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LEVERAGING COMMERCIAL SPACE FOR NATIONAL SECURITY

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The increasing commercialization of space is presenting new opportunities for national security acquisition. Because of commercial developments in space-based weather; remote sensing imagery; radiofrequency collection; communications; positioning, navigation, and timing; and space situational awareness—among other areas—U.S. intelligence and defense agencies are considering alternatives to the traditional model of hiring contractors to develop bespoke capabilities. Some space capabilities could be treated like personal computers or passenger cars, which the government acquires as commodities from private companies rather than develops via contractors. Or space services could be treated like email clients or search engines, such as Microsoft Outlook or Google search, which the government licenses but does not own. In this new space era, U.S. space leadership will face many decisions over which acquisition model to use in a particular case. Given the potential of leveraging commercial services to accelerate the fielding of important capabilities and to preserve resources for quintessentially military capabilities, it behooves leadership to prepare for the analytic task of answering that question in many different mission areas, and to take the necessary steps to prepare to acquire commercial capabilities and services at scale for military applications. Our national security space enterprise and the commercial space sector are at critical junctures. National security leadership needs to consider the models it wants to use for its next-generation systems and business rules for how to balance them.

Introduction

In May 2020, U.S. astronauts launched into orbit aboard a commercially procured rocket for the first time in history.[1] The launch was both a direct manifestation of, and a metaphor for, the dramatic growth we have witnessed in the commercial space sector in the last decade. This growth is largely due to rising private investment, lower technical barriers to entry, and conscious choices by government to permit commercial activity in previously restricted areas. Private investment in startup space firms increased from less than $500 million per year from 2001 to 2008 to roughly $2.5 billion per year in 2015 and 2016.[2] Satellites are getting smaller and cheaper; launch costs have fallen.

In this new space era, increasing commercialization extends to national defense, with private companies offering services such as space situational awareness, responsive launch, synthetic aperture radar, and hyperspectral imagery that used to be exclusively carried out by the governments of major powers. In other areas, such as in communications and electro-optical

imagery, private companies have been engaged for decades but are now fielding systems in quantities that dramatically surpass those of the U.S. military and intelligence community. Based on Seradata's Spacetrak subscription database, Figure 1 shows the number of active satellites in orbit from 2005, 2010, 2015, and 2020.[3] As shown in the figure, satellites owned by U.S. private companies are driving much of the increase in satellite activity.

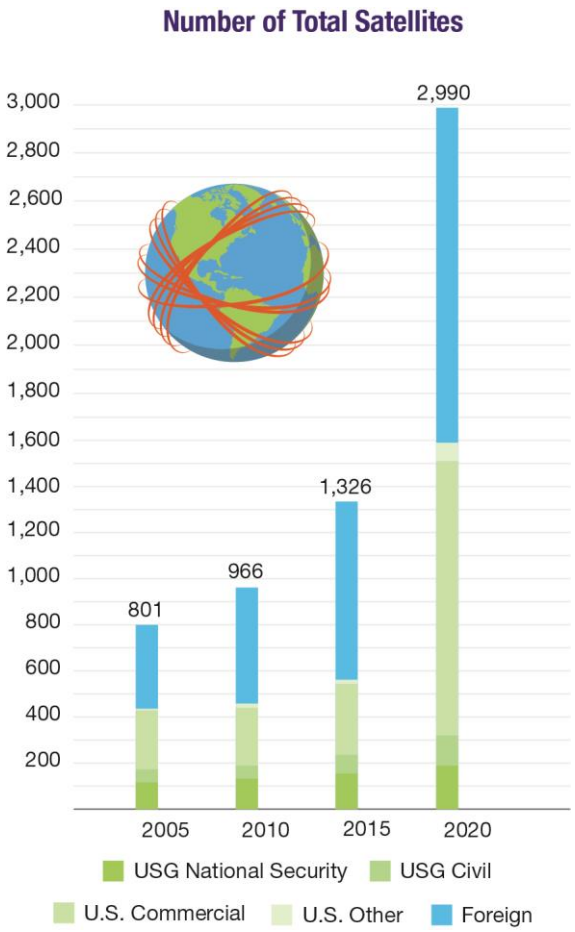

Figure 1: Satellites by owner, from 2005 to 2020.

Three Models of Space Acquisition and Hybrids

The increasing commercialization of satellite technology with defense applications presents serious opportunities for defense acquisition. It also places pressure on the traditional model of hiring contractors to develop bespoke capabilities for government programs. But conceiving of the changes as offering a binary choice of make-versus-buy is overly narrow and could lead to missed opportunities. It is more productive instead to think of the democratization and commercialization of space as offering a spectrum of opportunities to leverage commercial capabilities.

Over time, some space capabilities could be treated like personal computers or passenger cars, which the government acquires as commodities from private companies rather than develops via contractors. Or space services could be treated like email clients or search engines, such as Microsoft Outlook or Google search, which the government licenses but does not own. Table 1 lists these three broad models but, in the emerging environment, acquisition approaches are likely to be less frequently a pure manifestation of one of these models and instead a hybrid that combines the different models to meet different parts of the need.[*]

In this new space era, U.S. space leaders will find themselves considering the latter models more frequently in multiple capability areas, and likely will shift further toward the latter approaches to take advantage of ongoing and future commercial developments. Currently, U.S. national security space leadership is seeking to reduce the cost of providing basic capabilities on which the national leadership, the joint force, and the nation as a whole rely in order to free up resources for addressing potential adversaries' efforts to deny those capabilities to the United States. In this environment, programmatic options that rely on commercial and hybrid architectures to provide some degree of capability may enable the national security space community to shift investment to next generation bespoke systems, and these options may also deliver novel capabilities.

[*] For more information about the defense acquisition models, please see Karen Jones and Geoffrey Reber's chapter in the Space Agenda 2021 titled, "Continuous Production Agility: Future Proofing the National Security Space Enterprise," September 17, 2020 (https://aerospace.org/policy/space-agenda-2021).

Table 1: Three Models for Defense Acquisition	
Name	**Description**
1. Traditional (Developmental Programs of Record)	Hiring contractors to develop custom-made capabilities
2. Commercial Off -the-Shelf	Procuring existing commercial hardware, which the government would own and operate, including for government-unique purposes
3. Purchased Services	Procuring services from commercially owned and run space and ground systems (including potentially in a Services Oriented Architecture or Infrastructure as a Service)

Shifting Balance Among Models

Some areas in commercial space activity that have national security applications have progressed substantially in recent years. Notable examples include remote sensing or Earth observation, satellite communications, and space situational awareness. U.S. national security space acquisition has been shifting to leverage some of these commercial capabilities. This includes defense and intelligence agencies contracting with commercial companies for capabilities and services as well as promoting concepts that would integrate commercial and government systems.

Remote Sensing/Earth Observation. Remote sensing satellite capabilities are advancing significantly, both qualitatively and quantitatively. Commercial systems now comprise a large share of remote sensing satellites. Based on data from Seradata, about 270 of the 620 remote sensing satellites in orbit are privately-owned, about 200 of which are owned by U.S. companies. In contrast, about 50 are owned by the U.S. military or intelligence agencies.[4] Figure 2 shows, from 2005 to 2020, the evolution in the quantity of U.S. commercial remote sensing satellites in comparison to remote sensing satellites owned and operated by U.S. defense and intelligence agencies. While the number of U.S. national security assets has stayed relatively flat, the number of commercial systems has jumped dramatically – nearly tripling from 2005 to 2010, nearly quadrupling from 2010 to 2015, and nearly quintupling from 2015 to 2020.

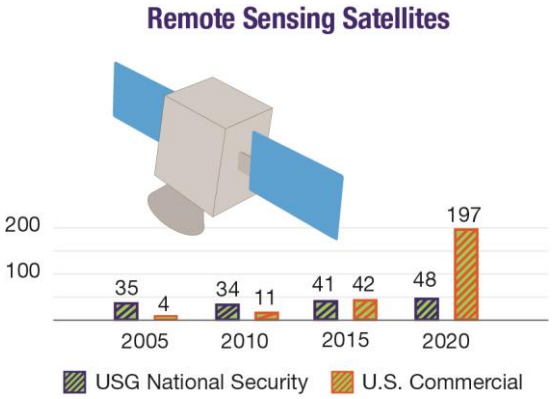

Figure 2: Remote sensing satellites by owner, from 2005 to 2020.

The large number of commercial remote sensing satellites is due, in part, to companies offering traditional electro-optical imagery (digital pictures) with high revisit rates (being able to take imagery of the same location frequently), which can help companies monitor changes on the ground to make informed decisions. Commercial providers have realized that excellent temporal resolution (revisit rates) can be complementary or in some cases more valuable than high spatial resolution. To achieve this capability, companies are deploying large numbers of small or midsized satellites. Planet, for example, achieved a 150-satellite constellation in 2018 with the goal of being able to take an image of the entire Earth each day.[5] Maxar is working on its next generation constellation called WorldView Legion, which reportedly will be able to revisit some locations on Earth up to 40 times per day.[6] Other remote-sensing satellite companies, such as BlackSky and SatRevolution, are also seeking to deploy large satellite constellations for electro-optical imagery.[7]

And the rise in commercial remote sensing is not limited to just electro-optical. Companies such as PredaSAR Corp, Iceye, Umbra Lab, and Capella Space are developing commercially-owned synthetic aperture radar satellites, which can take imagery of the Earth through different atmospheric conditions during the day and at night.[8] Maxar and other firms market

infrared imagery.[9] HawkEye360 and Aurora Insight are two examples of companies that offer satellite-based radiofrequency collection services, which—by detecting and geolocating a range of radiofrequency emitters—could be valuable for transportation tracking and search and rescue, among other applications.[10] A slew of companies are also proposing hyperspectral remote sensing satellite systems, technology that could theoretically identify chemical composition, which might help agricultural conglomerates better decide what crops to plant in which fields but also can be used to spot a camouflage tarp hiding a weapon system.[11]

The surge in activity and improvement in quality is contributing to what we have called a "GEOINT Singularity"—the potential for the "convergence, and interrelated use, of capabilities in artificial intelligence, satellite-based imagery, and global connectivity, where the general population would have realtime access to ubiquitous intelligence analysis."[12]

As of late, U.S. national security elements have been leveraging more of these commercial remote sensing ventures. Maxar, Planet, and BlackSky have contracts in place for their data with an intelligence agency.[13] In 2019, HySpecIQ was awarded an intelligence contract for a commercial hyperspectral imaging study.[14] In June, Capella Space announced a cooperative research and development agreement with the National Geospatial Intelligence Agency (NGA), the first such agreement for commercial synthetic aperture radar data, and has received contracts from the Navy and the Air Force.[15,16,17] Another intelligence agency recently established a Commercial Systems Program Office that will oversee procurement of commercial imagery.

Perhaps more so than any other satellite service capability, remote sensing epitomizes the rapid commercialization of previously tightly held government national security technology, allowing national security organizations around the world to use the third model: buying commercial services rather than simply designing their own capabilities. That many world-leading companies are based in the United States provides an advantage to the U.S. and its allies.

Space Situational Awareness. Space situational awareness capabilities have historically been primarily owned by major government powers. A 2018 Institute for Defense Analysis report says: "Until recently, the United States Department of Defense (DOD) was the only organization in the world—outside perhaps Russia—to develop high-fidelity space situational awareness information."[18] But in recent years, commercial players have been more involved in developing space situational awareness capabilities for purchase. LeoLabs established a space radar in New Zealand in 2019 that allows it to track objects as small as two centimeters in low Earth orbit.[19] Numerica offers commercial space situational awareness services, and it receives data from more than 130 optical sensors positioned worldwide. These are just two examples of a burgeoning industry trying to fill a need for commercial companies to monitor and track their satellites.

U.S. defense organizations are seeking to exploit these commercial projects. The Air Force has collected information from several commercial space situational awareness companies as it experiments with how to integrate a wide variety of data sources. According to a report from *Breaking Defense,* Assistant Secretary of the Air Force Will Roper said that the Air Force was receiving information from LeoLabs, Numerica, ExoAnalytic Solutions—which can track objects in geosynchronous orbit using optical and passive radio frequency telescopes—and Rincon, a commercial network using passive radio frequency telescopes.[20,21,22] The Air Force is not the only government customer for these companies: on its website, ExoAnalytic Solutions also notes that it has been "committed to developing technologies for the U.S. Missile Defense Agency to enable robust missile defense architectures."[23]

As commercial solutions improve, DOD will have more options for integrating and using more commercial space situational awareness data. In some case, the companies, such as LeoLabs, are only selling their data, not their radars or telescopes, which might push the department to rely more on the third model of purchasing capabilities as a service.

Communications. Satellite communications are perhaps the richest place for defense agencies to leverage commercial capabilities. The vast majority of communications satellites are owned and operated by private companies. Based on data from Seradata, there are approximately 1,570 communications satellites in orbit, about 1,040 of which are U.S. systems. Of the U.S. satellites, about 960 are owned by private companies and 50 are owned and operated by the U.S. military and intelligence community. Figure 3 shows, from 2005 to 2020, the evolution in the quantity of U.S. commercial communication satellites in comparison to communication satellites owned and operated by U.S. defense and intelligence agencies. As is the case with remote sensing satellites, the number of U.S. military and intelligence community-owned assets has stayed relatively flat while the number of U.S. commercial systems has increased dramatically.

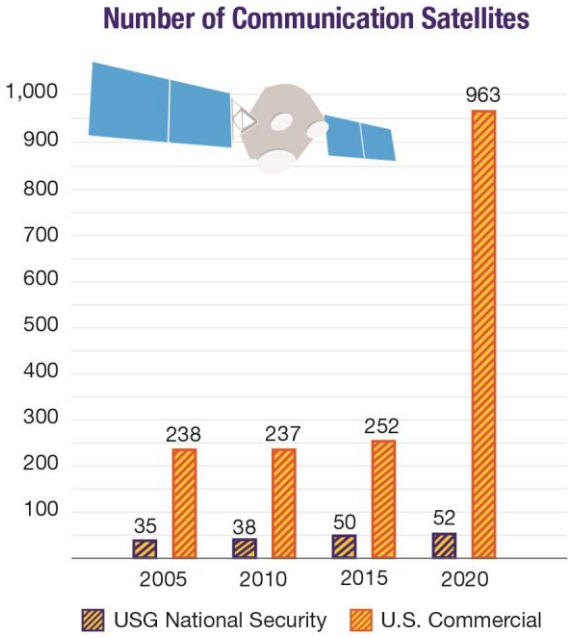

Figure 3: Communications satellites by owner, from 2005 to 2020.

Even these large numbers may see geometric growth in the next few years. Multiple companies, including SpaceX and Amazon, have filed requests to launch hundreds or thousands of small communications satellites. This would represent a transformation in the level of activity we have grown accustomed to in space. For example, SpaceX has announced plans to launch 40,000 satellites for its Starlink constellation, far exceeding the about 3,000 active satellites of all kinds currently in orbit.[24] (This scale of increase would also create a need for space traffic management services far beyond those currently in use.[25])

The Department of Defense has contracted for some of its satellite communications needs for years.[†] But today the DOD is exploring new ways to capitalize on this explosion of commercial communications satellites, including in its "Fighting Satcom" operational vision released in 2020.[26] In it, the Space Force refers to Fighting Satcom as collectively using military satellite communications and commercial satellite communications, as a single enterprise, in a contested environment. While traditional commercial satellite communications are more susceptible to jamming and interference than military communications, a more diverse set of capabilities complicates adversaries' planning and investment. This ambitious vision will entail acquiring services from commercial entities in addition to acquiring unique military capabilities and commercially derived capabilities like the Wideband Global SATCOM system, thus pushing toward a hybrid of the first, second, and third acquisition model.

Other Capabilities and Services. Remote sensing, space situational awareness, and satellite communications are just three examples of the broader commercialization of space and the associated opportunities it brings to national security. Positioning, navigation, and timing (PNT) is another area where there are many players. To name just a few, Draper Laboratory offers alternative navigation technologies to GPS; The Aerospace Corporation (Aerospace) has demonstrated another GPS-independent positioning technology; CTSi and L3 Technologies developed an enhanced link navigation system that could be used in the absence of GPS; and Iridium uses communication links to provide satellite time and location services.[27,28,29] Like PNT, space-based weather has long been dominated by government-owned capabilities, but commercial providers are emerging. Companies such as Spire, GeoOptics, and PlanetiQ use small satellites in low Earth orbit to develop profiles of moisture and other properties of the atmosphere.[30]

[†] The Defense Information Systems Agency (DISA) has for decades contracted to gain additional bandwidth from commercial providers. "Satellite Communications: Strategic Approach Needed for DOD's Procurement of Commercial Satellite Bandwidth," Government Accountability Office, GAO-04-206, December 2003 (https://www.gao.gov/new.items/d04206.pdf).

The possibilities extend beyond simply satellites. For ground stations, for instance, Kongsberg Satellite Services and Amazon both offer access to a ground network of locations and antennas across the globe.[31,32] The first director of the Space Development Agency (SDA), Fred Kennedy, said that for its proposed proliferated satellite constellation the agency was looking to acquire commercially off the assembly line, espousing the second acquisition model, not just for the satellites but for an array of capabilities: "If I can buy payloads, if I can buy ground command and control software, hardware, user equipment, if we could get user terminals from the commercial side, then I can maybe do minimal ruggedization and put [it] on ships, planes, Humvees, you name it. That's big," said Kennedy.[33] The SDA architecture now includes elements from all three models, and explicitly embraces hybrid approaches which build on strengths of each. The opportunities for using commercial systems span the full range of capabilities and services.

Advantages and Risks in Acquiring More Commercial Services

Realizing the potential of commercial systems for national security acquisition—relying on the latter acquisition models—will pose advantages and risks. For several space capabilities, the advantages of using commercial capabilities are significant enough that U.S. space leadership should seriously consider embracing more risk.

Quicker Acquisition and Technology Refresh Versus Giving Up Control. A big advantage of buying off-the-shelf capabilities or services is saving time. As Aerospace has previously reported, "Under the current approach, it can take more than 10 years to develop, build, and launch highly complex space systems."[34] Where they exist, buying off-the-shelf capabilities or services could enable circumvention of the lengthy requirements, contracting, and development process.

A related advantage of using commercial capabilities is rapidly incorporating new technology. Steve Jobs famously said, "People don't know what they want until you show it to them." This completely flips the traditional government development and acquisition model, which begins with users identifying a gap in capabilities, defining specific requirements of a materiel solution to close that gap, hiring a contractor to develop a system to meet those requirements, and then procuring that bespoke system. While there are many areas where that model is still appropriate, the democratization of space technology means that there are an increasing number of areas where that kind of commercial development logic can apply to the government and even national security capabilities. National security agencies may not know which technologies to pursue until they are available and demonstrated. Buying commercial capabilities and services allows them to take advantage of technological maturation rather than try to predict which technologies may mature or force them to mature through direct government investment.

A trade-off in cutting lengthy requirements definition and procurement processes is that the government will have less control over the exact parameters of the capabilities it buys and will have to rely on what it can buy. And in cases in which the government uses the third model—buying services, not capabilities—it will have even less control over the system. Further, some of the companies that the government may want to use may be foreign. For example, according to the data from Seradata, roughly 27 percent of the commercial remote-sensing satellites in orbit are owned by foreign companies.[35] Many U.S.-domiciled technology firms raise funds from a global investor base, which may include both innocuous passive investors and more problematic players. Acquiring more from commercial industry in a globalized economy will require appropriate vetting of companies and their products, done in a way that does not raise unreasonable obstacles to new players.

But the risks should not dissuade us from using these alternative models, even if problematic companies are off-limits. Quicker acquisition offers huge advantages. It would create more agility in our enterprise, generate potential savings, and allow us to adapt our national security space architecture to the threats as they evolve. In the past, the gap between commercial and government capabilities was so large that it was worth waiting to develop something exceptional; the shift to commercial advantage is accelerating and will likely continue to do so.

Undefended Assets Versus More Resiliency. A critique of acquiring commercial capabilities for defense purposes is that they will not be as protected as military systems. We would not ideally bring a cruise ship to a naval battle, for instance, though many ocean liners were pressed into service as troop transports in World War I and World War II and several were sunk. However, incorporating more commercial systems could actually enhance the overall resiliency of a network or capability. All else equal, more satellites would be more resilient to an attack than a comparable attack on fewer satellites. And in areas like communications, more diversity of spectrum and waveform creates more challenges for an adversary looking to obstruct communications. This is part of the rationale and theme underlying the Fighting Satcom concept for satellite communications. By integrating commercial and military communications capabilities, our forces would have more assurance that they have global connectivity even in contested environments where one or more signals are denied or degraded.

Construct for Considering Which Acquisition Model to Use. In considering the value of commercial systems in producing an architecture that is resilient as a whole, it is also important to consider the capabilities where governments ought to retain maximal control, and those are the military capabilities directly tied to the use of violence. For instance, if the United States were to adopt one or more forms of space weapons (e.g., weapons from ground-to-space, space-to-space, or space-to-ground), the third capability acquisition model (services) would be extremely problematic, and the applicability of the second model (commercial off-the-shelf) would also be limited.[♯] Such capabilities should warrant serious reflection and debate, and likely would be considered through a more traditional requirements process.

As noted, acquiring off-the-shelf capabilities or services entails a certain level of risk; for capabilities directly tied to violence, the appetite for risk should be much lower. While governments may buy simpler weapons systems like firearms based on commercial developments, more complex weapons capabilities are much more likely to be custom-made to reflect precisely what the government wants. This is particularly true in uncharted areas where civilian weapon analogues are unavailable, like satellites. Additionally, while some private companies have been willing to sell militarily-relevant services like communications or imagery to the government, some may be reticent to be directly engaged in the kill-chain, much less to directly sell lethal effects; therefore, drawing a sharp line at capabilities tied to violence could also help with commercial cooperation. But while weapons get much of the attention when it comes to equipping and operating a military, in the real world beans are often as important as bullets; for many capability areas, the advantages of commercial resiliency are likely to outweigh any risk.

Figure 4 diagrams the spectrum of options for acquiring military space capabilities, showing which capabilities would be appropriately procured under more traditional models (blue) versus the second model of acquiring commercial capabilities (yellow) and the third model of acquiring services from commercially owned capabilities (orange). Moving left to right, the space capabilities shift from the innocuous (e.g., ground stations and weather satellites) to force enhancement (e.g., tactical intelligence and communications in the kill chain) to direct force application (e.g., space-to-Earth weapons, Earth-to-space weapons, and space-to-space weapons, potential capabilities most closely tied to the use of violence). The figure gradually shifts from orange to yellow to blue (least control with acquisition approach three to most control with acquisition approach one), but the three colors are interspersed throughout because the acquisition model for any particular capability will depend not just on whether it is tied to violence but also on the options for that capability or service from commercial companies – which will often raise capital and make investments based on an ability to serve a market that reaches well beyond government purchasers.

[♯] There are areas where the U.S. government and its contractors do employ private companies in areas closely tied to the use of violence, including private security firms in war zones, but this model has multiple problematic aspects, especially if extended to space.

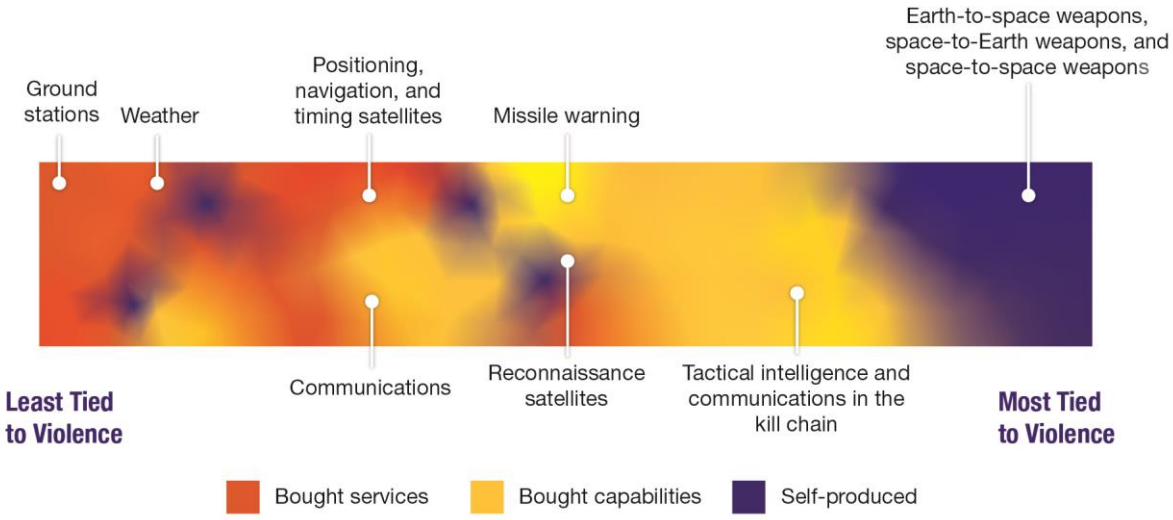

Figure 4: Spectrum of Acquisition Approaches for Space Capabilities

Still, acquiring non-commodity commercial technology is a tricky matter for the federal government, where there are strong legal requirements for competition in contracting. There are well-understood acquisition pathways for buying mundane supplies, and also for buying bespoke technology. The in-between areas are harder because specifying the decision criteria can be tantamount to picking the winner of the competition. The Department of Defense's troubled cloud computing services contract competition is a cautionary tale here; multiple companies sued the department and concerns of political interference loomed over the process.[36]

A Way Ahead

U.S. space leadership will face many decisions that are essentially about considering which acquisition model to use in a particular case. Given the potential of leveraging commercial services to accelerate the fielding of key capabilities and preserving resources for quintessentially military capabilities, it behooves leadership to prepare for the analytic task of answering that question in many different mission areas, and to take the necessary steps to prepare to acquire commercial capabilities and services at scale for military applications.

This issue has received senior-level attention. In 2019, General John Raymond said: "And I see [our partnerships with commercial industry] as a big growth area going forward. We have a commercial integration cell on the floor at the Combined Space Operations Center. I see great, great steps ahead in being able to leverage this."[37] The U.S. Space Force seems intent on pushing for hybrid architectures with commercial partner services playing a growing role.

Driving towards the latter acquisition models may require further changes in organizations. Traditionally, users who might be most interested in what the commercial capabilities and services could deliver to them today do not have money. In the Defense Department, acquirers—who have the money—are organized to design and build stuff, not buy services. The commercial integration cell at the Combined Space Operations Center and intelligence community offices aimed at acquiring commercial products are a good start to bridging this gap, as are cooperative research and development agreements, which allow agencies to explore opportunities for deeper partnerships and commitments with commercial players. The Defense Department should continue these efforts and revisit whether its organizational models need to adjust to better leverage commercial developments.

In a democratized space environment, for most defense applications, leadership should start by first looking to the non-traditional acquisition models and leaning more heavily on commercial capabilities. This includes the capabilities mentioned above as well as others—space weather, meteorology satellites, perhaps even missile warning. The list goes on. After looking at the more commercial models, leaders will likely find that capability gaps remain—but they may well require only narrower solutions, and in some cases the gaps may simply be acceptable given the faster timelines for adopting commercial technology.

Our national security space enterprise and the commercial space sector are at critical junctures. Our space leadership needs to consider the models it wants to use for its next-generation systems and business rules for how to balance them.

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