Trust	Derby
Derbyshire Children's Hospital	Derby
Dovedale Day Hospital	Derby
East Midlands Academic Health Science Network	Nottingham
East Midlands Ambulance Service NHS Trust	Nottingham
European Association for Cancer Research	Nottingham
Feilding Palmer Hospital	Lutterworth
George Eliot Hospital	Nuneaton
George Eliot Hospital NHS Trust	Nuneaton
Glenfield Hospital	Leicester
Grantham and District Hospital	Grantham
Highbury Hospital	Nottingham
Hinckley and Bosworth Community Hospital	Hinckley
Hinckley and District Hospital	Hinckley

Organisation	*Place*
Kettering General Hospital	Kettering
Kettering General Hospital NHS Trust	Kettering
Kings Mill Hospital	Sutton in Ashfield
Leicester Frith Hospital	Leicester
Leicester General Hospital	Leicester
Leicester Royal Infirmary	Leicester
Leicestershire Partnership NHS Trust	Leicester
Lincoln County Hospital	Lincoln
Lings Bar Hospital	Nottingham
London Road Community Hospital	Derby
Loughborough Hospital	Loughborough
Mansfield Community Hospital	Mansfield
Market Harborough Hospital	Market Harborough
Mayfair Day Hospital	Kettering
Melton Mowbray Hospital	Melton Mowbray
Mental Health Research UK	Leicester
Motor Neurone Disease Association	Northampton
MRC Institute of Hearing Research	Nottingham
MRC Toxicology Unit	Leicester
Newark Hospital	Newark on Trent
Newholme Hospital	Bakewell
NIHR Leicester Cardiovascular Biomedical Research Unit	Leicester
NIHR Leicester Respiratory Biomedical Research Unit	Leicester
NIHR Leicester-Loughborough Diet, Lifestyle and Physical Activity Biomedical Research Unit	Leicester
NIHR Nottingham Digestive Diseases Biomedical Research Unit	Nottingham
NIHR Nottingham Hearing Biomedical Research Unit	Nottingham
Northampton General Hospital	Northampton
Nottingham City Hospital	Nottingham
Nottingham General Hospital	Nottingham
Nottingham University Hospitals NHS Trust	Nottingham
Nottinghamshire Healthcare NHS Foundation Trust	Nottingham
Pilgrim Hospital	Boston
Queen Elizabeth Hospital King's Lynn NHS Foundation Trust	Kings Lynn
Queen's Hospital	Burton-on-Trent
Queen's Medical Centre	Nottingham
Rampton Hospital	East Retford
Retford Hospital	East Retford
Royal Derby Hospital	Derby
Ruth Lancaster James Hospital	Buxton
Schizophrenia Research Fund	Leicester
Scunthorpe General Hospital	Scunthorpe
Seaford Day Hospital	Seaford
Sherwood Forest Hospitals NHS Foundation Trust	Mansfield
Skegness and District General Hospital	Skegness
St Andrew's Hospital	Northampton
St Luke’s Hospital	Market Harborough
St Mary's Hospital	Kettering
St Oswalds Hospital	Ashbourne
Stamford and Rutland Hospital	Stamford
Stroke Association	Nottingham
Tavistock Hospital	Tavistock
University Hospitals of Leicester NHS Trust	Leicester

Organisation	*Place*
Walton Hospital	Chesterfield
West London Mental Health NHS Trust	Southall
Whitworth Hospital	Matlock

B JACS Codes for Upstream Space

F110 Applied chemistry
F111 Industrial chemistry
F200 Materials science
F300 Physics
F310 Applied physics
F311 Engineering physics
F320 Chemical physics
F321 Solid-state physics
F341 Electromagnetism
F343 Computational physics
F361 Laser physics
F380 Acoustics
F520 Space & planetary sciences
F521 Space science
F522 Planetary science
F530 Solar & solar terrestrial physics
F000 Physical sciences
G100 Mathematics
G120 Applied mathematics
G121 Mechanics (mathematical)
G130 Mathematical methods
G140 Numerical analysis
G150 Mathematical modelling
G160 Engineering/industrial mathematics
G170 Computational mathematics
G200 Operational research
G310 Applied statistics
H100 General engineering
H110 Integrated engineering
H120 Safety engineering
H130 Computer-aided engineering
H131 Automated engineering design
H140 Mechanics
H141 Fluid mechanics
H142 Solid mechanics
H150 Engineering design
H300 Mechanical engineering
H310 Dynamics
H311 Thermodynamics
H320 Mechanisms & machines
H340 Acoustics & vibration
H342 Vibration
H360 Electromechanical engineering
H400 Aerospace engineering
H410 Aeronautical engineering
H420 Astronautical engineering
H430 Avionics
H440 Aerodynamics
H441 Flight mechanics
H450 Propulsion systems
H460 Aviation studies
H600 Electronic & electrical engineering
H610 Electronic engineering
H611 Microelectronic engineering
H612 Integrated circuit design
H643 Satellite engineering
H650 Systems engineering
H651 Digital circuit engineering
H652 Analogue circuit engineering
H660 Control systems
H661 Instrumentation control
H671 Robotics
H672 Cybernetics
H700 Production & manuf' engineering
H710 Manufacturing systems engineering
H711 Manufacturing systems design
H712 Manufacturing installation systems
H720 Quality assurance engineering
H730 Mechatronics
H000 Engineering
I100 Computer science
I200 Information systems
I210 Information modelling
I230 Systems analysis & design
I300 Software engineering
I310 Software design
J200 Metallurgy
J210 Applied metallurgy
J220 Metallic fabrication
J410 Polymers technology
J490 Polymers & textiles not elsewhere
J510 Materials technology
J511 Engineering materials
J910 Energy technologies
J960 Transport logistics
N120 International business studies
N213 Project management
N611 Industrial relations
W240 Industrial/product design

C Questionnaires

C.1 HEI Questionnaire

Science and Innovation Audit: Upstream Space

As part of the third wave of Science and Innovation Audits, the topic of Upstream Space is being undertaken. This looks in particular at the part of the space sector that includes:

> Space Manufacturing: Design and/or manufacture of space equipment and subsystems Including: launch vehicles and subsystems, satellites/payloads/spacecraft and subsystems, ground segment systems and equipment (control centres and telemetry), suppliers of materials and components, scientific and engineering support, fundamental and applied research.

The space sector is broad and necessarily includes many disciplines that at first glance may be associated with different sectors. Where we can we've given examples of such subject areas, but for the purpose of completeness if you are unsure about whether subject areas form part of "upstream space" then please include.

Teaching

1. Do you teach space related courses at UG/PG level?
   For example engineering (all types), computing, manufacturing, physics, mathematics
2. What are the numbers of graduates in relevant subjects?
3. Do you have any plans to start (or close) such courses?
   a. And what is the rationale behind this

Research

1. Do you undertake research applicable to the upstream space sector?
   a. Access to Space (incl propulsion, engineering)
   b. Satellites & Vehicles (incl materials, data processing)
   c. Ground Systems (incl telecoms)
   d. Exploration & Enabling technologies (incl robotics, autonomy)
2. Number of 4* rated departments and researchers in relevant subject areas (REF 2014)?
3. Do you currently partner with industry to deliver this research? (if yes, please detail)
4. What are your levels of research income in this area (split by public/private)?
5. Are you receiving public support to deliver this research?
   ie grant funding from UK or EU, please detail.
6. Do you own any patents in relevant subject areas?
7. Are there any spin out companies/plans for spin out companies in these areas?

Business Development/Knowledge Transfer/Enterprise/Innovation

1. What equipment or facilities do you have to support research and teaching in upstream space and/or related disciplines?
2. Are these available to external parties (details – availability, price etc)?
3. What technical short courses do you run?
4. What is the current levels of income by business type?
5. Are you delivering any ESF/ERDF projects relevant to technology development?
6. Are you participating in any H2020 projects?
7. Are there any case studies available for BD/KT engagement?

Wider engagement

1. Is your institution involved in partnerships/strategic alliances eg MOUs with other HEIs/industry in UK or internationally in relation to technology development activity?

C.2 LEP Questionnaire

UKSA Science and Innovation Audit: Upstream Space

As part of the third wave of Science and Innovation Audits, the topic of Upstream Space is being examined. This looks in particular at the part of the space sector that includes:

> Space Manufacturing: Design and/or manufacture of space equipment and subsystems Including: launch vehicles and subsystems, satellites/payloads/spacecraft and subsystems, ground segment systems and equipment (control centres and telemetry), suppliers of materials and components, scientific and engineering support, fundamental and applied research.

The space sector is broad and necessarily includes many industries that at first glance may be associated with different sectors. Where possible we've given examples of such sectors, but for the purpose of completeness if you are unsure about whether to include something as "upstream space" then please include it anyway.

1. How many businesses do you have in your LEP area that you think are relevant to the upstream space sector (all sizes)?
   This could include manufacturing, engineering, technology development, energy, communications (not media)
   a. What's the value of this market in your local area?
2. How does your strategy support technology development/engineering/manufacturing?
3. Have there been any recent changes in the strategy, approach or support mechanisms in your LEP since the publication of your growth plan/strategic plan?
4. What business support is available?
   a. In general
   b. Is this applicable or targeted to technology/manufacturing/engineering businesses?
   c. To what extent are you satisfied with the uptake/traction of business support services by –
      - startups
      - SMEs
      - medium or larger companies.
5. What's the level of inward investment/FDI in technology/manufacturing/engineering sectors?
   a. Can you share case studies/examples?
   b. Do you have plans to target this?
6. Are you supporting the development/use of technology facilities to support business? Can you give examples?
7. What level of skills are present in the local area to technology or manufacturing sectors?
8. Do you have any partnerships/strategic alliances with other areas (national / international) in space or relevant technology areas (such as manufacturing, engineering, communications, energy etc)?

C.3 Questions for Multinational Space Companies

1/ Are there any strong regional connections you have made that support the UK part of your business?

2/ Does your regional operation engage in national-level or international collaborations (of any kind) - outside your own family of companies? e.g. direct bilaterals, publicly funded R&D projects?

3/ Are there any capability/resource gaps you wish to highlight regionally? (e.g. supply chain, service support, workforce recruitment). i.e. 'what would you improve?'

D Company List

For each company in the final list, a short proforma table is completed; most fields in the table are self-explanatory (see example below). Product tree scope refers to specific aspects of the upstream product tree described above.

'Sector Score' is a classification applied to describe current level of engagement with the space industry. This is akin to the scoring classifications used for HEIs in §2. The possible scores are:

0 No engagement or relevance at all (should not then appear in SIA audit)
1 Foundation relevance (e.g. general engineering services, parts, etc. for adjacent sector)
2 Supply-chain relevance (i.e. directly relevant but not self-identified as space sector)
3 In-sector (component, subsystem, service provider already in the space sector)

'Innovation Score' is a similar classification based upon evidence of the company having sought or obtained external funding or collaborative opportunities to pursue innovation-led projects beyond core business. The possible scores are:

0 No obvious evidence for innovation culture
1 Local innovation activities/support
2 National-level innovation activities/support (e.g. InnovateUK, NSTP)
3 International-level innovation activities/support (e.g. FP6, FP7, H2020)

Company	**The Company of Spaceship Builders**	*No.*	**01234567**
Location	**Place name**	*Postcode*	**LE4 9JQ**
Established	**1900**	*Workforce*	**123**
Website	**www.thiscompany.com**	*Sector Score*	**2**
Product tree scope	**12, 34**	*Innovation Score*	**1**

Table D-1: Example company table

Each such table is followed by a brief descriptive justification for the company's inclusion within this Upstream Space sector audit.

The set of **45 companies** listed here have been identified in the regional footprint as relevant to upstream space, using the sources described in §3.1. Doubtless many others could be identified as alternatives within the supply chain. The KTN landscape tool [SSAL] lists 13; the UK space directory [UKSD] only 3.

A comprehensive resource of relevant organisations and capabilities is still lacking.

3C Test

Company	**3C Test Ltd**	*No.*	**03261803**
Location	**Towcester**	*Postcode*	**NN12 8GX**
Established	**1996**	*Workforce*	**>15**
Website	**http://3ctest.co.uk/**	*Sector Score*	**2**
Product tree scope	**10, 40, 50, 70**	*Innovation Score*	**1**

Independent EMC test facility (primarily aerospace and automotive).

4Links

Company	**4Links Ltd**	*No.*	**03938960**
Location	**Milton Keynes**	*Postcode*	**MK3 6EB**
Established	**2000**	*Workforce*	**>5**
Website	**www.4links.co.uk**	*Sector Score*	**3**
Product tree scope	**14, 15**	*Innovation Score*	**3**

Spacewire test equipment.

ABACO Systems

Company	**ABACO Systems Ltd**	*No.*	**02151516**
Location	**Towcester**	*Postcode*	**NN12 6PF**
Established	**1987**	*Workforce*	**~100 (>700 global)**
Website	**https://www.abaco.com**	*Sector Score*	**2**
Product tree scope	**13, 14, 15, 50, 70**	*Innovation Score*	**2**

Avionics, vehicle computers, rugged embedded systems.

Abbott & Co. (Newark)

Company	**Abbot & Co. (Newark) Ltd**	*No.*	**02833304**
Location	**Newark**	*Postcode*	**NG24 2EJ**
Established	**1993**	*Workforce*	**>20**
Website	**http://www.air-receivers.co.uk**	*Sector Score*	**2**
Product tree scope	**61**	*Innovation Score*	**1**

Pressure vessels – design, build, test.

Amphenol Antenna Solutions- Jaybeam

Company	**Jaybeam Ltd**	*No.*	**01008835**
Location	**Wellingborough**	*Postcode*	**NN8 6AX**
Established	**1948**	*Workforce*	**Global >45,000**
Website	**https://amphenol-antennas.com/company/jaybeam/**	*Sector Score*	**2**
Product tree scope	**11, 12**	*Innovation Score*	**2**

RF conditioning products, amplifiers, etc. VHF/UHF/SHF antennas.

Barnes Aerospace

Company	**Barnes Aerospace**	*No.*	**UK Status Unclear**
Location	**Derby**	*Postcode*	**DE1 1UQ**
Established	**1857**	*Workforce*	**(Global)**
Website	**http://www.barnesaero.com**	*Sector Score*	**2**
Product tree scope	**31, 33**	*Innovation Score*	**1**

European headquarters in central Derby. Global aerospace components and machining.

Brush Electrical Machines

Company	**Brush Electrical Machine Ltd**	*No.*	**00111849**
Location	**Loughborough**	*Postcode*	**LE11 1EX**
Established	**1910**	*Workforce*	**>350**
Website	**http://www.brush.eu/**	*Sector Score*	**1**
Product tree scope	**74**	*Innovation Score*	**1**

Generators, switchgear, transformers.

Carlton Laser Services Ltd

Company	**Carlton Laser Services Ltd**	*No.*	**01514280**
Location	**Leicester**	*Postcode*	**LE4 9LN**
Established	**1980**	*Workforce*	**57**
Website	**http://www.carltonlaser.co.uk/**	*Sector Score*	**2**
Product tree scope	**31, 32, 33, 24**	*Innovation Score*	**1**

Laser CNC manufacturing (mostly for automotive), robotic folding, welding.

Cinch Connectors Ltd

Company	**Cinch Connectors Ltd**	*No.*	**02178707**
Location	**Worksop**	*Postcode*	**S80 3HA**
Established	**1987**	*Workforce*	
Website	**https://belfuse.com/cinch**	*Sector Score*	**3**
Product tree scope	**14, 15, 74**	*Innovation Score*	**1**

Part of Bel Group. High frequency, high precision electronic connectors.

Codamotion (Charnwood Dynamics)

Company	**Charnwood Dynamics Ltd.**	*No.*	**02152715**
Location	**Rothley**	*Postcode*	**LE7 7PJ**
Established	**1987**	*Workforce*	**10**
Website	**http://codamotion.com/**	*Sector Score*	**3**
Product tree scope	**40**	*Innovation Score*	**2**

3D motion capture. Some technology approved for space flights and space station use by both NASA and ESA.

Cooper Bussmann (Eaton)

Company	**Cooper Bussmann Ltd**	*No.*	**00363685**
Location	**Burton-on-the-Wolds**	*Postcode*	**LE12 5TH**
Established	**1940**	*Workforce*	**(Global)**
Website	**http://www.cooperindustries.com/content/public/en/bussmann**	*Sector Score*	**1**
Product tree scope	**70, 72, 73**	*Innovation Score*	**1**

Electrical protection, isolation, fuses. Supercapacitors.

CST

Company	**CST UK Ltd**	*No.*	**06503335**
Location	**Strelley**	*Postcode*	**NG8 6PE**
Established	**2008**	*Workforce*	**>10**
Website	**https://www.cst.com/**	*Sector Score*	**3**
Product tree scope	**11, 15, 42, 43, 44, 54, 74, 76, 84**	*Innovation Score*	**3**

3D electromagnetic design, simulation, analysis.

Cytec Industrial Materials

Company	**Cytec Industrial Materials (Derby) Ltd**	*No.*	**02264869**
Location	**Heanor**	*Postcode*	**DE75 7SP**
Established	**1988**	*Workforce*	**>1000 (global)**
Website	**http://www.cytec.com/**	*Sector Score*	**3**
Product tree scope	**22, 24, 31, 33**	*Innovation Score*	**3**

Advanced composites for spaceflight with enhanced thermal and electrical properties. Collaborates with SSTL. Multinational (Solvay Group).

Devtank

Company	**Devtank Ltd**	*No.*	**08973706**
Location	**Ashbourne**	*Postcode*	**DE6 1HD**
Established	**2014**	*Workforce*	**<10**
Website	**https://www.devtank.co.uk/**	*Sector Score*	**3**
Product tree scope		*Innovation Score*	**1**

Test, measurement and automation solutions. Worked with space supply chain to ECSS-Q-H-30-01A and ECSS-Q-ST-30-11C on a UHF receiver and digital radio, using both micro and FPGA technologies.

Diamond Hard Surfaces Ltd

Company	**Diamond Hard Surfaces Ltd**	*No.*	**05304968**
Location	**Towcester**	*Postcode*	**NN12 8EQ**
Established	**2004**	*Workforce*	**n/a**
Website	**http://diamondhardsurfaces.com/**	*Sector Score*	**2**
Product tree scope	**61, 62, 63**	*Innovation Score*	**2**

Surface treatment for extended life in high temperature, chemically aggressive and abrasive environments.

Dynex Semiconductor Ltd

Company	**Dynex Semiconductor Ltd**	*No.*	**03824626**
Location	**Lincoln**	*Postcode*	**LN6 3LF**
Established	**1999**	*Workforce*	**~ 200**
Website	**www.dynexsemi.com**	*Sector Score*	**1**
Product tree scope	**73, 76**	*Innovation Score*	**2**

High-power semiconductor devices; power electronics. Active development of SiC technology products, likely to be applicable to space.

European Thermodynamics

Company	**European Thermodynamics Ltd**	*No.*	**04345086**
Location	**Kibworth**	*Postcode*	**LE8 0RX**
Established	**2001**	*Workforce*	**~ 20**
Website	**http://www.europeanthermodynamics.com**	*Sector Score*	**3**
Product tree scope	**22, 23, 24, 40, 72, 76**	*Innovation Score*	**3**

Thermal modelling and analysis; embedded electronics; mechanical design. Collaborator in development of European RTG (with University of Leicester and Airbus D&S).

Gardner Aerospace

Company	**Gardner Aerospace- Derby Ltd**	*No.*	**03563546**
Location	**Derby**	*Postcode*	**DE24 8ZF**
Established	**1998**	*Workforce*	**1500 (global)**
Website	**http://www.gardner-aerospace.com/**	*Sector Score*	**2**
Product tree scope	**30**	*Innovation Score*	**1**

Structures, detailed machining, heat treatment.

G.E. Sensing

Company	**GE Sensing Ltd**	*No.*	**03645466**
Location	**Groby**	*Postcode*	**LE6 0FH**
Established	**1998**	*Workforce*	**n/a**
Website	**https://www.gemeasurement.com**	*Sector Score*	**2**
Product tree scope	**64**	*Innovation Score*	**1**

Part of GE group. Pressure Detectors, sensors for actuators and primary flight control system. Collaborates with Airbus, Moog.

Glenair UK Ltd

Company	**Glenair UK Ltd**	*No.*	**01198102**
Location	**Mansfield**	*Postcode*	**NG18 5BY**
Established	**1975**	*Workforce*	**>450**
Website	**http://www.glenair.co.uk**	*Sector Score*	**3**
Product tree scope	**15, 74**	*Innovation Score*	**1**

High performance interconnect products with demanding EMC performance. Harnesses, connectors, backshells, testing and compliance. Strong aerospace heritage.

Holscot Fluoroplastics

Company	**Holscot Fluoroplastics Ltd**	*No.*	**01721982**
Location	**Grantham**	*Postcode*	**NG31 9SE**
Established	**1983**	*Workforce*	**>10**
Website	**http://holscot.com/industries/aerospace**	*Sector Score*	**3**
Product tree scope	**30**	*Innovation Score*	**1**

Applies versatile fluoroplastic products to diverse aerospace challenges. Developed replacement tank liners for ISS resupply and flown on each ATV mission.

HORIBA-MIRA

Company	**Motor Industry Research Association Ltd**	*No.*	**04246451**
Location	**Nuneaton**	*Postcode*	**CV10 0TU**
Established	**2001**	*Workforce*	**>100**
Website	**https://www.horiba-mira.com/**	*Sector Score*	**3**
Product tree scope	**30**	*Innovation Score*	**3**

Test and development facilities; hosts ASDEC vibration facility.

Integrated Navigation Systems Ltd

Company	**Integrated Navigation Systems Ltd**	*No.*	**04995132**
Location	**West Haddon**	*Postcode*	**NN6 7BX**
Established	**2003**	*Workforce*	**< 10**
Website	**http://www.inavsystems.com/**	*Sector Score*	**2**
Product tree scope	**10**	*Innovation Score*	**2**

Design and manufacture of GNSS RF Record and Replay systems.

ITP Engines UK Ltd

Company	**ITP Engines UK Ltd**	*No.*	**06519506**
Location	**Whetstone (and Lincoln)**	*Postcode*	**LE8 6LH**
Established	**2008**	*Workforce*	**3500 (global); 230**
Website	**https://www.itpaero.com**	*Sector Score*	**1**
Product tree scope	**30, 55**	*Innovation Score*	**1**

Design of critical mechanical parts.

Jaltek Systems Ltd

Company	**Jaltek Systems Ltd**	*No.*	**02312905**
Location	**Luton**	*Postcode*	**LU3 3HP**
Established	**1988**	*Workforce*	**>20**
Website	**www.jaltek.com**	*Sector Score*	**3**
Product tree scope	**11, 12, 13, 14, 73, 74, 76**	*Innovation Score*	**2**

Aerospace electronics, including to Cobham, Selex, Thales and L3.

Linwave Electronic Manufacturing LLP

Company	**LINWAVE Electronic Manufacturing Services LLP**	*No.*	**04478971**
Location	**Lincoln**	*Postcode*	**LN6 3RS**
Established	**2002**	*Workforce*	**N/A**
Website	**http://www.linwave.co.uk/**	*Sector Score*	**2**
Product tree scope	**12**	*Innovation Score*	**1**

Microwave and RF components and subsystems.

Lockheed Martin

Company	**Lockheed Martin UK Ampthill Ltd**	*No.*	**00585852**
Location	**Ampthill**	*Postcode*	**MK45 2HD**
Established	**1957**	*Workforce*	**>780**
Website	**www.lockheedmartin.co.uk**	*Sector Score*	**3**
Product tree scope	**10, 20, 30, 50, 60, 70**	*Innovation Score*	**3**

US system prime; UK activity primarily military but space interests increasing.

Magna Parva

Company	**Magna Parva Ltd**	*No.*	**08148793**
Location	**Leicester**	*Postcode*	**LE4 5NU**
Established	**2005**	*Workforce*	**~10**
Website	**www.magnaparva.com**	*Sector Score*	**3**
Product tree scope	**20, 30, 64**	*Innovation Score*	**3**

Engineering services, design, R&D for exploration and enabling technology.

Manthorpe Engineering

Company	**Manthorpe Engineering Ltd**	*No.*	**01810526**
Location	**Ripley**	*Postcode*	**DE5 3ND**
Established	**1984**	*Workforce*	**n/a**
Website	**http://www.manthorpe.co.uk/engineering**	*Sector Score*	**1**
Product tree scope	**30**	*Innovation Score*	**1**

Design-for-manufacture and collaborative engineering; testing, assembly, supply chain management; advanced materials, alloys and composites.

Microwave Technology

Company	**Microwave Technology Ltd.**	*No.*	**06037958**
Location	**Northampton**	*Postcode*	**NN3 3XD**
Established	**2006**	*Workforce*	**<10**
Website	**http://www.microwavetechnology.co.uk/**	*Sector Score*	**1**
Product tree scope	**12**	*Innovation Score*	**3**

RF front end and solid state power amplifiers to 95 GHz (GaN and GaN MMIC technology).

Nexor

Company	**Nexor Ltd**	*No.*	**05152465**
Location	**Nottingham**	*Postcode*	**NG2 1AE**
Established	**2004**	*Workforce*	**45**
Website	**https://www.nexor.com/**	*Sector Score*	**1**
Product tree scope	**81, 82, 83**	*Innovation Score*	**2**

Secure multi-site information exchange for operational networks. Spin-out from Nottingham University.

Nottingham Scientific

Company	**Nottingham Scientific Ltd**	*No.*	**03645072**
Location	**Nottingham**	*Postcode*	**NG7 2TU**
Established	**1998**	*Workforce*	**>20**
Website	**www.nsl.eu.com**	*Sector Score*	**3**
Product tree scope	**50, 81**	*Innovation Score*	**3**

Advanced GNSS hardware and software.

Oclaro Technology

Company	**Oclaro Technology Ltd**	*No.*	**02298887**
Location	**Towcester**	*Postcode*	**NN12 8EQ**
Established	**1988**	*Workforce*	**>1800 (global)**
Website	**https://www.oclaro.com/**	*Sector Score*	**1**
Product tree scope	**15**	*Innovation Score*	**3**

InP photonic wafers; photonic integrated circuits; tunable lasers; photonic transceivers for DWDM.

RS Components Ltd

Company	**RS Components Ltd**	*No.*	**01002091**
Location	**Corby**	*Postcode*	**NN17 9RS**
Established	**1971**	*Workforce*	**n/a**
Website	**https://uk.rs-online.com/**	*Sector Score*	**1**
Product tree scope	**(any)**	*Innovation Score*	**1**

Component supplier and distributor, primarily electronic but mechanical, test, and tooling also.

SafeTTy Systems

Company	**SafeTTy Systems Ltd**	*No.*	**08718423**
Location	**Melton Mowbray**	*Postcode*	**LE14 2EY**
Established	**2013**	*Workforce*	**<5**
Website	**https://www.safetty.net/**	*Sector Score*	**3**
Product tree scope	**14, 76, 50**	*Innovation Score*	**2**

Software for real-time, secure embedded systems, including for space (ECSS-E-ST-40C, ECSS-Q-ST-80C).

Selex (Leonardo)

Company	**Selex ES Limited Lincoln**	*No.*	**Various companies in Selex group**
Location	**Various (inc. Lincoln,**	*Postcode*	**LN6 3TA**
Established	**1969 (holding company, Selex ES)**	*Workforce*	**~7000 (UK wide)**
Website	**http://www.uk.leonardocompany.com/uk-activities/space**	*Sector Score*	**3**
Product tree scope	**10, 41, 60, 81**	*Innovation Score*	**3**

Leonardo is the largest inward investor in the UK defence sector, the largest Italian inward investor to the UK, and one of the biggest suppliers of defence equipment to the UK MoD. Ground segment; payloads; RF comms.

Space Science Solutions

Company	**Space Science Solutions Ltd**	*No.*	**09462001**
Location	**Milton Keynes**	*Postcode*	**MK5 7AB**
Established	**2015**	*Workforce*	**<5**
Website	**N/A**	*Sector Score*	**3**
Product tree scope	**41**	*Innovation Score*	**2**

Novel camera systems and post-processing techniques.

Semelab

Company	**Semelab Limited**	*No.*	**06649272**
Location	**Lutterworth**	*Postcode*	**LE17 4JB**
Established	**2008**	*Workforce*	**>130**
Website	**http://ttelectronics.com/semelab**	*Sector Score*	**3**
Product tree scope	**14, 15, 50, 74, 76**	*Innovation Score*	**3**

Designs and manufacture of high performance semiconductor devices.

Seradata

Company	**Seradata Ltd**	*No.*	**08750033**
Location	**Northampton**	*Postcode*	**NN6 6HJ**
Established	**2013**	*Workforce*	**n/a**
Website	**http://www.seradata.com**	*Sector Score*	**3**
Product tree scope	**81**	*Innovation Score*	**1**

Launch, satellite database and analysis system. SpaceTrak powers the marketing and risk decisions of key launch providers, manufacturers, insurance companies, governments and satellite operators worldwide.

Taylor Hobson

Company	**Taylor Hobson Ltd**	*No.*	**03230332**
Location	**Leicester**	*Postcode*	**LE4 9JQ**
Established	**1996**	*Workforce*	**230**
Website	**https://www.taylor-hobson.com/**	*Sector Score*	**1**
Product tree scope	**(any)**	*Innovation Score*	**3**

Advanced and automated ultra-precision metrology.

Telespazio Vega UK

Company	**Telespazio Vega UK Limited**	*No.*	**07420777**
Location	**Luton**	*Postcode*	**LU1 3LU**
Established	**2010**	*Workforce*	**~ 100**
Website	**www.telespazio-vega.com**	*Sector Score*	**3**
Product tree scope	**10, 80**	*Innovation Score*	**3**

Mission operations software; spacecraft simulators; launch authority software; satcomms and geoinformation processing.

TenCate Advanced Composites

Company	**TenCate Advanced Composites Ltd**	*No.*	**02271414**
Location	**Langley Mill**	*Postcode*	**NG16 4BE**
Established	**1988**	*Workforce*	**~85**
Website	**https://www.tencatecomposites.com/markets/space/space-and-satellite**	*Sector Score*	**3**
Product tree scope	**30**	*Innovation Score*	**2**

Part of US company developing and producing advanced materials for satellite and space exploration programs. Familiar with NASA and European standards for outgassing and moisture resistance and overall qualification. Supplier to satellite and launcher programmes internationally.

Texas Instruments

Company	**Texas Instruments (UK) Ltd**	*No.*	**05779236**
Location	**Northampton**	*Postcode*	**NN4 7YL**
Established	**2006**	*Workforce*	**(global)**
Website	**http://www.ti.com/**	*Sector Score*	**2**
Product tree scope	**10, 50**	*Innovation Score*	**1**

Semiconductor design (European design HQ).

UK Optical Plastics

Company	**UK Optical Plastics Ltd**	*No.*	**04543838**
Location	**Leicester**	*Postcode*	**LE3 3DH**
Established	**2002**	*Workforce*	**<10**
Website	**www.ukopticalplastics.com**	*Sector Score*	**2**
Product tree scope	**40**	*Innovation Score*	**2**

Bespoke optical components; optical path analysis and design.

XCAM

Company	**XCAM Ltd**	*No.*	**03114535**
Location	**Northampton**	*Postcode*	**NN3 8RF**
Established	**1995**	*Workforce*	**10**
Website	**http://www.xcam.co.uk/**	*Sector Score*	**3**
Product tree scope	**41**	*Innovation Score*	**3**

Compact imaging payloads.

E HEIDI+ Data

E.1 Graduate Numbers per Subject

Bishop Grosseteste University

JACS principal subject v3	Non-European Union				Other European Union				United Kingdom			
	PG		UG		PG		UG		PG		UG	
	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT
(G1) Mathematics			0								10	
(N1) Business studies											15	

Cranfield University

JACS principal subject v3	Non-European Union				Other European Union				United Kingdom			
	PG		UG		PG		UG		PG		UG	
	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT
(G2) Operational research		0							0	20		
(H1) General engineering	50	25			80	15			45	190		
(H3) Mechanical engineering	80	15			85	5			35	60		
(H4) Aerospace engineering	215	40			285	45			95	130		
(H6) Electronic & electrical eng.	5				0	5			5	150		
(H7) Production & manuf. eng.	105	15			125	15			40	110		
(I2) Information systems		5				5			5	210		
(J5) Materials technology not o/s	5				15	0				5		
(J9) Others in technology										0		
(N1) Business studies	55	40			5	20			30	140		
(N2) Management studies	125	20			45	5			30	365		
(N6) Human resource mgt.		10				5				5		

De Montfort University

JACS principal subject v3	Non-European Union				Other European Union				United Kingdom			
	PG		UG		PG		UG		PG		UG	
	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT
(F1) Chemistry	0		50				10		0	5	180	10
(F2) Materials science	5								0	0		
(F3) Physics							5				55	0
(G1) Mathematics			0		0		5			0	75	0
(H1) General engineering	20		40		0		5		0		85	0
(H3) Mechanical engineering	70	0	40		0	0	15		5		315	30
(H6) Electronic & electrical engineering	40	0	35		0		0		5	5	70	15
(H7) Production & manuf. eng.	15				0				10	0		
(I1) Computer science	70	5	20		10	15	25		20	40	785	10
(I2) Information systems	20	0	20		0	5	5		15	45	315	10
(I3) Software engineering	5		5			0	0			5	70	5
(J4) Polymers & textiles	5		25				5		5	5	55	
(J9) Others in technology			5				20		0	0	210	0
(N1) Business studies	390	0	555		15	5	65		60	30	1,155	10
(N2) Management studies	75	5	0		5	0	5		35	25	45	45
(N6) Human resource mgt.	10		20		0		5		20	105	110	
(W2) Design studies	110	0	80		10		45		30	15	1,265	15

Loughborough University

JACS principal subject v3	Non-European Union				Other European Union				United Kingdom			
	PG		UG		PG		UG		PG		UG	
	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT
(F1) Chemistry	25	0	10	0	10	0	5		35	10	380	10
(F3) Physics	10		5		5		5		10	0	230	10
(G1) Mathematics	25		35		10	0	10		25	15	495	15
(G2) Operational research	10				5				5			
(G3) Statistics			5				0				15	0
(H1) General engineering	10	10			5	0			15	25		
(H3) Mechanical engineering	55	0	105	0	20	5	55		60	125	765	10
(H4) Aerospace engineering	10		25		10	5	15	0	20	5	345	5
(H6) Electronic & electrical eng.	85	25	40	0	15	20	15		40	95	405	5
(H7) Production & manuf. eng.	10	0	45	0	0	0	30	0	10	30	525	0
(I1) Computer science	60	0	20	0	5	0	20		10	0	390	5
(I3) Software engineering			0								5	0
(J4) Polymers & textiles			5	0			0				30	0
(J5) Materials technology not o/s	35	5	15	0	10	5	15		20	15	155	0
(J9) Others in technology	0	0	0			5	5		5	45	100	
(N1) Business studies	430	30	15		20	5	15		55	50	155	0
(N2) Management studies	125	20	65		20	5	95		55	240	700	10
(N6) Human resource mgt.	15				5				5			
(W2) Design studies	120	0	50		20	5	25		45	20	920	5

Nottingham Trent University

JACS principal subject v3	Non-European Union				Other European Union				United Kingdom			
	PG		UG		PG		UG		PG		UG	
	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT
(F1) Chemistry	10	0	5			0	5		10	0	260	20
(F3) Physics			5				0		0	0	245	0
(F5) Astronomy			0				0				25	0
(G1) Mathematics			5				5	0			285	10
(G2) Operational research	40	5			5	0			80	25		
(H1) General engineering	25	25			0				5	0		
(H6) Electronic & electrical engineering	15	10							0	0		
(I1) Computer science	35	20	45	5	0		10		10	15	555	30
(I2) Information systems			10			0				10	40	5
(I3) Software engineering			10				5		0		55	5
(J4) Polymers & textiles		0				0				0		
(J5) Materials technology not o/s					0				0			
(J9) Others in technology							0				85	
(N1) Business studies	95	85	190	5	45	35	100	0	25	30	1,570	60
(N2) Management studies	125	135	35	5	5	20	10		50	265	605	10
(N6) Human resource management	30	10	10	0	5	5	0		15	70	85	5
(W2) Design studies	135	10	335	0	10		65		70	35	2,555	15

The Open University

JACS principal subject v3	Non-European Union				Other European Union				United Kingdom			
	PG		UG		PG		UG		PG		UG	
	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT
(F1) Chemistry						0			5	150		
(F2) Materials science	0								0			
(F3) Physics								0	10	5		485
(F5) Astronomy									25	40		85
(G1) Mathematics								5	10	375		3,695
(G3) Statistics								0	5	0		510
(H1) General engineering	0			5				10	5	215		4,085
(H3) Mechanical engineering									0	0		
(H6) Electronic & electrical eng									5	0		
(I1) Computer science				5				5	10	340		1,495
(I2) Information systems				0				10	0	20		6,075
(I3) Software engineering									0	0		
(J5) Materials technology not o/s	0								0	0		
(J9) Others in technology		0				5		0	0	740		375
(N1) Business studies				0				5	10	20		2,545
(N2) Management studies		5		0		0			15	1,195		1,120
(N6) Human resource management						0				240		
(W2) Design studies				0				0	0	5		905

The University of Leicester

JACS principal subject v3	Non-European Union				Other European Union				United Kingdom			
	PG		UG		PG		UG		PG		UG	
	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT
(F1) Chemistry	35		30		5		10		35		305	
(F3) Physics	10		10		5		20		45	0	440	
(F5) Astronomy	5				0				10			
(G1) Mathematics	60		45		5		15		25	5	315	
(G3) Statistics	0	0							20	5		
(H1) General engineering	55		5		5	0	0		20	0	110	
(H3) Mechanical engineering	0		45				10		0		195	
(H4) Aerospace engineering			20				15				145	
(H6) Electronic & electrical engineering	30		25		0		5		5	10	35	
(I1) Computer science	80		40		10	0	35		15	10	310	
(I2) Information systems	0											
(I3) Software engineering	30		5		0		0		5	5	10	
(J5) Materials technology not o/s	0											
(N1) Business studies			5								5	
(N2) Management studies	90	10	205		15	0	30		30	170	380	15
(N6) Human resource management	70	5	5	0	5		0		5	25	5	20

The University of Lincoln

JACS principal subject v3	Non-European Union				Other European Union				United Kingdom			
	PG		UG		PG		UG		PG		UG	
	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT
(F1) Chemistry	5		0				0	0	5	0	100	
(F3) Physics									0		25	
(G1) Mathematics					0				0	0	70	
(H1) General engineering	5	0			5	0			0	5		
(H3) Mechanical engineering	0	0	30	0			0		0	5	115	25
(H6) Electronic & electrical eng.			5								10	5
(I1) Computer science	20	5	30	0	5		0		25	20	525	10
(N1) Business studies	230	0	135	10	5		15	5	20	15	530	100
(N2) Management studies	40	0	45	15	0	5	0	15	20	170	180	560
(N6) Human resource mgt.	15		0		0				20	15	15	40
(W2) Design studies	10	0	30	0	5		10		20	10	760	5

The University of Northampton

JACS principal subject v3	Non-European Union				Other European Union				United Kingdom			
	PG		UG		PG		UG		PG		UG	
	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT
(H0) Broadly-based programmes eng./tech.			5								15	0
(H1) General engineering	5	5	5			5	0		5	10	110	25
(H3) Mechanical engineering			10	0			5				20	5
(H7) Production & manufacturing eng.			10				0				35	0
(I1) Computer science	20		20			0	25		5	5	260	25
(I2) Information systems		5	5	0		5	0			15	25	5
(I3) Software engineering			0								10	0
(J4) Polymers & textiles	5	15	15		0		10		5	5	10	
(N1) Business studies	165	45	245	0	0	10	35		40	185	475	30
(N2) Management studies	60	5	10		0	0	5	0	15	25	195	10
(N6) Human resource management	0		10	0		5	5	0	5	40	70	20
(W2) Design studies			25				40			0	310	10

University of Derby

JACS principal subject v3	Non-European Union				Other European Union				United Kingdom			
	PG		UG		PG		UG		PG		UG	
	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT
(F2) Materials science								0				15
(F3) Physics										10		
(G1) Mathematics					0		5		5		145	10
(G3) Statistics							0				0	
(H0) Broadly-based programmes eng./tech.										0		
(H1) General engineering			0				0	0		15	40	0
(H3) Mechanical engineering	10		75	5	5	0	15	0	15	10	300	180
(H4) Aerospace engineering	0											
(H6) Electronic & electrical engineering	15		35	0	0		5		10	10	120	65
(H7) Production & manufacturing eng.							0		0	5	10	15
(I1) Computer science	15		15	0	5		25	0	5	5	355	25
(I2) Information systems	10	5	5	10	5		5	5	0	25	105	80
(I3) Software engineering	0						5		5		10	
(J9) Others in technology	0		0			0	10	0	5	30	90	10
(N1) Business studies	5		10	5	0	0	10	0	5	10	145	255
(N2) Management studies	35	5	45	5	0	5	30	5	10	210	375	70
(N6) Human resource management		0	10	0			5			65	20	0
(W2) Design studies	5		5	0	0		45	0	10	10	470	25

University of Nottingham

JACS principal subject v3	Non-European Union				Other European Union				United Kingdom			
	PG		UG		PG		UG		PG		UG	
	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT	FT	PT
(F0) Broadly-based programmes phys. sci.			5				0				10	
(F1) Chemistry	40		30		30		25		110	5	645	10
(F2) Materials science	10				0				5	0		
(F3) Physics	20	0	10		20	0	20	0	70	0	650	5
(F5) Astronomy			0				0	0			30	0
(G1) Mathematics	30		90		30		45		75		740	5
(G3) Statistics	5		0		5		0		10		10	
(H1) General engineering	5		45		5		5		10		75	0
(H3) Mechanical engineering	50	0	180		20		50	0	25	5	600	5
(H4) Aerospace engineering	5		5		0		5		5		45	
(H6) Electronic & electrical engineering	115	0	135	5	25	0	10		25	10	175	0
(H7) Production & manufacturing eng.	20		70		15		5		35	5	125	0
(I1) Computer science	50		95	0	15	0	40		50	5	390	0
(I2) Information systems	15				5				20			
(I3) Software engineering			15				0				10	0
(J2) Metallurgy	0				0				5			
(J5) Materials technology not o/s	15				5				5	0	0	
(J9) Others in technology	10								0	15		
(N1) Business studies	115	5	0		10	5	5		35	55	50	0
(N2) Management studies	130	5	235	0	20	0	60		20	25	800	5
(N6) Human resource management	20				0							

E.2 Retention Numbers

JACS principal subject v3	Location of employment (region)																
	East Midlands	East of England	England region unknown	Guernsey, Jersey and the Isle of Man	London	Non UK	North East	North West	Northern Ireland	Not known	Scotland	South East	South West	UK region unknown	Wales	West Midlands	Yorkshire and the Humber
Bishop Grosseteste University																	
(G1) Mathematics	0		0												0	0	0
De Montfort University																	
(F1) Chemistry	10	5			0		0					0			0	5	0
(H3) Mechanical engineering	10	5			5	0		0				0	0		0	5	0
(H6) Electronic & electrical engineering	5	0			0			0				0				0	
(I1) Computer science	20	0	0		5		0					0			0	5	
(I2) Information systems	30	0			5							0				0	
(I3) Software engineering	5	0						0									0
(J9) Others in technology	25	10	0		0	0							0			5	0
(N1) Business studies	80	15	0		30	0		5				20	0		0	20	
(N2) Management studies	5	0			5			0			0	5			0	0	
(N6) Human resource mgt.	5	0			5	0						0				5	
(W2) Design studies	100	35	0		45	5		10			0	10	5			20	10
Loughborough University																	
(F1) Chemistry	10	5			5	0		0			0	5	0			5	0
(F3) Physics	5	0			5						0	0	0			5	0
(G1) Mathematics	10	5		0	20	5	0	5				5	5			5	5
(G3) Statistics	0				0							0				0	
(H3) Mechanical engineering	25	10			15	5	0	5			0	20	10		0	20	5
(H4) Aerospace engineering	20	5			5			0				0	5		0	0	0
(H6) Electronic & electrical engineering	10	5			10			0			0	10	15			10	5
(H7) Production & manufacturing engineering	10	5			15	5	5	5				15	10		0	10	5
(I1) Computer science	5	5	0		20	0		0				5	5			0	0
(I3) Software engineering		0			0							0	0				
(J5) Materials technology not otherwise specified	0					0		0				5	0		0	5	0
(J9) Others in technology	0	0			10	0		0				5	5		0	5	0
(N1) Business studies	5	5			15	0		0				5	0			0	
(N2) Management studies	5	10		0	40		0	5				15	0			10	0
(W2) Design studies	25	20			40	5	0	5				10	10		0	20	0
Nottingham Trent University																	
(F1) Chemistry	10	5			5	0		0								0	
(F3) Physics	15	0		0	0			5	0			5	0			5	0
(F5) Astronomy	0								0			0					
(G1) Mathematics	15	5			5		0	5	0							5	5
(I1) Computer science	45	5			5		0	0				5	5		0	5	5
(I2) Information systems	5	0			5												
(I3) Software engineering	5				0												
(N1) Business studies	45	30			55	10	0	15			0	20	0		0	20	5

JACS principal subject v3	Location of employment (region)																
	East Midlands	East of England	England region unknown	Guernsey, Jersey and the Isle of Man	London	Non UK	North East	North West	Northern Ireland	Not known	Scotland	South East	South West	UK region unknown	Wales	West Midlands	Yorkshire and the Humber
(N2) Management studies	35	15			35	0		5				15				10	5
(N6) Human resource management	0				0			0								0	0
(W2) Design studies	135	30		0	165	15	0	30			0	35	10		5	35	25
Open University																	
(F3) Physics						0		0									
(G1) Mathematics	10	25	5		30	5	5	5	5		10	25	15		5	20	10
(G3) Statistics	0	0	0		5	0	0	5	0		0	5	5		0	0	0
(H1) General engineering	10	20	5		15	10	5	10	5		25	30	20		0	5	10
(I1) Computer science	0	0			5	0		5	0		0	5	0			5	0
(I2) Information systems	5	15	5		20	5	5	5	5		10	10	10		5	10	5
(J9) Others in technology	0	0			5	0	0	0			5	5	0		0	0	
(N1) Business studies	5	20	5		25	10	5	10	5	0	5	25	20		5	10	5
(N2) Management studies	10	10			15	0	0	10	0		5	10	5		0	10	5
(W2) Design studies	0	0			5			0	0			10	0		0	0	0
University of Leicester																	
(F1) Chemistry	15	0			5		0	0				5	5		0	0	0
(F3) Physics	10	5			5			5				5	10			5	5
(G1) Mathematics	5				5		0	0			0	5	0		0	5	0
(H1) General engineering					0							0					
(H3) Mechanical engineering	10	5			5	0		5				5	5			5	0
(H4) Aerospace engineering	5	0	0		5							0	5			0	0
(H6) Electronic & electrical engineering	0				0							0					
(I1) Computer science	10	0			10	0		0				5	0			0	0
(I3) Software engineering	0																
(N1) Business studies	0																
(N2) Management studies	10	0		0	20	0		0			0	5	0			5	0
(N6) Human resource management	0	0			0												
University of Lincoln																	
(H3) Mechanical engineering	10	5						0					0				5
(I1) Computer science	30	10			5			5		0		5	5			5	5
(N1) Business studies	30	20			15	5	0	5			0	10	5			5	10
(N2) Management studies	25	15			10	5	0	5	0	0	5	15	15		5	5	5
(W2) Design studies	60	10			25	5	0	5				10	0		0	5	20
University of Northampton																	
(H1) General engineering	10	5			5							10				5	
(H3) Mechanical engineering		0															
(H7) Production & manufacturing engineering	5				0								0			0	
(I1) Computer science	10	5		0	0							5				5	0
(N1) Business studies	30	5			15	0		0				10	0			5	0
(N2) Management studies	5	0			0								0				
(N6) Human resource management	5	0			0							0				0	
(W2) Design studies	30	5			10			5			0	10	0			5	0

JACS principal subject v3	Location of employment (region)																
	East Midlands	East of England	England region unknown	Guernsey, Jersey and the Isle of Man	London	Non UK	North East	North West	Northern Ireland	Not known	Scotland	South East	South West	UK region unknown	Wales	West Midlands	Yorkshire and the Humber
University of Derby																	
(G1) Mathematics	10								0							0	
(H1) General engineering	0												0				
(H3) Mechanical engineering	20	0									0	5				5	5
(H6) Electronic & electrical engineering	15	5		0	0	0							5			5	
(H7) Production & manufacturing engineering	5																
(I1) Computer science	15				0	0						0	5			5	5
(I2) Information systems	5				0						0					0	0
(J9) Others in technology	5	0										0				0	
(N1) Business studies	15				5	0		0					0			0	0
(N2) Management studies	30				5		0	5				5	0		0	10	5
(N6) Human resource management	0	0			0							0				0	
(W2) Design studies	45				0	0	0	0				0	0			20	5
University of Nottingham																	
(F1) Chemistry	10	5	5		10	5	0	0				5	0	0		5	
(F3) Physics	15	5	5		10	5	0	0				5	0	5	0	5	
(F5) Astronomy	0					0						0				0	
(G1) Mathematics	10	10	25		35	0		10		0	0	10	5	0		10	5
(G3) Statistics	0		0		0			0					0			0	0
(H1) General engineering	0														0	0	0
(H3) Mechanical engineering	15	10	10		10	0	0	0				5	5	5	0	5	0
(H6) Electronic & electrical engineering	5	5	5		5		0	0				0	0	0	0	0	0
(H7) Production & manufacturing engineering	5	0	5		0							0	5			0	
(I1) Computer science	10	0	5		10	0		0					0	0	0	5	
(I3) Software engineering	0	0															
(N1) Business studies	0		0		5	0						0	0		0	0	
(N2) Management studies	10	10	20		45	5		5		0		5	0	5		10	0

F European Framework Programme Participation

Companies either involved in the space industry, or in adjacent sectors as identified in Annex D, or that are regional HEIs, are highlighted in **boldface**.

F.1 H2020 Regional Participation

Organisation	# Projects	Grant Value (€)	Location	Postcode
Acclimatise Group Ltd	2	300181	Newark	NG22 8LS
Aegis Trust	1	269508	Newark	NG22 0PA
Aircraft Research Association Limited	3	3962612	Bedford	MK41 7PF
Aisolve Limited	1	133898	Luton	LU3 1RJ
Altek Europe Limited	2	3333294	Chesterfield	S40 2UB
Applied Inspection Limited	2	291814	Chesterfield	S42 5RB
Aquisense Technologies (Europe) Limited	1	351521	Grantham	NG31 6SF
Bombardier Transportation UK Ltd	1	22220	Derby	DE24 8AD
Castlet Ltd	1	50000	Lincoln	LN3 4NR
Chalice Medical Limited	1	793750	Worksop	S80 2RS
Clear Communication Associates Limited	2	452075	Milton Keynes	MK14 5HE
Clearhead Media	1	111598	Luton	LU1 2EY
Commagility Limited	1	414688	Loughborough	LE11 3AQ
Composites Evolution Limited	1	1102588	Chesterfield	S41 9QG
Cranfield University	**50**	**17850113**	**Cranfield**	**MK43 0AL**
Critical Pharmaceuticals Limited	1	50000	Nottingham	NG1 1GF
Custom Laboratory Products Ltd	1	953458	Bletchley	MK1 1SW
Dassault Systemes Geovia Ltd	1	525250	Coalville	LE673HB
David Tinker & Associates Limited	1	130875	Ampthill	MK45 2LD
De Montfort University	**15**	**4885097**	**Leicester**	**LE1 9BH**
Derbyshire And Nottinghamshire Chamber	2	0	Chesterfield	S41 7NA
Docobo Ltd	1	754188	Bookham	KT23 4AA
Dynamic Imaging Analytics Limited	1	110350	Milton Keynes	MK3 6EB
Dynex Semiconductor Limited	**1**	**954158**	**Lincoln**	**LN6 3LF**
Easyjet Airline Company Limited	1	186532	Luton	LU2 9PF
Ecovisum Ltd	1	81448	Leicester	LE1 5XY
Ecton Mine Educational Trust	1	195000	Ashbourne	DE6 2AH
Electric Corby Community Interest Co.	1	995959	Corby	NN17 5EU
Embedded Rail Technology Ltd	1	276125	Derby	DE23 8GG
Euram Limited	3	644746	Lincoln	LN1 1XW
European Thermodynamics Limited	**3**	**940957**	**Kibworth**	**LE8 0RX**
Fabis Consulting Limited	1	177603	Barton	NG110AE
Far-Uk Ltd	2	970063	Nottingham	NG11 7EP
Four04 Packaging Limited	1	50000	Derby	DE21 6LY
Galson Sciences Limited	2	895281	Oakham	LE156AX

Organisation	# Projects	Grant Value (€)	Location	Postcode
Global Biotechnology Transfer Foundation	1	203438	Lincoln	LN8 6HF
Guidance Navigation Holdings Ltd	1	50000	Leicester	LE19 1RP
Highway Resource Solutions Ltd	1	809645	Sileby	LE127PU
Hybrid Manufacturing Technologies	1	691250	Moira	DE12 6EJ
Imosphere Ltd	2	1308821	Leicestershire	LE115RE
Infohub Ltd	1	287613	Nottingham	NG7 2QJ
Intelligent Energy Limited	4	1839369	Loughborough	LE113GB
Interkonsult Ltd	1	329875	Newark	NG242TN
Lace Housing Limited	1	200156	Lincoln	LN2 4UZ
Laser Optical Engineering Limited	1	514735	Loughborough	LE113X2
Leicester City Council	2	281000	Leicester	LE1 1FZ
Loughborough University	**31**	**12552787**	**Loughborough**	**LE11 3TU**
Lstech Ltd	1	270000	Milton Keynes	MK9 2HR
Matrix Recycling Systems Ltd	1	50000	Grantham	NG32 3LT
Meadows Ozone Energy Services Ltd.	1	378530	Nottingham	NG2 2JD
Micromix Plant Health Limited	1	50000	Melton Mowbray	LE14 3JB
Micropropagation Services (E.M.) Limited	1	50000	Loughborough	LE12 6PE
Microwave Technology Ltd	**1**	**357213**	**Northampton**	**NN3 3XD**
Miles-Bramwell Executive Services Limited	1	111250	Alfreton	DE55 4RF
Mill House Manufacturing Design Limited	1	445585	Woodhall Spa	LN10 6YL
Milton Keynes Council	3	386313	Milton Keynes	MK9 3HG
Mologic Ltd	1	273288	Bedford	MK44 2YP
Motor Neurone Disease Association	2	51188	Northampton	NN1 2BG
Mws Limited	1	0	Leicester	LE4 3EH
Netcomposites Limited	4	865951	Chesterfield	S41 9QG
Northamptonshire County Council	1	51875	Northampton	NN1 1AN
Nottingham City Council	3	4727269	Nottingham	NG1 4BT
Nottingham Scientific Ltd	**6**	**2038219**	**Nottingham**	**NG2 1RT**
Notts. Healthcare Nhs Foundation Trust	1	36000	Nottingham	NG3 6AA
Oag Aviation Worldwide Limited	1	249375	Luton	LU1 3LU
Pds Computer Software Limited	1	553375	Leicester	LE2 2LF
Pera Consulting (UK) Limited	1	225794	Melton Mowbray	LE13 0PB
Promethean Particles Ltd	4	1284775	Nottingham	NG9 8AA
Ranplan Wireless Network Design Ltd	3	583788	Luton	LU2 0SX
Renewable Technical Services Limited	1	475278	Kettering	NN15 6NL
Renovagen Ltd	1	50000	Milton Keynes	MK12 6HR
Residual Barrier Technology Limited	1	50000	Daventry	NN11 4HE
Resources Computing International Ltd	2	448313	Matlock	DE4 5JA
Rieke Packaging Systems Limited	1	0	Leicester	LE3 1UG
Rolls-Royce Power Engineering Plc	**4**	**165690**	**Derby**	**DE24 8BJ**
Samworth Brothers Limited	1	1765363	Melton Mowbray	LE13 1GA
Sarissa Biomedical Limited	1	546576	Bedford	MK403JY

Organisation	# Projects	Grant Value (€)	Location	Postcode
Sasie Ltd	1	172393	Nottingham	NG6 8FX
Scitek Consultants Limited	1	208653	Derby	DE24 8HP
Scott Bader Co Ltd	1	45426	Wellingborough	NN29 7RL
Skf (U.K) Limited	1	281113	Luton	LU3 3BL
Skymark Packaging International Limited	1	532691	Ilkeston	DE7 8EF
Strain Solutions Limited	1	85175	Chesterfield	S41 8NG
T4i Engineering Ltd	1	324188	Loughborough	LE11 3QF
Taylor Hobson Limited	**1**	**390755**	**Leicester**	**LE4 9JQ**
Telespazio Vega UK Limited	**1**	**123176**	**Luton**	**LU1 3LU**
Terravesta Assured Energy Crops Limited	1	1167500	Lincolnshire	LN5 7DB
The National Energy Foundation	1	1666008	Milton Keynes	MK5 8NG
The Nottingham Energy Partnership	1	412750	Nottingham	NG8 1FW
The Nottingham Trent University	**8**	**3583038**	**Nottingham**	**NG1 4BU**
The Open University	**37**	**11553448**	**Milton Keynes**	**MK7 6AA**
The Technology Research Centre Limited	1	50000	Grantham	NG32 3LT
The UK Health & Env. Research Institute	1	51011	Melton Mowbray	LE13 0PB
The UK Intelligent Systems Research Inst.	1	0	Melton Mowbray	LE13 0PB
U. Northampton Higher Ed. Corp.	2	763628	Northampton	NN2 7AL
The University of Nottingham	**121**	**51127452**	**Nottingham**	**NG7 2RD**
Tqc Limited	1	268188	Nottingham	NG3 2NJ
Transport Systems Catapult Limited	4	1369681	Milton Keynes	MK9 1BP
Tumour Trace Ltd	1	50000	Nottingham	NG90 6BH
University of Bedfordshire	4	1944943	Luton	LU1 3JU
University of Derby	**2**	**344572**	**Derby**	**DE221GB**
University of Leicester	**42**	**17879238**	**Leicester**	**LE1 7RH**
University of Lincoln	**12**	**5920241**	**Lincoln**	**LN6 7TS**
Upperton Limited	1	1697778	Nottingham	NG2 5NA
Wearable Technologies Limited	1	50000	Leicestershire	LE9 4DA
Zeroshift Transmissions Ltd	1	50000	Milton Keynes	MK4 1GA
TOTALS	**460**	**168386894**		

F.2 FP7 Regional Participation

Organisation	# Projects	Grant Value (€)	Location	Postcode
Aggregate Industries UK Limited	1	301206	Markfield	LE67 9PJ
Agw Electronics Limited	1	101641	Chesterfield	S433LS
Aircraft Research Association Limited	13	3907517	Bedford	MK41 7PF
Alphagary Limited	1	26248	Melton Mowbray	LE13 0DG
Alpro UK Ltd	1	87500	Kettering	NN15 5YT
Altek Europe Limited	2	933817	Chesterfield	S40 2UB
Amber Composites Ltd	1	219543	Nottingham	NG16 4BP
Amberjac Projects Ltd	1	37728	Grantham	NG31 6SF
Aos Technology Ltd	1	537409	Melton Mowbray	LE13 0RG
Apd Communications Ltd	1	488100	Milton Keynes	MK5 6LB
Applied Inspection Limited	3	837077	Chesterfield	S42 5RB
Applied Materials Technology Limited	4	794982	Lincoln	LN6 3RU
Archimedes Development Limited	1	977621	Nottingham	NG7 2TN
Arthritis Research UK	1	0	Chesterfield	ST41 7TD
Axon Automotive Limited	3	786121	Wollaston	NN29 7RG
Balfour Beatty Rail Technologies Limited	1	27600	Derby	DE1 2SA
Baxi Heating UK Limited	1	55950	Derby	DE21 6BF
Beacon Research Limited	1	0	Market Harborough	LE16 9RX
Bhr Group Limited	3	592156	Cranfield	MK43 OAJ
Biomech Technologies International	1	212560	Nuneaton	CV11 5HP
Bishop Grosseteste University College	**1**	**141600**	**Lincoln**	**LN1 3DY**
Blankney Estates Limited	1	309120	Leicester	LE1 1LD
Bluesky International Limited	1	520656	Coalville	LE67 3NR
Bombardier Transportation UK Ltd	3	426080	Derby	DE24 8AD
Boots UK Limited	1	26830	Nottingham	NG2 3AA
Briton Ems Limited	2	275783	Bedford	MK41 0EP
C.Wright & Son Gedney Ltd	2	94180	Spalding	PE12 OAJ
Carbolite Limited	1	22693	Hope Valley	S33 6RB
Castlet Ltd	1	258749	Lincoln	LN3 4NR
Cathelco Ltd	1	480557	Chesterfield	S41 8NY
Catt-Sci Limited	1	33126	Wellingborough	NN8 5XG
Cemmnt Hub Limited	1	67323	Loughborough	LE11 3TU
Certain Indexes Limited	1	167580	Loughborough	LE12 7TJ
Charnwood Technical Consulting Ltd	**1**	**232578**	**Quorn**	**LE12 8AT**
Clear Communication Associates Limited	2	354946	Milton Keynes	MK14 5HE
Computerised Information Technology Ltd	6	1834503	Milton Keynes	MK11 3JB
Cranfield Aerospace Limited	**1**	**51357**	**Cranfield**	**MK43 0AL**
Cranfield University	**100**	**26959956**	**Cranfield**	**MK43 0AL**
Cressall Resistors Limited	1	378207	Leicester	LE5 5LZ
Dawson Construction Plant Ltd	1	295879	Milton Keynes	MK6 1NE
De Montfort University	**24**	**5453428**	**Leicester**	**LE1 9BH**

Organisation	# Projects	Grant Value (€)	Location	Postcode
Deritend International Limited	1	62332	Burton On Trent	DE14 2WH
Devan-Ppt Chemicals Ltd	2	324520	Belper	DE56 2EY
Dynex Semiconductor Limited	**3**	**280893**	**Lincoln**	**LN6 3LF**
Eclectic Energy Limited	1	206957	Nottingham	NG21 9 PR
Econolyst Limited	1	21048	Wirksworth	DE4 4FF
Ehs Data Ltd	1	168843	Newark	NG24 1BS
Electric Corby Community Interest Co.	1	314520	Corby	NN17 5EU
Elforlight Limited	1	255075	Daventry	NN11 8RB
Etalon Research Ltd	1	133000	Long Eaton	NG10 4QE
Euram Limited	9	2526492	Lincoln	LN1 1XW
European Association for Cancer Research	1	57780	Nottingham	NG7 2RD
European Distance & E-Learning Network	1	21828	Milton Keynes	MK19 7ES
European Technology for Business Ltd	1	185000	Luton	LU1 1QZ
European Thermodynamics Limited	**4**	**1889918**	**Kibworth Harcourt**	**LE8 0RX**
Euroteknik Ltd	2	867172	Lutterworth	LE17 6LZ
European Society for Precision Engineering and Nanotechnology	1	134295	Cranfield	MK43 0AL
Evonik Membrane Extraction Technology	4	1146014	Milton Keynes	MK10 0AF
Fabis Consulting Limited	1	216167	Barton	NG11 0AE
Food Processing Faraday Partnership	1	252438	Leicester	LE13 0PB
Formax (UK) Ltd	1	60548	Leicester	LE19 2FZ
Fully Distributed Systems	1	80995	Loughborough	LE12 8RE
Galson Sciences Limited	4	751838	Oakham	LE15 6AX
Geeknet Media Ltd	2	171329	Northampton	NN1 2NE
General Robotics Limited	1	220691	Milton Keynes	MK12 5TW
Genewatch UK	1	75957	Buxton	SK17 7BB
George Barnsdale & Sons Limited	1	259995	Spalding	PE11 4TA
GL Industrial Services UK Ltd	1	384648	Loughborough	LE11 3GR
GR Aero Ltd	3	62012	Milton Keynes	MK17 8EA
Greenbank Terotech Ltd	3	924226	Derby	DE11 7GT
Greenfinch Limited	1	209238	Bedford	MK44 1YU
Groundswell Research Associates Ltd*	1	54995	Bedford	MK40 3TJ
Guttridge Ltd	2	551079	Spalding	PE11 3UU
H. J. Enthoven Limited	1	0	Matlock Derbyshire	DE4 2LP
Heavyweight Air Express Limited	1	285692	Derby	DE74 2SA
Highway Resource Solutions Ltd	1	259998	Sileby	LE127PU
Hi-Tech Automation Limited	1	240194	Kettering	NN9 6PX
Hitek Electronic Materials Limited	1	158345	Scunthorpe	DN17 2AX
Incontrol Ultrasonics Ltd	1	0	Sileby	LE12 7NW
Industrial Microwave Systems Ltd	1	34463	Milton Keynes	MK12 5TL
Infoterra Limited	**13**	**4340908**	**Leicester**	**LE3 1UT**
Innovative Materials Processing Tech.	3	809695	Nottingham	NG7 2QP

Organisation	# Projects	Grant Value (€)	Location	Postcode
Intamac Systems Limited	1	209098	Northampton	NN4 7YD
Intelligent Energy Limited	1	3996829	Loughborough	LE113GB
Intercede Limited	1	366000	Leicester	LE17 4PS
Interkonsult Ltd	1	136009	Newark	NG242TN
Intrepid Minds Ltd	1	213000	Nuneaton	CV10 0TW
Ionscope Limited	1	681207	Melbourn	SG8 6HB
Krestos Limited	1	214000	Nottingham	NG2 7BA
Land Quality Management Ltd	1	212672	Nottingham	NG7 2TU
Laser Expertise Ltd	3	524948	Nottingham	NG7 2TR
Laser Optical Engineering Limited	1	364231	Loughborough	LE113X2
Ledinlight Ltd	1	765	Nottingham	NG7 2RU
Leicester City Council	1	381890	Leicester	LE1 1FZ
Leicester Housing Association Limited Ips	1	199352	Leicester	LE2 7EA
Linwave Technology Limited	**1**	**35949**	**Lincoln**	**LN6 3LQ**
Locate Therapeutics Limited	1	492344	Nottingham	NG90 6BH
Loughborough University	**87**	**26673453**	**Loughborough**	**LE11 3TU**
Lubriserv Limited	1	211599	Nottingham	NG16 2RD
Lubrizol Limited	2	155916	Hazelwood	DE56 4AN
Magna Parva Ltd	**1**	**388638**	**Leicester**	**LE19 1WY**
Mark Group Limited	1	30071	Leicester	LE4 1AW
Mct Engineering Limited	1	96958	Daventry	NN11 8QT
Metalmark Engineering Limited	2	349448	Nottingham	NG7 2TR
Michael Stuart	1	75489	Hinckley	LE10 2BQ
Micropore Technologies Ltd	1	285057	Hatton	DE65 5DU
Mira Ltd (now Horiba-Mira)	**10**	**3130733**	**Nuneaton**	**CV10 0TU**
Moniteye Ltd	1	42631	Oakham	LE15 6AS
Multi Packaging Solutions UK Limited	1	120628	Nottingham	NG8 6AW
Nde Consultants Ltd	1	40258	Nottingham	NG2 3NG
Netcomposites Limited	15	6452085	Chesterfield	S41 9QG
Northamptonshire County Council	1	53580	Northampton	NN1 1AN
Nottingham City Council	2	35736	Nottingham	NG1 4BT
Nottingham Scientific Limited	**8**	**1568243**	**Nottingham**	**NG2 1RT**
Nottingham University Hospitals Nhs Trust	1	14175	Nottingham	NG7 2UH
Oclaro Technology Ltd	**5**	**2537210**	**Towcester**	**NN12 8EQ**
Office Depot International (UK) Limited	1	47520	Leicester	LE4 2BN
Palmhive Technical Textiles Ltd	1	0	Nottingham	NG7 2TA
Pca Engineers Limited	3	261626	Lincoln	LN2 2LL
Peak Ndt Limited	2	210287	Derby	DE1 2BU
Pepceuticals Limited	1	228422	Enderby	LE19 4JS
Pera Consulting (UK) Limited	1	407398	Melton Mowbray	LE13 0PB
Pera Technology Limited	10	2356279	Melton Mowbray	LE13 0PB
Premier Worksurfaces Limited	1	0	Leicester	LE14 4JG

Organisation	# Projects	Grant Value (€)	Location	Postcode
Promethean Particles Ltd	3	1217510	Nottingham	NG9 8AA
Prometheus Developments Ltd	1	9316	Belper	DE56 2TH
Ranplan Wireless Network Design Ltd	3	3045283	Luton	LU2 0SX
Recycling of Used Plastics Limited	1	343040	Lincoln	LN1 1XW
Renasci Limited	1	260997	Nottingham	NG1 1GF
Rolls-Royce Controls and Data Services	5	1823684	Derby	DE24 8BJ
Rolls-Royce Fuel Cell Systems Limited	1	1894318	Derby	DE24 8BJ
Rolls-Royce Marine Power Operations	1	177200	Derby	DE1 6EX
Rolls-Royce Power Engineering Plc	7	792937	Derby	DE24 8BJ
Romax Technology Limited	4	1073860	Nottingham	NG7 2TU
Rototek Ltd	2	180930	Newark	NG24 3UT
Rutland Biodynamics Limited	1	211631	Oakham	LE15 8DG
Samworth Brothers Limited	1	0	Melton Mowbray	LE13 1GA
Sarah Davenport Ltd	1	160883	Nottingham	NG5 8ND
Scitek Consultants Limited	5	1636392	Derby	DE24 8HP
Scott Bader Co Ltd	1	59999	Wellingborough	NN29 7RL
Semelab Ltd	**3**	**434940**	**Lutterworth**	**LE17 4JB**
Sigma Precision Components UK Ltd	1	575000	Hinckley	LE10 3BP
Silicone-Altimex Limited	1	244308	Nottingham	NG9 8HR
Skf (U.K) Limited	2	258746	Luton	LU3 3BL
Skymark Packaging International Limited	3	528976	Ilkeston	DE7 8EF
Smithers Purslow Property Services Ltd	1	0	Oakham	LE15 9BZ
Soletec Systems Ltd	1	340088	Leicester	LE18 2BL
Source Bioscience Plc	6	1892769	Nottingham	NG8 6PX
Stellarview Limited	1	0	Melton Mowbray	LE13 1TT
Sun Chemical Limited	1	105573	South Normanton	DE55 2DT
Surescreen Diagnostics Limited	1	225382	Derby	DE1 3QB
Sygnature Discovery Limited	1	5114237	Nottingham	NG1 1GF
T. Baden Hardstaff Limited	2	714350	Kingston On Soar	NG11 0DF
Tech4i2 Limited	6	471852	Thurcaston	LE7 7JP
Telespazio Vega UK Limited	**2**	**266706**	**Luton**	**LU1 3LU**
Terrasalus Limited	1	25000	Oakham	LE15 9EL
Testex Ndt Limited	1	0	North Killingholme	N/A
The National Energy Foundation	1	0	Milton Keynes	MK5 8NG
The Nottingham Trent University	**20**	**4981002**	**Nottingham**	**NG1 4BU**
The Open University	**83**	**31218885**	**Milton Keynes**	**MK7 6AA**
The Packaging And Films Association	2	780811	Nottingham	NG7 7GR
The Technology Research Centre Limited	1	4776	Welby Grantham	NG32 3LT
The Thatched Owners Group Limited	1	327784	Spalding	PE12 ONR
The Tile Studio Ltd	1	0	Nottingham	NG9 7AS
UK Health & Environment Research Inst.	29	1392863	Melton Mowbray	LE13 0PB
UK Intelligent Systems Research Inst.	50	1764487	Melton Mowbray	LE13 0PB

Organisation	# Projects	Grant Value (€)	Location	Postcode
The University of Northampton	**2**	**534784**	**Northampton**	**NN2 7AL**
The University of Nottingham	**308**	**132244567**	**Nottingham**	**NG7 2RD**
Torclad Limited	1	414309	Leicester	LE1 7LF
Tqc Limited	1	370319	Nottingham	NG3 2NJ
Trent Mouldings Limited	1	321414	Newark	NG23 7NB
Tte Systems (now SafeTTy Systems)	**1**	**0**	**Melton Mowbray**	**LE1 7EA**
Tts- (Shipping) Limited	2	280038	Melton Mowbray	LE13 1TT
U-Marq Limited	1	368720	Milton Keynes	MK8 0AD
Unipath Limited	1	70800	Bedford	MK44 3UP
Uniscan Instruments Limited	5	1370721	Buxton	SK17 9JB
University of Bedfordshire	26	6159769	Luton	LU1 3JU
University of Derby	**1**	**140700**	**Derby**	**DE22 1GB**
University of Leicester	**96**	**44956268**	**Leicester**	**LE1 7RH**
University of Lincoln	**13**	**4842506**	**Lincoln**	**LN6 7TS**
Upperton Limited	1	278280	Nottingham	NG2 5NA
Uvasol Limited	6	935957	Loughborough	LE11 3PE
Vesuvius Uk Ltd	1	0	Chesterfield	N/A
Virtualpie Ltd	8	4364124	Cranfield	MK43 0AJ
West Northamptonshire Development Corp.	1	0	Northampton	NN5 5WU
Willow Photonics Ltd	3	833344	Towcester	NN12 8QU
X-Link Limited	2	450337	Nottingham	NG1 1GF
Xrgenomics Ltd	1	484396	Nottingham	NG5 1AZ
Zeeko Limited	3	945618	Coalville	LE67 3FW
TOTALS	**1201**	**387036264**		