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SPACE ACQUISITIONS

DOD Faces Significant Challenges as it Seeks to Address Threats and Accelerate Space Programs

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GAO-19-482T

GAO Highlights

Highlights of GAO-19-482T, a testimony before the Subcommittee on Strategic Forces, Committee on Armed Services, House of Representatives

Why GAO Did This Study

DOD space systems provide critical capabilities that support military and other government operations. They can also be expensive to acquire and field, costing billions of dollars each year.

As DOD seeks to replenish its satellite constellations, it faces a number of challenges to ensuring funds are used effectively. Because space-based capabilities are fundamental to U.S. national security and civilian activities, it is essential that DOD manage its space system acquisitions carefully and avoid repeating past problems.

This statement provides an update on DOD's space acquisitions, focusing on challenges facing acquisitions of new space systems.

This statement is based on GAO reports issued over the past 10 years on DOD space programs. In addition it draws on recent work performed in support of GAO's 2019 annual reports on the progress of major defense acquisition programs as well as duplication, overlap, and fragmentation across the federal government, among other sources.

What GAO Recommends

Past GAO reports have recommended that DOD adopt acquisition best practices to help ensure cost and schedule goals are met. DOD has generally agreed and taken some actions to address these recommendations.

View GAO-19-482T. For more information, contact Cristina Chaplain at (202) 512-4841 or chaplainc@gao.gov.

April 3, 2019

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What GAO Found

DOD is simultaneously undertaking new major acquisitions to replenish its missile warning, protected communications, navigation, and weather satellites. At the same time, it is boosting efforts to increase space situational awareness and protect space assets. Such widespread acquisition acitivites could face a wide range of resource and management challenges that GAO has reported on, including:

- **Growing threats to satellites.** Threats to satellites from both adversaries—such as jamming and cyber attacks—and space debris are increasing. DOD is making changes to how it designs its space systems to increase the resilience and survivability of space capabilities. But it has been challenged in adopting new approaches, such as using commercial satellites to host payloads, and in prioritizing cybersecurity for all of its weapon systems. For hosted payloads, GAO recommended, and DOD concurred, that the department bolster and centralize collection and analysis of cost, technical, and lessons learned data.
- **Implementing leadership changes**. DOD is planning major changes to leadership for space. It recently proposed legislation to establish a United States Space Force—initially to be housed within the Department of the Air Force—that would, according to the President's Space Policy Directive, consolidate existing military space activities and minimize duplicative efforts across DOD. GAO found in July 2016 that changes are needed to reduce fragmentation that has negatively affected space programs for many years. But open questions remain about governance as new programs get underway and whether the changes themselves may result in further fragmentation. For example, it is unclear at this time how the new Space Development Agency will mesh with organizations currently involved in testing and acquiring new space technologies.
- **Having the right resources and know-how.** While there is increased attention on funding for space and building the Space Force, new programs can still face resource challenges. DOD has begun over 9 new space programs at a time when it is also seeking increased investments in ships, aircraft, and the nuclear triad, among other programs. Moreover, it is unclear whether DOD has a sufficient workforce to manage its new programs. GAO issued a report last month that found DOD does not routinely monitor the size, mix, and location of its space acquisition workforce. Further, DOD has difficulty attracting and retaining candidates with the requisite technical expertise. GAO recommended that DOD collect and maintain data on its space acquisition workforce. DOD did not concur, but GAO maintains that DOD should have better information on such personnel, especially in light of its proposal for establishing the Space Force. GAO also found in March 2019 that selected software-intensive space programs often did not effectively engage users to understand requirements and obtain feedback. GAO recommended, and DOD concurred, that the department ensure its guidance addressing software development provides specific, required direction on the timing, frequency, and documentation of user involvement and feedback.

Chairman Cooper, Ranking Member Turner, and Members of the Subcommittee:

I am pleased to have the opportunity to discuss the Department of Defense's (DOD) space system acquisitions. DOD's space systems provide critical capabilities that support military and other government operations and can take years to develop, produce, and launch. These systems can also be expensive to acquire and field, amounting to billions of dollars each year. Given the time and resource demands of DOD's space systems and the need for funds to be used effectively, and because space-based capabilities are fundamental to U.S. national security and civilian activities, it is essential that DOD manage space system acquisitions carefully and avoid repeating past problems.

My statement will focus on (1) the current status and cost of major DOD space programs and (2) challenges facing acquisitions of new space systems.

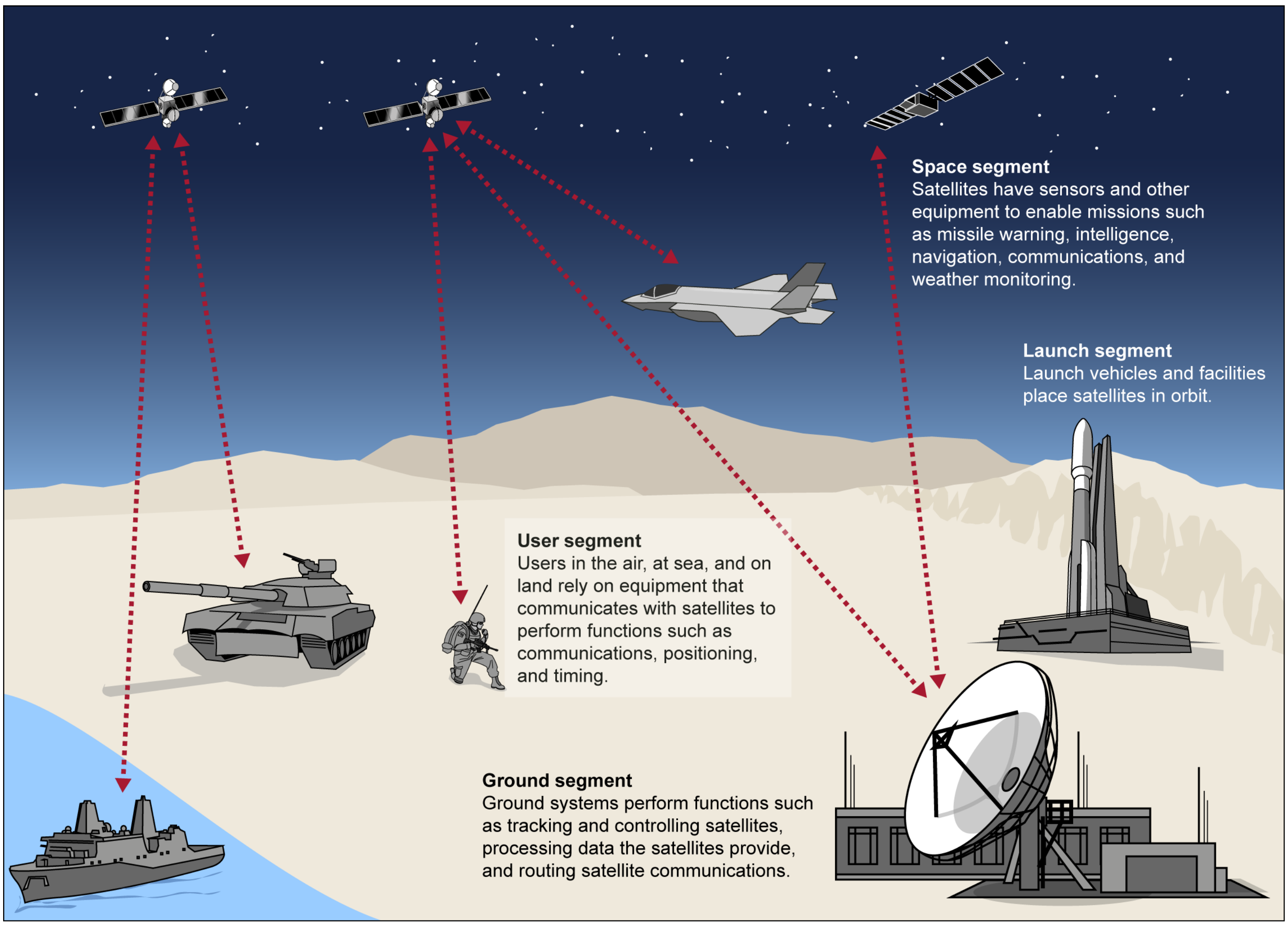
This statement is based on our reports on DOD space programs issued over the past 10 years and recent work performed in support of our annual weapon systems assessments to be issued later this year. It is also based on space-related work in support of our forthcoming 2019 annual report on duplication, overlap, and fragmentation across the federal government; and our updates on cost increases, investment trends, and improvements in the last year. More information on our objectives, scope, and methodology is available in our related products, which are listed at the end of this statement.

More detailed information on our objectives, scope, and methodology for our work can be found in the issued reports. We conducted the work on which this statement is based in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Status of Major Space Systems

DOD space systems support and provide a wide range of capabilities to a large number of users, including the military services, the intelligence community, civil agencies, and others. These capabilities include positioning, navigation, and timing; meteorology; missile warning; and secure communications, among others. Space systems can take a long time to develop and involve multiple segments, including space, ground control stations, terminals, user equipment, and launch, as figure 1 below shows. DOD satellite systems are also expensive to acquire. Unit costs for current DOD satellites can range from $500 million to over $3 billion. The associated ground systems can cost over $6 billion to develop and maintain and the cost to launch a satellite can climb to well over $100 million.

Figure 1: The Segments of Space Systems



Source: GAO analysis of Department of Defense (DOD) documentation. | GAO-19-482T

Table 1 provides highlights of the current status of DOD's major space programs. As the table shows, DOD is also in the beginning phases of acquiring several constellations of new satellites and ground processing capabilities—including for missile warning, protected communications, space-based environmental monitoring, and space command and control. We have work underway to assess the Air Force's space command and control development efforts and examine DOD's analysis of alternatives for wideband communication services. For a more complete description of these major space programs, see appendix I. In addition, DOD is exploring alternatives for acquiring wideband satellite communications as well as funding development of new launch vehicles as it pursues a new acquisition strategy for procuring launch services.[1]

Table 1: Status of Major Department of Defense (DOD) Space Acquisitions

Program	Cost and percentage change from first full estimate (in FY 2019 billion dollars)	Quantity	Associated new programs
Advanced Extremely High Frequency (AEHF) (satellite communications)	$15.5 116.7%	**Original:** 5 **Current:** 6	Evolved Strategic SATCOM (ESS); Protected Tactical SATCOM (PTS); Protected Tactical Enterprise Service (PTES)
Enhanced Polar System (EPS) (satellite communications)	$1.5 -0.9%	**Original:** 2 **Current:** 2	Enhanced Polar System Recap (EPS-R)
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T) Command Post Terminals (CPT) (satellite communications terminals)	$1.9 7.2%	**Original:** 95 **Current:** 109	FAB-T Force Element Terminals (FET)
Global Positioning System (GPS) III (positioning, navigation, and timing)	$5.8 31.8%	**Original:** 8 **Current:** 10	GPS IIIF
Global Positioning System Next Generation Operational Control System (GPS OCX) (command and control system for GPS III satellites)	$6.2 68.1%	**Original:** 1 **Current:** 1	Not determined
Joint Space Operations Center Mission System (JMS) Increment 2 (space situational awareness data system)	$0.5 42.0%	**Original:** 1 **Current:** 1	Space Command and Control (C2)

[1]We have work underway to examine the Air Force's space command and control programs as well as DOD's analysis of alternatives for wideband communications. We expect to issue the results of that work by fall 2019.

Program	Cost and percentage change from first full estimate (in FY 2019 billion dollars)	Quantity	Associated new programs
Military GPS User Equipment (MGUE), Increment 1 (GPS receiver)	$1.5 -5.1%	**Original:** N/A **Current:** N/A	MGUE Increment 2
Mobile User Objective System (MUOS) (satellite communications)	$7.1 -6.0%	**Original:** 6 **Current:** 5	Not determined
National Security Space Launch (NSSL) (launch)	$57.0 193.2%	**Original:** 181 **Current:** 161	Not determined
Space Based Infrared System (SBIRS) (missile warning, infrared intelligence, surveillance, and reconnaissance)	$19.9 265.0%	**Original:** 5 **Current:** 6	Next Generation Overhead Persistent Infrared (Next Gen OPIR); Future Operationally Resilient Ground Evolution (FORGE); Enterprise Ground Services (EGS)
Space Fence Ground-Based Radar System Increment 1 (space object detection)	$1.6 -5.7%	**Original:** 1 **Current:** 1	Not determined
Wideband Global SATCOM (WGS) (satellite communications)	$4.2[a] 216.3%	**Original:** 3 **Current:** 10	To be determined following Analysis of Alternatives
Weather System Follow-on (WSF) (weather)	$0.5 N/A	**Original:** 2 **Current:** 2	Electro-Optical/Infrared Weather Systems (EWS); Electro-Optical/Infrared Weather Systems Geostationary (EWS-G)

Source: GAO analysis of Department of Defense information | GAO-19-482T

Note: Dollar figures are rounded to the nearest tenth and reported in fiscal year 2019 dollars based on the programs' original and most recent Selected Acquisition Reports or program office updates.

[a]This value does not include the cost of 2 satellites funded by international partners.

Our prior work has shown that many major DOD space programs have experienced significant cost increases and schedule delays. For instance, the total program cost for the Advanced Extremely High Frequency (AEHF) satellite program, a protected satellite communications system, has grown 117 percent since the program's original cost estimate and its first satellite was launched more than 3.5 years late. For the Space Based Infrared System (SBIRS), a missile warning satellite program, the program cost grew 265 percent from its original estimate and the launch of the first satellite was delayed roughly 9 years. Both programs moved to the production phase where fewer problems tend to surface, and where there is typically less risk of significant cost and schedule growth. A more recent major satellite program, Global Positioning System (GPS) III, has seen an almost 4-year delay due to technical issues and program cost growth of about 32 percent.

Cost and schedule growth has also been a challenge for satellite ground systems and user equipment. Ground system delays have been so lengthy, that satellites sometimes spend years in orbit before key capabilities can be fully exploited. For example,

- The command and control system for GPS III satellites, known as the Next Generation Operational Control System, or OCX, is approximately 5 years behind schedule. As a result, the Air Force has had to start two separate back-up efforts to modify the current ground system to ensure the continuity of GPS capabilities and to make anti-jamming capabilities available via Military Code, or M-code, until OCX is delivered. Our ongoing review of GPS includes an assessment of OCX schedule risk and potential impacts on OCX delivery, acceptance, and operation. We expect to issue our report on GPS in spring 2019.
- Development of GPS user equipment that can utilize the M-Code signal has lagged behind the fielding of GPS M-code satellites for more than a decade, due to prolonged development challenges. In December 2017, we found that while DOD had made some progress on initial testing of the receiver cards needed to utilize the M-code signal, additional development was necessary to make M-code work with the over 700 weapon systems that require it.[2] We also found that DOD had begun initial planning to transition some weapon systems to use M-code receivers, but significantly more work remained to understand the cost and schedule of transitioning to M-code receivers across DOD. Further, in December 2017, we found that multiple entities were separately maturing their own receiver cards. We recommended that DOD assign responsibility to a single organization to collect test data, lessons learned, and design solutions so that common design solutions are employed and DOD could avoid duplication of efforts. DOD concurred with the recommendation, but has not yet taken action on it.
- We have previously reported that over 90 percent of the capabilities to be provided by Mobile User Objective System communications satellites—currently, five satellites are in orbit, the first of which

[2]GAO, *Global Positioning System: Better Planning and Coordination Needed to Improve Prospects for Fielding Modernized Capability*, GAO-18-74 (Washington, D.C.: Dec. 12, 2017).

launched in 2012—are being underutilized because of difficulties with integrating the space, ground, and terminal segments and delays in fielding compatible user terminals.[3]

- Largely because of technical and management challenges, the Joint Space Operations Center Mission System (JMS) Increment 2 program—intended to replace and improve upon an aging space situational awareness and command and control system—was almost 3 years behind schedule and 42 percent over budget before the Air Force stopped development work last year. Last month, we reported that operational testing in 2018 found that JMS Increment 2 was not operationally effective or suitable due, in part, to missing software requirements, urgent deficiencies that affected system performance, and negative user feedback.[4]

Cost and schedule growth in DOD's space programs is sometimes driven by the inherent risks associated with developing complex space technology; however, over the past 10 years we have identified a number of other management and oversight problems that have worsened the situation. These include making overly optimistic cost and schedule estimates, pushing programs forward without sufficient knowledge about technology and design, and experiencing problems in overseeing and managing contractors, among others. We have also noted that some of DOD's programs with operational satellites, such as SBIRS, were also exceedingly ambitious, which in turn increased technology, design, and engineering risks. While SBIRS and other satellite programs provide users with important and useful capabilities, their cost growth has significantly limited the department's buying power at a time when more resources may be needed to protect space systems and recapitalize the space portfolio.

[3]GAO, *Space Acquisitions: DOD Continues to Face Challenges of Delayed Delivery of Critical Space Capabilities and Fragmented Leadership,* GAO-17-619T (Washington, D.C.: May 17, 2017).

[4]GAO, *DOD Space Acquisitions: Including Users Early and Often in Software Development Could Benefit Programs*, GAO-19-136 (Washington, D.C.: Mar. 18, 2019).

Challenges Facing Acquisitions of New Space Systems

DOD faces significant challenges as it replenishes its satellite constellations. First, DOD is confronted with growing threats in space, which may require very different satellite architectures and acquisition strategies. Second, DOD is in the midst of planning major changes to its leadership for space. While these changes are designed to streamline decision-making and bring together a dispersed space workforce, they could cause some disruption to space system acquisition programs. Third, in fiscal year 2016, Congress required DOD to establish guidance to speed up acquisition timeframes by streamlining acquisition processes and oversight for certain acquisitions. GAO is examining DOD's application of streamlining to its weapons programs. For space, challenges with past streamlining efforts may offer some lessons learned. And fourth, DOD may face resource and capacity challenges in taking on multiple space acquisitions at one time. For example, our work and other reports point to potential gaps in the space acquisition workforce and ongoing difficulties managing software development.

Growing Threats to Satellites Require New Approaches

According to Air Force Space Command and others, U.S. space systems face intentional and unintentional threats that have increased rapidly over the past 20 years. These include radio frequency interference (including jamming), laser attacks, kinetic intercept vehicles, and ground system attacks. Additionally, the hazards of the already-harsh space environment (e.g., extreme temperature fluctuations and radiation) have increased, including numbers of active and inactive satellites, spent rocket bodies, and other fragments and debris. According to a February 2019 Defense Intelligence Agency report, China and Russia in particular are developing a variety of means to exploit perceived U.S. reliance on space-based systems and challenge the U.S. position in space. The report also states that Iran and North Korea have demonstrated some counterspace capabilities that could pose a threat to militaries using space-based services.

In response, recent governmentwide and DOD strategic and policy guidance have stressed the need for U.S. space systems to be survivable or resilient against such threats and DOD has taken steps to be more resilient in some of its new programs. As we found in October 2014, one way to do this is to build more disaggregated systems, including dispersing sensors onto separate satellites; using multiple domains, including space, air, and ground to provide full mission capabilities; hosting payloads on other government or commercial spacecraft; or some combination of these.[5] With capabilities distributed across multiple platforms, rather than centralized onto just a few satellites, it may be more difficult for an adversary to target all assets to attack full system capabilities, and if an attack does take place, the loss of one smaller satellite or payload could result in less capability loss than damage to, or loss of, a large multifunctional satellite. In addition to disaggregation, DOD could make satellites more maneuverable and build in defense capabilities to protect themselves as a means to increase survivability.

We also found in October 2014 that some of these options could have beneficial impacts on acquisition.[6] For example, acquiring smaller, less complex satellites may require less time and effort to develop and produce. This may be in part due to improved requirements discipline, as more frequent production rates may allow program managers to delay new requirements to the next production cycle instead of incorporating them into ongoing timelines midstream. Building more, less-complex satellites might also provide DOD the opportunity to use commercial products and systems that have already been tested in the market. At the same time, however, addressing the need to make satellites more resilient could introduce complications. For example, DOD may need to acquire higher quantities of satellites, which may make it more difficult to manage acquisition schedules. In addition, potentially more development and production contracts may result in more complexity for program offices to manage, requiring increased oversight of contractors. Adding more satellites and new technologies may also complicate efforts to synchronize satellite, terminal, and ground system schedules, limiting delivery of capabilities to end users.

Our work has also found potential barriers to making satellites more resilient. For example, in October 2014, we found that disaggregation could require DOD to make significant cultural and process changes in how it acquires space systems—for instance, by relying on new contractors, relinquishing control to providers who host government payloads on commercial satellites, using different contracting methods, and executing smaller but more numerous and faster-paced acquisition programs.[7] It will likely require DOD to be more flexible and agile when it

[5]GAO, *DOD Space Systems: Additional Knowledge Would Better Support Decisions about Disaggregating Large Satellites*, GAO-15-7 (Washington, D.C.: Oct. 30, 2014).

[6]GAO-15-7.

[7]GAO-15-7.

comes to satellite acquisitions, especially with regard to coordinating satellite delivery with interdependent systems, such as user equipment. Yet, as we have previously found, DOD's culture has generally been resistant to changes in space acquisition approaches, and fragmented responsibilities have made it very difficult to coordinate and deliver interdependent systems.[8] Senior leaders have recognized the need to change the space acquisition culture, and as discussed below, changes are being made to space leadership and acquisition approaches.

More recently, in July 2018, we found that two factors have contributed to DOD's limited use of commercially hosted payloads.[9] First, DOD officials identified logistical challenges to matching government payloads with any given commercial host satellite. For example, most of the offices we spoke with cited size, weight, and power constraints, among others, as barriers to using hosted payloads. Second, while individual DOD offices have realized cost and schedule benefits from using hosted payloads, DOD as a whole has limited information on costs and benefits of hosted payloads. Further, the knowledge DOD obtained is fragmented across the agency—with multiple offices collecting piecemeal information on the use of hosted payloads. The limited knowledge and data on hosted payloads that is fragmented across the agency has contributed to resistance among space acquisition officials to adopting this approach. We recommended, and DOD concurred, that the department bolster and centralize collection and analysis of cost, technical, and lessons learned data on its use of hosted payloads.

Lastly, in October 2018, we found that DOD faced mounting challenges in protecting its weapon systems—satellites and their ground systems included—from increasingly sophisticated cyber threats.[10] We reported that this was due to the computerized nature of weapon systems, DOD's late start in prioritizing weapon system cybersecurity, and DOD's nascent understanding of how to develop more secure weapon systems. In operational testing, DOD routinely found mission-critical cyber vulnerabilities in systems that were under development, yet program

[8] GAO-17-619T.

[9] GAO, *Military Space Systems: DOD's Use of Commercial Satellites to Host Defense Payloads Would Benefit from Centralizing Data,* GAO-18-493 (Washington, D.C.: July 30, 2018).

[10] GAO, *Weapon Systems Cybersecurity: DOD Just Beginning to Grapple with Scale of Vulnerabilities*, GAO-19-128 (Washington, D.C.: Oct. 9, 2018).

officials GAO met with believed their systems were secure and even discounted some test results as unrealistic. Using relatively simple tools and techniques, testers were able to take control of systems and operate largely undetected, due in part to basic issues such as poor password management and unencrypted communications. DOD has recently taken several steps to improve weapon system cybersecurity, including issuing and revising policies and guidance to better incorporate cybersecurity considerations. Further, in response to congressional direction, DOD has also begun initiatives to better understand and address cyber vulnerabilities.

Space Leadership Changes Are a Positive Step, But Have Some Risk

We and others have reported for over two decades that fragmentation and overlap in DOD space acquisition management and oversight have contributed to program delays and cancellations, cost increases, and inefficient operations. For example, in February 2012 we found that fragmented leadership contributed to a 10-year gap between the delivery of GPS satellites and associated user equipment.[11] The cancellations of several large programs over the past 2 decades were in part because of disagreements and conflicts among stakeholders.

In July 2016, in response to a provision of a Senate Report accompanying a bill for the National Defense Authorization Act for Fiscal Year 2016, we issued a report that reviewed space leadership in more depth and concluded that DOD space leadership was fragmented.[12] We identified approximately 60 stakeholder organizations across DOD, the Executive Office of the President, the Intelligence Community, and civilian agencies. Of these, eight organizations had space acquisition management responsibilities; eleven had oversight responsibilities; and six were involved in setting requirements for defense space programs. At the same time, many experts stated that no one seemed to be in charge of space acquisitions. Our report highlighted the pros and cons of various options to reorganize space functions recommended in prior congressionally-chartered studies. The issue has taken on more importance in recent years, as DOD has realized satellites are highly

[11]GAO, *2012 Annual Report: Opportunities to Reduce Duplication, Overlap and Fragmentation, Achieve Savings, and Enhance Revenue*, GAO-12-342SP (Washington, D.C.: Feb. 28, 2012).

[12]GAO, *Defense Space Acquisitions: Too Early to Determine if Recent Changes Will Resolve Persistent Fragmentation in Management and Oversight,* GAO-16-592R (Washington, D.C.: July 27, 2016).

vulnerable to attacks and needs to make dramatic changes in space system architectures and operations. We have found that leadership has not been focused enough to overcome interagency rivalries and resistance to change, and it has not been able to get concurrence on future architectures.

The President's Administration and DOD have taken significant steps to change space leadership. Most recent is the President's Space Policy Directive-4, issued on February 19, 2019, and DOD's subsequent legislative proposal submitted on March 1, 2019, to establish a United States Space Force as a sixth branch of the United States Armed Forces within the Department of the Air Force.[13] The Policy Directive states that this is an important step toward a future military department for space and that the Space Force will (1) consolidate existing forces and authorities for military space activities, as appropriate, to minimize duplication of effort and eliminate bureaucratic inefficiencies; and (2) not include the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the National Reconnaissance Office, or other non-military space organizations or missions of the United States Government.

According to the Policy Directive, the Space Force would include the uniformed and civilian personnel conducting and directly supporting space operations from all DOD Armed Forces, assume responsibilities for all major military space acquisition programs, and create the appropriate career tracks for military and civilian space personnel across all relevant specialties. Pertaining to organization and leadership, the Policy Directive states that there should be a civilian Under Secretary of the Air Force for Space, to be known as the Under Secretary for Space, appointed by the President, and establishes a Chief of Staff of the Space Force, who would serve as a member of the Joint Chiefs of Staff.

Furthermore, the Policy Directive states that as the Space Force matures, and as national security requires, it will become necessary to create a separate military department, to be known as the Department of the Space Force. This department would take over some or all responsibilities for the Space Force from the Department of the Air Force.

[13]Space Policy Directive–4, 84 Fed. Reg. 6049 (Feb. 25, 2019); *Legislative Proposal to Establish the U.S. Space Force* (Mar. 1, 2019), available at https://media.defense.gov/2019/Mar/01/2002095010/-1/-1/1/UNITED-STATES-SPACE-FORCE-LEGISLATIVE-PROPOSAL.PDF (last visited Mar. 15, 2019).

The Policy Directive requires the Secretary of Defense to conduct periodic reviews to determine when to recommend that the President seek legislation to establish such a department.

Our past work has identified fragmentation in space leadership, but because implementation has not yet occurred, it remains to be seen whether this policy directive and proposed legislation would resolve these issues. In implementing these changes there are many complexities to consider. For example, because space capabilities are acquired and used across the military services and defense agencies, it will be important to address many details on how to implement a Space Force among these equities. Our past work suggests that without close attention to the consequences of the compromises that will inevitably have to be made to carve out a new force structure from existing space functions, there is risk of exacerbating the fragmentation and ineffective management and oversight the Space Force is intended to address. For instance, in March 2019, DOD established the Space Development Agency to unify and integrate efforts across DOD to define, develop, and field innovative solutions.[14] But it is unclear how this new organization will mesh with the Air Force Space and Missile Systems Center, which acquires satellites, the Defense Advanced Research Projects Agency, which creates breakthrough technologies and capabilities, and similar organizations.

Moreover, even if changes are implemented effectively, they are only a first step toward addressing space acquisition problems. As we discuss below, programs will still need to embrace acquisition best practices, such as using demonstrable knowledge to make decisions. Our prior work has found that they will also need to be open to flexible and innovative approaches, and work effectively with a very wide range of stakeholders, including those that will not be part of the Space Force, such as the intelligence agencies, civilian space agencies, the current military services, as well as entities within the Office of the Secretary of Defense who help oversee and manage acquisitions.[15] Senior leaders have acknowledged that additional changes are needed and have taken steps to help bring them about, such as the restructuring of the Air Force's Space and Missile Systems Center, which is designed to break down stovepipes and streamline acquisition processes.

[14]DOD, *Establishment of the Space Development Agency* (Washington, D.C.: Mar. 12, 2019).

[15]GAO-18-493, GAO-16-592R, and GAO-17-619T.

Past Streamlining Efforts Offer Lessons Learned

DOD is managing a number of new space acquisition programs using a new authority, established under Section 804 of the National Defense Authorization Act for Fiscal Year 2016, which is to provide a streamlined alternative to the traditional DOD acquisition process. Specifically, the programs—which include follow-on missile warning and protected communications satellites, among others—will be exempted from the acquisition and requirements processes defined by DOD Directive 5000.01 and the Joint Capabilities Integration and Development System.[16] Instead, program managers are encouraged to use a tailored approach to documentation and oversight to enable them to demonstrate new technologies or field new or updated systems within 2 to 5 years. We have ongoing work looking across the military departments at how middle-tier acquisition authority is being implemented, including for the Air Force's space acquisition programs, and plan to issue a report later this spring.

GAO and others have highlighted lessons learned from past efforts to streamline, specifically with an approach adopted for space systems in the 1990s known as Total System Performance Responsibility (TSPR). TSPR was intended to facilitate acquisition reform and enable DOD to streamline its acquisition process and leverage innovation and management expertise from the private sector. Specifically, TSPR gave a contractor total responsibility for the integration of an entire weapon system and for meeting DOD's requirements. We found in May 2009 that because this reform made the contractor responsible for day-to-day program management, DOD did not require formal deliverable documents—such as earned value management reports—to assess the status and performance of the contractor.[17] As a result, DOD's capability to lead and manage the space acquisition process diminished, which magnified problems related to unstable requirements and poor contractor performance. Further, the reduction in DOD oversight and involvement led to major reductions in various government capabilities, including cost-estimating and systems-engineering staff. This, in turn, led to a lack of technical data needed to develop sound cost estimates.

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[16] DOD Directive 5000.01, the Defense Acquisition System (Aug. 31, 2018); and Chairman of the Joint Chiefs of Staff Instruction 5123.01H "Charter of the Joint Requirements Oversight Council (JROC) and Implementation of the Joint Capabilities Integration and Development System (JCIDS)" (Aug. 31, 2018).

[17] GAO, *Space Acquisitions: DOD Faces Substantial Challenges in Developing New Space Systems*, GAO-09-705T (Washington, D.C.: May 20, 2009).

Best practices that we identified in the aftermath of TSPR include retaining strong oversight and insight into programs; using quantifiable data and demonstrable knowledge to make decisions to proceed, not allowing development to proceed until certain thresholds are met, empowering program managers to make decisions on the direction of the program but also holding them accountable for their choices, and canceling unsuccessful programs. Similarly, in its study of TSPR programs, the Defense Science Board/Air Force Scientific Advisory Board Joint Task Force emphasized the importance of managing requirements, sufficiently funding programs, participating in trade-off studies, and assuring that proven engineering practices characterize program implementation, among other actions. See appendix II for a more complete list of the best practices we have identified for developing complex systems.

DOD May Face Resource and Capacity Challenges in Taking on Multiple Programs at One Time

DOD is simultaneously undertaking new major acquisition efforts to replenish its missile warning, protected communications, GPS, and weather satellites. At the same time, it is boosting efforts to increase space situational awareness and protect space assets. It is also helping to fund the development of new launch vehicles, and it is considering additional significant acquisitions in wideband satellite communications and in support of missile defense activities. While there is increased attention within DOD on funding for space and building the Space Force, such widespread acquisition activities could still pose resource challenges. For example:

- Funding requests for space system modernization have in the past 10 years represented a small percentage (3.9 to 5 percent) of total weapon system modernization funding DOD requested. Space is competing with ships, aircraft, and the nuclear triad, among other programs for funding. This can be challenging, because over the past 2 years, DOD has begun over 9 new space acquisition programs to recapitalize current space capabilities and enhance system resiliency.[18] In the past, we have found that it has been difficult for DOD to fund multiple new space programs at one time, particularly

[18]These programs include Electro/Optical Weather System; Enhanced Polar System Recapitalization; Evolved Strategic SATCOM; GPS III Follow-on; Military GPS User Equipment, Increment 2; Next Generation Overhead Persistent Infrared (OPIR) – Ground; Next Generation (OPIR) – Space; Protected Tactical Enterprise Service; Protected Tactical SATCOM; and Space Command and Control.

when it was concurrently struggling with cost overruns and schedule delays from its legacy programs. For example, OCX system development challenges have resulted in a $2.5 billion cost increase and approximate 5-year delay to the system becoming operational—using more resources for a longer time—at a cost to other programs.

- It is unclear whether DOD has a sufficient workforce to manage multiple new space programs. We issued a report last month that found DOD did not routinely monitor the size, mix, and location of its space acquisition workforce.[19] We collected and aggregated data from multiple DOD space acquisition organizations and found that at least 8,000 personnel in multiple locations nationwide were working on space acquisition activities at the end of 2017. Echoing concerns raised in our prior work, we also found that DOD had difficulty attracting and retaining candidates with the requisite technical expertise. Officials from the Air Force's Space and Missile Systems Center were concerned that there are not enough experienced mid-level acquisition personnel and also expressed concern that the bulk of military personnel assigned to program management positions were more junior in rank than the Center was authorized to obtain. We recommended that DOD (1) identify the universe of its space acquisition programs and the organizations that support them, and (2) collect and maintain data on the workforce supporting these programs. DOD concurred with our first recommendation but not the second.[20]
- Software is an increasingly important enabler of DOD space systems. However, DOD has struggled to deliver software-intensive space programs that meet operational requirements within expected time frames. Although user involvement is critical to the success of any software development effort, we found in our report issued last month on DOD software-intensive space programs that the programs we reviewed that experienced cost or schedule breaches often did not effectively engage users to understand requirements and obtain feedback.[21] Program efforts to involve users and incorporate feedback

[19]GAO, *Defense Space Systems: DOD Should Collect and Maintain Data on Its Space Acquisition Workforce*, GAO-19-240 (Washington, D.C.: Mar. 14, 2019).

[20]In response to DOD's non-concurrence with our second recommendation, we stated that we continue to believe that taking steps to identify military and civilian personnel supporting space acquisition programs would support DOD's strategic workforce planning, particularly considering DOD's recent legislative proposal for establishing the United States Space Force.

[21]GAO-19-136.

frequently did not match plans. The lack of user engagement has contributed to systems that were later found to be operationally unsuitable. The programs we reviewed also faced challenges in delivering software in shorter time frames, and in using commercial software, applying outdated tools and metrics, as well as having limited knowledge and training in newer software development techniques. DOD acknowledged these challenges and is taking steps to address them, including identifying useful software development metrics and ways to include them in new contracts. We recommended, and DOD concurred, that the department ensure its guidance addressing software development provides specific, required direction on the timing, frequency, and documentation of user involvement and feedback. Moreover, it should be noted that software development has been a struggle for other non-space weapons programs as well. The Defense Innovation Board recently reported that the department’s current approach to software development is broken and is a leading source of risk to DOD—it takes too long, is too expensive, and exposes warfighters to unacceptable risk by delaying their access to the tools they need to assure mission success.

Chairman Cooper, Ranking Member Turner, and Members of the Subcommittee, this concludes my statement. I am happy to answer any questions that you have.

GAO Contact and Staff Acknowledgments

If you or your staff have any questions about this statement, please contact me at (202) 512-4841 or chaplainc@gao.gov. Contacts for our Offices of Congressional Relations and Public Affairs may be found on the last page of this statement. Individuals who made key contributions to this statement include Rich Horiuchi, Assistant Director; Erin Cohen (Analyst in Charge); Emily Bond; Claire Buck; Maricela Cherveny; Susan Ditto; Burns C. Eckert; Laura Hook; and Anne Louise Taylor. Key contributors for the previous work on which this statement is based are listed in the products cited.

Appendix I: Status of Major Department of Defense Space Acquisitions

Table 2: Current Status of Major Department of Defense (DOD) Space Acquisitions

Program	Cost and quantity change from first full estimate (in FY 2019 billion dollars)	Current status	Associated new programs
Advanced Extremely High Frequency (AEHF) (satellite system to provide survivable, jam-resistant, worldwide, secure satellite communications for strategic and tactical operations)	**Cost and percentage change:** $15.5 billion, 116.7% **Original quantity:** 5 **Current quantity:** 6	Four satellites have been launched. The 5th and 6th to be launched in 3rd quarter fiscal year 2019 and 2nd quarter fiscal year 2020. The program's first launch was delayed by more than 3.5 years.	Evolved Strategic SATCOM (ESS); Protected Tactical SATCOM (PTS); Protected Tactical Enterprise Service (PTES)
Enhanced Polar System (EPS) (satellite system to provide protected, extremely high frequency satellite communications in polar region)	**Cost and percentage change:** $1.5 billion, -0.9% **Original quantity:** 2 **Current quantity:** 2	Operational testing for the second payload is scheduled to begin by 3rd quarter fiscal year 2019, with initial operational capability scheduled for 4th quarter fiscal year 2019.	Enhanced Polar System Recap (EPS-R)
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T) Command Post Terminals (CPT) (user terminals to provide protected and survivable satellite communications for airborne and ground-based users)	**Cost and percentage change:** $1.9 billion, 7.2% **Original quantity:** 95 **Current quantity:** 109	As of December 2018 the contractor had delivered 22 terminals and the program had installed 5 to begin testing. The program expects to reach initial operational capability by June 2021, an 18 month delay from its previously reported estimate	FAB-T Force Element Terminals (FET)
Global Positioning System (GPS) III (system to provide positioning, navigation, and timing to military and civil users)	**Cost and percentage change:** $5.8 billion, 31.8% **Original quantity**: 8 **Current quantity:** 10	The first satellite launched in 2018 and a second will be available for launch in mid-2019. The third satellite is expected to be launched in late fall 2019. The program continues to face delayed deliveries of certain satellite components which could affect the schedules for satellites 4 through 10.	GPS IIIF
Global Positioning System Next Generation Operational Control System (GPS OCX) (ground system to provide command and control for current and new GPS III satellites)	**Cost and percentage change:** $6.2 billion, 68.1% **Original quantity:** 1 **Current quantity:** 1	A new cost and schedule baseline was approved in September 2018. The program has yet to fully mature the critical technologies that underpin the full OCX system.	Not determined

Program	Cost and quantity change from first full estimate (in FY 2019 billion dollars)	Current status	Associated new programs
Joint Space Operations Center Mission System (JMS), Increment 2 (provide applications, net-centric services and databases, and dedicated hardware to improve space situational awareness)	**Cost and percentage change:** $0.5 billion, 42.0% **Original quantity:** 1 **Current quantity:** 1	While the program had planned to deliver the full capabilities in Increment 2 by 2016, the program ended development in October 2018 and only delivered a limited number of capabilities. Requirements that were not met by JMS were deferred to the follow-on program, Space Command and Control (C2)	Space Command and Control (C2)
Military GPS User Equipment (MGUE), Increment 1 (military-code capable GPS user equipment)	**Cost and percentage change:** $1.5 billion, -5.1% **Original quantity:** N/A **Current quantity:** N/A	It is unclear when M-code capable receivers will be fielded. The program expects to complete operational testing in April 2021.	MGUE Increment 2
Mobile User Objective System (MUOS) (satellite system to provide worldwide narrowband satellite communications)	**Cost and percentage change:** $7.1 billion, -6.0% **Original quantity:** 6 **Current quantity:** 5	Constellation complete with four satellites and an on-orbit spare. The program did not pass operational testing in 2015. Another operational test is planned to begin in May 2019.	Not determined
National Security Space Launch (NSSL) (provides spacelift support for DOD, national security, and other government missions with viable domestic launch service providers)	**Cost and percentage change:** $57.0 billion, 193.2% **Original quantity:** 181 **Current quantity:** 161	The program awarded launch service agreements to 3 companies in October 2018 to develop launch system prototypes that will be able to launch national security space missions beginning in fiscal year 2022.	Not determined
Space Based Infrared System (SBIRS) (satellite and ground system to provide missile warning, infrared intelligence, surveillance, and reconnaissance)	**Cost and percentage change:** $19.9 billion, 265.0% **Original quantity:** 5 **Current quantity:** 6	Planned launch dates for GEOs 5 and 6 planned for early 2021, and 2022, respectively. The baseline program was delivered about 9 years later than planned. GEOs 5 and 6 are at risk for delay.	Next Generation Overhead Persistent Infrared (Next Gen OPIR); Future Operationally Resilient Ground Evolution (FORGE), Enterprise Ground Services (EGS)
Space Fence Ground-Based Radar System, Increment 1 (detect and track objects in low and medium Earth orbit in support of DOD's space surveillance network)	**Cost and percentage change:** $1.6 billion, -5.7% **Original quantity:** 1 **Current quantity:** 1	The program plans to conduct operational testing in Spring 2019, and expects to reach initial operational capability by July 2019.	Not determined

Program	Cost and quantity change from first full estimate (in FY 2019 billion dollars)	Current status	Associated new programs
Wideband Global SATCOM (WGS) (worldwide communications services to U.S. warfighters, allies, and other special users)	**Cost and percentage change**: \$4.2 billion,[a] 216.3% **Original quantity:** 3 **Current quantity:** 10	Funding for the Air Force to procure two additional WGS satellites was included in the Consolidated Appropriations Act, 2018. Analysis of Alternatives (AoA) to identify options for providing capabilities beyond WGS completed its analysis phase in June 2018.	To be determined following AoA
Weather System Follow-on (WSF) (satellite to provide remote sensing of weather conditions using polar-orbiting satellite)	**Cost and percentage change:** \$0.5 billion, N/A **Original quantity:** 2 **Current quantity:** 2	Program is to enter development in March 2019. First satellite expected to be launched late 2023.	Electro-Optical/Infrared Weather Systems (EWS); Electro-Optical/Infrared Weather Systems Geostationary (EWS-G)

Source: GAO analysis of Department of Defense information | GAO-19-482T

Note: Dollar figures are rounded to the nearest tenth and reported in fiscal year 2019 dollars based on the programs’ original and most recent Selected Acquisition Reports or program office updates.

[a]This value does not include the cost of 2 satellites funded by international partners.

Appendix II: Best Practices GAO Has Identified for Space and Weapons Systems Acquisitions

Our previous work on weapons acquisitions in general, and space programs in particular, identified best practices for developing complex systems. We summarize these best practices in table 3, below.

Table 3: Summary of Best Practices GAO Has Identified to Address Space and Weapons Acquisition Problems

Before undertaking new programs
Prioritize investments so that projects can be fully funded and it is clear where projects stand in relation to the overall portfolio.
Follow an evolutionary path toward meeting mission needs rather than attempting to satisfy all needs in a single step.
Match requirements to resources—that is time, money, technology, and people—before undertaking new development efforts.
Research and define requirements before starting programs and limit changes after they are started.
Ensure that cost estimates are complete, accurate, and updated regularly. Commit to fully fund projects before they begin.
Ensure that critical technologies are proven to work as intended before programs begin. Assign more ambitious technology development efforts to research departments until they are ready to be added to future generations (or increments) of a product.
Use systems engineering to close gaps between resources and requirements before launching the development process.
During program development
Use quantifiable data and demonstrable knowledge to make decisions to proceed, covering critical facets of the program such as cost, schedule, technology readiness, design readiness, production readiness, and relationships with suppliers.
Do not allow development to proceed until certain thresholds are met—for example, a high proportion of engineering drawings completed or production processes under statistical control.
Empower program managers to make decisions on the direction of the program and to resolve problems and implement solutions.
Hold program managers accountable for their choices.
Require program managers to stay with a project to its end.
Encourage program managers to share bad news, and encourage collaboration and communication.
Hold suppliers accountable for delivering high-quality parts for their products through activities including regular supplier audits and performance evaluations of quality and delivery.

Source: GAO | GAO-19-482T

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