United States Government Accountability Office

Report to Congressional Committees

September 2021

MISSILE WARNING SATELLITES

Comprehensive Cost and Schedule Information Would Enhance Congressional Oversight

A Century of Non-Partisan Fact-Based Work

GAO-21-105249

GAO@100 Highlights

Highlights of GAO-21-105249, a report to congressional committees

September 2021

MISSILE WARNING SATELLITES

Comprehensive Cost and Schedule Information Would Enhance Congressional Oversight

Why GAO Did This Study

The U.S. Space Force plans to spend around $14.4 billion over the next 5 years to develop the Next Gen OPIR system, comprised of satellites and a ground system to detect and track missiles, among other things. The Air Force experienced significant problems when it developed the predecessor to Next Gen OPIR—it was roughly 9 years late and cost more than three times its initial estimate.

A report to the National Defense Authorization Act for Fiscal Year 2019 contained a provision for GAO to review Next Gen OPIR efforts. This report (1) identifies the challenges Next Gen OPIR acquisition efforts face and the extent to which the Space Force is addressing them, and (2) assesses the extent to which Next Gen OPIR capabilities will address missions supported by the current system. GAO reviewed program documentation, acquisition strategies, and Air Force and DOD acquisition guidance, and interviewed DOD officials. GAO assessed this information against acquisition and collaboration best practices. Information that DOD deemed to be sensitive has been omitted.

What GAO Recommends

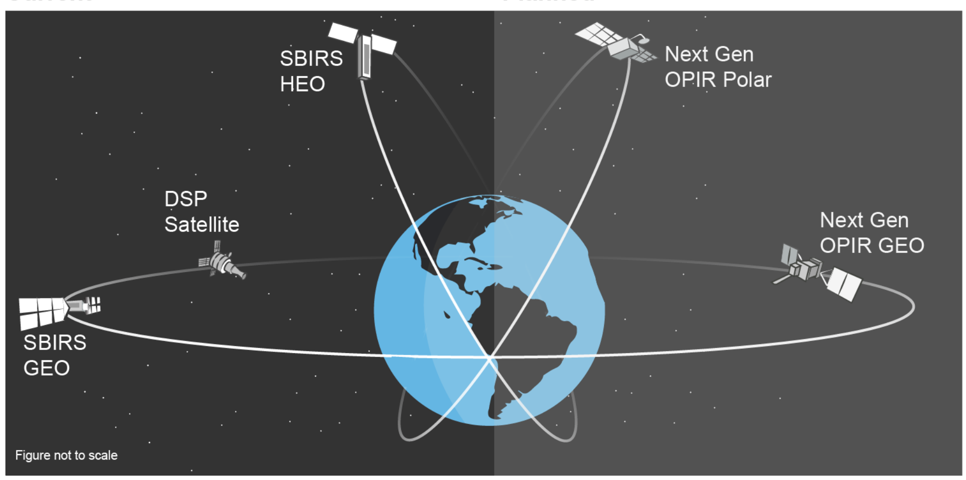
GAO recommends that the Space Force provide congressional committees more transparent cost and schedule risk information for Next Gen OPIR, and that DOD formalize coordination across agencies. DOD partially concurred with both recommendations. Regarding the first, GAO believes DOD's plan will meet the intent of the recommendation; on the second, GAO maintains the importance of formalizing coordination.

View GAO-21-105249. For more information, contact Jon Ludwigson at (202) 512-4841 or ludwigsonj@gao.gov.

What GAO Found

The U.S. defense and intelligence communities depend on data from overhead persistent infrared sensors. These sensors provide early warning of ballistic missile launches and contribute to other defense and intelligence missions. The planned Next Generation Overhead Persistent Infrared (Next Gen OPIR) system is intended to replace the Space Based Infrared System, which began in the mid-1990s. The Space Force plans to launch the first of five Next Gen OPIR satellites in 2025. The figure below presents a notional depiction of current and planned OPIR systems.

Notional Depiction of Current and Planned OPIR Satellite Orbits



Next Gen OPIR	Next Generation Overhead Persistent Infrared		
DSP	Defense Support Program	**HEO**	Highly Elliptical Orbit
GEO	Geosynchronous Earth Orbit	**SBIRS**	Space Based Infrared System

Source: GAO analysis of Department of Defense information and depiction of © 2007 Lockheed Martin Corporation, All Rights Reserved. | GAO-21-105249

Despite early steps to speed up development, the Next Gen OPIR program faces significant technical and managerial challenges—such as developing a new mission payload and serving as the lead system integrator for the first time in this area—that are likely to delay the initial launch. Significant schedule delays typically result in cost increases. Although officials are aware of schedule risks, they continue to present an on-track timeline and stable cost estimates in reports to congressional committees. More transparency in schedules and costs would contribute to better Department of Defense (DOD) and congressional oversight and decision-making.

The first Next Gen OPIR satellites are intended to provide missile warning capabilities and support other mission partners. DOD has initiated multi-agency efforts to determine how to meet future needs. However, coordination mechanisms are not formalized. Without documenting roles, responsibilities, and plans, DOD risks ineffective collaboration and unsynchronized delivery of warfighter capabilities.

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Abbreviations

AOA	analysis of alternatives
DOD	Department of Defense
DSP	Defense Support Program
FORGE	Future Operationally Resilient Ground Evolution
GEO	geosynchronous earth orbit
HEO	highly elliptical orbit
JOG	Joint OPIR Ground
JROC	Joint Requirements Oversight Council
MDAP	major defense acquisition program
MTA	middle-tier acquisition
Next Gen OPIR	Next Generation Overhead Persistent Infrared
NIO-F	Next Generation Interim Operations on FORGE
OBAC	OPIR Battlespace Awareness Center
OPIR	Overhead Persistent Infrared
SBIRS	Space Based Infrared System
SMC	Space and Missile Systems Center
TAP Lab	Tools, Applications, and Processing Laboratory
TRL	technology readiness level

U.S. GOVERNMENT ACCOUNTABILITY OFFICE
A Century of Non-Partisan Fact-Based Work
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September 22, 2021

Congressional Committees

The newly created U.S. Space Force plans to spend approximately $14.4 billion through 2025 on the Next Generation Overhead Persistent Infrared (Next Gen OPIR) system.[1] Space systems using overhead persistent infrared sensors support U.S. defense and intelligence communities with essential launch detection, missile tracking, and reconnaissance data to mitigate, predict, track, and respond to a variety of threats. Next Gen OPIR will replace the current satellite system—Space Based Infrared System (SBIRS)—and primarily consists of space and ground segment development efforts. Initiated in 2018, the first phase of the space segment, Block 0, will consist of five satellites. At the same time, the Space Force is developing a new ground system, called the Future Operationally Resilient Ground Evolution (FORGE), to operate the satellites and process the mission data they collect. The Space Force plans to launch the first satellite in late fiscal year 2025.

The conference report to the National Defense Authorization Act for Fiscal Year 2019 contained a provision for us to review the early planning of Next Gen OPIR efforts and associated ground capabilities. Our report (1) identifies the challenges Next Gen OPIR acquisition efforts face and the extent to which the Space Force is addressing them, and (2) assesses the extent to which Next Gen OPIR capabilities will address missions that SBIRS currently supports.

This report is a public version of a sensitive report that we issued on March 11, 2021.[2] DOD deemed some of the information in our March 2021 report to be sensitive, which must be protected from public disclosure. Therefore, this report omits sensitive information. Although the information provided in this report is more limited, the report addresses

[1]On December 20, 2019, the National Defense Authorization Act for Fiscal Year 2020 established the United States Space Force as a new branch of the Armed Forces within the Department of the Air Force. Pub. L. No. 116-92, Sec. 952 (2019). In this report, as appropriate, we refer to the U.S. Space Force even when some program activities were initiated under the Air Force.

[2] GAO, *Missile Warning Satellites: Comprehensive Cost and Schedule Information Would Enhance Congressional Oversight*, GAO-21-218SU (Washington, D.C.: Mar. 11, 2021).

the same objectives as the sensitive report and uses the same methodology.

To identify the challenges facing the Next Gen OPIR Block 0 and ground system acquisition efforts, we reviewed program documentation, including a 2017 Joint Requirements Oversight Council Memorandum, which set program requirements, as well as program acquisition strategies and cost and schedule estimates. To understand the extent to which the Space Force is addressing challenges, we analyzed risk-tracking documentation, including risk mitigation documentation from the Next Gen OPIR acquisition efforts. Additionally, we reviewed Air Force and Department of Defense (DOD) guidance on the middle tier of acquisition pathway to understand reporting and oversight policies applicable to the Next Gen OPIR Block 0 and FORGE programs.[3] We interviewed officials from the Office of the Under Secretary for Defense for Acquisition and Sustainment; Office of the Under Secretary of Defense for Research and Engineering; Office of Cost Assessment and Program Evaluation; Office of the Secretary of the Air Force; Space Force Headquarters; and Space Force Space and Missile Systems Center (SMC) and its Next Gen OPIR and FORGE program offices. We also interviewed officials of and reviewed documentation from Next Gen OPIR prime contractors and subcontractors, including Lockheed Martin, Northrop Grumman, Northrop Grumman/Ball Aerospace, and Raytheon Technologies. We analyzed

[3]Department of Defense Instruction No. 5000.80, Operation of the Middle Tier of Acquisition (MTA) (Dec. 30, 2019); Department of Defense, Under Secretary of Defense (Acquisition and Sustainment): *Middle Tier of Acquisition (Rapid Prototyping/Rapid Fielding) Interim Governance* 2 (March 20, 2019); Department of Defense, Under Secretary of Defense (Acquisition and Sustainment): *Middle Tier of Acquisition (Rapid Prototyping/Rapid Fielding) Interim Governance* (Oct. 9, 2018); Department of Defense, Under Secretary of Defense (Acquisition and Sustainment): *Middle Tier of Acquisition (Rapid Prototyping/Rapid Fielding) Interim Authority and Guidance* (Apr. 16, 2018). Department of the Air Force, Office of the Assistant Secretary, Memorandum: *Air Force Guidance Memorandum for Rapid Acquisition Activities* (June 27, 2019); Department of the Air Force, Office of the Assistant Secretary of the Air Force (Acquisition, Technology and Logistics), Memorandum No. AFGM2018-63-146-01: *Air Force Guidance Memorandum for Rapid Acquisition Activities* (June 13, 2018); Department of the Air Force, AF/A5R Requirements Development Guidebook, Vol. 5: Air Force Procedures: Middle Tier of Acquisition Requirements Validation Process v.1.0 (Jan. 11, 2019).

Space Force acquisition plans for Next Gen OPIR and compared them to our best practices for estimating program cost and schedules.[4]

To assess the extent to which Next Gen OPIR capability will address missions that SBIRS currently supports, we reviewed the 2017 Joint Requirements Oversight Council memorandum and compared it to documentation on SBIRS mission areas. Additionally, we reviewed documentation from recent and ongoing efforts that leverage SBIRS data and interviewed officials across the Air Force and Space Force to understand whether and how those efforts will continue under Next Gen OPIR. We also reviewed the Missile Warning and Missile Defense Capability Development Document and other documentation on future OPIR requirements and planning efforts. We interviewed officials from the Assistant Secretary of the Air Force on the status of planning efforts for determining a future OPIR architecture and compared those efforts to our best practices on interagency collaboration.[5] Additional information we obtained and assessed at the classified level does not change our findings and is not contained in this report.

We conducted this performance audit from October 2019 to March 2021 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. We subsequently worked with DOD from May 2021 to August 2021 to prepare this public version of the sensitive report. This public version was also prepared in accordance with these standards.

Background

The Space Force is acquiring the Next Gen OPIR system to augment and eventually replace the current system, SBIRS, which provides worldwide initial warning of ballistic missile attacks on the U.S., its deployed forces, and its allies. OPIR satellites use infrared sensors to detect heat from missile and booster plumes against the background of Earth. In the mid-

[4]GAO, *GAO Schedule Assessment Guide: Best Practices for Project Schedules*, GAO-16-89G (Washington, D.C.: Dec. 22, 2015); and *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, GAO-09-3SP (Washington, D.C.: Mar. 2, 2009).

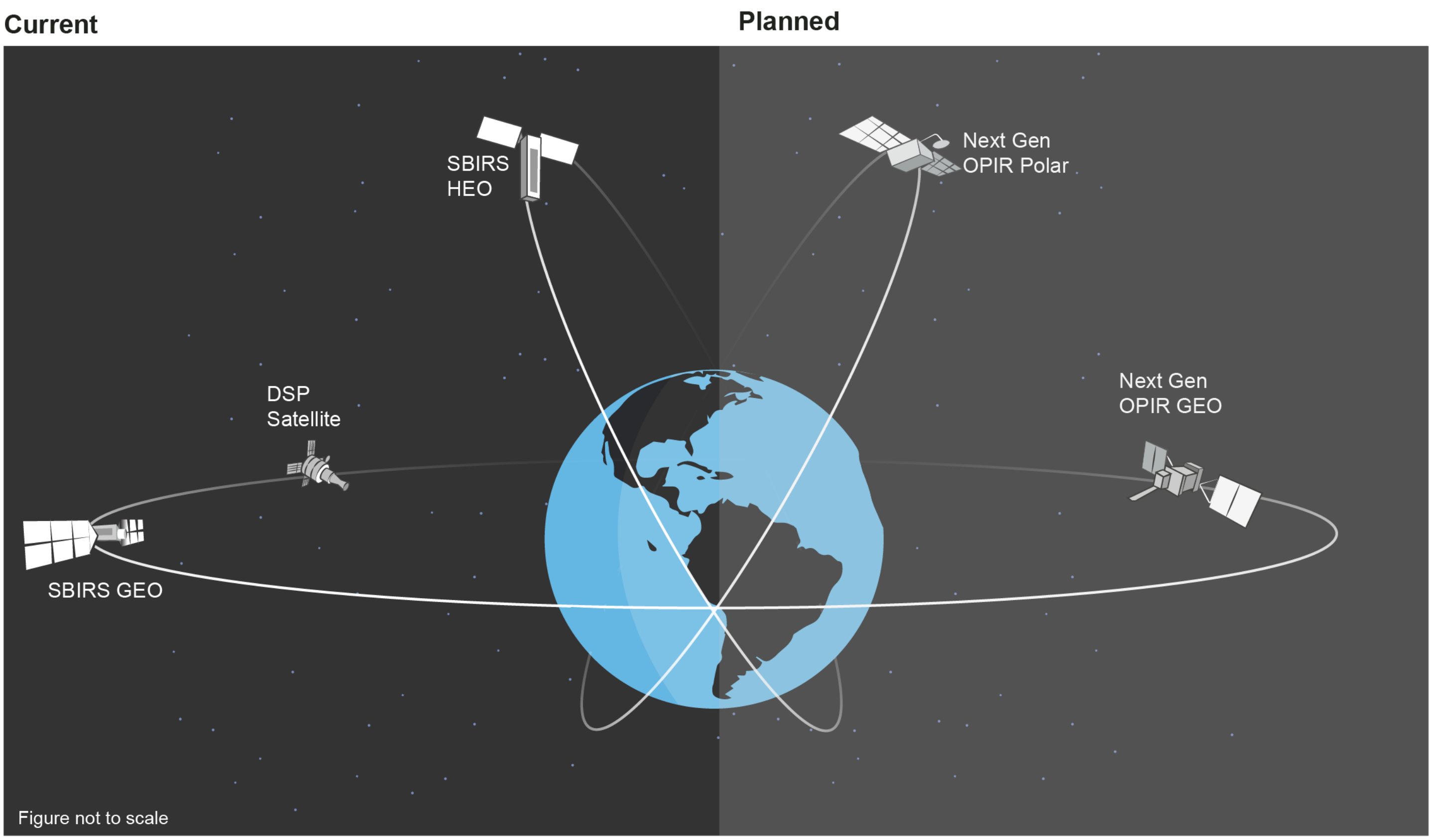
[5]GAO, *Managing For Results: Key Considerations for Implementing Interagency Collaborative Mechanisms*, GAO-12-1022 (Washington, D.C.: Sept. 27, 2012).

1990s, DOD selected SBIRS to replace the Defense Support Program (DSP), which is now nearly 5 decades old.[6] The SBIRS constellation consists of satellites in geosynchronous earth orbits (GEO) and highly elliptical orbits (HEO).[7] Figure 1 notionally depicts the current and planned OPIR satellites and their associated orbits.

[6]The first operational DSP satellite was deployed in 1971 and the first SBIRS satellite launched in 2011.

[7]HEO satellites, which linger over a designated area of the Earth, can provide polar coverage. A GEO satellite's revolution is synchronized with the Earth's rotation giving it a seemingly stationary position above a fixed point on the Equator.

Figure 1: Notional Depiction of Current and Planned Overhead Persistent Infrared Satellites



Next Gen OPIR	Next Generation Overhead Persistent Infrared
DSP	Defense Support Program
GEO	Geosynchronous Earth Orbit
HEO	Highly Elliptical Orbit
SBIRS	Space Based Infrared System

Source: GAO analysis of Department of Defense information and depiction of © 2007 Lockheed Martin Corporation, All Rights Reserved. | GAO-21-105249

Space systems are complex and take a long time to develop. Over the past 20 years, we have reported on SBIRS development challenges leading to cost increases and schedule delays, including four separate

Nunn-McCurdy unit cost breaches.[8] The Air Force mismanaged the early stages of the SBIRS acquisition by moving forward with immature technologies, unclear requirements, unstable funding, underestimated software complexity, and ineffective government oversight. Total program costs for SBIRS grew approximately 260 percent from $5.6 billion in 1996—when the Air Force initiated the program—to $20.3 billion in 2020, and launch of the first satellite was delayed roughly 9 years, from 2002 to 2011. Even after restructuring the program several times, SBIRS continued to face development challenges, including test failures and technical issues that resulted in cost growth and schedule delays on the third and fourth satellites. Additionally, the fifth and sixth SBIRS GEO satellites experienced technical issues leading to delays.

Moreover, software development associated with the ground system proved much more difficult than originally anticipated and continued until August 2019, when SBIRS delivered the ground processing capabilities needed to take full advantage of the satellites' advanced infrared sensors. These ground processing capabilities were delivered 8 years after the first SBIRS GEO satellite launch and after several SBIRS GEO satellites were already on orbit. We have reported for over 10 years that DOD struggles to align space systems with their associated ground systems to ensure a fully functioning capability.[9] Still, the program has largely overcome cost, schedule, and other technical issues on recent GEO satellites.

[8]The Nunn-McCurdy statute (10 U.S.C. §2433) requires the DOD to report to Congress when a Major Defense Acquisition Program's (MDAP) unit cost experiences cost overruns that exceed certain thresholds. MDAPs are generally programs designated by the Secretary of Defense or that are estimated to require eventual total expenditure for research, development, test, and evaluation of more than $480 million, or for procurement of more than $2.79 billion, in fiscal year 2014 constant dollars. The SBIRS program was an MDAP. A program whose acquisition unit cost growth compared to the acquisition unit cost goals established in the Acquisition Program Baseline exceeds the statutory thresholds is said to have a Nunn-McCurdy breach. See for example, GAO, *DOD Space Acquisitions: Including Users Early and Often in Software Development Could Benefit Programs,* GAO-19-136 (Washington, D.C.: Mar. 18, 2019); *Space Based Infrared System High Program and its Alternative*, GAO-07-1088R (Washington, D.C.: Sept. 12, 2007); and *Defense Acquisitions: Space-Based Infrared System-low at Risk of Missing Initial Deployment Date*, GAO-01-6 (Washington, D.C.: Feb. 28, 2001).

[9]See for example 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); *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); and *Defense Acquisitions: Challenges in Aligning Space System Components,* GAO-10-55 (Washington, D.C.: Oct. 29, 2009).

SBIRS is designed to support the defense and other communities and provide global surveillance capabilities in four key mission areas, as shown in figure 2.

Figure 2: Space Based Infrared System (SBIRS) Capability Mission Areas

SBIRS	Space Based Infrared System
GEO	Geosynchronous Earth Orbit
HEO	Highly Elliptical Orbit

Source: GAO analysis of Department of Defense information. | GAO-21-105249

Several stakeholders across DOD and the Intelligence Community play a part in collecting, disseminating, and processing OPIR data.[10] The DOD mission partners include the Space Force and the Air Force as well as the Space Development Agency, the Missile Defense Agency and Intelligence Community elements.

Because the SBIRS design is decades old and has limitations in adapting to a changing adversary threat environment, in 2014 DOD completed an

[10]The Intelligence Community is comprised of 18 executive branch agencies and organizations, generally referred to as IC elements.

analysis of alternatives (AOA) to address upgrading or replacing SBIRS.[11] In December 2017, the Joint Requirements Oversight Council (JROC) validated requirements for a new system to replace SBIRS—known as Next Gen OPIR Block 0—including a requirement to launch the first satellite in 2025.[12] The requirements for Next Gen OPIR Block 0 also include developing and fielding a ground system, known as FORGE, to support current and new missile warning satellites.

In May 2018, the Air Force formalized the acquisition strategy for Next Gen OPIR Block 0. Block 0 is planned to consist of three GEO satellites and two polar satellites. FORGE is to consist of mission data processing capabilities to analyze and disseminate data to users, command and control capabilities to operate the satellites, and relay ground stations for communicating with the satellites.[13] This report omits additional, sensitive information about Next Gen OPIR Block 0 space and ground segments, and their planned capabilities.

The Space Force is acquiring Next Gen OPIR Block 0 and FORGE using a relatively new acquisition approach. Specifically, the Space Force initiated Next Gen OPIR Block 0 as a rapid prototyping middle-tier acquisition (MTA) program. Section 804 of the National Defense Authorization Act for Fiscal Year 2016 required DOD to issue guidance establishing two new acquisition pathways for DOD: rapid prototyping and rapid fielding pathways, which DOD formalized in 2019. These pathways are to provide an expedited and streamlined "middle tier" of acquisition programs intended to be completed within 5 years. The rapid prototyping pathway provides for the use of innovative technologies to rapidly develop

[11]An AOA is a key first step in DOD's acquisition process and assesses alternative solutions for addressing future needs. DOD Instruction 5000.02, Operation of the Defense Acquisition System, Enclosure 9, "Analysis of Alternatives," provides the purpose and procedures associated with conducting an AOA for major defense acquisition programs to support decision making. This Instruction was reissued Aug. 4, 2020.

[12]The Joint Requirements Oversight Council (JROC) assists the Chairman of the Joint Chiefs of Staff to assess joint military capabilities and identify, approve, and prioritize gaps in such capabilities to meet requirements in the National Defense Strategy.

[13]Satellite control operations essentially consist of (1) tracking—determining the satellite's location based on position and range measurements to receive commands from the ground, (2) telemetry—collecting health and status reports which are transmitted from the satellite to the ground, and (3) commanding—transmitting signals from the ground to the satellite to control satellite subsystems. Tracking, telemetry, and commanding are accomplished by a network of ground stations, ground antennas, and communication links strategically located around the world.

fieldable prototypes to demonstrate new capabilities and meet emerging military needs. Rapid fielding provides for the use of proven technologies to field production quantities of new or upgraded systems with minimal development required.

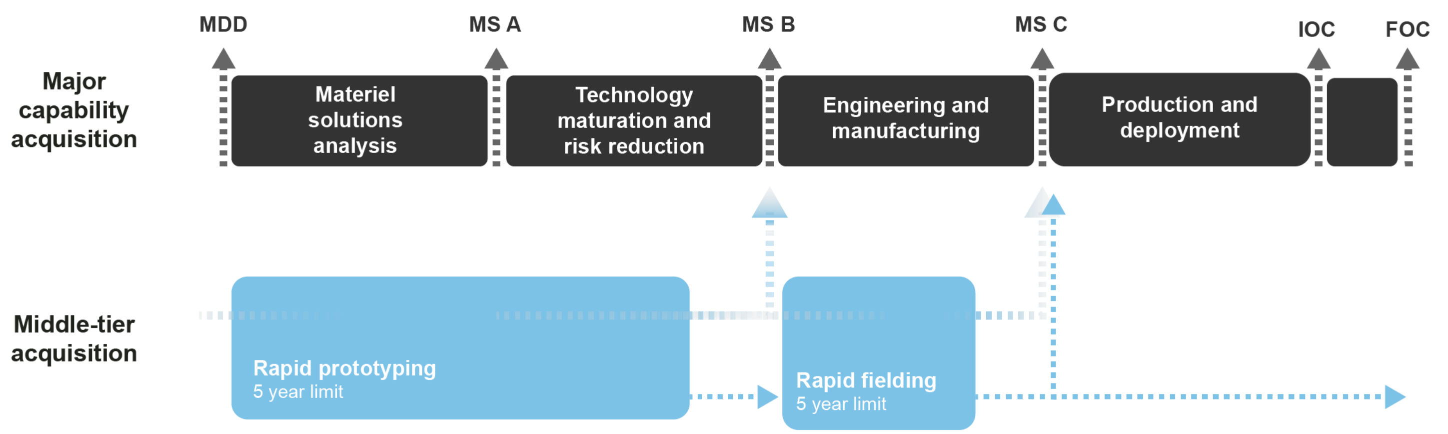
Middle-tier acquisitions are exempt from acquisition and requirements-development processes defined by DOD Directive 5000.01 and the Manual for the Operation of the Joint Capabilities Integration and Development System, unless required by DOD's guidance.[14] To support the new approach, the Under Secretary of Defense for Acquisition and Sustainment issued interim guidance in April 2018 on middle-tier acquisitions with a final instruction in December 2019.[15] In January 2020, the same office issued restructured defense acquisition guidance.[16] As part of these changes, the traditional milestone-based approach described in earlier defense acquisition guidance is now called the major capability acquisition pathway. DOD's acquisition guidance provides multiple options for completing MTAs, transitioning from one MTA to another, or transitioning from an MTA to a major capability acquisition, as shown in figure 3.

[14]National Defense Authorization Act for Fiscal Year 2016, Pub. L. No. 114-92, § 804 (c) (2016); J-8, Joint Staff, Manual for the Operation of the Joint Capabilities Integration and Development System (Aug. 31, 2018); Department of Defense Directive 5000.01, The Defense Acquisition System (Sept. 9, 2020).

[15]DOD Instruction 5000.80, *Operation of the Middle Tier of Acquisition (MTA)* (Dec. 30, 2019).

[16]DOD Instruction (DODI) 5000.02, *Operation of the Adaptive Acquisition Framework* (Jan. 23, 2020). The DOD transition plan for the restructured guidance is that DODI 5000.02 lays the groundwork for operation of the Adaptive Acquisition Framework and will eventually cancel the January 7, 2015, version of DODI 5000.02, which was renumbered DODI 5000.02T (Transition) to establish a distinction between the two issuances. DODI 5000.02T, *Operation of the Defense Acquisition System* (Jan. 7, 2015, Incorporating Change 7, Apr. 21, 2020), will remain in effect, with content removed as it is canceled or transitions to a new issuance.

Figure 3: Comparison of Department of Defense Acquisition Processes for Major Capability and Middle-Tier Acquisition Pathways



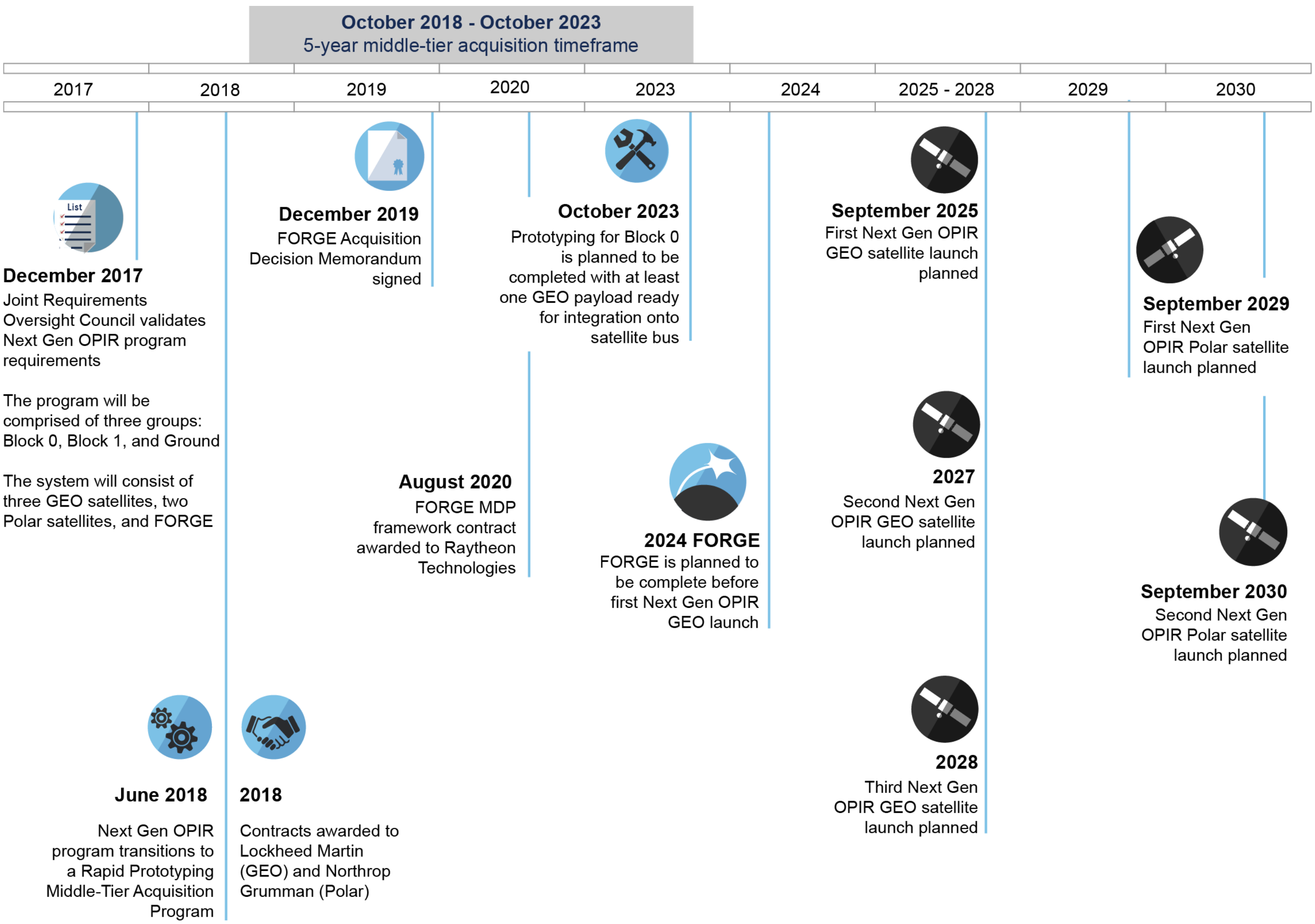
MDD Materiel Development Decision
MS Milestone
IOC Initial Operational Capability
FOC Full Operational Capability

Source: GAO. | GAO-21-105249

Note: Department of Defense Instruction 5000.80 states that acquisition programs following the middle-tier acquisition rapid prototyping or rapid fielding pathways may not be planned to exceed 5 years to completion, and in execution, may not exceed 5 years after middle-tier acquisition program start without a waiver from the Under Secretary of Defense for Acquisition and Sustainment.

The Space Force plans to transition Next Gen OPIR Block 0 to a major capability acquisition pathway at the end of its 5-year middle-tier acquisition window, following the delivery of its prototype in 2023. According to the program office, the Block 0 rapid prototyping effort will end once the main mission payload—an infrared sensor—has completed two steps to demonstrate operational capability: (1) a successful thermal vacuum test (a critical test to determine space-worthiness that subjects the satellite to space-like operating conditions), and (2) delivery to the spacecraft for integration. At that time, the main mission payload will still need to be integrated onto the spacecraft. Figure 4 presents the Next Gen OPIR middle-tier acquisition pathway time frame compared to that of the total system development.

Figure 4: Next Gen OPIR Block 0 Acquisition Timeframe



FORGE	Future Operationally Resilient Ground Evolution
GEO	Geosynchronous Earth Orbit
MDP	Mission Data Processing
Next Gen OPIR	Next Generation Overhead Persistent Infrared

Source: GAO analysis of Department of Defense information. | GAO-21-105249

Despite Efforts to Address Next Gen OPIR Program Challenges, Schedule Risks Remain That Are Not Reflected in Reports to Congressional Defense Committees

Space Force officials recognized development and schedule challenges at the inception of the Next Gen OPIR program and structured the program to address them. However, significant technical and managerial challenges remain. Based on our review of various program assessments, the Next Gen OPIR program is at high risk of schedule delays due to its aggressive launch schedule and technical complexities. The Space Force has not reflected the resulting schedule risks in its recent quarterly reports to congressional defense committees.

Space Force Structured Next Gen OPIR Program to Try to Meet Aggressive Schedule

Given the highly aggressive development and launch schedule validated by the JROC, hastening the start of the program was important for Next Gen OPIR. The Next Gen OPIR middle-tier acquisition designation helped to streamline initiation and expedite the start of the program. For example, Space Force officials said that by using the middle-tier acquisition pathway, they were able to award contracts quickly before conducting many of the steps required by a traditional acquisition.

In addition to its middle-tier acquisition designation, the Space Force developed an acquisition strategy designed to reduce risk and help the program meet its 2025 launch date. For example:

- To minimize the level of new development under the program, officials chose prime contractors that already had proven spacecraft designs for the needed orbits—Lockheed Martin for GEO and Northrop Grumman for Polar—and awarded sole source contracts to each in 2018.
- To address technical risk in developing new sensors and ensure a new OPIR sensor payload would be ready for integration with the GEO spacecraft in time to meet the launch date, the Space Force decided to fully fund two competing subcontractors to design and build the first mission payload. The program planned for the prime contractor for the GEO mission—Lockheed Martin—to select the subcontractors. The program is implementing this strategy to incentivize the mission payload subcontractors to employ their most successful practices and deliver their payload within the required launch schedule. According to the contractors, the subcontracts include an option for at least one additional payload from the winning payload vendor. In addition, the polar spacecraft prime contractor—Northrop Grumman—will hold a similar

competition for the polar mission payload. According to officials at Northrop Grumman, the polar payload competition will leverage the most appropriate GEO payload design, to the extent possible. The subcontractors that will compete to design and build the polar payload are the same subcontractors currently competing to design and build the GEO payload.

- To help ensure DOD will be able to use Block 0 GEO satellites after they are launched—in the event that the FORGE delivery is late—the Next Gen OPIR program is developing an interim ground capability, as noted above, called Next Generation Interim Operations on FORGE (NIO-F). The Space Force is developing NIO-F simultaneously with the FORGE efforts to ensure the most critical ground processing is ready in time for the first Next-Gen OPIR satellite launch. This report omits additional, sensitive information about the ground segment schedule and planned capabilities.

Remaining Program Challenges Are Likely to Delay Initial Launch

Based on our assessment of program status and remaining risks, the measures the program has taken to ensure the on-time delivery of the mission payload and subsequent launch date are likely to fall short given the challenges remaining. Next Gen OPIR faces significant technical and management challenges that we determine are likely to delay the first launch beyond 2025. For example, the program is developing a new payload, integrating the payload onto a modified spacecraft, managing concurrent development efforts with little schedule margin, and creating a contingency ground capability at the same time it is developing its FORGE system.[17] This report omits additional, sensitive information about program and independent risk assessments.

The Next Gen OPIR program conducts periodic assessments that examine program development risks and the likelihood of various outcomes as the program seeks to address those risks. Program officials acknowledge the remaining challenges, and agree that success in overcoming them will drive whether the program can achieve initial launch capability by 2025. For example:

- **Developing the main mission payload:** According to program officials, the primary critical event for the program is development of the mission payload. Historically, novel payloads have encountered delays during

[17]"Schedule margin" refers to extra time in the schedule that programs reserve to accommodate unforeseen challenges and manage risk.

integration. We reported in January 2020 that numerous problems and technical challenges often emerge during integration and testing activities for complex space systems.[18] In fact, the integration and testing phase of development is where programs tend to experience the most problems, and schedules tend to slip.[19] Further, we reported in 2016 when examining best practices for product development, that unprecedented designs are by nature more complex and inherently higher risk.[20] Delayed delivery of the new payload would postpone integration with the new spacecraft, likely necessitating a launch delay.

- **Maturing critical technologies:** The Block 0 space segment has 18 critical technologies, 10 of which the program considers mature.[21] Technologies considered to be mature are those that have been tested in a relevant space environment and are less likely to encounter failures during test and integration. The program continues to develop and test the eight remaining immature critical technologies, most of which are related to the payload. See appendix I for a description of technology readiness levels, which are commonly used to measure technology maturity. Our previous work has shown that there is no way to accurately estimate how long it takes to design, develop, and build a satellite system when key technologies planned for that system are still in the relatively early stages of discovery and invention.[22]
- **Integrating the new payload onto a modified Lockheed Martin spacecraft:** Program officials acknowledge that first-time integration of a payload onto a spacecraft is difficult, and becomes even more

[18]GAO, *James Webb Space Telescope: Technical Challenges Have Caused Schedule Strain and May Increase Costs*, GAO-20-224, (Washington, D.C.: Jan. 28, 2020).

[19]GAO, *James Webb Space Telescope: Integration and Test Challenges Have Delayed Launch and Threaten to Push Costs Over Cap*, GAO-18-273 (Washington, D.C.: Feb. 28, 2018).

[20]GAO, *Weapon System Requirements: Detailed Systems Engineering Prior to Product Development Positions Programs for Success*, GAO-17-77 (Washington, D.C.: Nov. 17, 2016).

[21]Critical technologies are technology elements deemed as critical if they are new or novel, or used in a new or novel way, and are needed for a system to meet its operational performance requirements within defined cost and schedule parameters. These technology elements may be hardware, software, a process, or a combination thereof that are vital to the performance of a larger system or the fulfillment of the key objectives of an acquisition program.

[22]GAO*, Space Acquisitions: Some Programs Have Overcome Past Problems, but Challenges and Uncertainty Remain for the Future*, GAO-15-492T (Washington, D.C.: Apr. 29, 2015).

challenging with the addition of new technology. Lockheed Martin's A2100 spacecraft, while successfully flown in space for years, will be modified for the Next Gen OPIR program to meet new requirements. For example, a significant portion of the spacecraft hardware and flight software will be modified or new.

- **Concurrent development and production of flight units:** Building representative test models allows initial design units to be tested for flaws ahead of major component builds. In other words, design units are used to inform the design and production of subsequent operational units, incorporating corrections and fixes to issues found during testing. However, the Next Gen OPIR program, in the interest of accelerating production to meet the required launch date, will build test units at the same time it is building operational units. This means that issues found in design units during testing will have to be corrected not only on the design units but on the operational units as well. We reported in June 2020 that concurrent design and production increases the risk of cost increases and schedule delays.[23]
- **Complex software development effort on ground segment:** This report omits sensitive information about software development effort.

Management Challenges Add Complexity

In addition to technical challenges, the program also faces management challenges. A key issue facing the program is the government's role as lead system integrator. The office within SMC acting as the lead system integrator is responsible for ensuring the space and ground segments of the Next Gen OPIR program work together. As such, this office is tasked with coordinating multiple prime and subcontractors to develop components such as sensors, software, and electronics across the space and ground segments. Ultimately, it is responsible for ensuring the many integrated components combine to form a functioning system that delivers the program's enhanced missile warning capability.

Although the Space Force has some previous experience acting as the lead system integrator on its Global Positioning System program, this is the first time the government will serve such a role for the missile warning capability area, according to program officials. The official primarily responsible for overseeing integration for Next Gen OPIR, who was staffed to his position in September 2020, told us that the current staffing level is insufficient for the Next Gen OPIR integration activities that are

[23]GAO, *Defense Acquisitions Annual Assessment: Drive to Deliver Capabilities Faster Increases Importance of Program Knowledge and Consistent Data for Oversight,* GAO-20-439 (Washington, D.C.: June 3, 2020).

expected to begin in earnest in the coming months. Specifically, the systems engineering area is understaffed and expected to remain so until the program awards a new support contract in mid-2021. He expects the systems engineering and integration staff number to increase significantly once the new contract is awarded. He further explained that the current support contract has been in place nearly 5 years and began under the SBIRS program, so the staff required to fulfill the needs of the Next Gen OPIR program are not well-accounted for in the current contract.

Complicating matters further is the ongoing stand-up of numerous space organizations within DOD. DOD is acquiring the Next Gen OPIR Block 0 system in the midst of a changing leadership environment, both within the Space Force and among other space organizations. In 2016, we reported that for over 2 decades, fragmentation and overlap in DOD space acquisition management and oversight had led to delays in space system development and increased risk of capability gaps across critical weapons systems.[24] Along with recent legislation, DOD is taking steps designed to ultimately streamline decision-making and clarify authorities for space, implementing these changes over several years. These recent changes include:

- **Establishing the United States Space Force.** In December 2019, the National Defense Authorization Act for Fiscal Year 2020 established the U.S. Space Force within the Department of the Air Force.[25] DOD is still determining the final composition of the Space Force and moving uniformed and civilian personnel conducting and supporting space operations from all DOD armed forces into the newly established force.
- **Establishing the Space Development Agency.** In March 2019, DOD established the Space Development Agency to unify and integrate efforts across DOD to define, develop, and field innovative satellite solutions such as communications and missile tracking. The Space Development Agency is focused on a low earth orbit constellation to provide missile tracking and other satellite-based operational support for DOD. DOD is still determining how this new organization will mesh with the Space Force's SMC which acquires satellite systems; the Defense Advanced

[24]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).

[25]National Defense Authorization Act for Fiscal Year 2020, Pub. L. No. 116-92, Sec. 1701 (2019); 10 U.S.C. § 9081 et seq.

Research Projects Agency, which creates breakthrough technologies and capabilities; and similar organizations within the department.

- **Reorganizing SMC.** SMC has been undergoing a restructuring for many months, and SMC officials told us they do not know when personnel will formally move from Air Force to Space Force. One official told us that integration planning documents were delayed while they determined roles and responsibilities as a result of the changes due to the SMC reorganization.

Establishing new—and clarifying existing—roles of the various space organizations is important to U.S. space operations, but the initial period of reorganization and stand-up is likely to introduce some risk in the near term to Next Gen OPIR.

Space Force Reports to Congressional Defense Committees Predict an On-Time Launch and Do Not Reflect Schedule Risks

In quarterly reports to Congress, the Space Force continues to maintain that the Next Gen OPIR program is on track to meet its goals. A Senate report on the DOD Appropriations Act for Fiscal Year 2020 designated Next Gen OPIR as a congressional special interest item for the Committee on Appropriations. The joint explanatory statement accompanying the DOD Appropriations Act, 2020 contains a provision for the Secretary of the Air Force to provide quarterly briefings to the congressional defense committees detailing progress against cost and schedule goals.[26] Next Gen OPIR successfully completed key planned development events and reviews in 2020. For example, the program completed preliminary design reviews for each of the mission payload designs in May 2020. Additionally, the polar program completed its system requirements review in March 2020. Next Gen OPIR quarterly progress reports to the congressional defense committees over 2020 predict on-time delivery of the main mission payload and on-time initial launch capability. However, as discussed above, remaining challenges and lack of schedule margin indicate an on-time launch is unlikely.

Reports to congressional decision makers that do not include realistic schedule estimates may prove counterproductive to the program's ultimate success. GAO's guides for estimating program costs and schedules illustrate that realistic estimates lead to better budgeting of

[26]Explanatory statement regarding H.R. 1158, Department of Defense Appropriations Act, 2020 (published in Cong. Record, Dec. 17, 2019 at p. H10873). This explanatory statement directs the Secretary of the Air Force to provide quarterly briefings to the congressional defense committees detailing progress against cost and schedule milestones. For the purposes of this report, we will refer to these milestones as goals.

resources and better program outcomes.[27] Congressional decision makers base budgeting decisions in part on schedule estimates, balancing funding to meet a program's planned goals. If the schedule estimates on which Congress bases its funding decisions are unrealistic, decision makers may be unable to match program resources to requirements in any given year. Further, unrealistic schedule estimates put the fidelity of a program's cost estimates in doubt, as significant schedule delays typically necessitate corresponding cost increases. Apprising congressional decision makers of likely schedule delays and cost increases earlier in the budgeting process affords the decision makers more flexibility in adjusting budgets across the space portfolio.

Next Gen OPIR Will Support Current Mission Needs, but DOD Lacks a Formal Plan for Coordinating Interagency Efforts to Meet Future Needs

This report omits additional, sensitive details about how Next Gen OPIR will address SBIRS mission areas.

Next Gen OPIR Block 0 Is Intended to Provide Missile Warning Capabilities and Will Support SBIRS Mission Partners

SBIRS will remain available for some time after Next Gen OPIR satellites launch and will continue providing data to its mission areas. The Space Force is planning for Next Gen OPIR Block 0 data to be made available to mission partners through a series of existing initiatives including:

- **Joint OPIR Ground (JOG) initiative**: In 2009, DOD and the Office of the Director of National Intelligence commissioned the JOG study to identify solutions for a more unified and interoperable OPIR ground architecture that can process data from multiple systems to meet the needs in all four OPIR mission areas. Previously, multiple DOD agencies and the Intelligence Community operated their own OPIR systems, which hindered the community from collaborating effectively, resulted in redundancy, and increased costs. As a result of the JOG study, agencies across DOD and the Intelligence Community signed a June 2011 memorandum of agreement to establish roles and responsibilities for implementing the study recommendations. According to Space Force and Missile Defense Agency officials, the JOG initiative resulted in the

[27] GAO-16-89G; and GAO-09-3SP.

creation of a ground architecture that uses common, or interfacing, data that can be shared across agencies and established roles and responsibilities for OPIR user agencies. FORGE program officials stated that FORGE plans to leverage JOG efforts as much as possible. Additionally, these officials said that other agencies within the JOG will be able to leverage FORGE efforts to inform additional mission areas.

- **Tools, Applications, and Processing Laboratory (TAP Lab):** In April 2016, the Air Force opened the TAP Lab to develop, test, and process OPIR data from legacy systems and weather satellites. According to TAP Lab officials, SBIRS satellites and sensors collect data at all times, with approximately 10 percent of those data used for the missile warning mission. Personnel at the TAP Lab use the data from SBIRS, DSP, and other sensors to develop and explore innovative algorithms for DOD and other users, including civilian agencies. The data are used to inform military and civil scenarios and mission areas such as battlespace awareness and technical intelligence. According to TAP Lab officials, the facility will incorporate Next Gen OPIR data into its products as it becomes available.
- **OPIR Battlespace Awareness Center (OBAC):** Air Force Space Command opened the OBAC in September 2016 to host software applications harnessing SBIRS data to provide battlespace awareness and technical intelligence capabilities to users. The OBAC and the TAP Lab collaborate to test and deploy mission data processing for SBIRS and other systems. Officials we spoke with said they expect this collaboration to continue as Next Gen OPIR satellites are integrated into TAP Lab systems.

This report omits additional, sensitive information about OPIR mission needs and the extent to which OPIR acquisition efforts will address them.

DOD Has Not Formalized Multi-Agency Efforts Aimed at Coordinating Future OPIR Needs

When it is functional, the Next Gen OPIR Block 0 will offer improved missile warning capability over the current systems and is intended to meet DOD's near term OPIR needs. Next Gen OPIR Block 0 will serve as a bridge from SBIRS to an undefined future architecture. According to the program office, the Block 0 designs anticipate evolution of the threats, and contain modularity to improve performance and resilience as more advanced subsystems mature.[28] Currently, DOD does not have a long-term plan for how agencies involved with OPIR capabilities will meet

[28]Broadly, resiliency is the ability of a system to continue to operate or recover in the face of manmade or natural interference.

future warfighter needs after Next Gen OPIR Block 0 is deployed. In a report on a bill for the Department of Defense Appropriations Act, 2020, Congress noted that DOD lacks a comprehensive long-term architecture for OPIR that integrates capabilities across the military community.[29] The Space Force recognizes that coordinating future OPIR systems across agencies is necessary to ensure needed capabilities are available to the warfighter. The Space Force and other agencies recently initiated efforts to define future missile warning and missile defense requirements, as well as coordinate to develop an OPIR Enterprise Architecture. These steps include:

- **Defining requirements to provide for future missile warning and missile defense:** In 2019, the JROC developed a set of future OPIR requirements for the missile warning and missile defense areas, which will inform the next stage of the Next Gen OPIR program. As envisioned, the missile warning and missile defense OPIR architecture will combine multiple elements from the Missile Defense Agency and Space Development Agency communities to provide a diverse interconnected, or mesh, network providing missile warning and tracking information to national defense authorities, and tracking and cueing data for missile defense elements. Air Force and Missile Defense Agency officials stated that the set of requirements were not intended to fully define the future OPIR architecture across all relevant agencies.
- **Defining future OPIR Enterprise Architecture:** Beginning in February 2020, Air Force officials stated that the newly established Office of the Assistant Secretary of the Air Force for Space Acquisition and Integration hosted a series of meetings, which contributed to an effort known as the OPIR Enterprise Architecture Summit (hereafter referred to as the Summit). According to the Air Force official primarily responsible for this effort, representatives from the Air Force, Space Force, Missile Defense Agency, Space Development Agency, and other mission partners joined to understand the breadth of OPIR assets under each organization. These organizations found that efforts across agencies are not strategically integrated or synchronized. Going forward, the Summit aims to integrate and synchronize future OPIR capabilities and programs. In October 2020, in response to the explanatory statement accompanying the Consolidated Appropriations Act, 2020, and subsequent Summit,

[29]H. Rep. No. 116-84. The bill contained a provision for agencies within DOD to define and coordinate to develop a unified and integrated space architecture, clarify roles and responsibilities in developing capabilities and to transition the future comprehensive OPIR architectures to programs of record.

DOD submitted a report to Congress outlining a strategy for meeting near term OPIR needs after Next Gen OPIR Block 0 is deployed.[30] The strategy lays out several prototype and risk reduction efforts planned or underway to inform a future, long-term plan for meeting OPIR needs. While the October 2020 report provides a high-level strategy for coordinating across agency areas of responsibility to meet near-term needs, these coordination efforts are not formally documented.

DOD's current efforts to ensure the timely and effective delivery of future OPIR efforts do not include several practices that can foster effective interagency collaboration. For example, Air Force officials stated that the Summit, which is the primary mechanism for synchronizing future OPIR capabilities across government agencies, does not have any written documentation, including terms of reference, memorandums of understanding with partner organizations, or other planning documentation that may help ensure the effort remains a priority. We reported in September 2012 as part of our work on key collaboration practices that mechanisms such as written guidance and agreements can benefit interagency collaborative efforts.[31] We found that agencies that articulate their agreements in formal documents can strengthen their commitment to working collaboratively. Documentation can incorporate agreements on issues such as leadership, accountability, roles and responsibilities, and resources. We also found that written agreements are most effective when they are regularly updated and monitored.

The official leading the Summit effort agreed that formal documentation, such as a charter, is needed. The official also said that one outcome of the Summit so far revealed that while work was being done and collaborated on at a technical level, interagency collaboration at the strategic level required more work. Without a formalized effort for determining roles, responsibilities, and plans for a future OPIR architecture that meets the needs of the wide array of users involved, agencies may not resolve significant differences in priorities. Further, the involved agencies may lose sight of roles and responsibilities needed to develop a coordinated architecture to ensure future warfighter needs are met.

[30]Department of Defense, Under Secretary of Defense, *Overhead Persistent Infrared (OPIR) Enterprise Architecture Strategy* (Oct. 1, 2020).

[31]GAO-12-1022.

Conclusions

The Space Force's efforts to update its missile warning systems include steps aimed at delivering these capabilities quickly. While the program has made early progress, there is little schedule margin and it is unlikely the program can meet its planned launch date. Transparent reporting to congressional decision makers on the likely schedule delays, and the subsequent risk of program cost increases, would improve the accuracy of information available to Congress for conducting its oversight. Furthermore, establishing realistic cost and schedule goals would help DOD ensure its own resources align with requirements—a known best practice in defense acquisitions—and something DOD failed to do with SBIRS.

In addition, because Next Gen OPIR Block 0 is intended to meet near term warfighter needs, DOD has begun planning for how it will meet its needs after Block 0 is deployed. The Summit effort and architecture strategy are good first steps in planning and coordinating future capabilities beyond Block 0, but DOD does not have a plan that formalizes the roles, responsibilities, and coordination mechanisms for agencies leveraging OPIR capabilities to meet future needs. Without such a plan, DOD may miss opportunities to integrate and synchronize development and fielding efforts for effective delivery of capabilities to the warfighter.

Recommendations for Executive Action

We are making the following two recommendations, one each to the Secretary of the Air Force and the Secretary of Defense:

1. The Secretary of the Air Force should direct the Space Force to work with congressional defense committees to provide transparent status information that identifies risks to meeting cost and schedule goals and any actions the Space Force plans to address these risks. (Recommendation 1)
2. The Secretary of Defense should formalize a plan to coordinate efforts across multiple agencies, either through the current OPIR Enterprise Architecture Summit or through a similar mechanism, to ensure OPIR capabilities meet warfighter needs, including, for example, developing terms of reference or memoranda of understanding, or establishing a charter to help guide efforts to plan the future OPIR architecture. (Recommendation 2)

Agency Comments and Our Evaluation

We provided a draft of this report to DOD for review and comment. DOD provided us with written comments, which are reprinted in appendix II. DOD also provided technical comments, which we incorporated as appropriate.

DOD partially concurred with our recommendation for DOD to provide transparent status information that identifies risks to meeting cost and schedule goals and any actions the Space Force plans to address them. DOD stated that its quarterly updates to congressional committees already provide cost and schedule assessment information that incorporates program risks. However, DOD stated its intent to provide further detail on cost and schedule risks through its quarterly briefings and to recommend that the Space Force deliver the additional information by no later than the third quarterly status update for fiscal year 2021. If DOD and Space Force take steps to provide this information, we believe that these actions would meet the intent of our recommendation.

DOD also partially concurred with our recommendation for DOD to formalize a plan to coordinate efforts across multiple agencies. DOD stated that it recognized the importance of synchronizing efforts to satisfy future missile warning requirements, and acknowledged that many managerial mechanisms had not been established and documented to coordinate across agencies. However, in its response, DOD disagreed with our finding that it lacks an overarching plan to acquire future OPIR systems. Further, DOD stated that it developed an integrated strategy with the goal of acquiring a resilient and affordable OPIR enterprise architecture and pointed to its OPIR Enterprise Architecture Strategy delivered to Congress in October 2020. According to DOD, the strategy document defines the framework and approach to coordinate multi-agency efforts with a near-term focus. DOD stated that such an approach is prudent and necessary so that it can analyze data and assess on-orbit performance from planned prototyping efforts before committing to an architecture. We agree that near-term planning efforts are underway to inform future OPIR architectures. As a result of these comments, we made changes to the report to clarify and add information on the October 2020 report (also reproduced in appendix II). However, as DOD considers future OPIR architectures, we maintain the importance of formalizing coordination mechanisms among agencies to ensure that warfighter needs are efficiently and effectively met.

We are sending copies of this report to the appropriate congressional committees and the Secretary of Defense. In addition, the report is available at no charge on our website at https://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-4841 or ludwigsonj@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix III.

Jon Ludwigson

Jon Ludwigson
Director, Contracting and National Security Acquisitions

List of Committees

The Honorable Jack Reed
Chairman
The Honorable James M. Inhofe
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Jon Tester
Chairman
The Honorable Richard Shelby
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Adam Smith
Chairman
The Honorable Mike Rogers
Ranking Member
Committee on Armed Services
House of Representatives

The Honorable Betty McCollum
Chair
The Honorable Ken Calvert
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Appendix I: Technology Readiness Levels

Technology readiness levels (TRL) are the most common measure for systematically communicating the readiness of new technologies or new applications of existing technologies (sometimes referred to as heritage technologies) to be incorporated into a system or program. TRLs are a compendium of characteristics that describe increasing levels of technical maturity based on demonstrated (tested) capabilities. The performance of a technology is compared to levels of maturity (numbered 1-9) based on demonstrations of increasing fidelity and complexity.[1] Table 1 describes the TRLs and descriptions.

Table 1: Technology Readiness Levels and Descriptions

Technology readiness level	Description	Hardware/software	Demonstration environment
1. Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties.	None (paper studies and analysis)	None
2. Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies.	None (paper studies and analysis)	None
3. Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.	Analytical studies and demonstration of non-scale individual components (pieces of subsystem)	Lab

[1]GAO, *Technology Readiness Assessment Guide: Best Practices for Evaluating the Readiness of Technologies for Use in Acquisition Programs and Projects*, GAO-20-48G (Washington, D.C.: Jan. 7, 2020).

Technology readiness level	Description	Hardware/software	Demonstration environment
4. Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that the pieces will work together. This is relatively “low fidelity” compared to the eventual system. Examples include integration of “ad hoc” hardware in a laboratory.	Low-fidelity breadboard. Integration of nonscale components to show pieces will work together. Not fully functional form or fit but representative of technically feasible approach suitable for flight articles.	Lab
5. Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include “high-fidelity” laboratory integration of components.	High-fidelity breadboard. Functionally equivalent but not necessarily form and/or fit (size weight, materials, etc.). Should be approaching appropriate scale. May include integration of several components with reasonably realistic support elements/subsystems to demonstrate functionality.	Lab demonstrating functionality but not form and fit. May include flight demonstrating breadboard in surrogate aircraft. Technology ready for detailed design studies.
6. System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond the breadboard tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology’s demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in simulated realistic environment.	Prototype. Should be very close to form, fit and function. Probably includes the integration of many new components and realistic supporting elements/subsystems if needed to demonstrate full functionality of the subsystem.	High-fidelity lab demonstration or limited/restricted flight demonstration for a relevant environment. Integration of technology is well defined.
7. System prototype demonstration in an operational environment	Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in a realistic environment, such as in an aircraft, vehicle, or space. Examples include testing the prototype in a test bed aircraft.	Prototype. Should be form, fit and function integrated with other key supporting elements/subsystems to demonstrate full functionality of subsystem.	Flight demonstration in representative realistic environment such as flying test bed or demonstrator aircraft. Technology is well substantiated with test data.
8. Actual system completed and “flight qualified” through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.	Flight-qualified hardware	Developmental Test and Evaluation in the actual system application.

Technology readiness level	Description	Hardware/software	Demonstration environment
9. Actual system "flight proven" through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of true system development. Examples include using the system under operational mission conditions.	Actual system in final form	Operational Test and Evaluation in operational mission conditions.

Source: GAO and its analysis of National Aeronautics and Space Administration data. | GAO-21-105249

Our knowledge-based acquisition practices work has shown that TRL 7—demonstration of a technology in its form, fit, and function within a realistic environment—is the level of technology maturity that constitutes a low risk for starting a program.[2] However, satellite technologies that have achieved TRL 6 are assessed as fully mature due to the difficulty of demonstrating maturity in a realistic environment—space.

[2]GAO, *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*, GAO-01-288 (Washington, D.C.: Mar. 8, 2001); and *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO/NSIAD-99-162 (Washington, D.C.: July 30, 1999).

Appendix II: Comments from the Department of Defense

DEPARTMENT OF THE AIR FORCE
WASHINGTON, DC

OFFICE OF THE ASSISTANT SECRETARY

11 Feb 21

SAF/AQ
1060 Air Force Pentagon
Washington, DC 20330-1060

Mr. Jon Ludwigson
Director, Contracting and National Security Acquisitions
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20548

Dear Mr. Ludwigson:

This is the DoD response to the GAO Draft Report 21-218, "MISSILE WARNING SATELLITES: Comprehensive Cost and Schedule Information Would Enhance Congressional Oversight (Project Code 103858)."

The Department reviewed the report and partially concurs with both GAO recommendations. Additionally, the DoD Office of Pre-Publication and Security Review (DOPSR) examined the report and issued a "Cleared as Amended for Open Publication" rating due to the extensive CUI and competition-sensitive material within the report. Lastly, the team documented several technical comments provided directly to your action officer to highlight factual inaccuracies.

Sincerely,

DUKE Z. RICHARDSON, Lt Gen, USAF
Military Deputy, Office of the Assistant Secretary of the Air Force (Acquisition, Technology & Logistics)

GAO DRAFT REPORT DATED DECEMBER 22, 2020
GAO-21-218 (GAO CODE 103858)

"MISSILE WARNING SATELLITES: COMPREHENSIVE COST AND SCHEDULE INFORMATION WOULD ENHANCE CONGRESSIONAL OVERSIGHT"

DEPARTMENT OF DEFENSE COMMENTS TO THE GAO RECOMMENDATIONS

RECOMMENDATION 1: The GAO recommends that the Secretary of the Air Force should direct the Space Force to work with Congressional defense committees to provide transparent status information that identifies risk to meeting cost and schedule goals and any actions the Space Force plans to address these risks. (Recommendation 1)

DoD RESPONSE: The DoD partially concurs with the GAO's recommendation for the Space Force to provide additional program risk data to congressional defense committees. The DoD currently provides information regarding cost and schedule assessments to Congress quarterly that already incorporates program risks. The Department can provide further detail on cost and schedule risks through the quarterly briefing procedures previously established with the congressional defense committees. The DoD recommends the Space Force deliver the additional material no later than 3QFY21's submission.

RECOMMENDATION 2: The GAO recommends that the Secretary of the Defense should formalize a plan to coordinate efforts across multiple agencies, either through the current OPIR Enterprise Architecture Summit or through a similar mechanism, to ensure OPIR capabilities meet warfighter needs, including, for example, developing terms of reference, memoranda of understanding, and/or establishing a charter to help guide efforts to plan the future OPIR architecture. (Recommendation 2)

DoD RESPONSE: The DoD partially concurs with the GAO's recommendation for the DoD to formalize planning efforts to coordinate activities across its Missile Warning procurement agencies.

The DoD recognizes the importance of synchronizing efforts to satisfy future Missile Warning requirements because advances in the adversary's technical capabilities will likely require a collaborative and innovative response. The DoD addressed these concerns, in part, through the Enterprise Architecture Summit, a forum tasked with assembling stakeholders with OPIR equities from across the DOD, to include the United States Space Force (USSF), Space Development Agency (SDA), and Missile Defense Agency (MDA). The Enterprise Architecture Summit was instrumental in socializing agency efforts, parsing technical requirements, and identifying gaps in future Missile Warning architectures. Yet the DoD acknowledges many internal managerial mechanisms have not been established and documented, such as memoranda of understanding (MOU) or organizational charters, that have been specifically highlighted by the GAO.

However, the GAO's supporting evidence referenced throughout the draft report incorrectly states that the DoD lacks a plan for how agencies involved with OPIR acquisition will meet future warfighter needs after Next-Generation OPIR, Block 0 is deployed. Specifically, the draft report states the DoD does not have an overarching plan to acquire these systems, giving the reader the impression planning activities for future space-based Missile Warning architectures have not commenced, or worse, have been willfully neglected.

Indeed, the DoD developed an integrated strategy with the goal of acquiring a resilient and affordable OPIR enterprise architecture. The *OPIR Enterprise Architecture Strategy* (attached), delivered to Congress 1 Oct 2020, defines the framework and approach to coordinate these multi-agency efforts. The strategy document was a major product of the Enterprise Architecture Summit. The strategy defines each agency's overall line of effort, describes the various prototyping efforts currently underway, outlines an integrated schedule and roadmap, and delineates the various metrics and grading criteria for the aforementioned prototyping efforts. Combined with the various weekly and monthly interagency working groups established to organize and synchronize the OPIR community, the DoD is successfully addressing long-term planning actions.

In discussions to remediate the language within the draft report, GAO personnel cited the lack of "long term planning" necessary for acquiring future OPIR systems as a strong basis for this recommendation. However, the *OPIR Enterprise Architecture Strategy* articulates the near-term focus will be on SDA, MDA, and SMC's prototyping efforts prior to a milestone decision point in CY2024. This strategic pause prior to an architectural pivot is both prudent and necessary so that the Service can analyze data and assess on-orbit performance before committing to a ~$20B architecture.

The DoD requests the GAO properly delineate within the report recommended organizational best-practices and the enterprise planning actions which have already occurred and are continuing today.

Thank you for the opportunity to review and comment on this draft report.

We omitted the OPIR Enterprise Architecture Summit Report as it contains sensitive information.

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Jon Ludwigson at (202) 512-4841 or ludwigsonj@gao.gov

Staff Acknowledgments

In addition to the contact named above, Rich Horiuchi (Assistant Director), Erin R. Cohen (Analyst-in-Charge), Peter W. Anderson, Claire Buck, Nicolaas Cornelisse, Brenna Derritt, Laura Hook, Chi Mai, James P. Tallon, Anne Louise Taylor, Hai Tran, Tanya Waller, and Robin Wilson made significant contributions to this review.

(105249)

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