CENTER FOR SPACE POLICY AND STRATEGY

JULY 2024

THE SPACE DEVELOPMENT AGENCY AND THE FUTURE OF DEFENSE SPACE ACQUISITIONS

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Summary

The Space Development Agency (SDA) is at the forefront of the DOD's efforts to reshape U.S. space capabilities, with plans to acquire and field hundreds of satellites over the next few years. This will have a significant impact on both national security space operations and acquisitions as relatively smaller, highly networked satellites perform missions previously reserved for larger, less networked satellites. Although still early in executing its plans, SDA has already shown that it can field systems with impressive speed, leading to claims that it has created a model for rapid acquisition that other defense organizations can follow.

SDA is creating a model for rapid acquisition with distinct characteristics that have contributed to its early progress. Yet analysis of SDA's approach also indicates that other defense acquisition organizations will face challenges adopting the SDA model for their programs. Further, SDA is likely to face its own challenges sustaining its model. Congress and DOD leadership have been supportive of the agency and have given it tremendous budgetary and acquisition flexibility. Whether SDA continues to receive flexibility may depend on its operational success as it pursues quantities and time frames never before achieved in defense space acquisition.

Introduction

The U.S. military is shifting the composition of its space architecture to better prepare for a new era of competition. While the DOD has historically relied on small numbers of large, highly sophisticated, but less networked satellites, it is now pursuing a future in which hundreds of small, highly networked satellites will provide many core space capabilities. A primary motivation for this change is the need to improve resilience in the face of increasing threats. As senior DOD leaders have stated, military services are "fundamentally transforming [DOD'S] space architecture to be more resilient, proliferated, and integrated to meet warfighter requirements to counter the growing threat from strategic competitors."[1]

The recent surge of interest in proliferated space systems for both defense and commercial applications is driven partly by complementary technical innovations: increasingly capable small satellites and decreasing launch costs.[2] But this concept is not new. Current efforts to increase resilience by fielding greater numbers of smaller space systems resemble those led by the Strategic Defense Initiative Organization starting in the 1980s.[3] Even so, the DOD's shift to a more

proliferated space architecture is having a profound effect on the defense acquisition system, the processes used to plan for, resource, and acquire new weapon systems. SDA, one of three U.S. Space Force acquisition organizations, is helping lead this shift.* Since its creation in 2019, SDA has launched 33 satellites or payloads, and it plans to field and sustain a constellation of about 500 satellites within about 4 years as part of its Proliferated Warfighting Space Architecture (PWSA).

SDA has been able to move from contract award to satellite launch in as little as 27 months, earning praise from Congress, senior military leaders, and other stakeholders more accustomed to measuring space acquisition programs by years or decades. Even though it has not yet demonstrated its systems' capabilities at scale, SDA has been touted for providing an acquisition model that other organizations should adopt. However, the precise features and mechanisms of SDA's acquisition approach have not been comprehensively studied, including whether it is exportable to other organizations.

This paper argues that SDA is creating a distinct acquisition model, enabling it to deliver new capabilities quickly and establish a foundation for continued growth. The characteristics of SDA's model can be organized in three broad categories—structure, culture, and process—each of which have contributed to SDA's progress. But other defense acquisition organizations will likely encounter challenges adopting this model and the underlying attributes that shape SDA's approach. For example, a structural characteristic of SDA's model is that it is designed to build and support a space architecture made up of many satellites that are regularly replaced over time. This provides notable benefits, including more predictable, stable funding and the ability to defer requirements to future efforts. In contrast, most defense acquisition organizations, for which each acquisition is a stand-alone effort, operate with less certainty and greater constraints.

SDA is in a critical period to show proof of its early promise, with near-term plans to demonstrate capabilities using satellites already on orbit and to greatly increase its launch tempo for follow-on satellites. The agency is likely to encounter several obstacles fielding and then maintaining its architecture, including sustaining a competitive industrial base and scaling its networking capabilities. The success of the SDA model, as well as the organization's ability to continue operating with the flexibility that has enabled its early progress, will depend on SDA's ability to navigate these challenges.

The DOD's Future Success in Space Depends on Rapid Acquisition

The Space Force was created, in part, to overcome space system acquisition challenges and to elevate the importance of space within the DOD.[4] Although the Space Force is struggling to field several critical acquisition programs that it inherited from the Air Force—most notably the Global Positioning System Next Generation Operational Control System (GPS OCX) and Space Command and Control (Space C2)—it is pursuing new approaches and initiatives to help the space acquisition community shake some of the pejorative labels that have hounded it for decades.[5] Shortly after being confirmed as the first Assistant Secretary of the Air Force for Space Acquisition and Integration, Frank Calvelli outlined three priorities for future acquisition efforts: speed, resilience, and integration.[6] The Space Force's use of authorities and processes to rapidly acquire and

*The other Space Force acquisition organizations are Space Systems Command and the Space Rapid Capabilities Office. For the purposes of this paper, a proliferated system is defined as one that uses many satellites to provide capabilities that either have been or could be provided by fewer satellites.

field space capabilities is critical to delivering on those priorities.

Achieving More Rapid Acquisition

Moving faster is a perennial acquisition objective. As the DOD's history of defense acquisition states, "few problems in acquisition have received more attention than the increasing length of the weapons procurement cycle," noting that numerous studies have tried to solve the issue since the end of World War II.[7] However, acquisition delays persist. Because an acquisition program is meant to deliver a system that closes one or more capability gaps, these delays have a direct warfighting impact, which may be exacerbated by changes in technology or threats before the acquisition program is complete. For example, an acquisition program designed around technologies available at conception may face obsolescence issues by the time the system is delivered. Similarly, the warfighting gap or gaps the program was designed to address may change in severity or priority due to advances in adversary capabilities. Space systems are particularly vulnerable to some of these challenges. Unlike other types of weapon systems, such as ships or aircraft, a fielded satellite cannot be readily retrieved from space for hardware upgrades or depot maintenance and then redeployed.

The *National Defense Authorization Act for Fiscal Year 2016* marks a significant milestone in the search for faster acquisitions. In it, Congress directs the DOD to create alternative acquisition pathways separate from existing procedures. These new pathways were intended to streamline processes and maximize legal and regulatory flexibility, in part so that capabilities that could be delivered quickly were not slowed by unnecessary tasks.[8] In a related provision, Congress mandates two specific pathways, one for rapid prototyping and one for rapid fielding, known as the middle tier of acquisition (MTA) pathways.[†] An acquisition program using either MTA pathway was intended to last between two and five years and provide options for transitioning to another acquisition pathway. The DOD quickly began initiating acquisition programs as either rapid prototyping or rapid fielding MTAs.[9] Despite later concerns from Congress and audit organizations that the authorities extended too far, potentially diminishing oversight and contributing to poor program outcomes, the Space Force adopted the MTA pathways as a primary mechanism for accelerating a range of space acquisition programs.[10]

SDA and Its Acquisition Model

Since its creation in 2019, SDA has been exploring approaches to rapidly acquire and field warfighting capabilities. SDA has shaped its acquisition approach around two central principles, proliferation and spiral development—the process of incrementally delivering new capabilities.[11] Because SDA has been able to demonstrate progress with its early efforts, prominent voices have cited it as a model for rapid defense acquisition and called on other organizations to adopt SDA's approach.[12] SDA's growing influence within the DOD, as well as with Congress, has translated into a surge in funding. SDA's budget increased by a factor of 35 from its first enacted budget in fiscal year 2020 to its enacted budget in fiscal year 2024. Since fiscal year 2022, Congress has also appropriated about $1.5 billion more for SDA than had been requested.[13]

[†]Rapid prototyping is meant to support the use of innovative technologies to develop fieldable prototypes that demonstrate new capabilities and meet emerging military needs. Rapid fielding is meant to support the use of proven technologies to field production quantities of new or upgraded systems with minimal development required. *National Defense Authorization Act for Fiscal Year 2016*, Public Law No. 114-92. (November 25, 2015).

Advantages of Proliferation

Proliferated space systems offer key advantages. First, they support faster acquisition cycles. These satellites typically operate in low Earth orbit (LEO) below an altitude of 2,000 kilometers, much closer than traditional missile warning, communications, and defense space systems.[14] Satellites in LEO have a relatively short design life of about five years, in part because they face greater atmospheric drag and have to burn more propellent to maintain orbit.[15] This constraint puts pressure on the defense acquisition system to deliver affordable replacements before operating satellites fail.[16] Second, proliferated space systems are more resilient against some types of threats. Traditional satellite systems improve resilience through hardware design features, such as reserve fuel and thrust capabilities to maneuver from an attack. In contrast, proliferated systems improve resilience through architectural design features in that the constellation can continue performing its mission even after the loss of one or more satellites. For some types of kinetic attacks, such as an anti-satellite missile, an adversary would likely need to expend considerable resources to sufficiently degrade or disable a proliferated space system.

Traditional defense space systems include small numbers of large, highly capable satellites built to demanding specifications. These systems rely on bespoke designs and dedicated production lines to provide the performance and reliability needed for national security space missions. In contrast, SDA's proliferated architecture will be comprised of greater numbers of smaller, simpler satellites that are easier and cheaper to design, build, launch, and replace. These systems deliver performance and reliability through improved networking, better leveraging commercial technologies, and more frequent launches of upgraded satellites.

The next few years mark a critical period for SDA. In addition to more fully demonstrating the capabilities of its satellites already on orbit, SDA plans to begin significantly increasing its launch tempo. In September 2024, for example, SDA expects to start a monthly, almost year-long launch campaign for its follow-on systems.[17] Demonstrating capabilities and increasing the number of satellites in its architecture will bolster SDA's plans to reach initial warfighting capability—154 operational satellites.‡ Figure 1 shows the anticipated growth of SDA's on orbit satellites over the next decade.

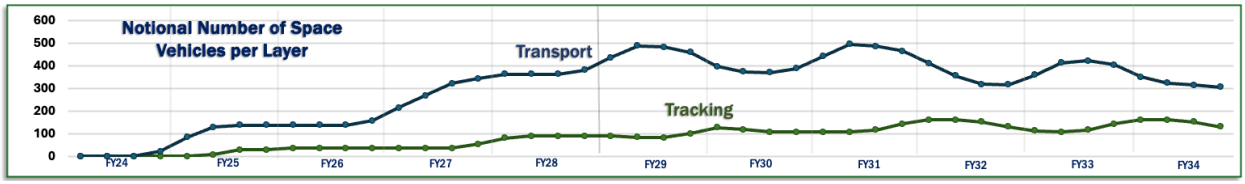

Figure 1. Current and planned number of SDA satellites in the Proliferated Warfighter Space Architecture (PWSA) per layer. (Source: Space Development Agency 2023)

‡SDA's definition for the PWSA's initial warfighter capability is tied to the successful launch of 126 Tranche 1 transport satellites and 28 Tranche 1 tracking satellites. This would provide "persistent regional access" for data and communications through the Transport Layer and a "limited global [missile warning and missile tracking] capability" for the Tracking Layer. Space Development Agency, "SDA 101: Delivering Capabilities," April 2024.

SDA is developing a distinct acquisition model, the features of which can be organized into three broad categories: structure, culture, and process. A more comprehensive understanding of the SDA acquisition model is necessary to better assess both the organization's acquisition progress and its potential exportability to other acquisition organizations. Figure 2 provides a basic definition of the SDA model's three categories.

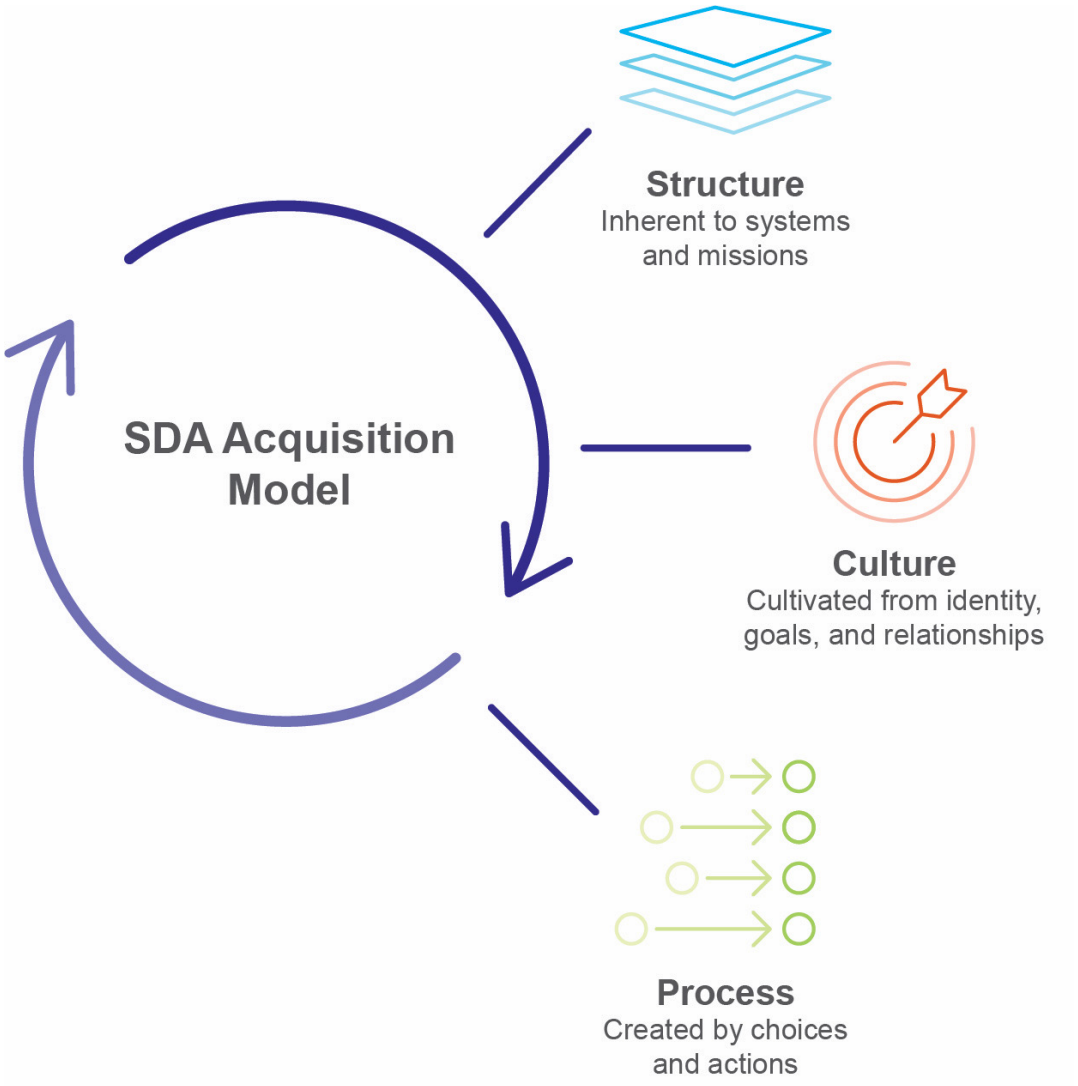

Figure 2. The SDA acquisition model's three categories.

Structural Components of the SDA Model Provide Key, Distinct Advantages

The SDA model's structural components are those attributes inherent to the types of systems SDA plans to deliver and the missions those systems will support. Absent significant changes to SDA's planned architecture or related missions, these structural components will remain constant, helping shape many features of the other two categories. Structural components are also the most difficult for other organizations to adopt, in large part because their acquisition programs are designed to deliver a discrete weapon system.

Architecture-Centric Acquisition

The first structural component of SDA's model, and its most distinctive and important feature, is that its acquisition programs are designed to populate and maintain a satellite architecture that will support a range of warfighting capabilities. This architecture-centric approach is the reverse of how most acquisition programs operate. Typically, a weapon system acquisition program starts by identifying a capability gap and then determining the most appropriate solution to fill that need. This results in a development article, or prototype, that is tested before the final system is produced and then fielded at scale. Fielded units are maintained throughout operations, and then decommissioned when no longer needed, too expensive to fix, or when a replacement system is available.

SDA began with an architectural approach and then worked backward to identify the most appropriate missions it would support. The March 2019 memorandum that created SDA explicitly defines the organization's mission through this perspective, outlining broad goals: "The SDA will define and monitor the Department's future threat-driven space architecture and will accelerate the development of new military space capabilities necessary to ensure our technological and military advantage in space for national defense."[18] The memorandum goes on to explain that the DOD needs a new space surveillance and communications architecture to address threats from near-peer competitors and that "no existing organization can deliver the proposed transformational architecture at the scale necessary to support the breadth of [DOD] requirements."[19]

SDA's mission objectives evolved over several years. In a 2018 report, known as the *DOD Space Vision*, the department outlined eight "capability development efforts" the DOD would pursue to compete in the space domain more effectively.[20] These efforts represent broad warfighting capabilities including "persistent global surveillance for advanced missile targeting," "highly-scaled, low-latency, persistent, artificial intelligence-enabled global surveillance," and "development of deterrent capability."[21] The document charged SDA, which had not yet been formally established, with developing and fielding the capabilities outlined in the DOD Space Vision.[22] However, these capabilities encompass a massive scope, likely far more than any organization could achieve in a meaningful time frame, and thus needed to be more narrowly defined into discrete objectives.[23] By 2020, SDA had defined its two initial capability goals: (1) beyond line-of-sight targeting for time-sensitive ground and maritime targets, and (2) beyond line-of-sight targeting for advanced missiles, such as hypersonic missiles and dim-upper stage missiles.[24] These capabilities remain the organization's near-term priorities.[§]

[§]This is not to suggest that SDA has abandoned the rest of the capabilities listed in the DOD Space Vision. Some of those capabilities are embedded within the beyond line-of-sight targeting efforts, while others have been incorporated in longer-term research efforts. Space Development Agency, "SDA One Pager," May 2023. https://www.sda.mil/wp-content/uploads/2023/05/SDA_One-Pager_Update_FINAL.pdf. Space Development Agency, "SDA Technology Roadmap," January 2024. https://www.sda.mil/wp-content/uploads/2024/01/SDA-Tech-Roadmap_Wide-v2.0-1.pdf

Mission Flexibility

The second structural component of SDA's model is that key parts of its architecture can support many different missions. The largest portion of SDA's planned architecture is the Transport Layer, which will eventually include hundreds of satellites that create a mesh communications network for low-latency data transmission.** All space-enabled missions rely on transmitting some type of data and benefit from increases in transmission speed and reliability. The Transport Layer is intended to deliver space sensor data directly to warfighters, including through existing tactical radios. Also, because SDA's iterative spiral development approach involves regularly refreshing hardware on orbit, the architecture can be modified over time to meet changing priorities far more easily than traditional acquisitions built to serve a particular mission or set of missions.

No Finish Line

The third structural component of SDA's model is that the planned proliferated architecture has no predetermined end point. The intended design life of SDA's satellites is up to five years, and SDA plans to replenish its satellites every two years. Therefore, even when the architecture is fully populated, SDA must execute concurrently at least two acquisition programs for each layer in perpetuity to ensure replacement systems are available on schedule. In important ways, this approach more closely resembles the acquisition of software than hardware, wherein each tranche acts as an update to provide regular, incremental improvements. And like software, a proliferated architecture is never done.[25] This implied, long-term commitment will likely be reinforced as SDA grows its user community, expanding the number and types of missions it supports.

Cultural Components of the SDA Model Strengthen Vision and Common Identity

The second group of characteristics that define the SDA model are related to culture. Cultural components arise from how the organization defines itself and its goals as well as how it relates to internal and external stakeholders, customers, and suppliers. These attributes are important, as many of the challenges the DOD faces are framed as artifacts of the department's current organizational culture.[26] SDA was founded, in part, as an organization "not bound by legacy methods or culture" to help address these challenges.[27] It also spent its early years cultivating its organization culture outside the Space Force acquisition bureaucracy before being integrated into the Space Force in 2022.[28] Other defense acquisition organizations looking to use the SDA model may face greater cultural constraints, including tradition, experience, or vested interests in status quo approaches.

Clear Vision

Although SDA has designed some flexibility to adapt to emerging capability and mission needs, as discussed above, the organization has maintained a clear, consistent vision of its priorities. While many other acquisition organizations must plan and execute a range of potentially diverse programs, SDA has kept a relatively narrow focus on proliferation and spiral development for its architecture. This is apparent in the organization's messaging, as SDA leadership has frequently and

**For space systems, a mesh network is a dynamic way to efficiently route data across all the nodes in a constellation or connected to a constellation, enabling an "adaptable network that has the capability to self-repair and self-configure." Greenfield T. Trinh and Kenneth C. Cheung, "Wireless Mesh Networks for Small Satellite Subsystems," NASA Ames Research Center, 2014. https://ntrs.nasa.gov/api/citations/20190001112/downloads/20190001112.pdf. David Andaleon, Assi Friedman, Jonathan Wolff, and Jeff Janicik, "Secure Space Mesh Networking," 35th Annual Small Satellite Conference. August 2021. https://digitalcommons.usu.edu/smallsat/2021/all2021/199/

consistently broadcast its objectives, and SDA's spiral development approach helps it maintain focus on near-term priorities. Importantly, for communicating and strengthening vision throughout the organization, SDA has been credited for having a "relatively flat management structure… [where] each person has direct access to the director with the expectation that each cell chief makes decisions or strong recommendations when issues arise."[29] This likely improves the organization's ability to create and sustain the workforce's commitment to the vision.

Alignment to Warfighter Needs

A second cultural component of the SDA model is the organization's close alignment to urgent warfighter needs. Just as the memorandum that created SDA cited the need to outpace advancing threats, SDA leadership has emphasized that the organization's guiding principle is being threat-driven and that its actions "start and end with the warfighter."[30] By clearly linking its acquisition activities to warfighter capabilities, SDA has imbued its vision with both an urgency and purpose it might otherwise lack. This urgency has been reinforced by recent events, including Russia's war in Ukraine, China's 2021 test of a hypersonic glide vehicle, and growing concern about the potential for conflict over Taiwan. Each of these events have increased pressure on the DOD to quickly modernize its missile detection, tracking, and defense capabilities.

Pursuing Constructive Disruption

SDA has fostered a cultural identity as a "constructive disruptor" for the DOD within space acquisition.[31] The genesis of this label is a theory of "disruptive" competition among commercial companies. Disruptive innovations typically represent modest or simple technology improvements that increase capabilities or performance over time, ultimately displacing more traditional technologies or practices.[32] SDA's addition of the term *constructive* is meant to modify the concept so that it works within a single organization.[33] In this sense, SDA's pursuit of faster and more efficient acquisition processes is intended to help the DOD achieve its goals.

SDA has experienced challenges operationalizing this identity. Even if SDA does not intend to displace other DOD acquisition organizations, its approach represents at least an implicit criticism of those organizations. Some amount of resistance was likely inevitable, and SDA has faced considerable skepticism at times.[34] Dr. Tournear has acknowledged this resistance, noting that some in the DOD have advised him to tamp down his rhetoric to avoid damaging relationships. His response seems to typify SDA's culture, linking the organization's vision and mission to its disruptive approach: "The professional relationship I hold as my highest priority is the one between my agency and the warfighter. To deliver on my end of that relationship, we have no choice but to change."[35] Importantly, SDA has been able to build and sustain momentum by building a strong coalition of support from within senior Space Force and Air Force leadership as well as within Congress.

Process components, the specific actions and mechanisms used to organize and execute an acquisition program, are the third category of characteristics in the SDA model. Acquisition reforms over the past several years have provided organizations greater ability to tailor process requirements to meet their specific needs. Thus, these characteristics now better reflect an organization's deliberate choices as opposed to prescribed processes. Many of SDA's processes reflect known characteristics of successful acquisition programs.[36] Also, the organization is

making progress operationalizing approaches, like portfolio management, that have long been advocated for by acquisition reform advocates.

Timely and Flexible Requirements

SDA is exempt from following the traditional acquisition requirements process—the Joint Capabilities Integration and Development System (JCIDS)—and has created a separate, distinct process for validating that each acquisition program will meet a warfighting need. Specifically, SDA established a Warfighter Council, co-chaired by the vice chief of space operations and the SDA director, that includes representatives from the combatant commands and other key stakeholders who meet every six months to review and validate each tranche's minimum viable capability.[37] This ensures the SDA director exercises some control over the requirements validation process and allows the organization to align the timing of requirements validation with contract actions and program execution. For example, in March 2023, the Warfighting Council approved the minimum viable capabilities for the Transport Layer's Tranche 2.[38] SDA began releasing final contract solicitations for that tranche within two months of that approval and began awarding contracts in August 2023.[39] Timeliness and responsiveness are two of the most frequent criticisms of the traditional acquisition requirements process. A recent Defense Business Board report noted, "poor requirements also cost the DOD speed…it is no wonder why the organizations revered for their procurement speed in the DOD are also the ones relieved from using the traditional JCIDS path."[40]

Although exempt from JCIDS, SDA has garnered additional support for its acquisition by linking them to some formal requirements. For example, the Tracking Layer is, in part, intended to help fill requirements from a set of JCIDS-approved requirements for missile warning and missile defense.[41] SDA has also drawn support from the Space Warfighting Analysis Center's (SWAC) force design process. In 2021, SWAC's analysis determined that satellites in both LEO and medium Earth orbit (MEO) were necessary to provide the performance and resilience requirements for a future missile warning and missile tracking architecture. The current plan is for the systems in MEO and LEO to initially augment and then replace the systems that perform the missile warning mission from more distant orbits, including Next Generation Overhead Persistent Infrared (Next Gen OPIR).[42] This transition is referred to as the "MEO/LEO pivot."[43]

SDA's use of spiral development to meet warfighter requirements also allows for a significant degree of flexibility. SDA's contracts for each tranche define both technical requirements, as guided by the Warfighter Council-approved minimum viable capability, and the anticipated start date for the launch campaign. To maintain its launch schedule, SDA is incentivized to define its minimum viable capabilities such that they deliver incremental performance improvements over the fielded systems.[44] Similarly, contractors competing for SDA awards are incentivized to submit proposals with realistic cost and schedule estimates. Since there is no end point for the overall architecture, any desired capabilities or technologies that are not ready on time can be carried over and incorporated in a future program. In contrast, most acquisition programs have strict performance requirements that must be achieved within the scope of the program, even at the expense of cost increases and schedule delays.

Portfolio Approach

Another key feature of the SDA model is its ability to apply portfolio management principles to its acquisition programs. Portfolio management involves managing a set of related programs such that resources and priorities are managed to provide the maximum value across all the programs.[45] This idea is often contrasted against stovepiped management in which each program owner attempts to optimize their system without due consideration

for how those choices affect the broader organization or the warfighter. A wide range of acquisition reform studies have called for the DOD to more broadly adopt portfolio management as a way to improve acquisitions and overall business practices as well as respond to threats and incorporate new technology.[46] As the Commission on Planning, Programming, Budgeting, and Execution Reform (PPBE Commission) reported, "through the use of portfolio management for space capability development, SDA benefits from being empowered as an organization to make cost, schedule, and technical trades throughout."[47] While SDA's architecture-centric approach is a key enabler for the organization's use of portfolio management principles, the specific processes SDA uses to align and operationalize its portfolio of acquisition investments deserve consideration.

One of the ways SDA conducts portfolio management is by consolidating several efforts in a small number of budget line items within a single "color of money," the Space Force's research, development, test, and evaluation (RDT&E) budget.[††] As mentioned, the largest portion of SDA's planned architecture is the Transport Layer. The Space Force's RDT&E budget includes two budget line items that contain development and production costs for all current Transport Layer tranches as well as a range of related technology development, design, test, and experimentation activities. For example, SDA tranches include demonstration and experimentation efforts to build and launch satellites with less mature technologies. These satellites are not primarily intended to support operations but to prove out technologies that could be incorporated into future tranches. The version of this effort aligned to Tranche 1, the Tranche 1 Demonstration and Experimentation System (T1DES), is expected to launch with the other Transport Layer satellites in Tranche 1 and demonstrate additional communications capabilities.[48] SDA's consolidated budget approach allows the organization to more easily realign funds to meet needs. Many acquisition experts have called for broader reforms to DOD's color of money divisions to enable this kind of flexibility.[49]

SDA's portfolio management approach is also evident in its research and development plans. In January 2024, SDA issued its first public technology roadmap.[50] The "SDA Capability Roadmap" organizes development efforts through the mid-2030s by key capability areas, such as navigation or missile tracking. Each development effort is also loosely aligned with the current and future tranches for which those technologies could be incorporated. But the roadmap is suggestive rather than definitive. The technology areas do not represent fixed targets but the "envisioned technological progress and architecture evolution of the Proliferated Warfighter Space Architecture (PWSA)."[51] The document further states that "an additional purpose of the technology roadmap is to encourage collaboration and innovation from potential partners…who wish to participate in and contribute to the SDA mission."[52] SDA routinely solicits proposals from industry on "novel architecture concepts, systems, technologies, and capabilities that enable leap-ahead improvements for future tranches."[53] Along with its budgeting approach, SDA's capability roadmap helps chart and execute a long-term plan for maturing the types of technologies that will be needed to enable the architecture to respond to warfighter needs.

Market Competition and Contractor Engagement

Improving engagement with commercial companies was a primary driver behind the decision to create

[††]"Color of money" refers to the different appropriation categories that serve as the top-level structure of the DOD budget: RDT&E, procurement, operations and management, military personnel, and military construction. The Space Force procurement budget does contain a dedicated budget line item to fund SDA launch costs.

SDA. The last set of process components in SDA's model relates to how it works with industry. There is broad consensus within the DOD and the Space Force that leveraging the innovation and dynamism of the commercial space market is a key strategic advantage the United States has over its near-peer competitors. As the U.S. Space Force Commercial Space Strategy states, "the United States Space Force will take full advantage of the speed, innovation, and capabilities offered by the commercial sector to create strategic advantage and support Combatant Commander objectives in times of peace, competition, crisis, conflict, and post-conflict."[54]

SDA has committed to fostering and maintaining a diverse, competitive marketplace as it builds out its systems. There are already signs of success, as SDA has awarded contracts to a range of both relatively small and large prime contractors after competitive contract solicitations. Part of this success is structural in that SDA's architecture-centric approach paves the way for a steady flow of long-term contract opportunities, as diversity and competition are easier to achieve when there are many opportunities. However, SDA has also made deliberate choices to promote these goals. For example, for each tranche, SDA has awarded contracts to at least two and as many as four different companies.[55] In total, seven different prime contractors, including three non-traditional defense contractors, have been awarded at least one contract for the Transport Layer or the Tracking Layer.[56] SDA has also awarded significant additional contracts for ground services, technology development, and other activities. Among other things, promoting competition helps SDA both avoid the vendor lock problem and ensure there is a range of firms available to build the proliferated architecture as it grows. Through this diverse, competitive marketplace, SDA has also been able to set and maintain low satellite cost targets, despite supply chain disruptions and inflationary pressures over the past several years.‡‡

Other process components of SDA's model relate to its contracting processes, specifically its use of fixed price contracts and other transaction authority (OTA). Fixed-price contracts, which have been reemphasized as part of the Air Force's recent "simple formula to go fast in space acquisition," are intended to ensure that contractors are prioritizing schedules and avoiding solutions that rely on unproven technologies.[57] Dr. Tournear has said the difference between SDA and other space acquisition organizations is that "we're not doing technology development…we want to take technology that's at a high technical readiness level…and implement it in a new architecture."[58] Fixed-price contracts also require that an acquisition organization has a thorough understanding of its requirements and scope, as any modification to the original contract terms will typically have negative cost and schedule impacts. Similarly, by allowing an acquisition organization to bypass federal procurement laws and regulations, OTAs are intended to accelerate the acquisition process and attract nontraditional contractors.[59] OTAs also "give DOD the flexibility necessary to adopt and incorporate business practices that reflect commercial industry standards and best practices" into its contract award processes.[60] SDA had originally planned to use more traditional contract mechanisms but revised its approach after one of its early solicitations was protested because of the appearance that that the terms unfairly favored some firms.[61] A 2023 Defense Business Board report states that "OTAs place a premium on capability over compliance," and recommends that the DOD work with Congress to encourage greater use of OTAs by streamlining the approval process.

‡‡Currently, SDA's average cost is around $15 million and $50 million per satellite for the Transport and Tracking layers, respectively.

Finally, SDA's architecture-centric approach and commitment to a diverse, competitive marketplace necessitates clear, effective standards for interoperability. To date, SDA has published two standards documents. The first establishes compliance requirements for optical communications, which is the use of infrared frequency to pass information between space assets or between space and terrestrial assets.[62] Optical communications are critical to SDA's planned architecture, enabling greater speed, security, and flexibility compared to radio frequency communications as well as reduced volume, weight, and power requirements.[63] SDA's optical communications standard specifies how terminals discover, establish, refine, and maintain connectivity. Satellites in LEO must manage several of these connections simultaneously, potentially with satellites at different altitudes and inclinations, traveling at about 17,000 miles per hour. The second standards document establishes compliance requirements and networking protocols for space-to-space and space-to-ground communications.[64] Because SDA's architecture relies on many different suppliers and is expected to provide a range of services to many users, networking and data standards are critical to ensure interoperability, reduce risk, and appropriately segment classified and unclassified data. SDA is also looking to enable interoperability for satellites that do not adopt its standards using "translator" satellites or payloads, which would receive the original transmission and then reformat and relay the transmission according to the standard.[65]

Remaining Challenges to Validating the Model and Achieving Operational Effectiveness

SDA may encounter its own challenges continuing to use its model. While this paper has highlighted SDA's acquisition progress, questions remain about how well and how quickly it will deliver warfighting capabilities. Beyond several successful launches and a few publicized tests, relatively little is known about how SDA's satellites currently on orbit are performing, individually or collectively. As noted earlier, 2024 provides key opportunities for SDA to demonstrate its systems' capabilities more fully. Operational success will go a long way to validate SDA's acquisition model and the flexibilities the DOD and Congress have granted the organization. The rest of this section briefly explores some of the challenges SDA may face in the coming years, particularly how those challenges relate to SDA's acquisition model.

Balancing Technology and Schedule Goals

SDA's plans for the PWSA require a delicate, difficult balance between technology and schedule goals. On the one hand, SDA adheres to a schedule-first approach and emphasizes that it "isn't doing technology development."[66] On the other hand, SDA has outlined an ambitious technology roadmap that will require sustained investment and coordination with both industry partners and the warfighter community. While SDA is pursuing mature, commoditized parts for its satellites, the U.S. Government Accountability Office (GAO) reported in 2023 that SDA plans to use some vendors that either have not produced their components at large scale or will not demonstrate their components in space prior to launching on one of SDA's missions.[67] These examples may become less common as SDA launches and operates more and more satellites, but developing and integrating new technologies without disrupting launch schedules or existing capabilities will not be easy.

Demonstrating Effective Networking Capabilities at Scale

To date, SDA's publicized capability demonstrations have been relatively small-scale, involving just one or a few satellites and basic functions.[68] Scaling up these demonstrations to show that the satellites function as a cohesive, reliable, and low-latency

network presents a significant challenge.[§§] This is largely the role of SDA's Battle Management Command, Control, and Communications (BMC3) Layer, which hosts and manages mission-specific applications, processes, and algorithms.[69] Dr. Tournear has described BMC3 as "the magic that makes all (SDA's capabilities) happen."[70] Therefore, a core part of the PWSA cannot be demonstrated fully until the complete architecture, including ground stations, is in place and in use for operational missions. Large-scale demonstrations are also necessary to prove basic features of SDA's acquisition and contracting model, most notably the use of several vendors operating as part of a single constellation.

Sustaining a Robust and Competitive Market

The success of SDA's model will partly depend on continued competition for future contract awards among a diverse marketplace of vendors. As discussed above, the initial evidence for competition and diversity is strong. Among other things, SDA has awarded contracts to several non-traditional vendors. But sustaining this competition over the long term may prove challenging. First, SDA's requirements may prove too onerous for companies whose products are primarily intended for commercial purposes. For example, SpaceX, which was the first to deliver its satellites for Tranche 0, has indicated reluctance to compete for future awards, allegedly because it did not want to modify its commercial satellite bus to meet SDA's requirements.[71] Second, the advantages of incumbency may become more pronounced over time. As SDA's architecture reaches operational capability and begins supporting increasing numbers of missions and users, the trade-off between encouraging competition and ensuring mission success will become more pronounced. It may be increasingly difficult to transition from a well-performing vendor to a new, less established vendor, particularly one that has not previously been awarded an SDA contract. This could lead to a relatively exclusive pool of potential vendors rather than the dynamic, competitive, and open market that SDA is trying to promote. Third, the rapid increase in demand for proliferated systems may strain supply chains.[72] SDA's short schedule requirements between contract award and launch mean suppliers will have little time to ramp up production or address unanticipated supply constraints.

Maintaining Support for the Model

SDA has benefited from the flexibility to bypass traditional acquisition process requirements, but maintaining this flexibility requires continued Congressional and departmental support for using approaches like the middle tier of acquisition (MTA) and other transaction authority (OTA). One potential challenge is that SDA's acquisitions do not cleanly match the stated intent of either the rapid prototyping or rapid fielding MTA pathways. SDA's tranches include too many satellites to reasonably constitute a rapid prototyping effort and too much development work to reasonably constitute a rapid fielding effort. Instead, SDA's approach resembles a kind of unspecified hybrid of both MTA pathways, whereby prototypes are developed and fielded at scale within a single acquisition effort. Importantly, this hybrid approach has not yet directly presented a challenge. In fact, despite objection from the Office of Management

[§§]As recent research of Russia's war in Ukraine has shown, satellites cannot independently deliver an effective warfighting capability. Despite its reliance on commercial or foreign partner satellite capabilities, Ukraine has made "better use of space than Russia" by more effectively disseminating and applying data, showing that "what matters is not only what satellite data or services are provided, but how they are delivered to the warfighter." Robin Dickey and Michael P. Gleason, "Space and War in Ukraine: Beyond the Satellites," in AETHER: A Journal of Strategic Airpower & Spacepower, Vol. 3 No. 1, Spring 2024.
https://www.airuniversity.af.edu/Portals/10/AEtherJournal/Journals/Volume-3_Number-1/Aether_Volume_3_Number_1..pdf

and Budget, Congress recently mandated that SDA continue to use the MTA rapid prototyping pathway for the first three tranches of the Transport and Tracking layers.[73] This may reflect a lack of good alternatives, as the MTA rapid prototyping pathway likely better aligns to SDA's approach than any other acquisition pathway. This also likely represents a practical adaptation by congressional stakeholders who are prioritizing demonstrated progress over process. However, this sort of accommodation to the SDA model could come under pressure as the SDA budget grows or if the agency experiences programmatic setbacks.

A related challenge is the overall cost of SDA's planned architecture. Even if SDA maintains its current cost per satellite targets, the PWSA will be a significant, long-term investment. Congress has expressed support for this more proliferated architecture but also raised concerns that the total cost, including the cost to continually recapitalize the architecture, is not well understood.[74] The Space Force's fiscal year 2025 budget request estimates the total cost of the Transport and Tracking Tranche 2 efforts at just over $9 billion.[75] Once the satellites from those tranches are fielded, SDA's architecture will reach full warfighting capability for its initial missions with roughly 450 operational satellites. Future tranches will maintain the architecture at close to that number of satellites, with some fluctuations.[76] Dr. Tournear has stated that he wants to keep the cost of each tranche stable, though with improved capability in each iteration.[77] Therefore, the $9 billion estimate sets a reasonable expectation for the total cost of future Transport and Tracking tranche, but Congress's concerns about the lack of information on long-term costs are valid. For example, it is difficult to know the extent to which downward cost pressures—technology development, competition, and economies of scale—will materialize and compensate for upward cost pressures—increased mission and capability demands. Further, Congress has raised concerns that the DOD's use of the MTA pathways obfuscates program costs and limits oversight.[78]

Confronting Evolving Threats

The advances of China and Russia in a range of counter-space weapon systems present a long-term challenge to the United States and the security of its space assets. Proliferation in LEO, an increasing part of the U.S. response to this challenge, improves space resiliency in some areas. Having many satellites with redundant capabilities lessens the consequences of losing one or even a handful of satellites, whether through adversary attack, technical malfunction, or another disruptive event. But this is not a panacea. There are several ways in which ensuring the resilience of proliferated systems is more difficult than it is for traditional systems. First, proliferated systems are innately more vulnerable to cyberattack because they have more access points a malicious cyber actor can target for exploit. Second, systems in LEO are operating in a congested environment. Debris is a persistent problem, and the Space Force will need to prepare for increasing numbers of both commercial and military systems expected in the coming years. Lastly, proliferated systems are vulnerable to the widespread, disruptive effects of a nuclear detonation in space. Because satellites in LEO generally are not hardened to protect electrical components against radiation, a nuclear detonation in LEO likely would damage or disable many nearby commercial and government satellites over a large area.[79] The effects would also pose a significant risk to satellites that subsequently traverse the radiation field during orbit.

Given the scale and scope of SDA's planned architecture, the potential challenges the organization may face to implement its vision should not be a surprise. Finding new, disruptive ways to acquire space systems is an ambitious task, and setbacks should be anticipated. The SDA acquisition model's emphasis on iteration and spiral

development provides an important mechanism for the organization to learn quickly from those setbacks.

Missile Defense Agency: A Case Study for Disruptive Acquisition

Aspects of its acquisition model are distinct, but SDA is far from the first DOD organization to be granted special acquisition authorities and flexibilities. In particular, given its similar focus on delivering a set of capabilities as part of an architecture, the acquisition history of the Missile Defense Agency (MDA) informs some of the challenges SDA might face as it matures, specifically in the areas of mission, requirements, and funding.

The MDA was created in 2002 in response to DOD studies that identified a need for "new approaches to acquire and deploy missile defenses."[80] The organization was charged with rapid development of an overall missile defense system—an architecture—that included a number of both existing and planned component systems, such as sensors, interceptors, and command and control systems. The DOD exempted the MDA from several traditional acquisition processes, and delegated oversight and decisionmaking authority to the new agency's leadership.[81]

The MDA organized its acquisitions into two-year capability blocks, utilizing spiral development to deliver incremental capabilities to "capitalize on missile defense technology advances…to adjust to threat and policy changes as appropriate."[82] This approach also assumed no predetermined end point: "while there is only a single ballistic missile defense system, there is no final or fixed missile defense architecture."[83] In addition, the MDA director exercised considerable control for oversight functions as well as requirements for the capability blocks. Because of its special acquisition authorities, the MDA's early budgets were almost entirely contained in the RDT&E appropriation, even though it also funded activities like procurement and operations that normally would be funded in separate accounts. One of the organization's goals was to focus on research and development, transferring systems to the military services once they were ready for large-scale production.

The MDA's special acquisition authorities enabled agility and the rapid fielding of some capabilities but at the cost of transparency and accountability.[84] Over the past two decades, Congress and the DOD have implemented several initiatives to curtail some of the MDA's authorities. For example, in 2008, following a series of test failures and slower than anticipated capability delivery, Congress mandated that the MDA revise its processes so that its future budget requests align to specific activities.[85] The MDA could no longer manage a large RDT&E budget for funding its broad range of activities. Congress also mandated other changes to improve transparency, accountability, and oversight, such as requiring cost, schedule, and performance baselines for each missile defense element. Over time, increased costs for procurement, operations, and maintenance have put pressure on the MDA's research and development budget, challenging its ability to invest in technologies to counter future missile threats.[86] In 2020, the DOD directed further changes to the MDA's acquisition authorities, requiring more independent reviews and oversight.[87] Yet, despite changes, the MDA has preserved some of its special acquisition authorities, including greater control over requirements.

The MDA's history provides a few relevant lessons for SDA. First, acquisition flexibility is not absolute. Demonstrating performance and meeting cost and schedule expectations is critical for maintaining the support needed to continue exercising special acquisition authorities. Second, unexpected constraints emerge as an organization grows.

Maintaining an organizational identity around disruption and innovation becomes more difficult as processes and equities become more routinized and entrenched. But this history also shows that there is a natural give-and-take between the various measures of acquisition success: cost, speed, performance, transparency, oversight, and accountability. Finding an appropriate balance between these objectives takes time, which reinforces the need to learn from past acquisition successes and failures.

Conclusion

SDA has proven to be a disruptive force in space acquisitions, moving quickly to implement the vision outlined at its creation and advancing the DOD's transition to a more proliferated space architecture. Its key challenge now is to deliver operational capabilities at scale, which requires launching hundreds more satellites and then linking those satellites together into a cohesive, reliable, low-latency network. Beyond delivering mission capability, SDA can also fulfill its goal of being a constructive force in space acquisitions by pathfinding approaches that support the DOD's goal to more rapidly acquire and proliferate its space systems. At the same time, the defense acquisition community must understand that some of the SDA model's distinct structural, cultural, and process components cannot easily be replicated. Acquisition decisionmakers should carefully consider the factors that contribute to SDA's approach, the circumstances of each new program, and the alignment between the two.

The SDA model does provide positive examples for others to imitate, including the organization's close alignment to warfighter needs and focus on iterative development. More broadly, SDA's experience may further bolster reform efforts around portfolio management, color of money, and flexible contracting. Effectively identifying and sharing lessons learned from the SDA acquisition experience would provide valuable evidence to support future reforms, which in turn will enable broader adoption of effective acquisition practices as the Space Force continues to pursue rapid acquisition and proliferation.

Acknowledgments

The author would like to thank Aaron Bateman, Karen Jones, and Cristina Chaplain for reviewing drafts of this paper and providing valuable comments. Additional thanks to Robert Samuel Wilson for editorial feedback and support, and to Julia Kopischke, Allan Kung, Jacob Bain, and Nina Isaia for assistance with the cover design, graphics, and copyediting.

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