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Accelerating Innovation in The Space Sector Through Public-Private Partnerships

Paul Kiesling [a]*

[a] *BLUECUBE Aerospace, 2300 Giralda Cir. E #102, Palm Beach Gardens, FL 33410, pkiesling@bluecubesat.com*
* Corresponding Author

Abstract

Since the 1950's innovation within the space sector has accelerated at an unprecedented pace, with humans stepping foot on the moon, distant worlds being explored, and large satellite constellations being launched. A significant amount of this progress has been due to government space programs. However, recently, major innovations within the space sector have been a result of private companies. These advances have led to a phenomenon known as the "privatization of the space sector" and sparked major debates about whether the future of space exploration lies in government organizations or the private sector. To answer this question, the current dynamic of the space industry must be understood. Currently, governments act in three primary roles: as lead developers, as customers of the private sector, and as partners in different projects that are co-funded by the private sector. Recently, the private sector has started evolving from being exclusively a contractor to government agencies to becoming a partner with space agencies by sharing more of the development costs and taking on more financial risks and responsibilities in joint projects. Despite this growth in the private sector, government programs and procurement still account for the vast majority of investments and represent a significant market for private firms. However, although governments provide the backbone for space funding, as the private sector continues to innovate at an unprecedented pace, it is likely that it will account for a larger market share of the space sector in coming years. Ultimately, the best way to stimulate growth within the space sector is through collaboration between the private and public sectors. One of the best ways to do this is through Public-Private Partnerships (P3s) which benefit both the government and the private sector. As P3s increase in popularity and importance, understanding key challenges and underlying economic arguments can help lay the groundwork for future success. This paper will examine the current relationship between the public and the private space sector and analyze how innovation and growth of the space industry can be stimulated through public-private partnerships.

Keywords: Public-Private Partnerships, P3s, Space Sector, Space Exploration

Acronyms/Abbreviations

Public-Private Partnership (P3), International Space Station (ISS), National Aeronautics and Space Administration (NASA)

1. Introduction

Over the course of the past century, humanity has made significant achievements in space exploration, from sending the first humans to space, to launching telescopes that can see to the beginnings of the universe. To date, more than 60 countries and regions have established space agencies while private sector investment in space experiences rapid growth. As space agencies and private companies around the world continue working on projects to send humans back to the moon, and eventually onward to Mars, establishing commercialization of space and a long-term interplanetary presence will be among the most challenging technical enterprises in human history. Accomplishing these goals and meeting the challenges of the new era of space exploration will require the multi-actor approach where governments continue to evolve innovation policies from clearly defined "mission-oriented" objectives to more open-ended objectives driven by global commercialization needs. Whether to facilitate rare earth elements mining operations in space or to establish an inter-planetary society, private sector and government agencies are racing to achieve pioneering breakthroughs. To maximize results, public private partnerships must be employed on a larger scale, which will also enable new actors and accelerate innovation in the rapidly transforming space industry.

1.1 Public Private Partnerships

A public-private partnership (P3) is a business relationship between a private company and government agency with the purpose to complete a project that serves the public. Financing a project through a P3 can allow a project to be completed more productively with less risk. Historically, P3s have been used primarily for projects relating to transportation or traditional public infrastructure (i.e., roads and bridges). However, recently the term has been applied broadly to all types of

contracting for important government service, such as schools, prisons, and provision of health care. Governments around the world are using P3s in various forms for public infrastructure delivery, ranging from simple collaboration models to joint ventures to models that use a mix of equity and loans via a special purpose vehicle. By combining the strengths of both government and commercial companies, P3s can be successfully used across various sectors, especially space.

Recent technological advances in aerospace industry have made it possible for private companies to launch their own rockets and deploy satellite constellations. Similarly, lower costs of manufacturing, propulsion and launch have made it possible for new space companies to emerge and compete in the sector that once seemed too expensive and difficult to enter. Therefore, it is now more important than ever before for the governments and private sector to join forces and pave the way for P3s. These partnerships promote competition within the private sector, allow government agencies to leverage commercial efficiencies and innovation, while diversifying risk in exchange for a shared profit linked to performance. Ultimately, collaboration between the private and public sectors is the most effective and efficient way to stimulate growth within the space industry. [1]

1.2 Benefits of P3s for the Public Sector

When it comes to growing the future of space, governments are increasingly relying on companies not just as contractors, but as strategic partners and service providers. P3s are critical instruments for innovation as they unlock new possibilities that might be unavailable when relied solely on public or private investment. They help governments become more inventive by creating a space outside the government structure that allow innovation to grow and accelerate. Now more than ever before, P3s can benefit governments as nations increasingly engage in the space activities to strengthen their domestic technology sector, promote scientific education and research, gather data on climate change, or even use space technologies to monitor borders, infrastructure and the military activities of potentially hostile foreign and domestic entities. [2] By partnering with the private companies and allowing them to take a lead role in developing space technologies, governments give themselves more bandwidth to focus on establishing effective legal and regulatory framework for space related activities or developing policies and governance frameworks on how people will utilize space once they get there.

1.3 Benefits of P3s for the Private Sector

P3s help private companies embrace innovation and bring together new financial resources and business capital to open the door for new actors, thus helping increase innovation in a competitive market. P3s allow companies to engage in large scale projects beyond their traditional capacities. P3s also stimulate innovation within the space industry by accelerating innovation as companies compete for lucrative government contracts. Additionally, through P3s, private companies can capitalize on government capabilities to navigate the complex international politics of space and develop mutually beneficial partnerships with other space agencies.

2. Methods and Examples

When governments seek to expand their ambitions and capabilities for space exploration, they must recognize that P3s can help them achieve these objectives in a more efficient and cost-effective manner. P3s can allow the governments to retain control over key capabilities, while leveraging efficiency, innovation and risk management with the private sector in an exchange for profits. In today's highly competitive global arena, governments can foster innovation in space technologies by utilizing P3s in a number of ways. For example, governments can get involved by either buying and bailing a struggling company, structing a P3 to reduce the risk for one or both parties and by establishing a collaborative relationship to achieve an end goal. Governments can also play a role by using regulations to encourage innovation, facilitate market entry, and to establish relationships with other space agencies in pursuit of multi-national or global space initiatives.

2.1 Past Success of P3s in the Space Industry

One of the best examples of a successful P3 that helped advance the space industry is the International Space Station (ISS). Not only was the ISS built with the help of P3s, but it continuously creates P3s by giving private companies a platform to conduct unique research and expand their innovative capabilities. While the original construction of the ISS was primarily a collaboration between governments around the world, P3s have been essential to its continued growth and success. For example, a private in-space services company Nanoracks, LLC has provided hardware and services to the ISS National Lab since 2009, and in 2016 the company Made in Space, Inc. gave the ISS three-dimensional printing capabilities in microgravity. [3] As a result of such partnerships, the ISS was able to thrive and offer a unique platform which enabled R&D access to a broad range of commercial, academic, and government users. Through this platform, the ISS has been able to provide many companies an opportunity to expand their business and conduct scientific research in microgravity. For example, since 2018 through NASA Space Act Agreement, the ISS National Lab has been facilitating Space Tango, an industry leader in automated systems, to pursue health and technology manufacturing

in microgravity. The ISS National Lab has been increasingly educating a wide variety of organizations about the opportunities that it presents and currently facilitates lab space to many organizations starting new space commercial activities.

2.2 On-going Success of P3s in the Space Industry

A strong example of a P3 structure currently in place in the space sector is the NASA's Artemis Lunar program, which is a collaboration of government space agencies and private spaceflight companies in a series of complex missions to enable human exploration to the Moon and Mars. To ensure continuous progress and ultimate success of the Artemis program, NASA identified technology areas needed for its missions and created a series of partnerships with private companies to accelerate the development and implementation of these technologies. Despite NASA's enormous budget, as well as amount and quality of its employees, facilities and resources, the US space agency selected more than a dozen private companies for partnerships in various categories such as: Advanced Communications, Navigation and Avionics; Advanced Materials; Entry, Descent and Landing; In-Space Manufacturing and Assembly; Power; Propulsion, and Other Exploration Technologies. Ranging from small business to giant aerospace corporations, these companies were selected by NASA in order to encourage the new ideas and technologies required to make the Artemis mission a success, as well as the subsequent Moon to Mars programs viable. In return, many of these companies benefit from NASA's expertise, facilities, hardware and software at no cost. [4] Now that the first phase of the Artemis program, the Artemis-1 mission, was recently executed successfully, it would not have been possible without the P3s, or it would have taken significantly longer for NASA to build and execute this mission if not for the aid of the private industry.

2.3 Understanding the Past for a Better Future

Many lessons can be learned from examining past public-private partnerships in the space industry and parallels can be drawn to understand how P3s that did not result in an immediate success were still instrumental for the advancement of the space industry. For example, this can be seen through a case study documented by Karen L. Jones of the Aerospace Corporation in her 2018 publication for Center for Space Policy and Strategy. Jones examined the Evolved Expendable Launch Vehicle (EELV) program, which was a partnership of the U.S. Air Force (USAF), Boeing, and Lockheed Martin, with SpaceX added in 2016. The program was started in 1990s by USAF to assure access to space for the Department of Defense (DoD), other government payloads and to make government space launch more affordable and reliable. A P3 was formed as the space industry was expecting a large market for commercial satellites, and thus, for launch vehicles. However, these market projections proved to be incorrect and many large satellite constellations never launched or went bankrupt. In retrospect, during a hearing for FY2017 Budget Request for National Security Space, it was noted that after 92 launches since EELV inception only 14 were for commercial sector. This example emphasized the need for public private partnerships because the commercial sector was not yet mature enough. Hence, the only way to propel the launch vehicle industry forward was through a partnership with the public sector. [5]

As a result, today, new launch related P3 investments can be observed and supported by successful mega-constellations projects by companies such as SpaceX and OneWeb. In particular, OneWeb success demonstrates how a collaborative venture partnership between a private company and UK government benefited all stakeholders at hand. Specifically, it benefited the people by providing satellite broadband, while bringing a large amount of income to both, OneWeb and the government of UK, which had bailed out OneWeb after it had filed for bankruptcy for failing to raise enough capital for manufacturing and launches. [6] After emerging from bankruptcy, OneWeb has been successfully launching their intended 648 satellites, with 542 operational satellites currently on orbit as of January 10, 2023. [7] With more than 80% of its first-generation constellations launched, OneWeb and its partners aim to provide high-speed, low-latency connectivity solutions to a greater number of unserved and underserved rural and remote communities and businesses. OneWeb success story serves as a great example of how a private company was able to revolutionize internet accessibility by partnering with the government sector.

2.4 Creating and Structuring a P3

Understanding the importance of P3s in the space sector is essential to understand the different methods that lead to the successful execution of these partnerships. As outlined by Jones for the Center for Space Policy and Strategy, typically, there are four key elements of a successful P3: Funding, Duration, Requirements, and Risk Allocation. The first element of a P3 is creating an efficient funding structure. Generally, in a P3 structure where public funds are allocated to the private company, it is provided in increments when specified milestones are reached. This makes it easier for a party to terminate a partnership if inadequate progress is made and continues to incentivize companies to make as much progress as possible in as short amount of time as possible. Secondly, the duration of the P3 must be clearly defined before the project begins. For example, determinations need to be made on whether the private company will be responsible for the project through the construction and deployment phase or if it will also have

a role in the operations and maintenance of a project. It is also important to have clear performance requirements and a schedule created for the project with certain performance related milestones. Finally, risk allocation must be clearly outlined. One of the most appealing parts of public private partnerships is how it diminishes the risk of projects, so it is important to think that through before a P3 is launched.

Another important characteristic of a successful P3 is how its structured. The first step should be to determine how the partnership is expected to improve the cost, schedule, or performance of a space system or service. Secondly, the objectives, scope, and roles, of the P3 partners should be clearly defined. Then a risk and decision framework should be created to effectively solve problems as they arise on the project. Based on this framework stakeholder needs can be balanced, and the risk allocations can be fairly given to all participants. If all of these considerations can be thought through, then a contract should be created to formalize the P3. [5]

3. The Current and Future Outlook

To understand the future outlook of the space sector, the current state of the United States space market can be analyzed. Over the past five years, the United States space market has seen a significant rise of private sector involvement. According to December 2021 report by McKinsey & Company, while the US government still funds most space sector R&D, private companies, including new space actors, have been driving a notable uptick in overall investment as well as achievements in the space industry. [8] With the increased involvement of the commercial sector, the space R&D funding has also been evolving. As shown below in Fig. 1, the US government continues to be the primary source of R&D spending in the space sector, however, the contributions from private sector have been consistently growing, especially from the new space companies.

The growing role of commercial space companies has been observed over the past five years, as commercial R&D spending within the space sector has risen by 22% annually, which is more than double 10% increase for US government spending. However, when looking at the absolute finding, the US government still spends about $12 billion per year, while commercial R&D is at only half of that, at approximately $6 billion. Nevertheless, it is important to note that the US government's contribution as a percentage of total R&D funding has been falling, despite absolute dollar increase. The US government went from funding about 90% of total space related R&D between 2010 and 2013, to only funding about 65% portion of R&D in the period of 2014-2017. Since then, the funding percentage split between government and private sectors has stabilized with the government still providing a majority contribution as can be seen in Fig. 2.

Fig. 1 Space-Related R&D Expenditures. Courtesy McKinsey & Company, 2021

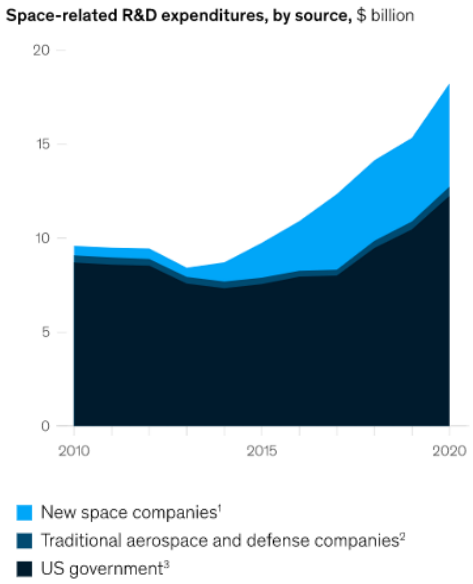
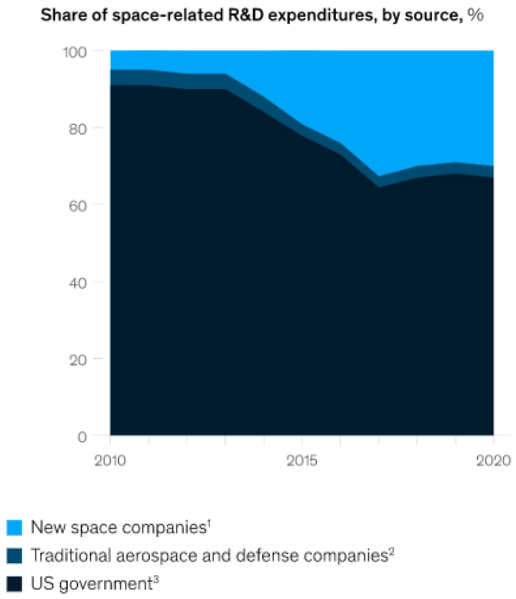


Fig. 2. Share of Space-Related R&D Expenditures. Courtesy McKinsey & Company, 2021



Based on McKinsey's data of the US space market, it is important to note the significant involvement in space R&D presented by the new companies founded since 2000. This shows that activities that were once considered only possible by well-developed government space agencies are now becoming more and more feasible for private sector companies including start-ups. Lower costs and recent technological advances have encouraged both, established aerospace companies and

new start-ups alike, to push their boundaries and explore novel solutions.

The global space market outlook similarly follows and supports what can be seen in the US. As noted in "The Space Report 2022 Q2" issued by the not-for-profit Space Foundation, the data from nations around the world shows that the global space economy was valued at $469 billion in 2021, which was a 9% increase from 2020 and the highest recorded growth since 2014. The report further shows that most of the money generated by the space industry came from the commercial space sector, which saw a 6.4% boost in revenues, with more than $224 billion coming from products and services delivered by space firms and $138 billion spent on infrastructure and support for commercial space enterprises. Additionally, this report outlined the record pace of successful launches, specifically noting that 1,022 space crafts were successfully placed on orbit during the first half of the 2022. According to the Space Foundation, that is more spacecraft attaining orbit in six months of 2022 than were launched in the first 52 years of the Space Age, and most of these, namely 958 out of 1,022, came from the commercial sector. [9]

4. Discussion and Conclusion

Global data shows a significant rise in the private sector's involvement in space activities. That, combined with understanding that governments' expertise and experience are essential, calls for support of P3s as a way to move forward to maximize results for all. While the space economy currently generates most value by enhancing activities on Earth, the future of space sector lies in significant value being derived from operations and functions on orbit and beyond.

Rapidly evolving technological advances coupled with intrigued investors have resulted in a surge of space funding over the past five years. With that said, the potential for space activities in orbit and beyond has become more of a reality than optimistic contemplations by scientists and space enthusiasts. The next era of space exploration promises to bring commercialization of space where businesses can conduct various activities ranging from development of novel technologies in microgravity to space tourism to establishing mining operations of rare earth elements on asteroids. As technological capabilities grow and costs of entry lower, P3s will pave the way forward by promoting competition within established aerospace corporations and encouraging and enabling younger space companies and start-ups to engage in space ventures, thus accelerating innovation.

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