Upstream Space: A Galaxy of Capability

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Annex B: Space SIA Analytical support

Analysis and assessment of research capacity

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1 This document

As part of the bespoke analytical support, this document summarises the level and scale of publicly funded research activity in within the Space SIA area. It also seeks to identify which organisations are most frequently engaged in Space research within the SIA area.

2 Methodology

The analysis draws on data from the UKRI's Gateway to Research[1], which includes most R&D activity funded by the UK research councils, but also grants awarded by InnovateUK, and also from the EU Framework programme during the period 2007-2017. The data therefore not only comprises research grants, but also feasibility studies, pilots, prototypes and proof of concepts, KTNs, innovation voucher grants, etc.).

Obtaining data on research topic areas relevant to the SIA is only possible with the use of more advanced data classification techniques. Using specialist software, we have run a semantic text analysis of the titles and abstracts of each project/activity (totalling more than 60,000 grants, which identified more than 100,000 different concepts and more than 140,000 different categories). The software has mined each of these funded projects, identifying those that correspond to a series of key words and phrases relevant to space research, as shown below. It also looks for relevant phrases and concepts associated with the key words, as well as synonyms and technical names for the phrases/concepts being studied.

Our analysis focuses on the following areas of space research (these broadly correspond with technology domains similar to those used by the European Space Agency):

- On-Board Data Systems
- Spacecraft Electrical Power
- RF Payload and Systems including electromagnetic technologies/techniques, and space weather (electromagnetic compatibility)

[1] Gateway to Research, August 2017 snapshot. Available at http://gtr.rcuk.ac.uk

- Space System Control
- Automation, Telepresence & Robotics, and optoelectronics
- Aerothermodynamics

These technology domains have been implemented as a set of semantic text analysis categories (Appendix B). Using these results, we have subsequently been able to better understand levels of research activity from different perspectives, most notably the number of projects led by SIA area-based organisations, the number of projects participated in by SIA-based organisations, the overall funding value of projects led, and the overall funding value of projects participated in.

3 Research activity and Location Quotients

Location quotients (LQs) provide a way of show whether the partnership area has a higher concentration of research activity relative to the UK average. A more detailed explanation on how we derive LQs is provided in Appendix A. In short however, an LQ of 1 indicates that research activity under a topic is as heavily concentrated in the partnership area as it is across the comparator geography overall (the UK in this case). An LQ greater than 1 indicates that a given topic accounts for a larger share of all the partnership area's research activity than would be expected when compared to the UK average. In other words, LQs substantially greater than 1 signal a level of activity/specialisation that exceeds what would normally be expected nationally. More narrowly defined topics can display LQ values that are more volatile, so comparison across topics should not be taken literally.

3.1.1 Research activity in UKRI's Gateway to Research

The following tables provide analysis of publicly-funded research and innovation activity in space research over the period 2007 to 2017, for UK-funded grants. For comparative purposes, the tables also summarise the situation for publicly funded research in any area relevant to the 'Space' topic more broadly.

Table 2 shows strong performance from the SIA area with respect to the space sector as a whole. As shown, the area accounts for 40% of all participants in publicly-funded space projects, and over half (53%) of the total public funding awarded to space research projects. The SIA area also has high LQs with respect to both its number of space project participants (1.2), and the value of funding to space project participants (1.21), demonstrating an above UK average concentration of space research activity in the area. Table 1 reinforces the SIA area's strengths in the space sector, highlighting that in comparative terms, it performs well with respect to leading publicly-funded space research projects. The SIA area has an LQ of 1.17 for space projects led, and 1.26 for funding given to project leads, demonstrating that there is a much higher concentration of space project management in the SIA area than would be typically be expected (in comparison to the UK average).

The SIA region performs especially strongly in aerothermodynamics. In terms of participation in UK publicly-funded research, it has an LQ of 1.29 for the number of project participants, and 1.23 for the amount of funding given to project participants (see Table 2). It also has an LQ of 1.11 for aerothermodynamics projects led, as per Table 1. The SIA region also has an especially high concentration of projects led in 'automation, telepresence & robotics, and optoelectronics,' as per the LQ of 1.52 here, albeit that the UK funds a relatively small number of research projects in this field.

Table 1 Space SIA organisations as project leads for publicly-funded research projects

	Projects led from the SIA	***% of UK projects***	***LQ***	***Value of projects led from SIA (£m)***	***% of UK funding***	***LQ***
Space (all)	1529	31.53%	1.17	891.84	35.94%	1.26

On-Board Data Systems	16	25.81%	0.96	19.06	2.21%	0.08
Spacecraft Electrical Power	8	25.00%	0.93	5.33	12.93%	0.45
RF Payload and Systems, including electromagnetic technologies and techniques and space weather (electromagnetic compatibility)	100	29.07%	1.08	31.12	22.42%	0.79
Space System Control	5	31.25%	1.16	0.28	15.31%	0.54
Automation, Telepresence & Robotics, and optoelectronics	16	41.03%	1.52	9.42	43.39%	1.52
Aerothermodynamics	58	29.90%	1.11	32.34	25.86%	0.91
All topics	**18019**	**26.95%**	**--**	**8228.38**	**28.49%**	**--**

Source: Technopolis Group, using Gateway to Research data and semantic text analysis powered by SpazioDati

Table 2 Space SIA organisations as project leads for publicly-funded research projects

	Projects with participants from the SIA	***% of UK projects***	***LQ***	***Value of projects with participants from the SIA (£m)***	***% of UK funding***	***LQ***
Space (all)	1955	40.30%	1.20	1320.55	53.21%	1.21
On-Board Data Systems	23	37.10%	1.10	7.93	34.09%	0.78
Spacecraft Electrical Power	14	43.75%	1.30	14.40	34.94%	0.80
RF Payload and Systems, including electromagnetic technologies and techniques and space weather (electromagnetic compatibility)	135	39.24%	1.17	55.05	39.66%	0.90
Space System Control	9	56.25%	1.67	0.61	33.34%	0.76
Automation, Telepresence & Robotics, and optoelectronics	16	41.03%	1.22	9.42	43.39%	0.99
Aerothermodynamics	84	43.30%	1.29	67.80	54.21%	1.23
All topics	**22503**	**33.60%**	**--**	**12701.24**	**43.92%**	**--**

Source: Technopolis Group, using Gateway to Research data and semantic text analysis powered by SpazioDati

3.1.2 Research activity in the European Framework Programme for research (2007-2017)

The following tables provide analysis of publicly-funded research and innovation activity in space research over the period 2007 to 2017, for grants funded via the EU Framework Programme. For

comparative purposes, the tables also summarise the situation for publicly funded research in any area relevant to the 'Space' topic more broadly.

As illustrated by Table 4, the SIA area compares favourably to the UK as a whole in terms of activity levels in European-funded space research projects. The SIA area accounts for over a third of all UK participants in all European-funded space projects (36%), and commands nearly half (46%) of the total European funding given space project participants in the UK. The SIA area's LQs of 1.15 for participants in all space projects, and 1.04 for participant funding in all space projects also illustrates that space activity is more heavily concentrated in the SIA area than might typically be expected at the UK level.

The data also reveal a certain specialism in some space sub-sectors. As Table 4 shows, the SIA is particularly strong in aerothermodynamics – the LQs of 1.57 for project participants and 1.39 for participant funding show the SIA area has a much higher concentration of aerothermodynamic activity than might typically be expected (i.e. relative to the national average). The SIA area also performs strongly with respect to space control, accounting for 71% of project participants and 95% of funding to project participants in the sector, albeit that the UK as a whole has little European funded research in this area.

Although the SIA compares favourably to the rest of the UK with regards to participation in European space research projects, it seems less strong at leading European research projects concerning space. As shown in Table 3, the SIA area has an LQ of 0.99 for leading European space projects, putting its performance only in line with the UK as a whole. Furthermore, the LQ of 0.16 for funding received by space project leads shows that the SIA area's share of European funding in the sector is low when compared to the national average.

Table 3 Space SIA organisations as project leads for publicly-funded research projects

	Projects led from the SIA	***% of UK projects***	***LQ***	***Value of projects led from SIA (£m)***	***% of UK funding***	***LQ***
Space (all)	92	9.88%	0.99	115.54	4.54%	0.16
On-Board Data Systems	3	17.65%	1.76	2.03	8.29%	0.29
Spacecraft Electrical Power	--	--	--	--	--	--
RF Payload and Systems, including electromagnetic technologies and techniques and space weather (electromagnetic compatibility)	9	6.16%	0.61	13.91	4.49%	0.16
Space System Control	2	28.57%	2.85	6.05	37.59%	1.32
Automation, Telepresence & Robotics, and optoelectronics	--	--	--	--	--	--
Aerothermodynamics	11	13.25%	1.32	22.67	8.30%	0.29
All topics	**1361**	**10.02%**	**--**	**1666.56**	**4.41%**	**--**

Source: Technopolis Group, using EU Framework Programme grant data and semantic text analysis powered by SpazioDati

Table 4 Space SIA organisations as project participants in publicly-funded research projects

	Projects with participants from the SIA	***% of UK projects***	***LQ***	***Value of projects with participants from the SIA (£m)***	***% of UK funding***	***LQ***
Space (all)	375	36.23%	1.15	1252.49	45.84%	1.04
On-Board Data Systems	7	38.89%	1.23	12.85	45.94%	1.05
Spacecraft Electrical Power	10	41.67%	1.32	68.33	73.88%	1.68
RF Payload and Systems, including electromagnetic technologies and techniques and space weather (electromagnetic compatibility)	55	33.54%	1.07	145.17	42.22%	0.96
Space System Control	5	71.43%	2.27	15.32	95.22%	2.17
Automation, Telepresence & Robotics, and optoelectronics	9	50.00%	1.59	21.93	54.48%	1.24
Aerothermodynamics	44	49.44%	1.57	173.26	61.08%	1.39
All topics	**4796**	**31.49%**	**--**	**17140.96**	**42.24%**	**--**

Source: Technopolis Group, using EU Framework Programme grant data and semantic text analysis powered by SpazioDati

4 List of active organisations

4.1 Organisations based in the SIA area

The following tables show the organisations in the Space SIA area that have most frequently been involved in publicly funded research between 2007 and 2017. Duplicates may exist where organisations have bid under different names (which is sometimes the case where an organisation uses different subsidiaries to bid for public funding).

4.1.1 Organisations in UKRI's Gateway to Research

Table 5 below shows the 50 SIA-based organisations with the most project participations across all research topics, for UK grants based on UKRI's Gateway to Research.

Table 5 Top 50 organisations in SIA area by UK grant participation across all space topics (2007-2017), based on Gateway to Research data

Rank	Name of organisation	Number of projects participated in	Overall value of projects participated in (£)
1	University of Oxford	296	215,710,841
2	University of Edinburgh	206	111,434,869
3	University of Southampton	169	106,452,666
4	University of Leicester	161	74,479,209
5	Cardiff University	95	69,365,696
6	University of Glasgow	95	42,960,205
7	Queen's University of Belfast	82	40,910,218
8	University of St Andrews	77	44,341,255
9	University of Strathclyde	64	21,877,048
10	STFC - Laboratories	62	23,717,786
11	University of Surrey	59	31,788,065
12	National Oceanography Centre	50	49,956,470
13	Heriot-Watt University	47	23,031,476
14	University of Hertfordshire	40	22,615,121
15	Swansea University	36	29,163,272
16	NERC Centre for Ecology and Hydrology	35	14,496,140
17	Loughborough University	31	20,039,365
18	Aberystwyth University	30	8,594,092
19	Royal Holloway, University of London	30	8,808,340
20	Rothamsted Research	24	20,668,993
21	Bangor University	20	4,022,280
22	University of Portsmouth	20	5,567,055
23	Science and Technology Facilities Council	18	8,332,911

24	Surrey Satellite Technology Limited	16	11,673,594
25	M-Squared Lasers Limited	15	2,837,945
26	Diamond Light Source	14	11,696,722
27	Satellite Applications Catapult Limited	14	80,932,654
28	University of the West of Scotland	12	3,564,623
29	TISICS Limited	11	5,937,253
30	EADS Astrium	10	7,050,720
31	University of Strathclyde Viz Royal College of Science & Technology	10	15,751,087
32	TMO Renewables Ltd	8	4,021,971
33	Fraunhofer UK Research Limited	7	1,541,892
34	Innoval Technology Ltd	7	23,404,556
35	Oxford Instruments plc	7	6,126,937
36	BAE Systems (Operations) Limited	6	22,617,808
37	Ordnance Survey	6	4,573,553
38	QinetiQ Limited	6	7,214,918
39	Satellite Applications Catapult	6	9,329,390
40	AgriFood and Biosciences Institute	5	2,822,695
41	Clyde Space Limited	5	350,760
42	Composite Metal Technology Limited	5	4,498,697
43	EURATOM/CCFE	5	186,420,072
44	GlaxoSmithKline PLC	5	1,466,032
45	H R Wallingford Ltd	5	5,988,331
46	Institute of Physics	5	930,419
47	Mars Space Ltd	5	301,538
48	Remote Sensing Applications Consultants Limited	5	508,807
49	Surrey Satellite Technology Ltd	5	5,145,573
50	AFC Energy	4	1,249,668

Source: Technopolis analysis of Gateway to Research data

4.1.2 Organisations in the European Framework Programme for research (2007-2017)

Table 6 below shows the 50 SIA-based organisations with the most project participations across all research topics, for EU grants based on EU Framework Programme data.

Table 6 Top 50 organisations in SIA area by UK grant participation across all space topics (2007-2017), based on Gateway to Research data

Rank	Name of organisation	Number of projects participated in	Overall value of projects participated in (£)

1	University of Southampton	42	154,985,434
2	The University of Edinburgh	36	84,641,277
3	University of Oxford	33	86,386,848
4	University of Surrey	29	101,192,798
5	University of Leicester	25	90,307,591
6	University of Strathclyde	24	106,967,280
7	University of Glasgow	17	43,985,866
8	The Queen's University of Belfast	15	47,543,194
9	University of St Andrews	14	20,935,401
10	Heriot-Watt University	10	22,433,578
11	Infoterra Limited	8	17,808,871
12	Loughborough university	7	11,825,666
13	BAE Systems (Operations) Ltd	6	67,771,290
14	M-Squared Lasers Limited	5	5,133,723
15	Swansea University	5	19,390,396
16	The UK Materials Technology Research Institute Limited	5	6,967,055
17	University of Hertfordshire	5	7,801,122
18	Gas Dynamics ltd	4	15,975,641
19	Helios Technology ltd	4	4,307,635
20	PHS Space limited	4	8,467,171
21	Surrey Satellite Technology Limited	4	12,113,262
22	The UK Intelligent Systems Research Institute Limited	4	4,259,137
23	De Montfort University	3	3,566,974
24	GKN Aerospace Services Limited	3	37,861,715

25	QinetiQ Limited	3	36,000,520
26	Samsung Electronics (UK) Limited	3	12,591,519
27	Thales Alenia Space UK Ltd	3	10,672,054
28	The 425 Company	3	5,534,610
29	University of Portsmouth Higher Education Corporation	3	4,729,536
30	Aerotex UK LLP	2	4,756,889
31	Andor Technology limited	2	6,177,273
32	Balton CP Ltd	2	7,991,146
33	Compound Semiconductor Technologies Global Limited	2	15,478,583
34	Deltacat Limited	2	5,772,840
35	Fluid Gravity Engineering Limited	2	3,949,674
36	Frost & Sullivan limited	2	2,004,545
37	IQE plc	2	15,478,583
38	Meta Vision Systems Limited	2	2,770,000
39	Mira ltd	2	4,604,899
40	Navevo limited	2	2,004,545
41	Police Service of Northern Ireland	2	12,048,013
42	Royal Holloway and Bedford New College	2	15,999,999
43	Smartcom Software Ltd	2	2,137,822
44	Thales UK Limited	2	7,432,654
45	United Kingdom Atomic Energy Authority	2	22,406,000
46	Air Products plc	1	2,438,919
47	Allsopp Helikites limited	1	8,016,000
48	Alphagary Limited	1	998,468

49	Analytics Engines Limited	1	4,533,863
50	Aquatec Telemetry Limited	1	3,000,000

Source: Technopolis analysis of Gateway to Research data

Appendix A Methodological note on the use and meaning of Location Quotients

Throughout the SIA process we have been asked as providers of data and analysis to provide not only raw figures, but also some help in making sense of them. If the data sources allow, we do this through metrics and indicators that are normalised or referenced to different baselines or comparators. This can help the readers of the figures to make comparisons or to figure out if a particular data point is high or low with regards to a particular baseline.

For this, we usually provide the shares of particular metrics with respect to the national averages. For some data sources where we work thematically in addition to geographically, we try to go a bit beyond and provide another metric called the Location Quotient (LQ). We use the LQs to try and abstract as much as possible the size of the object of analysis (in this case an SIA partnership region) and to give some indication on whether an activity (be it research and innovation funding, employment, patent output, etc.) is above or below an expected baseline/threshold.

Location quotients have been used in the past by the ONS and the ERC in the Witty review and the previous UK Industrial Strategy, using data of employment and number of companies, in order to work out areas of industrial and jobs concentration throughout the UK. It can be a bit tricky to unpack what the LQ conveys, because it is sometimes referred as a "concentration/specialisation" metric while in other occasions it is referred as "position over or under, relative to a baseline". These two explanations are compatible and come from the fact that you can write the formula for calculating the LQ in two (equivalent) ways (see formula below).

$$LQ = \frac{\frac{region_{theme}}{region_{all}}}{\frac{country_{theme}}{country_{all}}} = \frac{\frac{region_{theme}}{country_{theme}}}{\frac{region_{all}}{country_{all}}}$$

From the ERC's own paper Localisation of Industrial Activity across England's LEPs (which underpinned the LQs used in the Witty review): "Location Quotients are used to provide a broad illustration of the extent to which a particular activity is over- or under-represented [in a particular region] relative to the national average." [...] "If the LQ for an activity is less than 1, the [region] has a smaller share of [activity] than the GB average; if the LQ for an activity is greater than 1, the [region] has a larger share of [activity] than the GB average."[2]

At the same time, other definitions emphasise the "agglomeration" aspect. From NESTA's Creative Clusters and Innovation report: "Location quotients are a standardmetric of agglomeration in economic geography that measure a given area's degree of specialisation in a sector, compared with the national average. A location quotient larger than 1 indicates that a particular sector is more important to the local economy than it is to the British economy."[3]

[2] This paper is available at: https://www.enterpriseresearch.ac.uk/wp-content/uploads/2013/12/RP15-LEP-Clusters-Report-Dec-2013-Final.pdf

[3] This definition is very close to the phrasing used inprevious ONS papers and these NESTA reports are available at: https://www.nesta.org.uk/sites/default/files/creative_clusters_and_innovation.pdf

and https://www.nesta.org.uk/sites/default/files/summary_geography_uks_creative_high-tech_economies2015.pdf

Appendix B Topic Modelling

The following table describes the implementation of the different topics of interest for the SIA as a set of semantic text analysis categories.

SIA Topic	***Semantic text analysis category*** ***(each category contains multiple concepts and each concept is picked up in multiple spelling variations)***
Space (all)	spacecraft, spaceflight, space launch, space probe, space observatories, space programme, space radars, space science, space technology, space weather, rocket, satellite
On-Board Data Systems	Space (all) AND Computer data, Data analysis, Data management, Data mining, Data transmission, Telemetry, Onboard computers, Radio electronics, Telecommunication theory, Telecommunications engineering, Telecommunications equipment, Telecommunications infrastructure
Spacecraft Electrical Power	Space (all) AND Electrical breakdown, Electrical circuit, Electrical components, Electrical engineering, Electrical generators, Electrical parameters, Electrical phenomena, Electrical power control, Electrical power conversion, Electrical power resistance and conductance, Electrical systems, Electrical wiring, Electric power, Electric power systems components, Electrical power control, Electrical power conversion, Power electronics, Battery (electricity), Battery charging, Lithium-ion batteries, Rechargeable batteries, Solar cells') OR title IN ('Indium gallium nitride, Silicon carbide, Lithium-ion batteries
RF Payload and Systems, including electromagnetic technologies and techniques and space weather (electromagnetic compatibility)	Space (all) AND Electromagnetic compatibility, Electromagnetic radiation, Electromagnetic radiation meters, Electromagnetic spectrum, Radio frequency propagation, Antennas (radio), Radio frequency antenna types, Radio navigation, Telemetry, Microwave bands, Microwave technology, Microwave transmission, Electronic amplifiers, Linear filters, Nonlinear filters, Optical filters, Filter frequency response, Frequency domain analysis, Radio frequency antenna types, Radio frequency propagation, Radio-frequency identification, Time–frequency analysis, Galileo (satellite navigation), Navigation, Radio navigation, Satellite navigation systems
Space System Control	Space (all) AND Actuators, Hydraulic actuators, Control engineering, Control theory, Engine control systems, Nonlinear control, Optimal control, Spacecraft attitude control, Stochastic control, Orbits
Automation, Telepresence & Robotics, and optoelectronics	Space (all) AND Automation, Industrial automation, Telepresence, Telepresence robots, Electromechanical engineering, Embedded systems, Robotic manipulation, Robotic manipulators, Robotic sensing, Robotic telescopes, Robotics, Wireless robotics, Optoelectronics
Aerothermodynamics	Space (all) AND Propulsion, Rocket propulsion, Spacecraft propulsion, Engineering thermodynamics, Aerodynamics