LEVERAGING AND STRENGTHENING COMMERCIAL SPACE

A policy brief prepared for the Office of the Secretary of Defense

SAPANA

STRATEGIES FOR AEROSPACE POLICY AND NORM ADOPTION

About this project

This research was conducted over the course of 16 weeks by seven students at the University of Colorado. Our task was to offer policy recommendations to the Office of the Secretary of Defense pertaining to the use of outer space. Our research involved conducting over 60 interviews with government, industry, and research professionals across the country. We are indebted to those who shared their time, wisdom, and passion for space with us.

This project is dedicated to Sapana, the young girl from the Native American folk tale who bravely climbed all the way to the Sky World to protect the birds from their predator.

About SAPANA

SAPANA (Strategies for Aerospace Policy and Norm Adoption) is a student research team at the University of Colorado Boulder, brought together as part of the Department of Defense's *Designing for Defense* program. Our collective expertise includes aerospace engineering, mechanical engineering, political science, economics, business, and computer science. The team includes two recent PhD graduates, two Master's students, and two undergraduate students.

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1. Executive Summary

Space as a domain for government and private use is changing rapidly. Where activity in space was once the remit of only a small number of countries, led by government-driven programs, it now hosts a vast community of actors from across the globe, both public and private. This growth reflects three trends: space is becoming more *internationalized*, *commercialized*, and *integrated* into everyday infrastructure than ever before.

This change presents new challenges for the United States that only new policy directions can mitigate. First, the increase in global competition threatens the competitive edge in space that the U.S. has enjoyed for many years. Second, improving capabilities of adversaries raise new threats to national security for which the U.S. may be currently unprepared to address. Third, the extensive integration of space-based technology into U.S. economic and defense infrastructure leaves it highly vulnerable to a downturn in the domestic space economy or technological osbolescence. And fourth, the increasing decentralization of the business of space leaves the U.S. needing to find new partners and ways to manage those complex relationships.

However, the advances being observed also present the U.S. with opportunities. As space stands poised to dominate the security and economic domains in the coming decades, many benefits can be reaped. Moreover, leadership will be required to give a framework of governance norms and rules for the use of space. It is for these reasons that the U.S. government must adapt to new space practices that leverage the changes taking place. This is not an option for the U.S. Its national security, economic might, and global influence depend on it.

We offer insights into the challenges faced in today's space domain and some solutions to those problems. Our recommendations are specifically targeted at the Department of Defense, although a multi-agency approach to the problems will be imperative for mission success. Our recommendations fall broadly into two categories: **steps to leverage commercial space growth for DoD needs**, and **steps to support the vitality of the domestic space industry**. Ultimately, these two tasks are closely connected: one cannot occur without the other.

Within these categories, we offer a number of specific policy recommendations covering the following areas:

- Crisis contingency acquisitions
- Public-private partnership projects
- DoD-commercial relationship management
- Trade liberalization and market integration
- Risk tolerance measures
- Improved access to clearances

We recognize that these are not all new solutions. However, the importance of this moment in time is unparalleled, and therefore demands that the problems be confronted boldly. Our hope is that this research might contribute to that in some small way.

2. Our Approach

This research was compiled over 16 weeks from January to May 2019. We interviewed more than 60 space, law, academic, business, and engineering professionals. Collectively, these interviewees reflect more than a millennium of

experience in the commercial and government space domains. We also analyzed dozens of primary and secondary sources, from legislation, to Notices of Proposed Rulemaking (NPRMs), to GAO reports and academic papers. Our research process followed the "Lean StartUp" method, identifying value propositions for varied beneficiaries and maintaining a weekly Mission Model Canvas incorporating newly received information along the way.

Our solutions are informed by a broad understanding of the geostrategic, economic, and technical considerations associated with space. We bring substantial domain knowledge in international law, conflict resolution, resource management, economic policy, strategic play, aerospace and mechanical engineering, and business principles to the questions of DoD space policy.

We approached a vast and complex problem area: one that is multi-layered, longstanding, and deeply embedded. The underlying questions have been addressed *ad nauseum* by experts with far greater experience than us and over a much longer period than 16 weeks. However, we believe there is a distinct advantage to viewing an old problem with new eyes – a 2019 mindset – using a potent combination of graduate-level academic talent, bold inquisitiveness, and an innovative but proven business-driven research method. Moreover, we had no stake in this other than to offer insight and shed light on reality. Our independence and separation from the quagmire of the government-commercial space complex therefore offers fresh, thoughtful, and impartial input to a critical national dialogue.

3. Identifying the Problem

In recent years, the space domain has been marked by a number of changes that create new and complex challenges for the United States. These changes can be summarized as follows:

- Space is becoming ***internationalized***. While the United States only had one rival in space for several decades in the Soviet Union, the number of space-faring nations is growing rapidly.
- Space is becoming ***commercialized***. The development of space technology has until recently been primarily the remit of the government. Commercial activity has achieved unprecedented levels in the last two decades. Commercial space revenues doubled from $125 billion in 2005 to $249 billion in 2018. Space is one of the fastest-growing sectors in the global economy, worth $329 billion in 2016 and estimated to double to around $640 billion by 2030.[1]
- Space technology is becoming indispensably ***integrated*** into everyday life. Modern infrastructure, both of a government and private nature, is increasingly dependent on space technology. For example, cloud-based systems rely on GPS timing and communications satellites. Without these, systems from gas pumps, to stock exchanges, to energy grids could fail. Space is guaranteed to play a large role in virtually all sectors of the economy in the future.

These three trends are creating complex challenges for the United States, which will only increase in magnitude as time passes. These problems can be summarized as follows:

[1] Black, James. 2018. Defense News. "Our reliance on space tech means we should prepare for the worst." https://www.defensenews.com/space/2018/03/12/our-reliance-on-space-tech-means-we-should-prepare-for-the-worst/.

- The United States' ***competitive edge*** in the space domain is waning. As other countries develop their own space technologies, the U.S. becomes less influential in both global economic markets and the international space policy arena.
- United States ***national security*** faces ever-increasing threats as adversarial foreign entities develop technologies to challenge U.S. primacy both in space and on Earth. Both Russia and China have capable counterspace technologies ranging from ASAT missiles to high powered energy weapons designed specifically to counter U.S. space dominance.[2]
- The rapid integration of space technologies leaves the United States increasingly ***vulnerable*** to events such as deliberate attack, accidents in orbit, or technology failure. An on-orbit fragmentation – for example due to a deliberate ASAT attack, or accidental collision – could cripple U.S. space infrastructure.
- Space as an industry is becoming increasingly ***decentralized***, where the U.S. government's scope of control is shifting from a government-centric model to one where it is one player among many. Within this model, private actors play an important role in innovating the space environment.

How the United States government chooses to address these problems will determine its role in space for decades to come. Given the importance of this domain to both national security and economic interests, critical changes at various levels of government must be undertaken. By embracing forward-thinking policy changes before it is too late, the U.S. can cement its status not only as the dominant space-faring nation, but also the preeminent global superpower for the foreseeable future. Increasingly, the control of space will determine who commands the greatest influence on Earth in the decades ahead.

These changes motivate two substantive space policy questions for the Department of Defense.

First, ***how can the DoD better leverage commercial space innovation and capabilities?***

As global competition increases and the integration of space-based technologies into everyday life grows, the U.S. government faces an imminent need to acquire *new*, *more*, and *better* space technologies for national security purposes. In response to this question, we recommend:

1. Improved access to technology for crisis contingency planning;
2. Enhanced processes for communication between the DoD and commercial sector regarding potential technologies;
3. Increased use of public-private partnership contracts to improve product delivery;
4. Implementation of a structure of DoD-contractor management to oversee increasingly decentralized product development.

Second, ***how can the DoD take steps to better support the U.S. commercial space industry?***

The DoD benefits most from a robust private space sector, through which it can meets its own technology needs. Beyond this, being the world leader in space technology enhances U.S.

[2] Harrison, Todd and Kaitlyn Johnson and Thomas G. Roberts. 2019. "Space Threat Assessment 2019". Center for Strategic and International Studies. https://www.csis.org/analysis/space-threat-assessment-2019

influence globally. To achieve this outcome we recommend:

5. Revised barriers to exports and support for greater international trade of space technologies;
6. Reform of the process of acquiring clearances for government contracts;
7. Implementation of processes to reduce the degree of inefficient risk-aversion in space systems acquisitions and program management.

We argue that two broad areas – government acquisitions and global integration – are opposite sides of the same coin. In order to efficiently achieve solutions which address one area, the DoD must simultaneously take steps to address the other. We present a number of broad policy Courses of Action (COAs) the DoD should pursue. We additionally present several specific policies that might be implemented to support these COAs. We believe these policy changes will lead to a stronger United States both at home and abroad: security will be enhanced, the economy will be more robust and more resilient, and the U.S. will gain influence and leverage to direct the course of space use for decades to come.

In the following sections, we outline the current trends and problems in greater detail and then provide our recommendations for addressing these problems.

3.1. Space is Changing

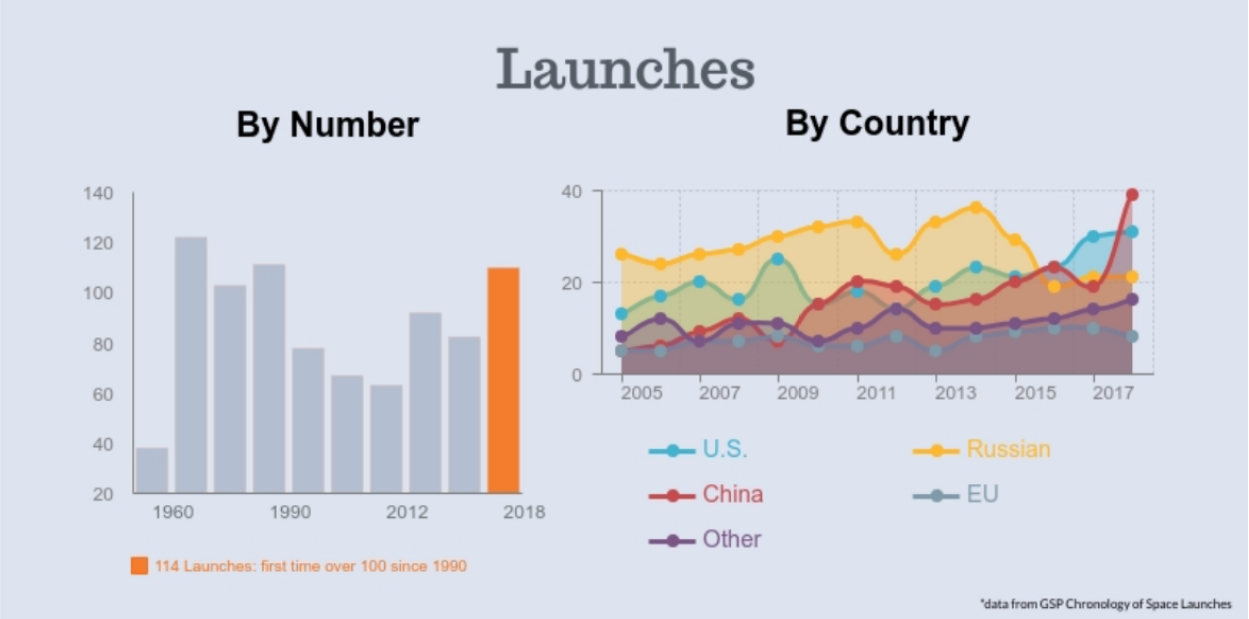
The domain of space has entered a period of rapid change in three main areas. Here, we discuss these changes in detail.

The Internationalization of Space

Space until recently has been dominated by two countries: the United States and the Soviet Union/Russia. Only in 2003 did a third country, China, launch a manned spacecraft into orbit. Although other countries launched satellites much earlier, starting with Great Britain's 1961 launch of Aerial One (albeit on an American rocket), this domain was similarly dominated by the two space superpowers. This has changed in recent decades. In 2018, China conducted 38 orbital launches, surpassing the United States' 34 launches. The number of space-faring nations is increasing as countries such as India, Israel, Iran, and South Korea build up their own capabilities. Even the developing world is seeking a piece of the action. In Africa, for example, Nigeria, Kenya, South Africa, Egypt, and Ethiopia have all expressed interest in developing a space program. In 2018, 57% of satellites in orbit belonged to countries other than the U.S.

The Commercialization of Space

Other governments are not the only players entering the space domain. In recent years, the use of space has becoming increasingly private in nature as companies capitalize on the vast possibilities space offers to technological advancement. Commercial space revenues doubled between 2005 and 2018. More space launches occurred in 2018 than at any time in the previous two decades. It is projected that by 2030, spending on space-related technologies, infrastructure, and services will reach $1 trillion, almost triple the amount spent in 2017.



As a result of this commercial boom, governments are increasingly interconnected with commercial space players, whether it be contracting with them for technology development, using their rockets for payload launches, or buying the services they offer through their systems. In short, the days of government-centered space programs are over: it is the private sector that will determine much of what occurs in space in the coming years.

The Integration of Space into Domestic Infrastructure

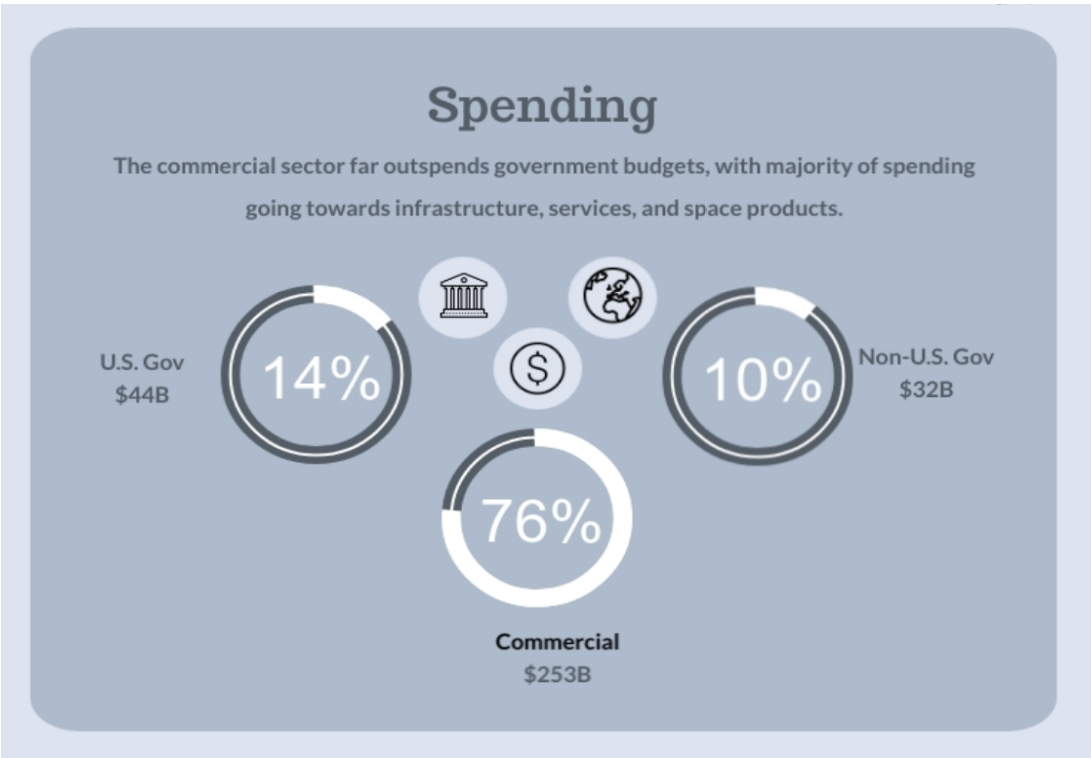
It is virtually impossible to go a day without depending on a space-related technology. Space systems are integrated into transit systems and mapping tools, financial exchanges, shipping routes, and a host of other activities. GPS alone creates a dependency for airlines, law enforcement, and app-based services. Even services such as credit cards, cloud computing, and energy grids indirectly rely on GPS timing. The same is true for governments, also. National security increasingly makes use of space-based systems and would face major challenges if that technology was compromised.

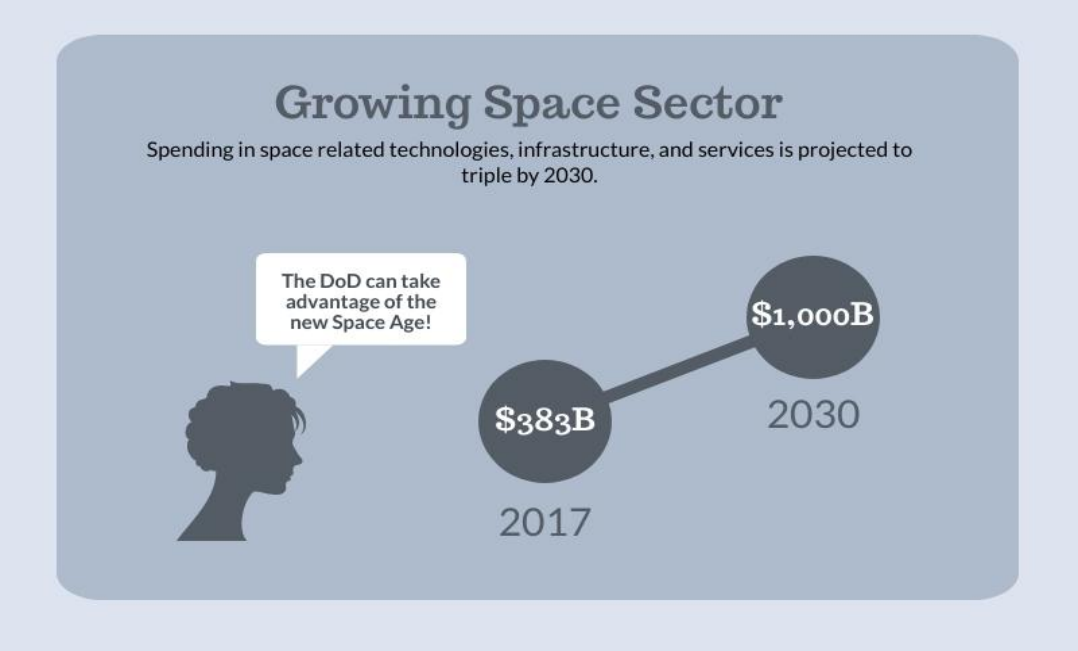
3.2. Broad-Scope Problems

These exogenous changes have resulted in several broad problems for the United States:

Threats to National Security

The United States has been largely unrivaled in space for decades. This trend is quickly shifting as other countries, and particularly adversaries and countries seeking to project global power, develop space-based defense systems. Such threats may be direct, such as from China. Others may be indirect, such as India's recent launch of an anti-satellite weapon (ASAT) that risks destabilizing relations with Pakistan and China and escalating to a potentially nuclearized conflict. Development in other potential adversary countries, such as Iran and North Korea, of munitions and technologies that can





take out U.S. space-based defense systems creates further concern for U.S. national security.

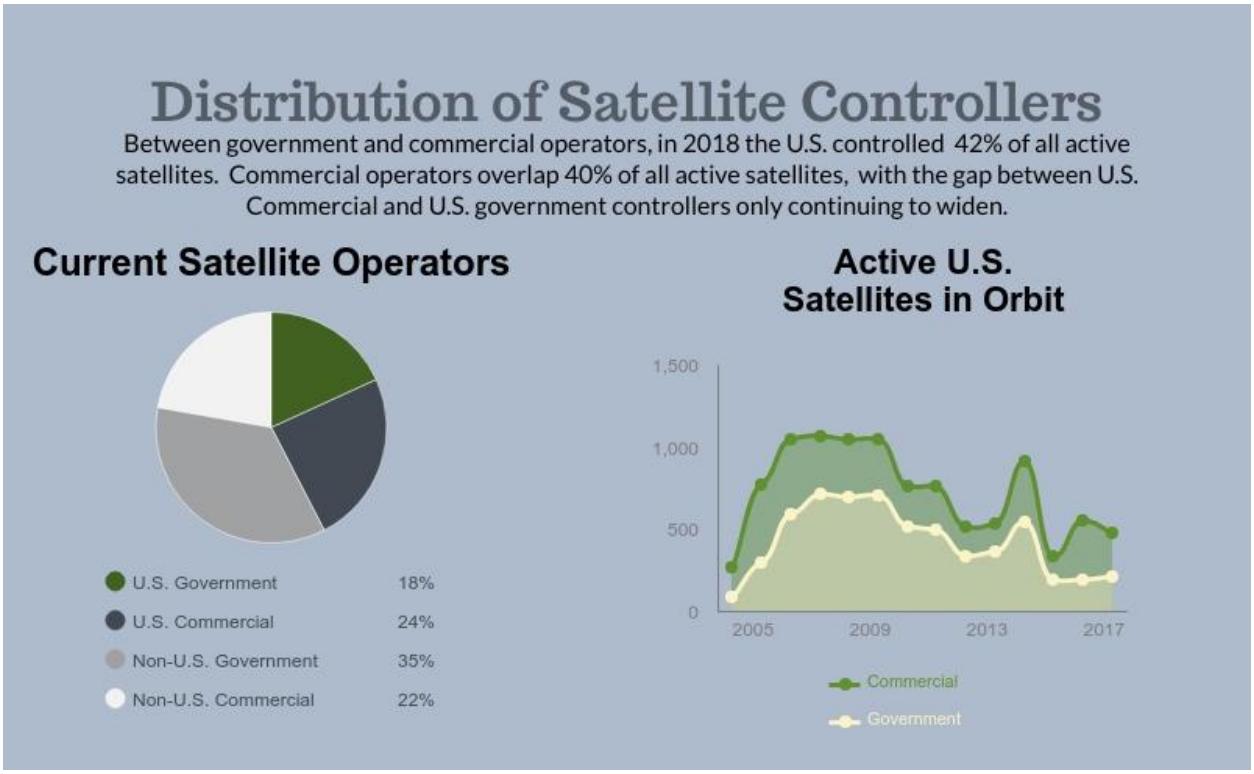
Decreasing Competitive Edge

As space becomes increasingly democratized, the technological gap between the United States and others will continue to close. In 2017, seed and venture investment in non-U.S. space startups totaled $480 million, up from only $153

million the year before.[3] As this trend continues, other major space-faring nations will be seen as sources of critical technology and will also develop the leverage to influence norms and regulations in the domain of space as they are developed.

Infrastructural Vulnerability

Related to national security, the United States is vulnerable to widespread economic and security threats posed by the fact that it has become increasingly depending on space-based technologies through widespread integration into everyday systems. Failure to secure space infrastructure leaves the U.S. vulnerable to severe economic disruptions through attacks on space assets.



Source: Union of Concerned Scientists, 2018.[4]

3.3. Narrow-Scope Problems

A number of more proximate issues exist that reduce the U.S.' ability to address the broad problems described above. These are largely issues within the U.S. government, and the DoD specifically, that suggest meaningful change from within could mitigate the effect of the global trends and even propel the United States into a position of steadier, more reliable

[3] Bryce Space and Technology. 2018. "Start-Up Space: Update on Investment in Commercial Space Ventures."
[4] Union of Concerned Scientists. 2018. "UCS Satellite Database." https://www.ucsusa.org/nuclear-weapons/space-weapons/satellite-database.

influence in the domain of space. These problems can be summarized as follows:

- Commercial space actors find it particularly difficult to work with the DoD – especially smaller and less well-established companies.
- Excessive regulation of technologies deemed "sensitive" prohibits exporting certain technologies abroad.
- The DoD continues to employ an antiquated way of doing business with commercial partners, resulting in an inefficient process and suboptimal outcomes.
- The culture of the DoD is one of resistance to change.
- The DoD struggles to manage relationships with partners and potential partners, including communication over prospective technologies and management of existing contracts.
- The political and public will to support an enlarged space program or a government-driven space sector is unpredictable at best, and lacking at worst.
- The centralization of the current space defense infrastructure leaves it vulnerable to foreign attacks or inadvertent crises (such as satellite collisions with space debris).

It is important to note that these problems all *already exist*. With the rapid expansion and integration of space into critical infrastructure, these problems will only be exacerbated to far greater proportions without adequate reform.

4. Policy Solutions and Recommendations

Our policy solutions and recommendations stem from recurring themes we heard across our interviews and in our extensive research of recently completed, ongoing, or proposed reforms. Our inputs fall into two broad categories and link directly to the specific questions our DoD sponsor posed:

Policies aimed at improving the DoD's ability to leverage commercial space for national defense, and **policies aimed at supporting the U.S. commercial space sector.**

For each category we have identified a set of potential solutions, and for each solution we have articulated a set of primary and secondary actionable recommendations.

4.1 Leveraging Commercial Space for National Defense

In the coming years, the DoD will require a much broader portfolio of spaced-based technologies to replace aging systems and defend against new threats. This will include systems to protect communication, navigation, and weather satellites, while acquiring new technology to address space situational awareness (SSA) in an increasingly congested space environment, as well as systems to protect existing assets.[5] Such a broad effort will require a quicker, more efficient path to acquiring such goods, which in turn demands a drastic reconsideration of the current acquisition process.

[5] Chaplain, Cristina T. 2019. "Space Acquisitions: DoD Faces Significant Challenges as it Seeks to Accelerate Space Programs and Address Threats." Testimony before the Subcommittee on Strategic Forces, Committee on Armed Services, U.S. Senate.

There is no shortage of research on flaws in the Federal acquisition process. In our discussions with industry and government professionals, this was the most commonly cited problem relating to space. This is not a new problem. What is new is the urgency with which this process must be updated to cope with the rapidly changing space environment. While there is no overnight fix for such a complex issue, here we identify a number of commonly raised concerns with the DoD acquisitions process and offer several recommendations for streamlining the process. The most common issues identified with the acquisitions process are as follows:

Cost – Space is expensive. Development of a DoD satellite can cost anywhere from $500 million to over $3 billion. Developing and maintaining satellite ground systems can cost more than twice that. Launching a satellite may cost a further $100 million. The DoD may be able to contract the lowest bidder for a project, but currently has little recourse for project cost overruns. The Space-Based Infrared System project (SBIRS) currently stands at a cost of $19.9 billion, a 265% increase on its initial projection of $5 billion. The advanced Extremely High Frequency satellite program (AEHF) has run 117% over budget, and the GPS III project currently stands at a 32% overrun.[6] The Evolved Expendable Launch Vehicle project had a final cost of $59.6 billion, a vast increase from the initial $18.8 billion projection.

Time – The DoD needs technologies fast to face current threats and avoid being obsolete. Much has been said of the slow acquisition process of recent decades. Attempts to reduce the time to deployment through such tools as Other Transaction Authorities (OTAs) have helped remove some of the obstacles to fast production. However, current remedies appear to have little capability to prevent delays. In fact, in addition to cost overruns, most recent projects have surpassed their initial deadlines: the first launch of SBIRS was delayed by 9 years, AEHF by 3 and a half years, GPS III by 4 years, and GPS OCX is currently 5 years behind schedule.[7]

Quality – It is not uncommon for a DoD contract to result in a product deemed inappropriate or insufficient for the initially intended purpose. This may occur for several reasons. First, product development in recent decades has often sought to placate Congress rather than create cutting-edge technology. During the post-Apollo period of the 1970s and 1980s, when attention on U.S. space supremacy had waned, the U.S.' space mission shifted from creating a world-leading space infrastructure to focusing on maintaining Congressional appropriations levels. The resulting shift in motivation heavily influenced the problems that would later plague the Shuttle program.[8]

Second, the end product may not be what the DoD originally sought, or may be rendered obsolete by the time it acquires it. The former can occur due to poor communication between the DoD and private companies, either from lack of technical expertise or an excessive clearance process that precludes a development team from understanding the true purpose of the technology. The latter can occur since acquiring

[6] Chaplain, 2019.
[7] Chaplain, 2019.
[8] Wiskerchen, Michael. 2010. "The Emerging Organizational Framework for the Space Commerce Enterprise." In Langdon Morris and Kenneth J. Cox (Eds) *Space Commerce.* Aerospace Technology Working Group: 130.

can take a number of years from the initial call for proposals, and thus may be outdated technology or no longer needed for the originally conceived purpose.

Third, the current incentivization structure of DoD contracts does not sufficiently push private companies to develop products of the highest possible quality. Cost-plus contracts, while appropriate for developing new products and services, are not appropriate for recurring deliveries of mature products and services. As the commercial sector matures, there will be increasing scope for the use of fixed-price IDIC/IDIQ-type contracts.

Risk – A common concern discovered through our conversations is the DoD's aversion to risk. At least one interview subject referred to this as "perhaps the biggest problem" with the current DoD acquisition process. This aversion informs its acquisition practices by leading to excessively cautious contracting plans, with unnecessarily high costs. Moreover, such caution makes it difficult for small or unseasoned companies to gain access to such contracts if more proven, larger companies seem less risky partners. This prevents the DoD from seeking new and potentially better technologies, or cheaper delivery methods, opting instead for what has worked in the past (referred to as "Heritage Hardware").[9]

Sensitivity to Political and Public Will – Government spending on space is determined by Congress, whose budgetary process is heavily impacted by political and public will. In the aftermath of the moon landing, space program budgets were slashed. While excitement over the establishment of the Space Force may offer a jump in political and public support that will increase spending on space, this too will pass. Such tenuous funding in a time of great need for space technology expansion suggests that a traditional, government-centered space program will be insufficient to meet needs.

Communication with smaller companies – Many commercial space professionals we interviewed, particularly those in smaller companies, cited the difficulty of communicating their needs and capabilities to government officials. Because such companies often do not have the staff to navigate the bureaucracy involved in government contracting, they struggle to advocate for their interests or share their capabilities. As the share of space technology innovation associated with smaller startups increases, the DoD will miss out on more and more opportunities due to such barriers.

Below, we outline several policy recommendations to address the problems described above.

4.1.1 Crisis Contingency Planning: A Civil Reserve Space Fleet

As the commercial space sector matures, the DoD will need to update its acquisitions process to reflect the increasingly service-oriented nature of commercial space businesses. For example, the growth in smallsat launchers who can reach LEO, and the corresponding growth in the use of constellations of smallsats in LEO, offers an opportunity to use spacelift as a commoditized service. On the other hand, during times of crisis, the DoD will need rapid access to large amounts of spacelift and orbital

[9] Pomerantz, William. 2010. "Moon 2.0: Private Planetary Exploration and the New Lunar Economy." In Langdon Morris and Kenneth J. Cox (Eds) *Space Commerce.* Aerospace Technology Working Group: 20.

capacity. Such crises could include ASAT attacks which disable existing space infrastructure or humanitarian crises in regions with limited U.S. military presence.

We propose that the DoD both take advantage of commercial space sector maturation and solve the problem of crisis capacity by establishing a Civil Reserve Space Fleet.[10] The CRSF proposal is modeled on the Civil Reserve Air Fleet, which has been effective at reducing operational costs and increasing agility during normal times and providing capacity surges during crises without the associated maintenance costs during normal times.[11] Unlike the CRAF however, the fully-matured CRSF would incorporate a variety of space-related services, from spacelift to orbital bandwidth and on-orbit servicing. The CRSF would involve two steps:

1. Enrolled providers pledge capacity which can be used during times of crisis.
2. During normal times, all providers are allowed to bid on contracts to deliver services for regular demands. Enrolled providers would be given "preferential treatment" proportional to their pledged capacity.[12]

This program does not necessarily involve a large change from the status quo – for example, the DoD already purchases bandwidth for SATCOM needs from commercial actors.[13] The CRSF would formalize this process for a wide range of commercial space products. Further, the CRSF could ensure that participating providers are guaranteed a reliable level of baseline demand – enough to smooth over some market turbulence, but not enough to supplant a sustainable commercial business model. This guaranteed baseline demand would ameliorate the problem of insufficient reliable demand, which we heard during our interviews as a reason to not prioritize DoD contracts.

The U.S. Merchant Marine program operated by the Navy offers another model for the CRSF. Commissioned ships primarily operate as troop and cargo transports during peacetime. During times of conflict or war, these ships serve as auxiliary supply vessels to supplement the U.S. Navy. This program could serve as an example for how the DoD can manage commercial satellite infrastructure as a part of the CRSF. As in the case of the U.S. Merchant Marine program, international conventions and agreements would play a large role in satellite-oriented operations.

From a security perspective, a CRSF offers two benefits. First, the program would provide a measure of "security by diversity" – rather than having one or a few large military targets for an

[10] For a more-detailed exploration of what such a program might look like, see Col. David C. Arnold's report on a SpaceCRAF.
[11] Defense Production Act, 1950.
[12] The preferential treatment mechanism we envision is similar to the one used by the FCC to rebate spectrum bidders for interference on the bands they receive: a provider who has pledged 20% capacity and submitted the winning bid would receive 120% of their bid. This mechanism has the potential to create Prisoner's Dilemma-like incentives for providers, such that pledging significant capacity becomes a self-enforcing equilibrium, while also driving down prices for contracts (reducing the acquisitions cost to the DoD) in normal times. In the equilibrium of this game, providers with preferential treatment are incentivized to submit lower bids to win, such that the total amount paid can be lower than what would have been paid with no preferential treatment.
[13] Brown, Don, and Michael W. Moyles. 2008. "Rethinking the Relationship." Space News. https://spacenews.com/rethinking-relationship/.

adversary to attack, the CRSF would create a collection of smaller commercial targets, such that an attack on one or multiple segments would not shut down the DoD's space systems. Second, by reducing the costs of acquiring and deploying capabilities, a CRSF would leave funds available for other defense needs.

While certain requirements may require dedicated military systems, there are military space needs which do not require such systems. The opportunity cost of dollars spent on dedicated military systems can be high when there are myriad defense needs and limited funds available. Further, as with government spending in other parts of the economy, military spending on space systems likely crowds out some degree of private spending.[14] While military investment in research and development is an important source of innovation in space technologies, reducing the degree of private investment into the space sector will likely increase the cost to the government of deploying and maintaining space capabilities.

Recommendations

House CRSF at Hq SMC due to familiarity with acquisitions and program management, and borrow a small team from USTRANSCOM to share experiences with CRAF operations. This team's responsibilities will include:

- *Creating day-to-day operation manuals*
- *Establishing appropriate contracting methods*
- *Connecting with relevant agencies (such as the FAA)*
- *Training a staff in SMC to manage the CRSF*

Start with small-scale initial program working with launch providers of small to medium sat devices (e.g. Rocket Labs, Firefly, Electron). Once the office managing CRSF in SMC is established and contracting with smaller launch providers, they can initiate contracts with larger and established providers.

We recommend beginning the program with 5-10 contracts for 2-3 years with a constant real (inflation-adjusted for aerospace industry) yearly budget.

- *If more time is needed for sufficient "lessons learned", extend the trial period by an additional 2 years.*
- *Once the program has been tested and is working effectively, SMC can draw up plans to expand the program to communications, data storage and transmission, Earth and Space based imaging, and present as well as future in-situ operations (e.g. re/de-orbits, on-orbit repair, refueling, and human transit).*

Alternate Recommendations

House CRSF at Hq Air Force Space Command, SAF/AQS, or Air Staff for their familiarity with acquisitions.

Follow same operational details as in the primary recommendation.

4.1.2 Use of Public-Private Partnerships

The acquisition of technologies by the DoD, and specifically relating to space, currently faces major problems outlined above. These problems can largely be attributed to a flawed

[14] Estimating the degree of crowd-out is an important step towards building an optimal military space investment portfolio, but is beyond our scope here. Crowd-out effects have been observed in other contexts, such as government-sponsored housing credit on private credit supply (Fieldhouse 2019, Sharpe and Sherlund 2016), charitable contributions (Kingma 1989), and foreign direct investment and domestic entrepreneurship (De Backer and Sleuwaegen 2003).

and antiquated acquisition process, ranging from the initial call for a project, through its development and construction, to its operational management and maintenance. Much of the foundation for this system is based on the DoD's desire to control most elements of a project, its strong aversion to risk, and an internal culture marked by resistance to change. This problem promises only to worsen as the DoD faces an increased demand for space-based defense systems with constraints on both its spending and management capacity to do so.

A primary tool to overcome many of these problems and create a more efficient process of acquisition is through the use of Public Private Partnerships, which leverage the resources and expertise of both the public (DoD) and private (space tech companies) parties, leading to reduced costs, more reliable timelines, more innovative products, and a reduction of risk shouldered by the DoD. Moreover, PPPs strengthen industrial competitiveness and allow the U.S. government to be driven by product needs rather than budgetary allowances.

The benefits of PPPs have been widely championed in both the space and non-space sectors. No fewer than 36 U.S. states have passed legislation since 1991 to support the use of PPPs for public projects.[15] At the Federal level, PPPs have been implemented for various public works, defense, and space exploration projects. PPPs also support a number of existing policies, including the 1958 National Aeronautics and Space Act, the 2010 National Space Policy, and the 2016 National Defense Authorization Act. Each of these promote the streamlining and tailoring of acquisitions for space or defense technologies. It also supports DoD Directive 5000.01 to "include the best use of public and private sector capabilities through government/industry partnering initiatives".[16]

PPPs differ from traditional government contracts in several ways. Most obviously, they use private funding rather than government funding at the outset of the project. This may be provided by the contracted firm itself or by third party capital investors. Costs can then be recouped through product usage fees, such as tolls paid for a privately-built road, or continued use of the product by the private actor after completion. Such projects offer myriad benefits to the DoD and resolve a number of the problems that currently plague the acquisitions process. Some of these benefits include:

1. Access to external funding

Since the project is initially funded by private entities rather than the DoD, pursuing spaced-based technologies can be driven by need rather than available resources. This is of particular benefit when space budgets are stymied by lack of political support or excessive budgetary earmarking. Moreover, the increasing need for more and better space technology demands a steady source of funding beyond what the U.S. government can provide.

2. Reduced cost and schedule overruns

Where cost and schedule overruns are a perennial problem for government space projects (as described above), PPPs offer an incentive structure to avoid such outcomes. First, while the traditional cost-plus contract format offered little incentive for companies to work efficiently and at a lower cost, PPPs

[15] National Conference of State Legislatures. 2017. "P3 Infrastructure Delivery: Principles for State Legislatures." http://www.ncsl.org/Portals/1/HTML_LargeReports/P3_Infrastructure_1.htm.
[16] Department of Defense. 2016. "Public-Private Partnering for Product Support Guidebook."

leverage private investment and tap into the profit-driven element of commercial enterprise. PPP projects therefore offer value for money to the government. Second, cost and schedule certainty can be delivered through incorporating penalties for missing targets.

3. Access to high-quality innovation

PPPs drive innovation and quality. As one example, unlike traditional contracts where the government assumes full control of and responsibility for the technology upon its completion, PPPs typically require the contractor to retain responsibility for the operation and maintenance of the product for a certain period thereafter. This incentivizes contractors to produce the best possible products that will require minimal maintenance and will be less likely to experience faults. With traditional contracts, the lack of such an incentive drives contractors to work according to design specifications (give the government what it asks for) rather than being performance-driven (give the government what it needs).[17] This is particularly problematic if the government lacks the expertise in the product it has requested, and is subsequently provided with an inappropriate product where the producer had little incentive to ensure mission success.

4. Reduced DoD risk while maintaining sufficient control

The PPP format helps resolve the problem of the DoD's significant aversion to risk by shifting a large portion of the risk onto the private contractor. This occurs in several ways. First, since the government does not provide initial funding for development and construction, it is the private actor that loses if the project fails. Second, PPPs typically have built-in penalties for failure to meet established standards or milestones.[18] This motivates project efficiency and reduces the likelihood of unforeseen costs to the government. Third, being responsible for operation and maintenance as well as construction, the risk incurred by failure is largely retained by the contractor.

The PPP format also provides benefits for the private contractor, as well as any third-party capital investors involved. Such benefits include:

1. Enhanced market competitiveness

Since the PPP arrangement spurs innovation, competitiveness, and good business models in private contractors, it strengthens that company for broader purposes. Traditional, cost-plus contracts lack these drivers, and therefore inhibit companies from being pushed towards efficiency and performance. Such improvements increase the viability of the company and make it more competitive in domestic and international markets.

2. Dual-use capability

In some instances, the technology developed for the DoD may have dual-use capability, such that it can thereafter be marketed for non-government purposes. This provides an additional and sustainable source of revenue for the company.

3. Return on investment

[17] Jones, Karen L. 2018. "Public-Private Partnerships: Stimulating Innovation in the Space Sector." Center for Space Policy and Strategy, the Aerospace Corporation: 7.

[18] Syracuse University. 2016. "Public-Private Partnerships: Benefits and Opportunities for Improvement Within the United Sates." http://eng-cs.syr.edu/wp-content/uploads/2017/04/P3Report.pdf: 10.

With lower costs and shorter schedules of delivery, return on investment is faster and larger. Moreover, if technologies have dual-use capabilities, either by customers paying for the government's service or the contractor selling the technology on the market, future revenues can be acquired beyond just the government's payment for the product.

Given the above benefits, PPP contracts might be considered a "win-win-win" for those involved: The DoD acquires better products for less cost, on time, and with minimal risk, while also supporting domestic space industry; the private space sector gains lucrative contracts and an ability to earn future revenues from offering their competitive products in broader markets; and capital investors fronting the initial funds for the project can gain a larger return on investment in a shorter amount of time.

It is also important to note that PPPs are very different from one project to the next, and as such are not guaranteed to be successful. Effective PPPs are heavily dependent on a number of factors, the most important of which is the quality of the contract.[19] A positive example of a PPP is NASA's Commercial Orbital Transportation Services program (COTS), where private entities provided transport to the International Space Station. The private entities had to develop and maintain the systems with only a portion of the seed money provided by NASA, and received revenues in a pay-for-performance system that promoted efficiency in development. The dual use capability of such technologies for purposes like space tourism offer further dividends for the private companies.[20]

Recommendations

Conduct analysis on the potential benefits of PPP contracts for upcoming space projects, gathering results and "best practices" from previous space-related PPPs including the National Geospatial Agency's Enhanced View program, the U.S. Air Force's Evolved Expendable Launch Vehicle program, NASA's Commercial Orbital Transportation Services program, and Germany's TerraSAR-X/TadDEM-X project.

Review outcomes of previous DoD PPP projects, including the Sniper Pod project, the F404 Engine project, the M1 Abrams program, and the F-35 Lightning II Fighter project.

Compile best practices and consolidate methods of existing PPP evaluative bodies including RRAD, LEAD, TACOM, and DLA, which were involved in evaluating performance of the U.S. Army's High Mobility Multi-Purpose Wheeled Vehicle project.

Engage the Defense Contract Management Agency in discussions of feasibility and capacity for developing a broader PPP portfolio.

Advance strategies for implementing PPPs in the establishment of the Space Development Agency.

4.1.3 Management of DoD-contractor project relationships

The disaggregation of space through the DoD working with more commercial actors is a necessity. However, such a transition is not without its own problems. The DoD already faces bandwidth problems in communicating and managing relationships with private entities

[19] Syracuse University. 2016. "Public-Private Partnerships: Benefits and Opportunities for Improvement Within the United Sates."
[20] Jones: 10.

in the space sector. Introducing a more diffused system of product acquisition will fail if structures are not put in place to manage such relationships effectively.

Working alongside more commercial partners and adapting to new roles in those relationships will require substantial training, pre-contract negotiation, and subsequent management of the carefully tailored relationships between the DoD and the contractor. As described above regarding PPPs, each contract will require a very specific set of guidelines, expectations, and responsibilities for each party involved. Such a workload demands devoted attention.

We therefore recommend the establishment of an independent or quasi-independent body charged with overseeing public-private contract relationships, specializing in reducing complexity, increasing transparency, and maximizing efficiency. This body would be best as an independent (i.e. non-government) entity both to reduce additional costs for the government as well as to signal neutrality between the parties: the office would not be beholden to government bureaucracy or political pressure. This task would therefore be inappropriate for bodies such as the Space Development Agency or the Defense Contract Management Agency, although they may work closely together. The tasks of the office would include the following:

1. Determining the projected benefit of the project compared with a traditional government contract;[21]
2. Oversee negotiations between the public and private parties to the contract;
3. Inspect and support the development of a viable business model from the private party;
4. Create and implement an evaluation and feedback structure for progress of the project;
5. Identify problem points and make recommendations to avoid cost and schedule overruns;
6. Manage communications between the parties throughout the life of the contract;
7. Create and conduct a training program to educate industry and government actors on the benefits and logistics of such contracts.

Recommendations

As in 4.1.2, collect analysis of prior PPPs and establish best practices in relationship/contract management.

Conduct a feasibility study of developing or supporting the establishment of an independent PPP oversight office, working in conjunction with the Defense Contract Management Agency.

4.2 Supporting the U.S. Commercial Space Sector

Successful acquisition of space technology for defense purposes is contingent on, and complementary to, a robust domestic space sector. Where private industry is supported and empowered to innovate and grow, it can better develop technologies to benefit the United States, while also generating revenues to support the U.S. economy. Given the increasing role of space in domestic infrastructure, future economic success will depend heavily on

[21] Jones: 8.

success in the domain of space. Here, we outline several options to accomplish this.

4.2.1 Trade Liberalization and Market Integration

While reducing frictions between the DoD and the U.S. commercial space sector is desirable from the perspective of increasing the DoD's access to cutting-edge space technologies and delivering cost efficiencies, it does not address the international competitiveness of U.S. space companies. A lack of international competitiveness has two main deleterious effects on U.S. national security. First, it reduces the probability that U.S. providers of strategically important capabilities will be commercially viable in the long run as they lose international markets to foreign competitors. Second, it increases the rest of the world's ability to produce these capabilities, which both cuts U.S. firms out of global value chains for space services and may lead to the rise of new capabilities to which the DoD does not have access. The latter effect reduces the U.S.' ability to affect international patterns of space use and creates openings for adversaries and competitors to gain global influence at the U.S.' expense. Further, the risk of "deemed exports" under ITAR can have a chilling effect on research and development into technologies which the DoD may find relevant.[22]

Increasing the presence of U.S. commercial space companies in global value chains can reduce the incentive for adversaries to attack U.S. commercial space infrastructure. There is no shortage of research to suggest economic interdependence reduces conflict between states.[23] This effect offers an additional layer of deterrence to protect U.S. commercial interests and strategic advantages in space. This "security by mutually-assured destruction" notion has historically been employed by the U.S. in other national security contexts. Additionally, military-commercial space interactions may increase the U.S. commercial sector's reliance on government contracts. To the extent that such reliance weakens the space industrial base by subjecting it to the vicissitudes of the DoD budget, it weakens U.S. national security. By fostering greater competition, a healthy commercial space ecosystem in the U.S. also reduces the prices of space services, further facilitating cost efficiencies for the DoD.

A key tension of trade liberalization in this context is between being too restrictive on state-of-the-world technologies and harming U.S. commercial competitiveness, and being too permissive on state-of-the-art technologies and harming U.S. national security. An indirect security cost of excessive restrictiveness is that it may encourage foreign customers to seek non-U.S. suppliers, reducing the commercial viability of U.S. suppliers of space systems.

To support the DoD's goals in maintaining a space industrial base with cutting-edge space technology and achieving low-cost space systems delivery, we believe OSD should support greater trade liberalization for space systems through two related fronts:

1. supporting processes which move space systems from the U.S. Munitions List and ITAR list to the Commerce Control List, and

[22] GAO 2019 report on "Commercial Space Industry Launches a New Phase Specialist in Industrial Organization and Business December 12, 2016, Author: Bill Canis.

[23] See for example Oneal, John R. and Bruce Russett. 2000. *Triangulating Peace: Democracy, Interdependence, and International Organizations.* New York: W.W.Norton & Co.

2. working with entities such as the Space and Missile Systems Center, the Space Development Agency, and industry partners to develop clarify existing definitions in the USML and CCL and an actionable definition of "state-of-the-world technologies" which would facilitate the transfer of items from the USML to the CCL.

Comments on the Department of Commerce's Advance Notice of Proposed Rulemaking emphasized some of the points here, including the need for clarification regarding specific terminology such as the distinction between "space launch vehicles" and "space vehicles".[24] and the reduction in space-related research activity due to the risk of "deemed exports" under ITAR.[25]

Recommendations

OSD should support processes which move space systems from USML and ITAR to CCL.

Develop a process to determine whether technologies are "state-of-the-world" on shorter timelines faster than the traditional NPRM cycles. "State-of-the-world" technologies should be given export licenses on expedited schedules, ideally on the order of two weeks or shorter.

4.2.2 Reducing risk aversion in acquisitions and program management

A complaint we heard frequently during our research, from both government and commercial space professionals, was that the acquisitions process is overly risk-averse. These problems were generally of two types: acquisitions officers facing strong disincentives against risk would opt for excessively cautious contracting plans, increasing costs and potentially reducing access to emerging technologies; and acquisitions and program management personnel being assigned 1-2 year rotating placement in space-focused offices struggling to accumulate enough institutional knowledge about the commercial space sector to be as efficient as possible during their tenure.

Recommendations

OSD should provide a clear set of guidelines and methods program managers and acquisition officers can follow to improve program speed and efficiency, while still maintaining an appropriate level of risk awareness. The Air Force RCO was often cited in our research as being able to find ways to move fast within the bounds of the FAR; it may be worthwhile to borrow 2-3 AFRCO members to develop best practices for other offices.

Reward healthy risk awareness through incentive programs. It is important that "no action" become less relatively attractive than a possible failure which can deliver valuable lessons learned.

- *One simple way to address this is through financial incentives for delivering lessons learned documentation from policies which failed to have the desired effect.*

Increase the prevalence of long-term placements for space acquisitions and program management, or design shorter rotational placements with the goal of developing a space acquisitions workforce. Longer placements or space-focused rotations would facilitate officials building relevant

[24] Tom Stroup. 2019. "Satellite Industry Association Comment on DOS_FRDOC_0001-4798." https://www.regulations.gov/document?D=DOS-2018-0048-0003.
[25] Eric Hammond. 2019. "Universities Space Research Association Comment on DOS_FRDOC_0001-4798." https://www.regulations.gov/document?D=DOS-2018-0048-0006.

institutional capital and knowledge. This is related to notions being currently discussed around creating more space-focused career tracks. Ensuring the presence of space-specific acquisitions and program management personnel can promote a stronger sense of acceptable risks for action and inaction.

Consider establishing a "Space Innovation Working Fund" for space-related acquisitions. The fund would have reporting requirements, but would be a fixed pot of funds that can be used on speculative projects which may incur greater risks.

Develop ways to integrate legal teams into acquisitions and program management processes, rather than having legal analysis "bolted on" separately.

4.2.3 Reducing the time to issue a clearance

The long time horizon to issue security clearances, and the requirement that clearances be tied to specific contracts, was often cited in our interviews as a hindrance for smaller space companies such as startups. The requirement to hold a contract in order to obtain a clearance, and to hold a clearance to view classified contracts, was cited as a particularly difficult hurdle for smaller space companies who did not yet possess clearances.

One way to think of these issues is as fixed costs which create barriers to entry. While the imperative to restrict access to classified material is a clear and real national security issue, the barriers created by clearance-related fixed costs reduce the number of firms competing for any given pool of contracts, driving prices up and leaving fewer dollars available for other national security needs. Ultimately, excessive delays and barriers in issuing clearances harms national security.

Many of our interviewees in both the commercial sector and government argued that over-classification has exacerbated these issues. The argument presented most often was that over-classification stemmed from strong risk-aversion from those managing contracts. In addition to limiting the DoD's ability to access emerging space technologies, over-classification can also harm commercial innovation and civil uses of space technologies. One example we heard in this regard was classification of high-resolution infrared imagery, which would assist firefighters dealing with wildfires. As environmental problems of this type become more frequent, the costs imposed by limited technology flows to the commercial and civil sectors will become more severe.

While we have determined a set of potential policy solutions to address this issue, it is a thorny problem area which has resisted solution attempts for decades. Our solutions all come with tradeoffs and open questions for implementation. Our primary recommendation to OSD, therefore, is to dedicate resources to investigating these and other solutions which can reduce inefficient clearance-related frictions between the DoD and the U.S. commercial space sector.

We have identified two potential solutions which we believe show promise. Below we describe each, along with some relevant tradeoffs and open questions.

1. Establishing "clearance clearinghouses"

One bottleneck in the security clearance process is the time it takes to assemble a dossier on

applicants. To reduce this time for a broad class of potential applicants in the space sector, we propose facilitating the creation of "clearance clearinghouses": commercial or non-profit entities operating in the aerospace industry who could begin the process of compiling the necessary information about individuals. It is important to leverage industry associations to the maximum extent possible to avoid the appearance of the DoD "picking winners and losers". However, the use of industry associations brings its own problems, largest among them the potential for conflicts of interest (i.e., industry associations being the ones "picking winners and losers"). To avoid potential conflicts of interest, industry associations whose members (a) pay substantial fees, (b) represent concentrated interests, and (c) compete for contracts, should likely be excluded from consideration. Such entities include the Satellite Industry Association or the Space Enterprise Consortium.

Instead, academic entities such as the AIAA or IEEE which have some experience dealing with classified aerospace research could be leveraged. While these entities collect nominal fees from individual members, as individuals their members face higher barriers to widespread collusive activity. While many of the members of such groups may be employed by companies in the SIA, SpEC, or other associations with the conflicts of interest described above, these members also include students and other potential applicants who may be less professionally connected to the commercial aerospace world. This could be conducted as an opt-in program, e.g. AIAA or IEEE members could be offered the opportunity to complete a pre-screening and opt-in to sharing regular information disclosures/updates to facilitate the process of receiving a security clearance should they apply.

The most relevant open questions we have identified here relate to the scope of information disclosures and ensuring their security. What is the right level of information for individuals in these programs to disclose? Who ensures the information is secure?

2. Using the SBIR system to accelerate clearances for small businesses

A more targeted approach would be to focus on accelerating the clearance process for small businesses which are already receiving federal grant money. Specifically, many different departments including the DoD already offer Small business Innovation Research grants (SBIRs). There are 3 phases of a SBIR: feasibility, prototyping, and commercialization. Since entities participating in DoD SBIRs are already working on technologies which are likely of value to the DoD, it seems reasonable to use this process as a way to accelerate the process of delivering clearances and contracts to appropriate companies.

We believe that Phase II of the SBIR process (prototyping) is a logical place to focus these efforts. Once a company has determined feasibility and begun prototyping, if the project seems likely to lead to a contract, the DoD entity managing the SBIR grant could initiate the clearance process for the grantee. Given the average time to process clearances and the length of the Phase II grant, the required clearances for the company would be at least partially processed by the time the company enters phase III (commercialization). This would enable the company to better understand the DoD's needs, and potentially begin work on any

needed modifications while pursuing commercial revenues.

While this proposal leverages existing program management infrastructure, it will likely require 2-3 years of trial implementation to determine pain points and viable solutions. One open question relates to the timeline. While Phase I is likely too early to initiate clearance processes as the project's feasibility has not been fully determined at that stage, initiating the clearance process in Phase II could make it difficult for grantees to make any necessary adjustments to their product in time to meet the DoD's needs at the end of the SBIR program. By the time the clearance has been processed and the grantee has access to relevant classified information on the DoD's needs, they will likely 6be along the road to commercialization in Phase III.

3. The third breakdown for accelerating the clearance process is categorizing the clearances.

It will provide an organized and robust system for offering clearances. This shall split up the clearances into classes such as military and civil. Furthermore, lots of confusion and delay occurs when investigators are reviewing an applicant in categories that are unrelated to the clearance they're applying for. The process for a single clearance is first conducting a background investigation, second, granting an interim or temporary clearance, and finally periodic investigations. This by nature is already a lengthy process. The government personnel that is investigating the applicant can grant the applicant the clearance in a much faster timeline. Further categorization can occur by dissolving military into special operations, cybersecurity, and defense. For civil, two direction are proposed: academic and industry.

Recommendation

Investigate ways to use industry associations or existing grant-funding programs to accelerate the clearance process for smaller space companies.

6. Conclusion

Bold changes to DoD space policy will be required in order to fully leverage the benefits of the changing space domain. More importantly, the extent to which the DoD – and the U.S. government more broadly – adapts to the emerging conditions will determine how central the U.S. will be in the coming decades: not only in space, but in global leadership. These changes may not occur overnight, nor will they receive universal support. However, the frustrations with the current processes will only be exacerbated as space continues to become internationalized, commercialized, and integrated. We believe the solutions and recommendations outlined above are a first step towards taking a modern approach to a modern problem, and establishing the U.S. as the leader in space for the foreseeable future.

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