FINAL REPORT

The Case for Space 2015

The impact of space on the UK economy

EXECUTIVE SUMMARY

A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency

LE London Economics

July 2015

About London Economics

London Economics (LE) is a leading independent economic consultancy, headquartered in London, with a dedicated team of professional economists specialised in the application of best practice economic and financial analysis to the space sector. As a firm, our reputation for independent analysis and client-driven, world-class and academically robust economic research has been built up over 25 years.

Drawing on our solid understanding of the economics of space, expertise in economic analysis and best practice industry knowledge, our space team has extensive experience of providing independent analysis and innovative solutions to advise clients in the public, private and third sectors on the economic fundamentals, commercial potential of existing, developing and speculative market opportunities to reduce uncertainty and guide decision-makers in this most challenging of operating environments.

All consultants of our space team are highly-qualified economists with extensive experience in applying a wide variety of analytical techniques to the space sector, including:

- Insightful and accurate market analysis and demand forecasting;
- Analysis of industrial structure, strategy and competitive forces;
- New technology adoption modelling;
- Estimation of public utility benefits;
- Opportunity prioritisation and targeting to maximise exploitation of investment;
- Sophisticated statistical analysis (econometrics, regression);
- Economic and financial modelling, including: Cost-Benefit Analysis (CBA), cost effectiveness analysis, Value for Money (VfM), impact assessment, policy evaluation, business case development, cash flow and sustainability modelling.

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Headline Findings

As an industry, space directly contributes **0.31% of UK GDP** and supports **0.13% of the UK labour force**, but as a catalyst for technological advancement and productivity growth, space punches well above its weight with **expansive catalytic effects**: **all nine national critical infrastructures rely on space**, and **almost all sectors would be disrupted in the absence of space services**.

- Aggregate UK space **turnover** in 2012/13 was **£11.8bn,** growing on average **8.8% per annum since 1999/00 and 8.6% since 2008/09** – well ahead of the growth rate of UK GDP (1.6%; 1.5%).
- The **UK captures 6.3% to 7.7% of the global space economy** turnover, varying by segment: **1.8% of space manufacturing**, **11.2% of space operations** and **10.3% of space applications.**
- **Broadcasting dominates** with total turnover of £7.5bn (63% of total UK space economy in 2012/13). Other **satellite communications** (20%) and **navigation** (9%) also feature strongly, though this conceals the UK's strength in **manufacturing** small satellites, including cubesats.
- The UK space economy **directly contributed £5.1 billion to UK GDP** in 2012/13, exhibiting a **high value-added share of 43.4%** of turnover. Including indirect and induced effects, **total GVA contribution of the UK space economy is estimated at £11.3bn.**
- **Space directly supports an estimated 37,000 jobs**, distributed across the UK. The total employment supported including **indirect and induced effects** is more than **115,000 jobs**.
- **Space economy employees are highly skilled** (3 in 4 hold a higher education qualification) and **highly productive** (labour productivity of £140,000 – over 3-times the UK average of £46,000).
- **All twelve UK countries/regions have headquarters of space companies. Space manufacturing is concentrated in the East of England** whereas **downstream segments (operations and applications) are concentrated in London**. Even where the direct effect is small, **indirect and induced channels ensure the space economy benefits all regions.**
- **7 in 10 organisations analysed are SMEs**, exhibiting more specialisation than larger enterprises.
- UK space exports in 2012/13 were estimated at £3.6bn – an **export share of 31% of turnover**, **more than double that of the UK economy as a whole (15%)**. When domestically-focused **Direct-To-Home broadcasters (BSkyB) are excluded, this doubles to an export-intensive 62%.**
- **There is a clear upward trend in Foreign Direct Investment (FDI) activity,** with 40% more new incorporations, mergers or acquisitions (value not available) in 2006-2015 than the previous decade – leading to nearly 100 foreign-owned space companies in the UK today.
- The UK space industry is **R&D intensive** (26.1% of GVA in space manufacturing), with higher R&D expenditure than many high-technology sectors. **Knowledge spillovers** benefit space and non-space companies able to **appropriate knowledge** to boost productivity or extend commercial offerings.
- Space applications are used by an **increasingly wide and diverse range of commercial, public sector and consumer end-users** throughout the UK economy and **almost all economic sectors are supported by satellite services to some degree – many to a significant extent.** Owing to limitations of available evidence, the full value of the catalytic effects of space is **not currently estimable in monetary terms**, but available quantitative estimates and qualitative analysis suggests that it is highly significant.
- **Space science** and **exploration** boosts knowledge, innovation and inspires future generations.
- **Government space investment has fluctuated between 0.015% and 0.02% of GDP** per annum over the past 15 years, putting the **UK in the bottom third compared to other OECD countries**.
- **The ambitious growth targets set out in the Space IGS appear feasible**, but require continued Government support in terms of regulation and development of IGS high growth markets, which could be **threatened by the comparatively low level of Government space investment.**

Summary Report

Space technology is already woven into the fabric of modern daily life in the UK, becoming an integral part of the everyday lives of UK citizens and enabling an increasingly diverse range of commercial applications. The supply and consumption of space technologies in the UK contributes to GDP, provides employment, boosts productivity in space and non-space sectors (knowledge spillovers), and offers utility benefits for consumers, producers, and society in general.

This report, *The Case for Space 2015*, represents an update and extension of research originally undertaken in 2006, and updated in 2009, to assess the gross impact of space on the UK economy.

London Economics were commissioned to undertake this study on behalf of **Innovate UK**, the **Satellite Applications Catapult**, **UKspace** (the trade association) and the **UK Space Agency**. This study complements and satisfies an Action (4.3) in the *IGS Space Growth Action Plan 2014-2030* for stakeholders to undertake a number of studies, including updating the economic impact study of the benefits of space for private business, UK citizens and government itself.

Objectives and approach

The purpose of the research is to draw together existing evidence and conduct new analysis to robustly measure the socio-economic contribution of space to the UK economy and society. Its aim is to provide a broader and deeper economic case to promote a better understanding of the economic arguments for continued and further government involvement in this growing sector.

This research has been carried out using a mix of desk-based research of existing literature and information sources, re-orientation of previous industrial analysis, enhanced by additional comparative analysis of secondary sources, and supplemented by a short programme of qualitative research involving semi-structured interviews with selected key stakeholders. This Summary Report presents the main findings of our research and analysis.

Although the recently (October 2014) published analysis of *The Size and Health of the UK Space Industry 2014* is an important input into this analysis, this current study differs in a number of important aspects: a focus on measuring the wide ranging socio-economic impacts of space to the UK economy and society; wider coverage of space applications and impacts; and freedom from legacy definitions and segmentation constraints for historical consistency. However, the Size and Health study still forms the basis of the analysis, with re-classification of the underlying data rather than methodological changes accounting for the majority of the differences that can be observed. A further difference has arisen as additional companies have been identified and researched in the context of this study (please see Full Report for details of methodology and the sample of firms).

Caveats and limitations: The research has been conducted by a team of independent professional economists with specialist knowledge of the space sector, using best practice and best judgement to calculate the most robust and fair estimates. Relevant caveats are noted throughout the report, but the following high-level limitations and caveats apply: Characteristics of the space sector make it inherently difficult to measure economic activity, and hence the analysis relies on survey response data, desk-based research and expert opinion, so the measurement error is uncertain; the research estimates the gross impact of the space economy in the UK – whilst it notes the role and contribution of HM Government historically, it does not draw causality towards economic impact; internationalisation of product and service supply chains for space systems inhibits isolation of the impact contribution of UK space organisations.

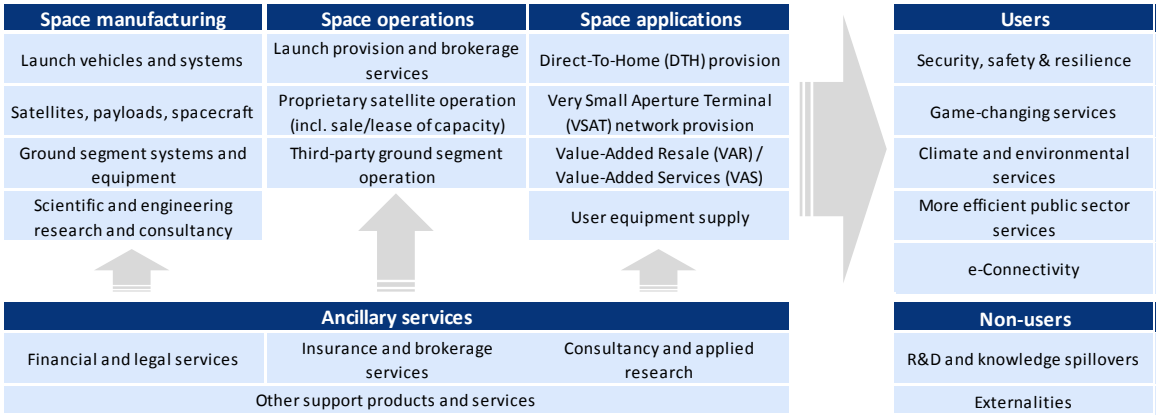
Defining the UK space economy

Historically, the *Size and Health* and *Case for Space* studies have focused on the space *industry* in isolation – including companies that manufacture, launch and operate space assets (e.g. satellites). However, there is a further layer of companies that utilise the signals and data supplied by these space assets to develop value-added applications (e.g. earth observation imagery, satellite broadband services, etc.). This latter group are not in the space industry, but earn revenues driven by equipment (e.g. satellite navigation devices) and/or services (e.g. maps, live satellite broadcasting), that are reliant on the continued operation of the space industry. In recognition of this expanded group of companies, a wider term is used – the '***space economy'*** defined below:

"The Space Economy is the full range of activities and the use of resources that create and provide value and benefits to human beings in the course of exploring, understanding, managing and utilising space. Hence, it includes all public and private actors involved in developing, providing and using space-related products and services, ranging from research and development, the manufacture and use of space infrastructure (ground stations, launch vehicles and satellites) to space-enabled applications (navigation equipment, satellite phones, meteorological services, etc.) and the scientific knowledge generated by such activities. It follows that the Space Economy goes well beyond the space sector itself, since it also comprises the increasingly pervasive and continually changing impacts (both quantitative and qualitative) of space-derived products, services and knowledge on economy and society."[1]

There is currently no single universally accepted standard classification of activities in the space economy, but the value chain used in this report combines the legacy definitions from the *Size and Health* studies with the OECD best practice to arrive at a hybrid classification as presented below.

Space economy value chain



Source: London Economics

UK space economy in perspective

Aggregate UK space economy **turnover** in 2012/13 was **£11.8bn**, up **4.1%** on the previous year – lower than the long-term growth trend of **8.6% per annum since 2008/09** and **8.8% per annum since 1999/00**, but still well ahead of the growth rate of UK GDP (1.6% and 1.5%, respectively).

[1] OECD (2012) *OECD Handbook on Measuring the Space Economy*, OECD Publishing. http://dx.doi.org/10.1787/9789264169166-en, p.20.

The **UK space economy accounts directly for 0.33% of total UK economy turnover** (excluding financial services, as financial flows distort turnover comparisons), but the capabilities it provides underpin all nine critical infrastructures and support economic activity across broad range of other economic sectors so the **total** impact of space considerably exceeds the direct impact.

With this turnover, the **UK captures 6.3% to 7.7% of the global space economy**, depending on whether global activity is measured using The Space Foundation's *The Space Report 2014* or OECD's *The Space Economy at a Glance 2014*, respectively. There is wide variation at the segment level: the UK has a **comparatively low share (1.8%) of space manufacturing**, but is a **strong global player in space operations (11.2%) and space applications (10.3%)**. The planned development of a UK spaceport and launch capability will provide a platform to grow the UK's space manufacturing share, as highlighted in the 'Future prospects' section – though this will not happen without continued government regulatory and development funding support.

At £9.3bn, **space applications is by far the largest segment**, accounting for 78% of turnover. Space operations is the second largest segment (12%) with space manufacturing (8%) in third, and the much smaller ancillary services (2%) completes the picture, though this conceals the UK's strength in **manufacturing** small satellites, including cubesats.

Analysing across the value chain by space capability, **broadcasting dominates** with a total turnover of £7.5bn, equating to 63% of total UK space economy turnover in 2012/13. Together with other **satellite communications** (20%) and **navigation** (9%), they account for 92% of turnover.

Regionally, **turnover is concentrated in London** (£8.4 billion) by headquarter locations, though all twelve UK countries/regions are home to headquarters of space companies. East of England is the largest region for space manufacturing while London is the largest generator of turnover further downstream. **Employment has a more balanced regional distribution** (more detail follows under 'Economic impact').

The UK space economy covers the full spectrum of company size, **from start-ups with very low turnover to multinational conglomerates turning over billions of pounds.** Organisations also vary in the intensity of space specialisation – from a limited range of targeted products or services to entire enterprises devoted to the industry. **71% of the organisations analysed in this report have fewer than 250 employees and are classed as SMEs**, and on average 45% of turnover in those companies is from space activities compared to 8% for larger enterprises.

The space economy employs an **exceptionally skilled labour force,** significantly higher skilled than all other UK sectors. Based on the qualifications of employees as reported by respondents to the 2014 *Size and Health* survey, 3 of every 4 employees hold a higher education qualification: 22% hold a higher degree; 35% hold a primary degree; and 17% hold a vocational qualification.

The UK space economy is **export-intensive**. At 31% of aggregate turnover (£3.6bn), the **UK space economy's export share is more than double the export share of the UK economy as a whole** (15%), comprised of the Rest of Europe including ESA (£1.5bn, 12%). Asia-Pacific and North America contribute just under £1bn each (8% and 7%, respectively). When domestically-focused **Direct-To-Home broadcasters (BSkyB) are excluded, this doubles to an export-intensive 62%.**

Commercial **turnover from sales to consumers (65%) and businesses (21%) amounts to 86% of total turnover.** Space agencies account for 4%, evenly split between ESA and other space agencies while other Government agencies procure 9% of the value of services (5% civil and 4% military).

The UK space industry is **R&D intensive,** spending more on R&D than many high-technology sectors such as telecommunications and computer programming services. **R&D in space manufacturing is particularly high**, at 26.1% of GVA compared to 9.8% for the full space economy, as would be expected given the technical challenges of space access, harsh operating environment, high-reliability requirements and remote operation capability of space equipment and systems. According to the OECD, the UK ranks 7th among OECD countries on the proportion of total civil government R&D expenditure devoted to space.

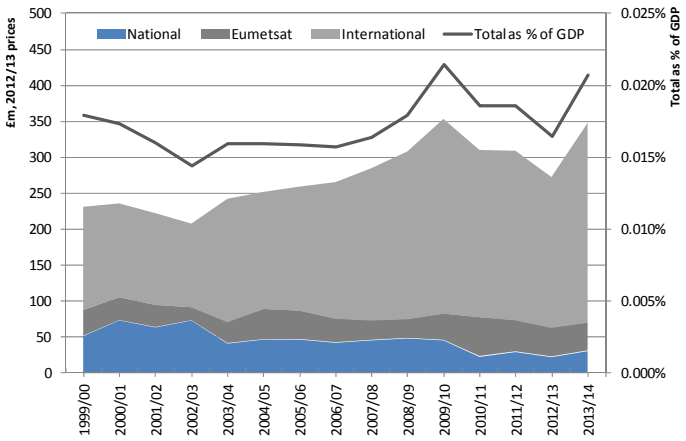
Government engagement in the space economy

Much of the UK government's involvement in the space economy is to **procure services** or **undertake scientific research** that requires, or is more efficiently done from, space. However, there is a broader role for the government – to **act to ensure that UK citizens and companies can access the benefits of space** for one or more of the following reasons:

- Overcome the failure of private capital market to provide necessary financing due to uncertainty, high risk, large fixed costs, and/or long lead times to break-even and return;
- Provide a re-investment loop between the R&D-intensive infrastructure-forming upstream and the commercially lucrative infrastructure-exploiting downstream segments;
- Remedy the failure of the innovation market to undertake a socially optimal level of R&D;
- Ensure provision where the public good attributes of space-enabled services would lead to private under-investment and under-provision;
- Re-balance potential distortions resulting from government role as an investor, owner, operator, regulator and customer (government failure);
- Regulate space as shared 'commons' (e.g. orbit and spectrum allocation, space debris);
- Incentivise agents to restrict negative externalities (costs imposed on third parties) and promote positive spillover effects (benefits to third parties) of space-related activity; and
- Establish and maintain a level playing field (equity).

A further justification for government intervention arises from the flow of technical knowledge and skills between the upstream and the downstream in the form of collaboration. Developing capabilities domestically rather than importing them, ensures that the knowledge, technology, intellectual property and competitive advantage are retained within the UK space economy, boosting the export potential of the UK.

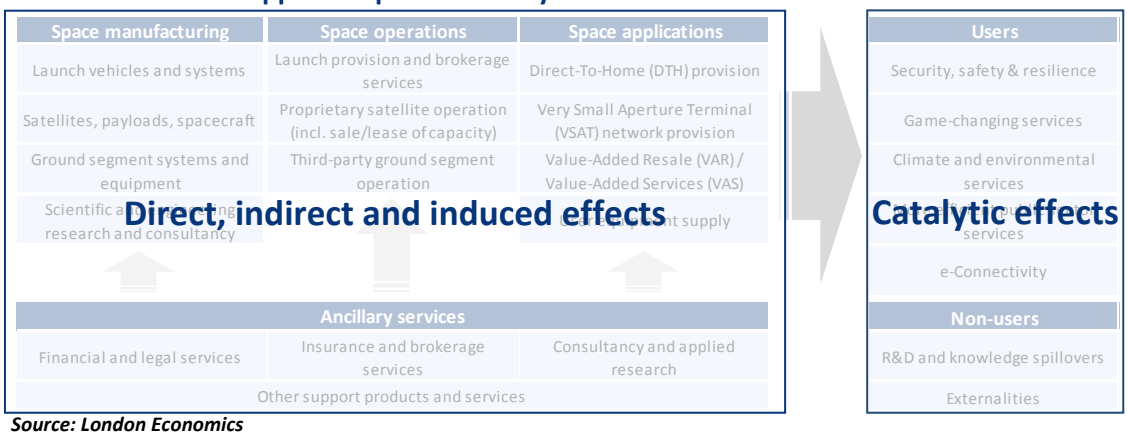
UK Government space investment 1999/00-2013/14



The UK Government invests in space through an increasing variety of channels split between **national and international programmes** (including funding of the European Space Agency, ESA), but at a low level compared to other space-faring nations. **Government space investment has fluctuated around 0.015% to 0.02% of GDP** per annum over the past 15 years, putting the UK in the bottom third compared to other OECD countries. Investment is increasing in nominal terms with the announcement of an increase in funding to ESA by more than £200 million, but despite this increase, public space investment as a proportion of UK space economy GVA is decreasing, as public investment has not kept pace with space economy growth.

Economic impact of the UK space economy

Economic effects mapped to space economy value chain



Source: London Economics

Direct, indirect and induced effects

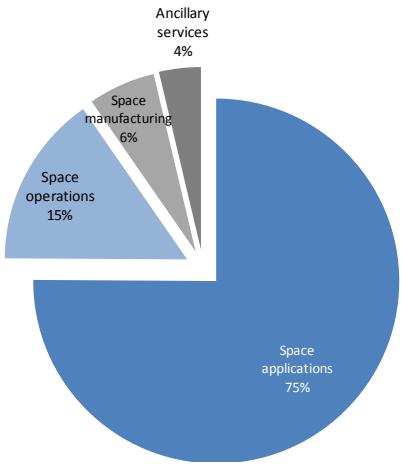
This study considers a wide array of impacts of the space economy in the UK. We consider three quantifiable parameters of economic impact, namely: **value-added**, **employment**, and **productivity**. Though this report makes considerations to give perspective towards a net analysis, **the impact analysis presented in this report is gross**.

Value-Added

The **UK space economy directly contributed £5.1 billion to UK GDP[2] in 2012/13**, equivalent to 0.51% of total UK GDP excluding financial services (0.31% if included). Furthermore, the space economy GVA has increased at an average annual rate of 6.8% since 2007/08, well above the growth in overall GDP. In addition, at 43.4%, the space economy's GVA contribution as a proportion of turnover is significantly higher than that of the general UK economy excluding financial services (28.5%), reflecting the strong capability of the growing space economy to boost productivity growth, a key driver of higher standards of living in the UK.

Direct Gross Value-Added of the UK space economy by segment

	2012/13
Segment	**£m**
Space manufacturing	306
Space operations	785
Space applications	3,866
Ancillary services	191
Total	**5,147**



As with turnover, the space applications segment is the space economy's leading contributor (75% of GVA, £3.9bn) and Direct-To-Home (DTH) broadcast services account for 57% of the segment's GVA (£2.2bn, equivalent to 43% of total space economy GVA).

[2] GVA is calculated using the same approach as the *Size and Health* study, but based on a larger sample (please see Full Report).

In addition to the direct effect, value-added also flows through indirect (supply chain) and induced (secondary spending effects of employees) channels, measured by the **Type II GVA multiplier,** estimated to be **2.2**[3] for the UK space economy at the national level. This implies that **each £1 of space economy GVA generates £1.20 worth of GVA in the supply chain and supporting sectors**.

Using this multiplier, the total contribution of the UK space economy including **direct, indirect and induced effects** to the UK economy is estimated to be **£11.3bn**.

Total GVA contribution of the UK space economy, 2012/13

Direct GVA: **£5.1bn**; Indirect + Induced GVA: **£6.2bn**; Total GVA: **£11.3bn**

Employment

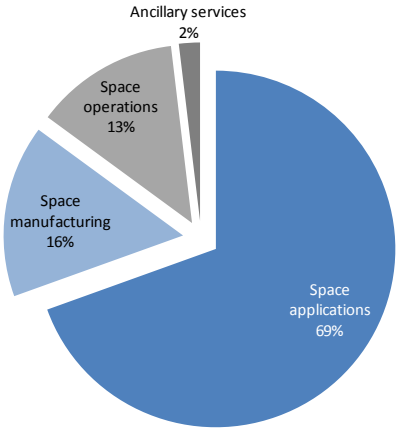
The **UK space economy directly employed approximately 37,000 employees**[4] **in 2012/13**, equivalent to 0.125% of the UK workforce. Employment has grown strongly since 1999/00 at a compound annual growth rate of 7.4% (and 8.4% in the last five years).

Unsurprisingly, the dominance of space applications in terms of space economy turnover is also found for employment, with the segment accounting for 69% of space employment.

UK space economy employment by segment

	2012/13
Segment	**# of employees**
Space manufacturing	5,761
Space operations	4,792
Space applications	25,599
Ancillary services	696
Total	**36,848**

Note: The analysis excludes companies for which no turnover data was available.



As with value-added, employment supported by the space economy is not limited to the direct effect, but extends to indirect and induced effects, measured by the **Type II employment multiplier,** estimated to be **3.1**[5] for the UK space economy at the national level. This implies that **each employee in the space economy demands inputs that support 2.1 employees in the supply chain and supporting sectors**.

The estimated **total employment supported** by the UK space economy including **indirect and induced effects** is therefore estimated to be more than **115,000 jobs**.

Compared with turnover, the **regional distribution of space employment is more even** because unlike turnover employees can be attributed to the region of work place. London and the South

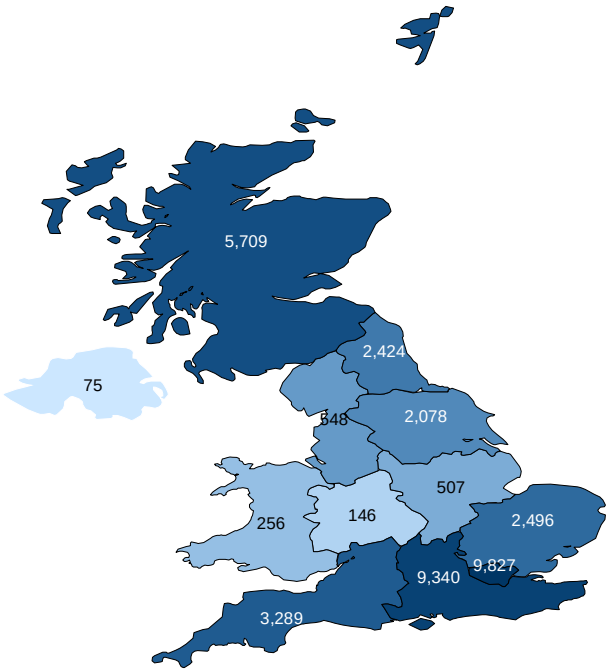
[3] For more details on methodology, please see the Full Report.
[4] Employment is calculated using the same approach as the *Size and Health* study (please see Full Report).
[5] For more details on methodology, please see Full Report.

East employ the most staff and account for more than half of all employees combined. However, 80% of turnover is generated by companies headquartered in those two regions, and the results show that large UK space organisations have subsidiaries in multiple regions.

UK space economy employment by region, 2012/13

Region	# of employees	% of total employment
East Midlands	507	0.030%
West Midlands	146	0.007%
North West	548	0.020%
North East	2,424	0.252%
Scotland	5,709	0.286%
Wales	256	0.024%
East of England	2,496	0.118%
South East	9,340	0.291%
South West	3,289	0.164%
London	9,827	0.264%
Northern Ireland	75	0.013%
Yorkshire and the Humber	2,078	0.102%
Total	**36,696**	**0.151%***

Note: A further 152 employees could not be attributed to a single UK region. *: excludes off-shore employment.

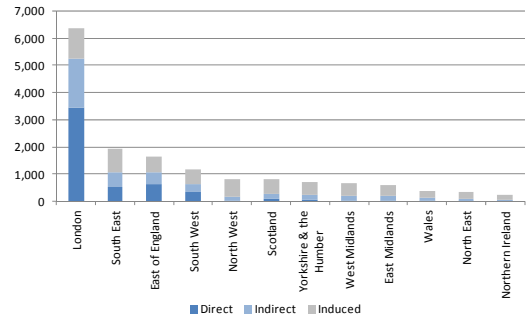


Regional multiplier effects

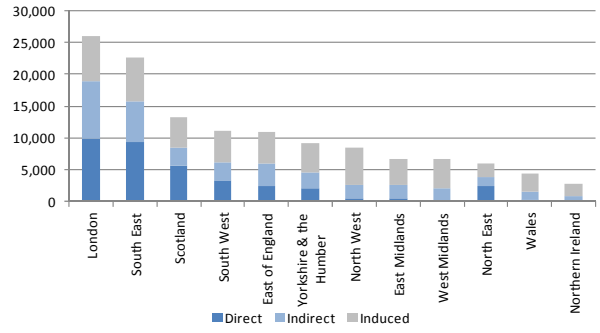
The **regional distribution** of **direct value-added** is concentrated in London (67%), with the East of England and the South East following at 12% and 10%, respectively. Tracing the **indirect** and **induced** impacts at the regional level, we find a **Type II GVA multiplier** of **3.0** and a **Type II employment multiplier** of 3.49, which imply that the **space economy has a more productive and higher paid regional distribution than the national average**.

Total GVA and employment by region and channel of impact, 2012/13

GVA:



Employment:



London, the South East, the East of England and the South West generate 96% of direct UK space economy GVA, but less than 60% of the indirect and induced GVA. Similarly, it is found that employment is supported in all UK regions. **Direct employment** as a proportion of total space related employment by region ranges from less than 3% in Northern Ireland and West Midlands to more than 40% in London, South East, North East and Scotland.

The implication is that **even regions where the direct GVA and employment contribution is small, indirect and induced channels ensure the space economy has a positive impact on all regions**.

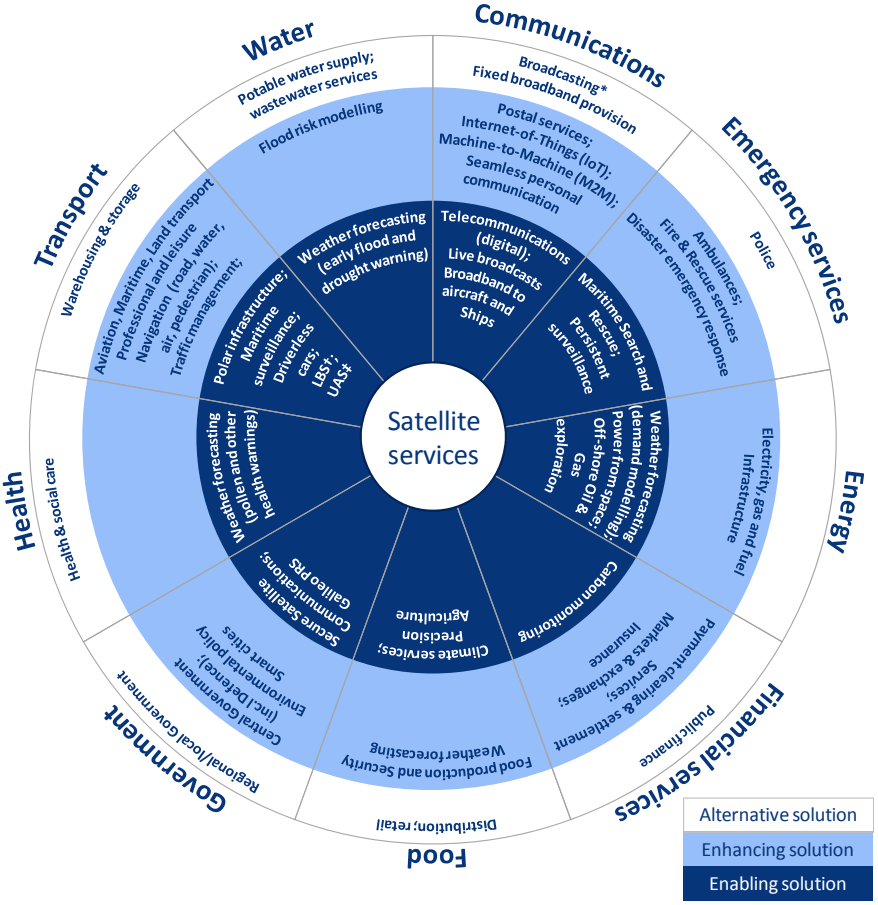
Productivity

Defined as GVA per employee, **labour productivity of the UK space economy (£140,000) is over three-times the UK average** (£46,000) and exceeds all other sectors in the non-financial business economy except mining and quarrying (£380,000) and electricity and gas supply (£192,000). This high labour productivity is likely caused by a combination of the high educational attainment in the space economy; a long research and development process, demanding high returns to offset cost of investment; and a global competitive environment in which firms need to obtain a strong market position to survive, which allows them to charge prices above marginal costs.

Catalytic effects

Span of influence of space-enabled applications

Space is a **General Purpose Technology** used by an increasingly wide and diverse range of commercial, consumer, government and science users throughout the UK economy. Firstly, space plays an enabling, enhancing or alternative role in each of the UK's nine critical national infrastructures. **If satellite services were to be lost, all of the critical infrastructures that underpin UK society would be disrupted, as illustrated below.**



Note: 'Alternative solution': Application could be achieved with terrestrial (non-satellite) solutions, but satellite services may be chosen based on cost or performance grounds. 'Enhancing solution': Satellite services offer clear cost efficiency and/or performance superiority. 'Enabling solution': Applications for which satellite services offer an enabling solution.
*: Alternative solution for critical broadcasting, but enables live broadcasting. **: Location-Based Services. ***: Unmanned Aerial Systems.

Secondly, **space-enabled services support economic activity across almost all other sectors of the UK economy.** The table below shows all the UK sectors in the SIC classification and the associated approximate GVA and employment as available from the ONS. The column labelled *'Use of Satellites'* provides a guideline to the degree of space influencing the section, for which each sector has been assigned a usage factor using subjective judgement based on industry knowledge. As the table shows, the **use of satellites differs across sectors, but almost all sectors depend on space – at least indirectly.**

Valuation of sectors supported by space-enabled services (2013)

SIC section	Sector	Turnover (£m)	Approx GVA (£m)	Employment ('000)	Use of satellites
A	Agriculture, forestry and fishing	4,443	1,804	41	●●●○○
B	Mining and quarrying	51,623	25,064	66	●●●○○
C	Manufacturing	522,106	156,975	2,483	●○○○○
D	Electricity, gas, steam and air conditioning supply	111,254	24,731	129	●●○○○
E	Water supply, sewerage, waste management, and remediation activities	33,713	16,808	165	●○○○○
F	Construction	204,282	79,900	1,301	●●●○○
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	1,487,353	153,384	4,803	●○○○○
H	Transport and storage	156,850	70,728	1,205	●●●●○
I	Accommodation and food service activities	76,412	38,096	1,973	●○○○○
J	Information and communication	198,895	99,656	1,118	●●●●○
K	Finance*	-	124,500	-	●●●○○
L	Real estate activities	54,250	36,789	540	●○○○○
M	Professional, scientific and technical activities	228,944	129,404	2,055	●●○○○
N	Administrative and support service activities	188,084	95,356	2,272	●●○○○
O	Public Administration and Defence; Compulsory Social Security**	-	87,094	-	●●●○○
P	Education	34,899	15,777	1,106	●●○○○
Q	Human health and social work activities	47,629	30,152	1,686	●●○○○
R	Arts, entertainment and recreation	120,222	22,518	661	●○○○○
S	Other service activities	31,192	15,437	547	○○○○○
T	Activities of households	-	-	-	○○○○○
	Total	**3,552,151**	**1,224,173**	**22,151**	-

Note: Legend: ●●●●●: The whole sector is fully enabled by space; ●●●●○: space plays a strong, central role (it cannot be inferred that space generates 4/5=80% of activity); ●●●○○: space plays a support role; ●●○○○: space plays a minor, but not negligible role; ●○○○○: space influences the sector in indirect fashion (e.g. supporting supplies, generating footfall); ○○○○○: space plays no role. Values quoted do not infer a valuation of the utility of space services, but rather the total value of sectors supported.
*: data from House of Commons Library, Financial Services: contribution to the UK economy, 2015; **: data from Public Administration, Defence and Compulsory Social Security Industry Review – 2014.
Source: London Economics analysis of ONS data

Typology of catalytic effects

Space applications benefit society through three separate channels: **directly** – the value, defined in a wide sense (efficiency gain, cost avoidance/reduction, new activities, products or services, etc.), that an end-user gains directly from using the product or service, and ideally measured above and beyond the price or cost of use; **indirectly**, where the beneficiary is not a user themselves, but benefit because of the changed behaviour of users (externality); and through **knowledge**

spillovers, where the beneficiary (a space or non-space company) is able to appropriate knowledge generated in the space economy. The table below summarises the benefits in these terms, and offers insights into the way that space benefits users and society.

Summary of the benefits from the use of space-enabled applications, by beneficiary

	Consumers	Commercial users	Public sector users	Society (Externalities)	R&D and knowledge spillovers	Education, exploration and space science
Security, safety & resilience						
Maritime Geospatial Services		✓	✓	✓	✓	
Secure satellite communications			✓		✓	
Galileo PRS	✓	✓	✓	✓	✓	
Polar infrastructure for shipping & exploration	✓	✓		✓	✓	
Disaster & emergency response	✓		✓	✓	✓	
Space Robustness Services	✓	✓	✓	✓	✓	
Game-changing services						
Low-cost access to space	✓	✓	✓	✓	✓	
Persistent surveillance	✓	✓	✓	✓	✓	
Power from space	✓	✓		✓	✓	
Climate and environmental services						
Insurance and finance		✓		✓	✓	
Agriculture and food security	✓	✓	✓	✓	✓	
Environmental services	✓	✓	✓	✓	✓	
Weather forecasting	✓	✓	✓	✓	✓	
Transport management	✓	✓	✓	✓	✓	
Smart cities/urban services for local government	✓	✓	✓	✓	✓	
Energy (and other critical) infrastructure services	✓	✓		✓	✓	
e-connectivity						
Direct-To-Home TV	✓	✓			✓	
Fixed satellite broadband	✓	✓	✓	✓	✓	
Broadband to ships	✓	✓		✓	✓	
Broadband to aircraft	✓	✓		✓	✓	
Ubiquitous M2M	✓	✓	✓	✓	✓	
Location based services	✓	✓	✓	✓	✓	
Managing unmanned vehicles (RPVs) and hosted payloads	✓	✓	✓	✓	✓	
Seamless personal communications	✓	✓	✓	✓	✓	
STEM, exploration and science						
STEM education and careers	✓	✓	✓	✓		✓
Space exploration beyond earth orbit	✓	✓	✓	✓	✓	✓
Space science	✓	✓	✓	✓	✓	✓
Other						
Driverless vehicles	✓	✓		✓	✓	
Space for Smarter Government	✓	✓	✓	✓	✓	

Legend:		
	✓	Direct end-user (e.g. subscriber, equipment user)
	✓	Indirect beneficiary (e.g. externality)
	✓	Potential for knowledge spillover

End-user benefits

The Full Report presents a detailed discussion of the use and benefits of space-enabled applications to end-users across a wide range applications structured using the *Space Action Growth Plan* market analysis.

Owing to a **dearth of quantitative research on the utility benefits of space applications**, the full importance of space is **not currently estimable in monetary terms.** However, valuation estimates are possible for a very limited range of applications, providing **an indication of the potential economic significance of space-enabled applications for the UK:**

- **Meteorological** satellites have been shown to contribute **£600m-£850m per year** to the value of the Met Office's **weather forecasting** work, and the Met Office's *DemandMet* application is forecast to help the retail industry grow by £1.1bn as a result of better product availability.

- **European satellite navigation and positioning systems** (EGNOS and Galileo – both part-funded by the UK) are forecasted to provide benefits to UK governments, businesses and consumers in the order of £6.2bn-£9.3bn over 20 years in addition to those provided already by GPS – an average of **£310m-£470m annually**.
- **Illegal, Unreported and Unregulated fishing** costs the UK **£50m-£100m per year**, which could be eradicated by efficient implementation of Earth Observation and GNSS AIS tools.
- Earth Observation satellites can help limit **flooding and storm damages** (£1.1bn on average per annum in the UK) by 1%, so avoided costs could amount to **£11m per year**.
- Near real-time satellite based **oil spill monitoring** has been shown to reduce monitoring costs by €25m per year at the EU level – indicating savings of **£3.5m per year** to the UK.
- **Precision Agriculture** using Earth Observation and GNSS can improve efficiency, productivity and yield, in addition to **reducing harmful environmental impacts** and **enhancing food security and sustainability**. The net benefit of **GNSS guidance and variable-rate fertiliser application** is around **£19 per hectare for a 750ha farm**.
- The UK has a significant **Oil & Gas industry** (1,100 companies, total revenue of **£27 billion,** 93,000 employees) which is a **heavy user of space-enabled services and technologies** throughout the process from exploration to extraction and beyond, in order to maximise the economic production of the UK's offshore Oil & Gas resources.
- Maritime vessel route optimisation using ocean current forecasts models can **save approximately 4%-8% of fuel costs** on average, depending on local conditions, whilst a**ir traffic management** relies on satellite services to operate **efficiently** and **effectively**.
- The UK's railway operator, **Network Rail**, use a **GNSS geo-tagged** Plain Line Pattern Recognition system to improve **efficiency of track maintenance operations** (the budget for track management in 2014/15 is £384.2m).
- **Energy companies** use the precise clocks on GNSS satellites to **identify spikes and anomalies in the power supply in real-time** and therefore introduce countermeasures before the problems spread beyond control.
- **Telecommunications** companies use GNSS timing to **synchronise calls** such that **multiple digital data packages can be sent on the same network.**
- The **finance sector** uses GNSS **time stamping** to ensure that instructions to purchase assets are **processed at the price that prevailed at the time of instruction** and not the prevailing price at the point of processing.
- E**fficiencies** such as **Insurance Telematics** can benefit both companies (e.g. producer surplus) and consumers (e.g. consumer surplus). The UK is one of the early adopters of insurance telematics products, where **insurance telematics private motor insurance gross written premium in 2013 is estimated to be about £350m**, and demand is forecasted to grow strongly. Satellite imagery and navigation data can **increase the accuracy of assessed risk**, resulting in **fairer premia** and **reduced losses** for insurers.
- The **Space for Smarter Government programme** (SSGP) seeks to enable the public sector to **save money**, **innovate** and make **more effective policy decisions** by exploiting space products, data and services in everyday operational activities to deliver routine Government services efficiently.
- Fixed satellite broadband **can be the only option for some areas** of the UK. Rural areas with low population density and a rugged countryside are often not considered to be a commercially viable target by terrestrial network operators. Access to fast internet could enable key services that would **improve the quality of life** through social services, or **telemedicine** services to **rural residents or off-shore sailors.**

- In addition, there is the unquantified **consumer surplus** resulting from commercial space applications such as **Direct-To-Home television**, **broadband to ships and aircraft, fixed and mobile satellite communication services and location-based services.**

Below we present some **additional examples** of direct and indirect benefits to the private and the public sector. The list of benefits is not exhaustive, but based on the case study evidence presented in this report.

Examples of direct benefits and externalities from space use

	Direct benefits (subscribers or equipment users)	Externalities (non-users)
Consumers (leisure time)	**Efficiency gains** defined as better use of time, fuel, and other resources, for example through better routing while driving or walking; **Access to information and entertainment** via satellite, and decision-making through weather forecasts; **Price reductions** from fairer insurance premia (insurance telematics and flood risk modelling).	**Reduced congestion and more efficient use of infrastructure** when other motorists use traffic-redistributing sat navs; **Lower prices on groceries and energy** resulting from demand modelling based on weather forecasts and more efficient production and distribution; **National security** from more efficient armed forces; **Quality of life** from better Government policies and improved response to floods or infrastructure problems; **Reduced taxes/increased services** as Government provisions are more efficient;
Professionals and companies	**Access to new markets** opened up by the connectivity and functionality offered by satellites; **Efficiency gains** defined as better use of time, fuel, and other resources e.g. from improved navigation, managing assets and performing agricultural tasks; **Resilience and continuity** where satellites provide an alternative means of securing continued service, e.g. when local communication infrastructure breaks down in disaster zones; **Access to information** for example when companies can perfect planning in response to weather forecasts or rural companies being able to access the internet and compete on level terms.	**Reduced congestion and more efficient use of infrastructure** when other motorists use traffic-redistributing sat navs; **Reduced illegal competition** due to better law enforcement; **Reduced taxes/increased services** as Government provisions are more efficient.
Government and agencies (and tax-payers and society at large)	**More efficient allocation of resources/ infrastructure** e.g. more focused effort from Government agencies thanks to early warning systems and search and rescue efforts; **Better disaster relief**, e.g. in flooding situations; **Law enforcement** satellite data can track illegal fishing or deforestation much more efficiently than conventional measures; **National security** is helped by satellites that provide precise, resilient, and encrypted navigation and communication services to armed forces.	**Improved food security** from more efficient agriculture and food wastage reduction; **Better use of infrastructure** when motorists use traffic-redistributing sat navs; **Climate change reduction** as efficiency in production results in inputs consumed; **Fewer lives lost** and less severe injuries from better air traffic control, telemedicine, advance weather warnings and better search and rescue activities.

R&D and knowledge spillovers

In addition to the benefits presented above, **knowledge spillovers** could revolutionise the way society works, and space is a prime candidate for the development. NASA documents spin-offs from its activities in the annual *Spinoff* publication, which contains nearly 1,800 examples of spin-offs. **ESA's Technology Transfer Programme**[6] has overseen more than 150 transfers during the last two decades, and it is estimated that the **revenue generated by those transfers amounts to a figure 15-20 times higher than the cumulative ESA contributions of all Member States**.

UK space spin-offs are strong in **medicine**, where the adverse conditions experienced by astronauts have prompted King's College London to invent a skinsuit designed to overcome degradation of bones and muscles while in space – the product is now used by elderly people.

Inspiration: Education, exploration and space science

Space science and exploration boost students' propensity to undertake a career in **STEM** (Science, Technology, Engineering and Mathematics), which has been shown to generate higher exchequer receipts than other careers, boost UK productivity, and living standards. **Space science** and **exploration** provide employment, value-added and knowledge that helps humankind understand the fundamental cosmological questions of how life and the universe started, and what opportunities are available beyond earth orbit.

Future prospects of the UK space economy

The UK space economy is strong and continues to grow rapidly thanks to highly developed space organisations that offer innovative services to professional and private users. The UK Government supports the space economy through national space missions, incubator support, and funding opportunities, and via membership of ESA, which ensures UK companies have access to international space missions and ESA's R&D support facilities. The European Union's space activities have returned large contracts to UK companies and given them access to R&D support schemes that encourage collaboration and knowledge sharing with international partners.

The ambitious growth targets set out in the Space IGS appear feasible for the growing space economy, but it is likely that further Government support is necessary to achieve the goals. **Successful anticipation, adaptation and exploitation of the game-changing trends in the global environment are key to future success of the UK space economy**. The UK is well placed to exploit the New Space Age with its focus on terrestrial applications of space, and commercial operations already account for a larger proportion of turnover than at the global level. However, as the UK space budget is currently in the bottom third in the OECD, other countries may grow faster than the UK and, over time, pose a threat to the successful attainment of the Space IGS target markets.

UK companies generate 31% of turnover from exports, and are on the way to reaching the 60% target set out in the Space IGS, but needs to **continue growing and integrate further with the international space community** to ensure they retain a competitive offer to foreign players – leading on issues such as **international standardisation** of regulation will help. **Foreign Direct Investment (FDI) is growing in terms of events** (value not available), with 40% more incorporations of foreign owned firms or Merger & Acquisitions by foreign owners in 2006-2015 than the previous decade – if this implies closer integration of value chains such that UK

[6] Available at: http://www.esa.int/Our_Activities/Space_Engineering_Technology/TTP2 [Accessed 06 March 2015].

subsidiaries can supply to foreign parents, this will help the growth path. **Existing UK industry is already very well equipped to exploit the trend towards small and micro satellites** and has a proven track record in larger satellites as well.

With a commitment to building a UK spaceport and a leading developer of low-cost access to space, a step change for the UK space economy could happen in the future, but a **benevolent regulatory environment** that is conducive to growth of businesses and public support through the development stage are **essential** to succeed and exploit this potential.

Future research should improve the evidence base: establish a comprehensive profile of the applications of space services and technologies used in the UK, and estimate the value they provide for end-users; investigate **space-specific spillovers** and value the impacts they generate; and establish a causal link between Government investment and rates of return to move towards a net assessment of the impact of public investment in the space economy.

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