



Future Skies Workshop:

Private Industry and Public Policies Shaping the Space Sector

A workshop organized by Oxford University's Centre for Technology and Global Affairs
in collaboration with The Flying Object and the UK Space Agency

Executive Summary

On June 21, 2019, Oxford University's Centre for Technology and Global Affairs – in collaboration with The Flying Object and the UK Space Agency – held its *Future Skies Workshop: Private Industry and Public Policies Shaping the Future of the Space Sector* in Oxford.

The workshop was the launch event of a leading effort to explore the future of the global space and aviation sectors. It followed from the successful *Robotic Skies Workshop* on policies and regulations of drones, which the Centre held in Oxford's Rhodes House in June 2018. The initiative seeks to create a cross-disciplinary research programme and sustainable forum for discussion and analysis gathering leaders from industry, government, and academia to explore the complex interplay between international relations, commerce, policy, governance, and technological innovation in the space sector.

The panel discussions explored the challenges and opportunities facing the global space sector – including commercialization, technological innovation, and regulatory uncertainty under conditions of economic and geopolitical flux. Panellists highlighted the potential for formidable disruption of the industry with the entry of diverse private companies, leading to the development of new technologies that present new investment opportunities and governance needs.

This report summarizes key points of the workshop proceedings. Setting the stage was the Keynote Speaker, Bas Landsdorp of Mars One, who discussed his vision for establishing a human outpost on Mars. We then held a series of panel discussions delving into the future of the space economy. The remainder of this report synthesizes the workshop proceedings and findings under the following three headline themes: (1) Existing Ecosystem, (2) Headwinds, (3) Opportunities, and (4) Questions for Further Discussion.

Workshop Proceedings

1. Existing Ecosystem

Contemporary space innovation was not built out of thin air. Rather, it was bolstered by previous aspirations, endeavours, and experience. While some observers call the current period of space development “New Space”, conceptually very little is in fact new. Commercial activity in space has had fits and starts over the last fifty years and more. While it is important to be aware of the technological advances and challenges of the modern era, we can learn a lot by understanding previous attempts to commercialize space and how the existing ecosystem emerged. Relevant experts and practitioners can present a rich history of thought and technology development that has fostered a sense of community among diverse actors. Together we can share a vision about the future of space in modern society.

Independent industry organizations represent a key part of the existing ecosystem and their growth represents an important factor in the development of the space economy. Several organizations provide important forums across the space sector and facilitate progressive dialogue. These independent institutions promote the mission of industry actors and represent the interests of the component space market. They provide a venue for like-minded individuals and organizations to grow, advocate, and connect their common interests across the space and adjacent economies. For example, the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS) seeks to provide an independent industry forum to advocate and promote on-orbit satellite maintenance, servicing, and rendezvous operations. The organization collaborates with different institutions to research, develop, and publish voluntary technical and safety standards. In addition, it engages with governments on policy and oversight of satellite servicing activities. International outreach is done consistently through workshops and publications all over the world. CONFERS collaborates with the ISO in seeking to develop top-level on-orbit satellite servicing (OOS) standards and a New Work Item Proposal on Satellite Servicing.

The public sector represents the single most important player in the current space ecosystem. Government has historically dominated the existing space economy, playing varying significant roles as developers, customers, and regulators. Today, with the rise in commercial space, companies supported by government funding have instigated a significant shift in the space economy. Public money is unlocking the private sector of outer space, supporting the incubation of fledgling private businesses, and lowering the barriers to entry for them. Yet some observers are concerned that the funding from government customers will artificially accelerate the space economy’s growth before the creation of true commercial customers, thereby setting up the sector for a dangerous expansive bubble – a situation that previously occurred in the 1990s. This prospect forces us to consider whether the space sector is unique or, if it is not, whether we can derive useful lessons and insights from the experience of other sectors (e.g., the telecom or the airline industries) that benefited from public investment and which fruitfully engaged government organizations in their development.

Innovative companies in the existing space ecosystem are helping to drive transformative disruptions, generating lessons for the rest of the sector as it evolves from “Old Space” into “New Space”. The following trends are notable in this regard:

- *Motivations*: beyond space exploration and tourism, new companies pursue broader commercial interests
- *Actors*: a diverse range of relevant private actors is emerging
- *Contents*: there is significant overlap and integration with other industries
- *Roles*: there is greater public and private sector synthesis
- *Technologies (and technological development)*: the simpler, the better
- *Business models*: services versus product

Today we see signs of commercial opportunity amid a growing and healthy space economy, but there are clearly areas of weakness that must be addressed. The current space ecosystem comprises a record number of start-up offerings and venture funds seeding a host of new products and services. Greater amounts of private equity pour into space companies. Across the United States and Europe, the growth of strategic mergers and acquisitions demonstrates the rising interest in and power of space technologies, while several space companies have gone public (or plan to do so) with stock offerings planned in the near to mid-term. Yet despite the growing investment in small companies over the last decade, the number of successful exits from venture portfolios remains small. This raises concerns about the long-term continuation of external investment that has fuelled new concepts and innovations in the space economy. Additionally, the consolidation within the space industry and the themes of scale and vertical integration have left a void of medium-sized companies while also producing a lack of diversity and stability in the supply chain.

2. Headwinds

The regulatory environment is a crucial influence in the development of the space economy. In many countries, it is not conducive to innovation. The current legislative and regulatory environment presents a paradox: Regulation seeks to encourage private investment and innovation, but too much regulation stunts and delays global commercialization and standardization. Regulations must enable and empower future success, not prevent it. Although governments today reap the primary benefits of space innovation, working with them can be frustrating in overcoming inertia and lengthy regulatory procedures. As a result, regulators should focus on the design of smart, responsible, and balanced regulation that monitors adherence to legislative processes, accommodates technological advancement, and ensures compliance with financial requirements, while stimulating the growth of space products and services as well as a sustainable customer base.

From an operations perspective, the presence of space debris left by satellites presents both an opportunity for and a challenge to innovation. There are an estimated 8,000 tons of debris and more than 25,000 known objects in Earth’s orbital regimes. Some players, including the U.S. government, have launched projects to track and remove space junk – but greater transparency is required in the execution of these efforts. Ensuring sustainability in space is becoming a global political imperative in relation to broader sustainability goals and challenges. The 2015 United Nations Sustainable Development Goals, for instance, furnish a sound list of requirements on specific aspects of space activity. Some national institutions are withdrawing from these commitments, however; consequently, big industrial groups are increasingly having to shoulder them.

Political change and contention can starkly affect the rate of innovation and commercialization as well as the industry’s focus on new initiatives. Brexit, for example, has generated predictions of ample loss – but also gains – of commercial opportunities for UK space companies. So far, however, the space industry’s growth has not been significantly affected by the political crisis in the United Kingdom. In

the United States, politics have clouded the creation and definition of the roles and responsibilities of a new “Space Force”.

3. Opportunities

Studies by Morgan Stanley and the Satellite Industry Association estimate that the current space economy is approaching a size of \$400 billion at an average yearly growth rate of 4.5%. By 2040 it is likely to grow to \$1.1 trillion. This steep growth curve presents tremendous opportunities to space companies and entrepreneurs. Understanding and predicting how market structures will evolve and where and how growth will occur will be an important exercise for companies seeking to position themselves for future commercial success.

What seems like a continuous flux of venture capital investment in the United States and Europe has generated a great deal of excitement and presented numerous novel ideas for commercial space with a lifeline to test the market. Some estimates show that annual venture capital investment in the United States alone was \$3 billion. While there have been few successful exits from these ventures at the time of this workshop, some experts expect that companies will “graduate” and secure funding from private equity or the public sector laying down the foundation of the future space economy. This role of venture money has generated a need for early conversations about business and investment models, partnerships needed to create strategic government and industry involvement, and exit strategies. The Silicon Valley venture model focuses on revenue, scaling quickly, and exiting in three to five years – a model that does not fit the space sector’s characteristics well. Venture capitalists must ensure a return on investment, or they will struggle to stay the course. This will require investors and business founders to have different conversations and think about their businesses in a different manner than in the past. These two groups must find ways to generate proxy revenues that initially might not relate to space, but which offer insights and a customer set from space derived products and services; or else they must develop non-traditional milestones indicating growing value that departs from the traditional “Series” investment structure.

The efforts of wealthy individuals (e.g., Jeff Bezos, Richard Branson, and Elon Musk) continue to shape visions of the new space economy while providing crucial investment for its development. Beyond the psychological value that these prominent individuals provide to the market, their direct investments have started to develop the sub markets around components and infrastructure that are necessary to support the emergence of new companies and a more vibrant industry.

Governments represent a vital customer in the current space economy due to the nature of their investment. Their funding represents non-dilutive capital that is necessary to buy down technical and business risk while helping to pay for the non-recurring costs of space infrastructure. Government customers represent a great test market; they offer confidence and validation to aspiring and intrepid investors. Given the slowly growing volume and maturity of commercial customers for space products and services, companies entering the space economy still require government customers to close their business case until the industry matures sufficiently to offer a multiplicity of sustained buyers. This requirement is typical of other frontier industries; it was evident, for example, in the development of the aviation industry, whose century long development has featured two broad phases – manned and unmanned – both of which entailed government involvement.

4. Questions for Further Discussion

The questions below build on key observations made during the panel discussions. They provide the basis for further exploration of the space economy in future workshops, research projects, and external engagement activities.

1. Throughout civil society, economies develop best through the encouragement of self-organizing and independent institutions (such as CONFERS). What other independent institutions might exist that are relevant to the development of a robust space economy? What role do such organizations play? How can they guide industry and government actors in the development of new standards and regulations?
2. Bureaucracy and regulation often stifle the space economy's growth and innovation. What is the proper role of public organizations in the development of the space economy? What types of public stakeholders are interested in the sector? Is public investment necessary and, if so, when and how should it be applied? What restrictions should (or should not) attach to the use of public money? What model of public-private interaction best serves the space sector's growth? Does the experience of other sectors provide valuable insights on these questions?
3. Modern industries with successful economies enjoy a healthy ecosystem of vendors, suppliers, financiers, buyers, and associated supporting infrastructure. What key parts of this ecosystem are missing in the space sector and how are they built? What steps can or should be taken to catalyze the creation and growth of supporting activities in the space economy? How could cheaper production processes, modern manufacturing techniques, and greater availability and development of off-the-shelf components aid this process?
4. What previous attempts at commercializing space are relevant to the resolution of contemporary challenges and what lessons can we derive from them? What lessons and insights do past failures and successes offer (e.g., Globalstar, Iridium, OneWeb, and SpaceX)?
5. The regulatory environment in some countries is not conducive to the stimulation of innovation in the space economy. Effective regulation brings forth important questions: What regulatory changes could support greater private sector innovation and entrepreneurship in the space sector? What policy measures could support a greater role for SMEs in the traditionally risk-averse and state-dominated space industry?
6. The presence of space debris left by satellites presents both an opportunity and a challenge to innovation – one that is important to the creation of a strong space economy. Questions lying at the core of this challenge including the following: How can national, regional, and international governance mechanisms safeguard the outer space environment against orbital collision and catastrophe? What are the key challenges facing the sustainable use of space resources? Who is responsible for removing space debris? Who should pay for this activity? Who should operate and own high value/recyclable space debris? How does the international community get “rogue nations” to behave responsibly in space?
7. In addition to the above questions on specific topics, the following miscellaneous questions also emerged in discussion:
 - a. Who is responsible for training specialists in sectors beyond engineering (e.g., business and finance) to meet the personnel needs of the growing space economy?
 - b. What are private investors looking for when it comes to seeking out successful companies in the space economy? Are there qualitative differences between the European and U.S. investor communities in this regard?
 - c. How should we balance government and private interests when these appear to be in conflict with each other?
 - d. Space activity can be considered a national capability and a source of pride. Often, European companies sell only to European companies and U.S. customers buy only from U.S. companies. Markets are not open to each other. What efforts could help to foster greater commercial exchange and collaboration across national frontiers?

- e. Is Europe behind the United States and the rest of the world in transportation and regulation? Insofar as Europe is lagging, what opportunities does this situation present to governments and businesses?
- f. What lessons can we learn for the space economy's growth from historical commercialization experiences, such as the Dutch East India company, telecommunications, or aviation? How effective are historical analogies in understanding present challenges and ways to overcome them?
- g. What is the role of universities and other research institutions in the space economy's development? Is more interdisciplinarity within the academy needed? Which disciplinary communities are most relevant to the study of the space economy (engineering, physics, economics, political science, etc.)?
- h. How can one foster innovation within volatile political and geopolitical contexts? What human and political problems (rather than merely engineering problems) afflict the space economy?
- i. Who is the "we" that cares about important questions of space regulation? What forums exist (or should be established) to foster meaningful discussion among diverse actors to address the questions herein?

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*** The findings of this report are based on discussions among panel members and participants of the workshop at Oxford University. The views expressed in this report are those of the participants and do not necessarily represent the views of the UKSA.*