Innovation Caucus

Analysing and Supporting Cluster / Ecosytem Development in the UK Space Sector

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About the Innovation Caucus

The Innovation Caucus supports sustainable innovation-led growth by promoting engagement between the social sciences and the innovation ecosystem. Our members are leading academics from across the social science community, who are engaged in different aspects of innovation research. We connect the social sciences, Innovate UK and the ESRC, by providing research insights to inform innovation policy and practice. We champion the role of social science in innovation and enhance its impact. The initiative is funded and co-developed by Innovate UK and the ESRC.

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1. Introduction

The UK Government[1] has established ambitious growth targets for the UK space sector, including the that the UK's share of the global space market should grow from 6.5% in 2014 to 10% by 2030. The stated view is that 'space matters' to the UK economy and that there is significant growth potential for the sector. The sector is estimated to have generated £14.8bn in income and contributed £5.7bn in GVA to the UK economy in 2016/17[2].

Whilst there is now regularly published evidence of the size and regional distribution of the space sector across the UK, there is little evidence of the scale and role of localised clusters of space activity which have developed across the UK as the industry has grown.

The starting point for the study is the understanding that the UK space sector operates as an ecosystem consisting of a range of localised clusters. In order to achieve growth across the ecosystem, these localised clusters need to be supported according to their own needs and challenges, accepting that these may be different from one cluster to another. A process through which these clusters are identified and better understood is therefore required.

Industry stakeholders and support organisations (including Innovate UK, the UK Space Agency, the Knowledge Transfer Network and the Department for International Trade) came together to commission a study into these localised clusters which has the aim of stimulating further thinking and policy to support the UK Space industry and local clusters within it. During the course of delivering the study, it became clear that the industry is fully supportive of this initiative.

The specific aims of the project were:

1. to analyse formative local or regional clusters in the UK space sector
2. to create an assessment tool to help policy makers and leaders within clusters to understand and reflect on their current maturity and future development needs ers
3. to support future planning of initiatives and investment in the space sector.

The project consisted of a number of stages that are summarised in the following sections of this report. Sections 2 and 3 outline the preliminary stages that involved a review of secondary data sources and the development of a conceptual framework drawing on the academic literature on clusters and innovation/entrepreneurial ecosystems. The core of the project consisted of primary research exploring the foundations, current characteristics, and factors affecting future growth of the space industry across five self-identifying clusters: i) Harwell, ii) Scotland, iii) Guildford/Farnborough, iv) Leicester and v) Cornwall. Section 4 discusses the methodology underlying this research, before Section 5 explores key findings from across the five case studies, focusing on three overarching themes. These findings then inform the assessment tool outlined in Section 6 and the policy recommendations and conclusions in the final section.

[1] HM Government, National Space Policy

[2] London Economics (2019), Size and Health of the UK Space Industry 2018

2. Secondary Data Review

There are several sources of secondary data on the UK space industry that together provide a useful overview of its basic size, composition, and geography. The most detailed of these is the *Size & Health of the UK Space Industry* report which is commissioned every two years by the UK Space Agency. This includes estimates (based on survey responses and desk-based research) for numbers of UK-based space-related organisations, their income and employment. In terms of geography, these are broken down at the level of the 12 NUTS 1 regions in the UK. The figures from the latest (2018) edition of the report are presented in the table below.

Table 1: Space-related organisations, income and employment by UK region.

Region	Space-related active organisations	*%*	Organisations head-quartered in region	*%*	Income (2016/17) £M	*%*	Employment (2016/17)	*%*
South East	368	*25.8*	269	*28.4*	2,364	*16.0*	9,023	*21.5*
London	218	*15.3*	172	*18.1*	9,484	*64.1*	12,286	*29.3*
South West	173	*12.1*	99	*10.4*	184	*1.2*	1,333	*3.2*
East of England	146	*10.3*	102	*10.8*	2,088	*14.1*	4,379	*10.4*
Scotland	132	*9.3*	83	*8.8*	140	*0.9*	7,555	*18.0*
East Midlands	83	*5.8*	54	*5.7*	77	*0.5*	868	*2.1*
North West	75	*5.3*	35	*3.7*	33	*0.2*	2,360	*5.6*
West Midlands	74	*5.2*	40	*4.2*	127	*0.9*	1,170	*2.8*
Wales	47	*3.3*	27	*2.8*	67	*0.5*	517	*1.2*
Yorkshire & Humber	44	*3.1*	24	*2.5*	102	*0.7*	1,302	*3.1*
North East	34	*2.4*	22	*2.3*	75	*0.5*	907	*2.2*
Northern Ireland	26	*1.8*	15	*1.6*	40	*0.3*	145	*0.3*
Crown Dependencies	4	*0.3*	-		-		-	
Total	**1,424**		**948**		**14,792**		**41,929**	

Source: London Economics (2019) *Size & Health of the UK Space Industry 2018. A Report to the UK Space Agency* https://www.gov.uk/government/publications/uk-space-industry-size-and-health-report-2018.

This indicates a concentration of UK space-related organisations, employment and particularly income in London and the South East of England. The very high proportion of income accounted for by London may, however, be explained by other findings in the *Size & Health* report. These, for example, show that income in the space industry is heavily dominated by the broadcasting segment and by a small number of large organisations. Comparison with previous editions of the report also indicate that direct-to-home broadcasting, while still clearly the biggest part of the industry, now accounts for a smaller proportion of total income as other activities (both upstream and downstream) are beginning to grow.

Other sources of data, although perhaps not as comprehensive as the *Size & Health* report, give an idea of significant sub-regional variations in the geography of the industry. In particular, the online *Space and Satellite Applications UK Landscape Map* that is maintained by the Innovate UK

Knowledge Transfer Network, provides information on the precise location of space-related organisations based on their postcodes. A key benefit of this source is that it allows the identification of individual businesses that are part of the national sector and local clusters. An exploratory analysis of this dataset in a compiled form made available for this study signalled that there were identifiable local groupings of space-related organisations in the South East (Harwell in Oxfordshire, Guildford, Portsmouth and Southampton, Milton Keynes, Reading); East of England (Hertfordshire, Cambridge); South West (Bristol and Bath, Devon, Swindon); Scotland (Edinburgh, Glasgow); and the East Midlands (Nottingham, Leicester).

This landscape map does not, however, directly include data on indicators such as organisation size, employment, or turnover that would give a more detailed picture of the UK space sector at a sub-regional scale. The landscape map also includes fewer businesses and organisations than the dataset which underpins the *Size and Health* report, primarily because it requires businesses to self-report as being part of the sector. However, it remains a very valuable resource and does support a degree of local cluster identification and mapping.

Other datasets were also identified and considered as part of this project. These include: Innovate UK Funded Projects data (publicly available); ESA Investment Data and ESA SME Office Data; and Cherry Space Investment Data. However, such sources are not specifically designed to respond to the type of research questions that are the focus of this study, and therefore have limitations when attempts are made to apply them in this context. For example, data categorisation is insufficiently specific to comprehensively identify space investments in the Innovate UK dataset, whilst data must be manually searched and lacks critical data fields such as investment value in the case of ESA investment data. The ESA SME dataset does support granular analysis and should be considered as a valuable source of data related to space SME distribution across the UK.

More generally, these types of quantitative secondary sources are not well suited to revealing the inter-organisational relationships, development processes, and other environmental factors that are needed to understand the nature and growth dynamics of local space clusters. This project therefore adopts a qualitative case study approach in seeking to understand the issues set out in the previous section. The selection of five of the locations mentioned above as cases for the primary research stage of the project will be explained in the methodology section (Section 4, below).

3. Conceptual Framing

The second stage of the project drew on academic literature relating to clusters and regional innovation/entrepreneurial ecosystems to develop a conceptual framework that informed the subsequent research. A number of salient points emerged from this review:

- **Clusters can occur at various scales:** The cluster concept, especially as promoted by Michael Porter (Porter 1998, Delgado, Porter, and Stern 2015), involves a high degree of definitional fuzziness in terms of the scale (e.g. local, regional, national) at which it is applied, and whether it focuses on a single industry or group of related industries (Martin and Sunley 2003, Swords 2013). The UK space economy is characterised both by localised agglomerations of space-related activity and sufficient relationships between regional nodes to identify a national-scale cluster. To distinguish between these two scales, we refer to the regional/sub-regional nodes as clusters and describe them as embedded in a national space ecosystem. This approach encourages a conceptualisation of an integrated space economy that enables the development of localised centres of excellence as well as the evolution of a national strategy that cohesively builds on evolving cluster capacity.

- **Evolution models should be tailored to cluster life cycle stages**: The wider cluster literature (here encompassing complementary concepts such as industrial districts) generally focuses on external economies generated by local supply chains, specialist labour supplies, and inter-organisational knowledge spillovers (Asheim, Isaksen, Martin, and Trippl 2017). However, while the UK space industry is relatively mature the development and recognition of clusters of space-related industries is still at a relatively early stage of developmentand agglomeration effects are unlikely to have yet formed on a significant scale in most locations. Therefore, it is more useful to adopt approaches and evaluation mechanisms relevant to the birth/inception phase of life cycle models and focus on the mechanisms and conditions that enable clusters to originate in certain places and move into a growth stage where the advantages of agglomeration can be fully realised . Given the nascent phase of UK clusters, strategies should be particularly sensitive to how path dependency can affect cluster evolution – where foundational conditions in a cluster formation shape its patterns of future development and prospects of becoming a leading centre of space activity – by endeavouring to understand the key anchors of each agglomeration.

- **A core set of factors are likely to be important to the development of space clusters in the UK**: A number of processes have been identified as especially important during the initial phases of a cluster's development. Most prominent here is new firm formation, which is enabled by a wider 'entrepreneurial ecosystem' of markets, finance, knowledge/skills, government and regulatory incentives, a favourable culture for start-ups, and other supporting institutions or infrastructure (Spigel and Harrison 2018, Spigel 2017). Some of these components – especially relating to a specialist industry - may not be present in the early stages of a cluster life cycle, but intermediary institutions such as incubators,

campus/science parks, and formal networks/associations can play a key nurturing role during this phase (Clayton, Feldman, and Lowe 2018). Also important are strategic factors such as directed policy support, local leadership, and the creation of a strong identity shared by the community of actors involved in the development of the cluster. These findings suggest that policy should focus on the following core factors:

- **Encouraging new firm formation, particularly through spin-offs**: The evolutionary economic geography literature emphasises spin-off firms as a mechanism through which clusters of companies can emerge (Boschma and Frenken 2011). These spin-offs may be from universities but can also be from other firms. This reflects the wider argument that clusters in new industries typically emerge out of a local context of existing technologies, knowledge/skills and markets that are a legacy of more established local economic capabilities. Concepts such as path branching, related variety, and smart specialisation/diversification all provide insights into the process through which the UK space industry is projected to grow (Asheim, Boschma, and Cooke 2011, Grillitsch, Asheim, and Trippl 2018).

- **Exploring how to leverage indigenous firms, MNCs, and core public institutions to grow cluster capacity**: The classic industrial district model of a cluster is comprised of predominately small firms and their dense network linkages (Belussi and Caldari 2008). However, clusters can equally be anchored around large indigenous firms, externally owned branches of multinational companies, or public institutions such as research universities. As the research evidence presented below will illustrate, this variety is evident within emerging clusters in the UK space industry. At the moment there is, therefore, no clear dominant model towards which all clusters are converging. This will be reflected in the tool alongside those components of a regional ecosystem that are features of all successful clusters.

- **Interactions between clusters and ecosystems are still poorly understood:** Both the clusters and regional innovation/entrepreneurial ecosystems literatures have a great deal to contribute to economic and industrial policy, particularly to the degree that each has recently adopted dynamic evolutionary perspectives on economic development (Alvedalen and Boschma 2017, Cavallo, Ghezzi, and Balocco 2019). However, while there are clearly conceptual overlaps between the two literatures, the relationship between them has not been rigorously explored. For instance, there remain questions about how national and localised economic ecosystems influence one another and which aspects affect cluster evolution (which also occurs at different scales) that complicate the translation of academic insights into policy and practice. Adopting a dual localised cluster and national ecosystem approach to studying the UK space ecosystem will contribute not only to the development of more sensitive and appropriate policy recommendations, but also to conceptual development in the field of innovation policy research.

4. Methodology

The primary research stage of the project consisted of case studies of five locations across the UK, each with a developing profile as a centre of space industry activity and the potential to grow into a cluster. The case study locations are: i) Harwell, ii) Leicester, iii) Scotland, iv) Guildford/Farnborough and v) Cornwall. These were selected by the research team in consultation with the project steering group. Reflecting the discussion above, the cases were chosen to represent the diversity of emerging clusters in the UK space sector. As a result, they vary significantly in terms of the geographical scale they cover, the current size and composition of their space sector, their institutional foundations and sub-national governance context.

The qualitative research conducted during this stage involved a mix of one-to-one interviews and focus groups with multiple local stakeholders. Focus groups were organised in three of the five locations (Harwell, Scotland, and Cornwall). The balance of one-to-one interviews and focus groups was largely pragmatic, being influenced by the availability and preferences of participants. Table 2 below shows the number of participants by case study. In each location these participants were from across the public, private, and university sectors.

Table 2: Interview and focus group participants by case study area

Case Study	Number of Interviews	Number of focus groups
Harwell	2	3 (with 15 participants in total)
Leicester	6	-
Scotland	2	1 (with 7 participants)
Guildford/Farnborough	7	-
Cornwall	2	1 (with 7 participants)
Total	**19**	**5 (with 29 participants in total)**

Both the interviews and focus groups were semi-structured but employed a consistent question template that was informed by the conceptual framework, developed in the preceding stage of the project. This template was divided into three parts: i) questions relating to the historical and institutional foundations of the prospective cluster; ii) its current characteristics in terms of, for instance, market specialisations and main forms of inter-organisational networks; and iii) factors affecting its prospects for future growth.

A report for each of the case studies was produced that also followed this three-part structure of foundations, current characteristics and future growth. The next section presents a summary and analysis of the key themes across the five cases that cover points of commonality and difference. The three themes featured here are: anchor institutions and assets, supporting agencies and intermediaries, and cluster development and structure.

5. Key Findings

UK space clusters have evolved in different ways and vary across a number of dimensions. However, they have almost all developed around a set of core anchor institutions, have established enabling environments populated by supporting agencies and intermediaries, and exhibit different constellations of firm structures and evolutionary dynamics. Exploring these various themes allows us to develop a more sophisticated understanding of the likely development trajectories of each cluster and interactions between them, in order to better tailor policy interventions at different scales.

5.1 Anchor institutions and assets

A common feature of the emerging clusters studied was the centrality of some form of 'anchor' institution or infrastructure to its existence and potential for growth. The long-term presence of these embedded assets in a region creates a repository of physical, knowledge, and organisational resources that can be leveraged to stimulate wider space-related activity around the institution or infrastructure in question. These anchors do however vary in nature from case to case, which influences the ways in which each cluster is developing.

A key organisations on the Harwell campus (itself a former RAF site) are the Satelite Applications Catapult and RAL Space. This is part of the larger Rutherford Appleton Laboratory that has roots on the site dating back to 1957. As a national public research organisation funded and managed by the STFC, RAL Space carries out leading scientific research and development and hosts large-scale testing facilities used by universities and companies throughout the UK. Its co-location has, however, facilitated a particularly close relationship with some companies based on the Harwell campus. The presence of RAL Space was also a major factor in subsequent strategic decisions to base other key national stakeholders in Harwell (see below) and develop it as a centre for the space industry in the UK over the past decade. RAL Space now employs over 250 people in Harwell. An important dynamic identified in the research as contributing to the recent development of the wider cluster was knowledge circulation through the movement of highly skilled people from RAL Space (and other public organisations) into jobs in growing private sector companies on the campus.

The dominant anchor institution in the Leicester cluster is the University of Leicester. This institution has a long history of space research since the 1960s, and now has over 200 academics working on related subjects across different disciplines. The applied dimension of this tradition has mainly involved working with government space agencies and industrial partners nationally and internationally. By comparison, up to now there have been relatively few leading space-related organisations in the surrounding region with which the University has been able to engage. It has, however, had close relationships with key local space companies (e.g. Magna Parva, EarthSense), and with the National Space Centre (a visitor and educational centre in the city). The University of Leicester is now leading an ambitious strategy to grow the space industry in the region through the Space Park Leicester development. This site in the city will include three

new specialist buildings that will bring together academics from the universities with space-related companies.

The dominant anchor institutions in the Guildford/Farnborough cluster are the Surrey Space Centre (SSC) at the University of Surrey and Surrey Satellite Technology Ltd (SSTL), the latter being a spin-out from SSC in the 1980s. SSC has a long history of research and technology development which began in 1979, focused on pioneering the development of small satellites. Its focus is on applied research rather than pure academic research, and it maintains strong links with SSC to this day through a long-term strategic collaboration. The University is also responsible for the development of the Surrey Research Park, which acquired its first tenant in the 1980s. Home to both SSTL and the Surrey Technology Centre (which includes a business incubator operated by SETSquared and focused on supporting and incubating technology start-ups), this asset is also considered key to the success of the Guildford/Farnborough cluster. Both SSC and SSTL have stimulated numerous spin-off companies over the course of their existence.

Farnborough is considered more of an aerospace hub located around the airport, with major players such as Airbus and Lockheed Martin siting operations there. In addition, numerous dedicated space businesses are also located in and around the Farnborough airport hub. There are currently concerns about the stability of the anchor institutions in this cluster and that related uncertainty is undermining the cluster's ability to grow.

The Cornwall cluster relies on two anchor institutions: Newquay Airport and Goonhilly Earth Station. Newquay Airport, which is a small regional airport, was originally an RAF base and benefits from one of the UK's longest runways (2,744m) as well as a rocket and propulsion test facility. The Airport is currently positioning itself as the location for space launch through its Spaceport Cornwall project, based around a partnership with Virgin Orbit. Goonhilly Earth Station is the oldest satellite earth station in the UK and the largest in the world. It was operated by BT until 2008. In 2014, the site was acquired by Goonhilly Earth Station Ltd (GES Ltd), with a vision to create a multi-faceted space hub. It is now the site for the Aerohub Enterprise Zone and is seeking to attract inward investors. There are a modest number of other upstream and downstream space companies across the County of Cornwall and whilst it is considered that Falmouth University and Exeter University at Penrhyn are well placed to support skills and knowledge development in the field of data (which is directly relevant to the downstream space sector), the region lacks the presence of a research-driven Higher Education Institution with a recognised space specialism.

In contrast with the cases discussed above, the emerging Scottish cluster does not have a single focal anchor institution. However, reflecting the larger geographical scale covered by this case, there are a number of actors and other assets across different locations that together fulfil some of these functions. Various universities in Scotland - including Glasgow, Strathclyde, and Edinburgh - are closely involved with different parts of the space industry, including as a leading centre in the development of satellite data applications and small satellite manufacture. Scotland's srengths can be traced back to missile testing activities in the Outer Hebrides after the Second World War, and the subsequent development of ballistic missiles through the Trident

programme. Like Cornwall, a more recent and potentially key piece of infrastructure in the future is the development of launch site capability in Scotland. Taking advantage of numerous potential sides for both horizontal and vertical launch a small number of companies (e.g. Skyrora) are beginning to be founded in Scotland with a focus on launch activities.

What is common across the different anchor institutions in the five cases that have been studied is that, whilst they are committed to their local cluster and to facilitating and supporting growth locally, they are also connected to and embedded within the wider UK space ecosystem. This demonstrates the key point that any isolated localised development within the wider UK space industry ecosystem is likely to cause fragmentation, when in fact greater cohesion is necessary. Developing more and better linkages and connectivity between different clusters, whilst recognising and building upon local specialisms, should therefore be a central theme in any development and support activities.

5.2 Supporting agencies and intermediaries

As mentioned earlier, new firm formation is a key dynamic in the early growth of clusters and this process is enabled by the presence of a wider entrepreneurial ecosystem within a region. Many of the components that mark an effective ecosystem (e.g. private sector financing, a customer base, specialist labour markets) may not, however, be fully formed during these embryonic stages of a cluster life cycle. In these cases, publicly funded agencies or intermediaries that support a new industry can be vital. This function may also overlap with a more strategic leadership role that helps coordinate the cluster and provides a vision for its future development. Accordingly, these types of organisations can be identified in all of the five clusters as key actors, often working in conjunction with the anchor institutions discussed above.

The status of Harwell as the gateway to the national space sector was reinforced by the decision to locate both the first ESA Business Incubation Centre (BIC) in the UK (2011) and the Satellite Applications Catapult (2013) on the campus. The ESA BIC programme (a partnership with the STFC) in Harwell hosts start-ups from different parts of the UK and provides them with access to test facilities and technical expertise, business development support, and other funding and networking opportunities. A significant proportion of companies that have graduated from this programme remain based on the Harwell campus. The Satellite Applications Catapult aims to facilitate the translation of research into commercial outputs by providing support to UK space companies and helping to stimulate demand in new downstream markets focused on strategic areas, including intelligent transport, sustainable living, and health and wellbeing. The ESA facilities in the UK also have a strong focus on co-funding R&D to facilitate the introduction of commercial products and services into the market.

Both of these national agencies are hubs of larger networks that encompass some of the other case study locations in this research. Two more UK-based ESA BICs were established in 2018, including one in Scotland. This is located on the Royal Observatory site in Edinburgh along with two other notable STFC funded facilities: the UK Astronomy Technology Centre and the Higgs Centre for Innovation. The Satellite Applications Catapult now also has five regional centres of

excellence (co-funded by the UK Space Agency) in addition to its Harwell base. These include Scotland (hosted by the University of Strathclyde), the East Midlands (hosted by the University of Leicester), and the South West (led by the University of Exeter and based at Goonhilly Earth Station). The only case study not represented in either of these networks is Guildford, but this does have two technology incubators with clients from the space industry (including SetSquared Surrey that is part of the UK Space Incubator Network).

The research also highlighted the importance of network facilitation roles in encouraging the formation of a cluster. For instance, the Harwell Campus organisation (funded by the STFC) employs a Space Cluster Development Manager who, with other key individuals, was credited with helping to cultivate a more close-knit community and raising wider awareness of the activities of different organisations on campus. Scotland has also had a number of people fulfilling this type of business support function, including those belonging to organisations supported by the Scottish government (e.g. Scottish Enterprise, Space Network Scotland), as well as UK-wide programmes (e.g. the Scottish Centre of Excellence in Satellite Applications). In addition, a private sector membership based Scottish Space Leadership Council has recently been formed to work with the devolved government and to develop a vision and strategy for the sector. These representative bodies together help to give coherence and identity to the Scottish space sector as a 'cluster' characterised by various distinct sub-regional centres and market specialisations.

In other cases, the anchor institutions discussed above may fulfil a leadership role in the emerging cluster. This is particularly the case where they are a main stakeholder in a project that is driving plans for growth of the local space industry. For instance, the University of Leicester, with the support of the City Council and Local Enterprise Partnership, is leading the expansion of the space sector in the city through its Space Park project. Similarly, in Cornwall the continuing development around Goonhilly Earth Station and the future Spaceport Cornwall project are being leveraged into a wider ambition to help grow a significant, 'end-to-end' space industry in the county. These plans draw together the different stakeholders involved in these projects. This includes the Cornwall Development Company's ERDF funded Aerospace Cornwall programme that acts as a sector development body for the space industry through provision of collaborative R&D grants and support for supply chains, as well as the South West Centre of Excellence in Satellite Applications, one of the five Satellite Application Catapult's regional centres of excellence. By contrast, the Guildford/Farnborough cluster has no primary organisation playing a co-ordinating leadership role, although it could be argued that SSC and SSTL, given their dominant position within the cluster, play a comparable role. However, other stakeholders such as the LEP and businesses within the cluster believe that there is currently a need to fill this gap and to increase the strategic leadership capacity of the cluster and the LEP is currently developing its own role in this respect. However, the LEP lacks capacity to take up this role directly, nor is there a central LEP project on which to build (although there are clear links to other important projects, such as the development of a Local Industrial Strategy which seeks to increase productivity within the local economy).

Given the context of the Industrial Strategy and related government policy, ensuring that appropriate support and development infrastructure and/or projects are in place where local clusters require or warrant them is crucial in achieving a more devolved approach to managing and facilitating growth. The evidence above indicates that the landscape is rather more patchy than it ideally might be, and the focus of policymakers should therefore be on establishing where major gaps exist and how they can be filled.

5.3 Cluster development and structure

The private sector component of the five prospective clusters selected as case studies for the project were marked by significant variations in their size, composition, and main market or technological focus. As discussed in the conceptual framework, this signals the presence of different models of clusters in terms of the centrality of different types of organisations and the nature of the network relationships that connect them together. These structuring features are important even in the embryonic stages of a cluster as, owing to path dependency effects, they will shape the form taken by its future development.

In Harwell, the last few years have seen a significant growth in the community of space companies based on the campus alongside the national funding, intermediary, and scientific research and testing organisations mentioned above. Many of the larger space companies that are active in other parts of the country also maintain a presence in Harwell to benefit from the profile and connections that come with being a member of the 'gateway' to the UK space sector. The development of the cluster has, however, been based on a recognition that the campus environment would not be suited to attracting a space prime company to locate large-scale manufacturing activities on the site and act as a nucleus around which local supply chains could form. Respondents believed that this distinguishes Harwell from other leading international space clusters, and it was identified as an enabling factor in the emergence of the alternative model of a vibrant ecosystem of small and medium companies with a greater openness to collaboration and knowledge exchange. Another noted feature of the ecosystem is the diversity of markets targeted by these companies, which exceeds other smaller or more specialised clusters in the UK. The multidisciplinary nature of the wider Harwell campus also provides opportunities for downstream space companies to develop links with co-located organisations in complementary fields such as health and energy technology.

In contrast, the Guildford/Farnborough cluster is home to one significant space company (SSTL) which continues to play the role of anchor private sector business. The cluster also contains a range of businesses in both the upstream and downstream sectors, including Airbus in Farnborough, which is home to major space projects, and a growing number of small and medium sized companies. The dominance of SSTL means that the cluster is best known for small scale satellites, but the wider ecosystem does respond to a range of market opportunities, particularly downstream, many of which are related to earth observation (EO).

The Scottish space industry has significant upstream and downstream activities across several sub-regional centres, with varying strengths. Taken as a single cluster it therefore exhibits a more

hybrid structure than Harwell or Guildford/Farnborough. The upstream sector includes a concentration of specialist small satellite manufacturers in Glasgow, such as Clyde Space, Alba Orbital, and Spire Global (a branch of a U.S. headquartered firm). Larger Scottish engineering companies, such as branches of the multinationals Honeywell and Smiths Interconnect, are also active in producing components for the space industry amongst other high value manufacturing markets. The growth of the downstream space sector in Scotland has, by contrast, been driven more by university spin-outs and other start-up enterprises in Edinburgh and other cities. Plans to build a Spaceport in one or more prospective sites has the potential to bring distinct advantages to Scottish companies that rely on launch capabilities and to raise the profile of the sector as a whole. This will also support the strategic aim of the sector to link together the upstream and downstream parts of its industry and develop a full 'end-to-end' supply chain capability within Scotland.

As mentioned in previous sections, both Leicester and Cornwall are home to some notable upstream and downstream space companies (for instance, Magna Parva and EarthSense in Leicester, Goonhilly Earth Station Ltd. in Cornwall). Beyond this, however, neither of these locations currently have the same scale of private sector space activity as the other three case studies. This lack of critical mass means that the emerging market specialisations and dense inter-firm networks that are a feature of maturing clusters have not yet formed in Leicester and Cornwall. The key strategic initiatives discussed above (respectively Space Park Leicester and Spaceport Cornwall) could provide vehicles to increase the number of space-related companies based in these regions. For example, in Leicester this is currently being pursued through a combination of supporting new local start-ups and attracting leading companies from outside to locate on the Space Park. There is also a common interest amongst economic development agencies and other stakeholders in Leicester and Cornwall in promoting new space-related markets or opportunities for innovation to established companies in other local industries. For instance, numerous mining companies in Cornwall have been identified as potential beneficiaries of using satellite data.

The future development of the private sector component of each of the five clusters is seen to be dependent on a diverse range of opportunities. In Harwell, commercial space constraints are seen as a limiting factor in a cluster which has been, and expects to be, successful in growing the number of private sector businesses in the future. In Cornwall, the opportunity to develop launch capability, together with growth ambitions in and around Goonhilly Earth Station, are seen as the major opportunities. In the case of launch in particular, this is seen as being a potential major stimulant to the growth of the cluster, with the expectation that success in acquiring this capability would prove a major inward investment stimulus for the Cornwall space cluster. Likewise, the Scottish sector seeks to add launch capability in order to establish a truly 'end-to-end' service, although major opportunities in the downstream sector, which build on related policy initiatives (e.g. data, informatics), are also seen as key to future growth. In Leicester, the successful attraction of an appropriate mix of occupants into the new Space Park is seen as the major opportunity to build on existing capabilities and specialisms. In Guildford, ensuring the

ongoing pre-eminence of SSC and the commercial success of SSTL are perceived as key factors in underpinning future growth.

As this section demonstrates, our qualitative case studies have generated significant understanding about the composition and dynamics at play within each cluster. These will be useful context to think through localised and national policies to further develop the firms, agglomeration and the national economy in this area. Yet there is also considerable scope for more reflection about what specific goals these policies should aim to achieve and what mechanisms might be most effective. To that end, we have developed an assessment tool to facilitate a visioning process and outline steps to strategy implementation.

6. The Assessment Tool

Cluster assessment and visioning are essential components of effective economic planning and development processes. The goal of this assessment tool is to provide policy makers and cluster actors with a snapshot of the components of the cluster (or potential cluster) in order to evaluate stage of development, identify opportunities for development, and to facilitate a strategic visioning process. However, we want to stress that, at this stage, the emphasis is on providing a basic mechanism for cluster comparison and to stimulate visioning processes for cluster development both at the national and local scales. As our understanding of the UK space cluster evolves it will be possible (and appropriate) to develop more sophisticated evaluation mechanisms.

In order to facilitate the visioning process, we developed a tool that enables stakeholders to visualise where their cluster stands today (including assessing existing strengths and weaknesses), envision the characteristics they would like to develop in the future, and establish interim steps. While this tool will be helpful in developing strategies for individual clusters, it was also designed to feed into a broader data collection and visioning process to support the development of a coherent and coordinated UK space ecosystem.

The tool is designed to be completed and scored by cluster leaders and/or external evaluators as appropriate given the stage of cluster evolution (see 6a, below) and then shared with Innovate UK, the KTN and the UKSA. The tool focuses on assessing and planning in four core areas: 1) Specialism; 2) Management and support; 3) Knowledge base and skills; and 4) Commercial base (see Table 3). Stakeholders are invited to respond to the accompanying prompts to identify current cluster characteristics and envision the qualities to which they want to aspire in the future. However, since the metrics that are relevant differ depending on the stage of cluster evolution it's important to first establish where it is in its life cycle.

6a. Establish the life-cycle stage of the cluster

Determining where a cluster is in its life cycle is not an exact science. We are inspired by Menzel and Fornhal (2010) who present "stylized facts" about cluster stages that we can operationalise to help situate where a cluster might be in its evolutionary arc.

Table 3: Characteristics of cluster life cycle stages

	Embryonic/Potential	Young/Immature	Mature/Established
Critical mass of firms (# of firms)	15> firms in designated SICs	15<firms in designated SICs and evidence of growth in firm formation over the preceding five years	15<firms in designated SICs including a significant percentage of firms over 8 years old
Innovation rates (patent filings)	Trace numbers of filings in designated SICs over previous five years	Significant growth in filings in designated SICs over previous five years	Significant filings in designated SICs over previous five years. Patents filed in related SICs
Spin-off activity (# spin off firms)	Few to no discernible spinoffs in designated SICs	Identifiable spinoffs in designated SICs	Identifiable spinoffs in designated SICs in operation for more than 5 years. Possible presence of generations of spinoff firms.
Support structures (specialised incubators, industry associations, etc.)	No or trace specialised support structures	Emerging cluster/industry associations and possible development of incubator infrastructure	Established cluster/industry association(s) and incubator infrastructure
Specialised knowledge production (anchor institutions, HE programmes, public research centres, etc.)	Some specialised higher education programmes/centres dedicated to research in the knowledge area – often limited to a specific university	An increase in specialised higher education programmes/centres dedicated to research in the knowledge area. Expansion of educational programmes to colleges and vocational schools (where appropriate)	Established and nationally recognised higher education programmes/centres dedicated to research in the knowledge area
Supply chain and specialised services (e.g. component manufacturers, IP services, etc.)	Some or no localised supply chain firms or service providers	Growth in localised supply chain activity over the previous five years and emergence of specialised service providers	Established supply chain firms and cadre of specialised service providers

This tool focuses on six dimension of the life cycle and establishes rough thresholds for each. Again, these thresholds are designed to "eyeball" where a cluster fits for evaluation purposes and so some variation in where a cluster scores across categories may occur. Be advised also that the process of cluster evolution is not always linear, nor do they spend consistent amounts of time at each stage. As such, it is possible for clusters to skip stages or 'regress' across evaluation periods.

The evaluation of cluster life cycle will ideally take place within a national organization - Innovate UK, the KTN and/or the UKSA – in collaboration with local cluster actors (where applicable). This will ensure, as much as possible, consistency in data and thresholds used and facilitate cross-cluster comparisons. Once life cycle stage has been determined the evaluators for the next phases of assessment should be designated as follows:

Embryonic / Non-Existent Cluster: Tool will be completed by policy officials and local enterprise, business and university professionals to assess potential of locality for Space opportunities. **(External Assessment)**

Nascent / Young / Immature Clusters: Tool will be completed by local cluster leaders **and** outside professionals and policy officials to assess direction, specialism and anchor development vs National Context **(Hybrid Assessment)**

Maturing / Establishing Clusters: Tool will be completed and used by local cluster leaders to define their own direction to define vision, brand, strategy, international and national engagement priorities etc **(Self-Assessment)**

6b. Describe the current cluster

While the process of establishing which phase of life cycle a cluster currently embodies generates some important descriptions that will guide evaluations in later phases the remainder of the tool focuses on establishing baseline descriptions of the *relationships*, *practices*, and *markets* that characterise the cluster outlined in Table 4.

Table 4: The four core concepts of the assessment tool

Concept	Questions
Specialism	Describe distinct capabilities and specialisation of the cluster
Management & Support	Describe what organisations support the development of the cluster, and how
	Describe the nature and intensity of participation of all partners
	Describe the prevailing governance arrangements and decision making of the cluster
Knowledge Base + Skills	Describe what those organisations that provide the knowledge base of the cluster
	Describe the knowledge exchange and commercial exploitation mechanisms
	Describe the culture of collaboration between companies and the knowledge base
Commercial base	Describe what organisations constitute the commercial basis the cluster
	Describe the key markets and segments in which these companies are focused
	What is the position and influence of cluster firms in national supply chains

This phase of the assessment exercise establishes the features of the current cluster to serve as a foundation for the visioning steps. This process has a descriptive as well as quantitative component. First, evaluators should answer the guiding questions in their own words. These answers should then be compared to the key in Table 5. Ideally, the cluster being evaluated should score within the column that corresponds to its level of evolutionary maturity. Where it falls into lower categories indicates where there are opportunities for interventions to develop cluster capacity. Scores of 10-15 indicate a weak and potentially developing cluster. A score of 15-25 indicates a young cluster, while scores of over 25 suggest that a cluster is mature or nearing maturity.

These scores are useful both for assessing the status quo versus objective measures and to compare clusters as part of national evaluation and strategy exercises. In the final step,

participants are invited to reflect on how their responses relate to and underpin broader lessons for the UK space economy.

Table 5: Scoring mechanism

Concept	Questions	Embryonic/Potential (Score 1)	Young/Immature (Score 2)	Established/Mature (Score 3)
Specialism	Describe the distinct capabilities and specialisation of the cluster	A small grouping of specialised firms in a broad category of related industries	Some emerging specialities in a critical mass of firms	Clearly identifiable world-leading capabilities
Management & Support	Describe what organisations support the development of the cluster and how	Few/no organisations	Cluster/industry organisations that aim to connect firms, raise awareness, and address collective issues	Established cluster associations that provide support, training opportunities, lobbying etc.
	Describe the nature and intensity of participation of all of partners	Little organisational engagement and coordination	Some emerging organisational engagement and coordination	Intense organisational engagement and coordination
	Describe the prevailing governance arrangements and decision making of the cluster	No governance arrangements. Cluster activities are uncoordinated	Emerging governance arragements. Some attempts to share information and raise awareness about the cluster and chart a strategic direction.	Clear leaders and cluster stratgies
Knowledge Base & Skills	Describe the organisations that provide the knowledge base of the cluster	Universities and colleges with courses in the cluster area but little else	Universities with specialised programmes, emerging research labs/centres of excellence	Diverse sources of knowledge creation and development from public and private sources
	Describe the knowledge exchange and commercial exploitation mechanisms	Little to no mechanism geared towards commercialising cluster specific knowledge	Emerging commercialisation activities	Established and successful commercialisation programmes
	Describe the culture of collaboration between companies and the knowledge base	Very little interaction	Some interaction and knowledge exchange. Firms interact with knowledge creators bilaterally and through emerging cluster organisations	Frequent collaboration with knowledge creating organisations through formal partnerships and cluster organisations
Commercial Base	Describe what organisations constitute the commercial basis of the cluster	Isolated firms with little relationship to one another	Firms that are beginning to interact with one another. An increasing number of new firms. Emerging incubators and science parks.	Firms with stronger relationships with one another through partnerships or supply relationships. Established incubators and science parks support new firm formation.
	Describe the key markets and segments in which these companies are focused	Various loosely related technologies and markets	Emerging core sub-specialties in the cluster area (e.g. satellites in a space cluster)	Clear specialties. Increasing diversity in nation- or world-leading specialties
	What is the position and influence of cluster firms in national supply chains?	Various positions in national supply chains. No clear functional role yet evident	Functions as a centre of excellence for a specific part of the industry's supply chain	Functions as a centre of excellence for parts of the supply chain and includes participants upstream and downstream

6c. Imagine the future cluster

The third phase invites participants to answer the same questions about the characteristics of the cluster some distance in the future (e.g. four years). Participants may wish to use the cluster life cycle model depicted in Table 3 and their weaknesses as identified in phase 6b to structure their thoughts about which goals to focus on. Once the desired qualities of the localised cluster have been established, participants are once again asked to reflect on how the characteristics of their cluster feed into the UK's national space economy.

6d. Chart the course

What resources and support are required to move from the present to the future outlined in the cluster strategy? In this phase, stakeholders imagine the interim objectives under each of the core areas and identify the support required – including inputs and activities – to enable the cluster to reach those goals. Figure 1 provides a framework to visualise these objectives over time, while Figure 2 can be used to rethink the logic model and better outline the inputs and activities required to move towards long term outcomes and impacts.

Figure 1: Mapping the way forward

	PAST/PRESENT	YEAR 1	YEAR 2	YEAR 3	YEAR 4
Specialism					
Management & Support					
Knowledge + Skills Base					
Commercial base					

Figure 2: Framework to direct rethinking the logic model

	INPUTS (e.g. resources required)	ACTIVITIES (e.g. events,)	OUTPUTS (e.g. completions)	OUTCOMES (e.g. jobs created, increased GVA)	IMPACT (e.g. change to the UK Space Economy)
What is the cluster currently doing?					
What is the vision for what the cluster can achieve?					
What support might be required?					

This tool was designed both as a procedure to support the development of individual clusters, as well as to inform national space policy, by collecting data about the complementarities between disparately located space clusters and by building reflexivity about the broader space economy into the evaluation mechanism. Omitting the steps focused on identifying cluster embeddedness in the national ecosystem and complementarities between nodes of the space economy, would risk (further) entrenching industrial and policy fragmentation. Finally, this tool can also be used to evaluate progress reflexively and to ensure accountability and enable clusters to track their progress relative to their initial goals.

7. Conclusions & Recommendations

7.1 Conclusions

Crucially, whilst there are multiple space clusters in the UK, it is important to understand that they exist and operate as part of a national ecosystem and that they are not independent clusters. The is potential for Innovate UK or the UKSA to cultivate and convene the connections across clusers, to share knowledge and build capacity Understanding the relationships between clusters is an important part of their future growth, which may range from firms with multiple sites as part of different clusters to project based collaborations between firms located in different clusters. This report concludes with a series of recommendations about developing a more coordinated approach towards developing the UK-wide space ecosystem and what this means for local clusters.

Academic and policy debate has long since identified the advantages of the local concentration of an industry in helping to increase levels of productivity, innovation, and entrepreneurship. However, given the size and scale of the space economy in the UK, there is a need to maintain both a UK-wide perspective, as well as supporting the activities of localised clusters. While Harwell is at the core of the UK space-industry, the strength of the UK space sector is in leveraging the strengths of key clusters in a coorginated way to ensure that the UK continues to be globally competitive. As an integral part of their development, there is a need for clusters to consider and articulate how they relate to other clusters and to the wider UK space ecosystem. This is about joining up the knowledge creation systems and knowledge exploitation systems sector wide, as opposed to just within specific clusters.

From a policy perspective, interventions aimed at supporting local or regional clusters in isolation risk producing a fragmented landscape of mainly sub-optimal centres of activity. The focus on local growth should therefore be supplemented with efforts to more effectively join up the varied specialised assets and capabilities that are distributed across different centres of space activity, as part of a wider UK industrial ecosystem. The different clusters studied have distinct knowledge bases and are engaged in different combinations of research and commercial activity, across a range of upstream and downstream markets. The roles of these clusters need to be understood in terms of their contribution to the UK space ecosystem, as opposed to viewing each in isolation or as independent. Approaching the development of the UK space economy in this way necessitates understanding the roles of clusters in relation to the ecosystem as a whole and needs to be about more than supporting the development of individual clusters.

Understanding the promise and prospect of growth of the space economy from both a UK-wide and place-based (i.e. cluster) perspective reduces the risk of the space economy becoming overly fragmented with competition between clusters, as opposed to enhancing the competitiveness of the entire sector. To achieve this goal, policy interventions and public sector support need to be approached in the same way. Prevailing policy under the Industrial Strategy has sought to devolve decision making to places and sectors and requires stronger coordinated strategic and

operational leadership from key national stakeholders (i.e. UKSA, Innovate UK, Satellite Applications Catapult, KTN) who can establish and maintain this UK-wide perspective.

In order to ensure the continued growth of the space economy a positive first step would be to develop a vision for the space economy through to 2030, which would enable the roles of individual clusters relative to that vision to be more clearly articulated and associated challenges more effectively addressed. In addition, the research highlighted the need for the greater facilitation of engagement and working across clusters/places. These brokerage, convening and animateur functions are critical in promoting knowledge spillovers and reducing the knowledge asymmetries that exist within the UK space sector ecosystem. Indeed, various existing organisations and initiatives partially fulfil this function (such as the UKSA, Satellite Applications Catapult, and KTN) although each is engaging UK-wide with a different remit. As such, there is an opportunity here to leverage existing capacity by adopting a more coordinated approach.

At the cluster level, a vision for the space economy to 2030 would enable clusters to more clearly identify how they regard themselves as contributing to this, both now and in the future. Further support for clusters could also be targeted to ensure that activities meaningfully contribute to the national vision. This approach could also avoid the notion of clusters 'tickboxing' and encourage them to build on their strengths as part of the broader UK space economy, as opposed to simply building stronger independent clusters of activity. By empowering local governance and leadership, the development of clusters needs to promote quality engagement of businesses and RTOs, that build UK wide ecosystems. Changing the basis of the conversation with clusters away from their individual development to their contribution is an important step in realising longer term sustainable growth in the UK space economy, by optimising knowledge creation and knowledge exploitation systems across the sector.

7.2 Recommendations

For Government and national stakeholders:

1) Establish a vision for the UK space economy, to enable and support the development of place-based clusters as constituent parts of a wider national ecosystem. Particularly, encourage widespread implementation of the cluster assessment tool and develop mechanisms to interpret feedback from these processes. This should be coupled with the continuation of frequent waves of independent data collection and analysis to continue to track and situate the growth of clusters around the country.

2) Given the multi-agency support available to organisations working in the space sector, and contributing through supply chains, there is a need to ensure more coordinated support from UKSA, Innovate UK, and the KTN for the clusters and their leadership. This should be engaged with local and regional clusters as appropriate in order to maximise the impact of public sector support for the space economy.

3) Further to the convening and facilitation role required centrally to better 'join up' local clusters, promoting engagement and collaboration has the potential to realise the benefits knowledge spillovers across the UK space economy. It is crucial that public investment in clusters in the space sector exploit synergies and avoid the potential of deadweight.

4) Promote the visibility and status of local clusters, to increase their attractiveness to private sector investors, with a view to leveraging investment. This represents an important life blood for the future development of clusters, especially where inward investment involves collaboration and contracting with existing cluster members.

For place-based clusters:

1) Local clusters seeking public support need to develop appropriate governance arrangements with representation of different stakeholder groups as well as clearer strategies detailing their own development as a part of the UK space economy.

2) Identify opportunities to extend and advance knowledge creation and exploitation that build on local strengths and leverage national strengths as appropriate. Customers need to be able to articulate and identify the differences and complementarities with other clusters.

3) Clusters should not be defined by administrative boundaries (i.e. LEPs and local authorities) but should instead be supported to identify geographically localised areas where there is a critical mass of organisations working in the space economy

4) Anchor institutions have a key role to play in supporting the quality and intensity of participation and engagement of all partners.

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