



June 2023

SPACE COMMAND AND CONTROL

Improved Tracking and Reporting Would Clarify Progress amid Persistent Delays

Accessible Version

GAO Highlights

Highlights of [GAO-23-105920](#), a report to congressional committees

Why GAO Did This Study

Between 2000 and 2022, the Department of the Air Force spent over \$1.7 billion to replace its systems that track and control satellites. These systems are well beyond their expected service lives.

DOD began the Space C2 program in 2018 to improve space command and control activities. Congress included a provision in statute for GAO to review annual Air Force Reports on Space C2. This report addresses (1) challenges to Space C2's development efforts and how the program is addressing them; and (2) the extent to which the Air Force's 2022 annual report included required elements and, with additional program reporting, provided information for oversight.

To conduct this work, GAO analyzed Space C2 program documentation of requirements, Agile software development practices, and its cost estimate. GAO then compared this documentation against leading practices in GAO's Agile and Cost Estimating Guides. GAO also assessed the 2022 Space C2 annual report against statutory requirements and, with other program reporting, against leading practices in GAO's Agile Guide. GAO also interviewed officials from the DOD, Air Force, and Space Force.

What GAO Recommends

GAO is making three recommendations to the Air Force to ensure the program includes consistent metrics in annual and internal reports, and documents how it will meet requirements. DOD concurred with all three of the recommendations.

View [GAO-23-105920](#). For more information, contact Jon Ludwigson at (202) 512-4841 or ludwigsonj@gao.gov.

June 2023

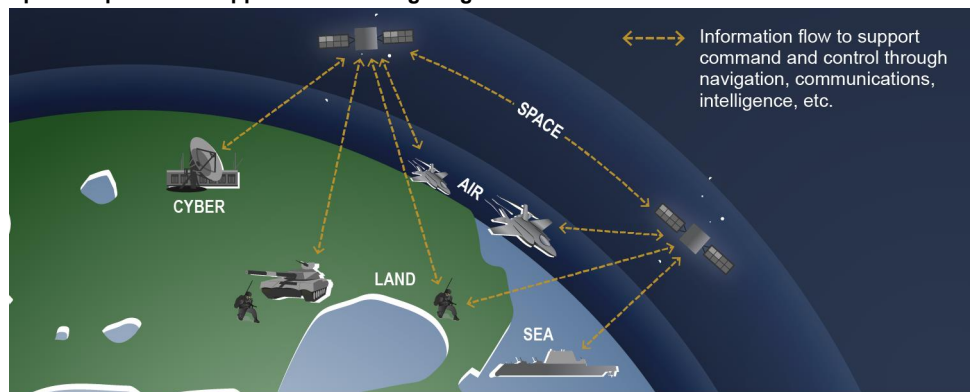
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What GAO Found

Space systems—such as satellites—are vital to the military's ability to project combat power, collect intelligence, navigate, and communicate across the globe. In an increasingly crowded space domain, threats to military space systems are also growing. Space command and control is the ability for military commanders to make timely, strategic decisions, take tactical actions to meet mission goals, and counter threats to U.S. space assets. This decision-making depends on underlying data collection and analysis. The Space Command and Control (Space C2) program is the Department of Defense's (DOD) latest software-intensive system intended to provide this capability.

Space Capabilities Support Other Warfighting Domains



Source: GAO representation of U.S. Space Force documents. | GAO-23-105920

The Space C2 program is making changes to address persistent management challenges, but it is too soon to tell if changes will lead to improvement. For example, in 2021, the program shifted additional resources to meet critical, complex requirements after years of focus on less critical requirements. However, to deliver some of these critical requirements sooner, Space C2 scaled back planned development efforts. Users will still rely on older, outdated systems until Space C2 can complete these development efforts.

The 2022 Space C2 annual report addressed statutory requirements. However, Space C2's program documentation and reporting—both in its annual report and internal reports—do not give a clear picture of progress.

- **Reporting.** Space C2's 2022 annual report does not provide context or performance results data necessary to understand overall progress. Similarly, internal reporting does not provide consistent results based on metrics that would enable comparison across reports.
- **Requirements tracking.** Program documents do not show how Space C2 will ensure it is on track to meet requirements. Historically, Space C2 did not complete all planned development efforts as scheduled, and the lack of documentation obscures a useful picture of progress.

With its persistent delays in delivering key capabilities, improved tracking and consistent metrics would help demonstrate the extent to which the Space C2 program is making progress.

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Abbreviations

ATLAS	Advanced Tracking and Launch Analysis System
DOD	Department of Defense
DOT&E	Director, Operational Test and Evaluation
NDAA	National Defense Authorization Act
OUSD(A&S)	Office of the Under Secretary of Defense for Acquisition and Sustainment
SPADOC	Space Defense Operations Center
Space C2	Space Command and Control

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June 8, 2023

Congressional Committees

Threats to U.S. space assets and the support they provide to the military's land, sea, air, and cyber operations continue to grow. The Department of Defense (DOD) recognizes that potential adversaries may target U.S. space assets to diminish U.S. capabilities, such as those enabled through GPS. Further, debris proliferation in space poses a threat of collision with satellites. Space command and control is the ability for military commanders to make timely, strategic decisions, take tactical actions to meet mission goals, and counter threats to U.S. space assets. Effective command and control of space assets depends on quality information about where objects are in space and where they will be in the future. From 2000 to 2022, the Department of the Air Force spent over \$1.7 billion toward developing enhanced space command and control systems and expects that total to increase to \$2.4 billion by fiscal year 2028.¹ Despite this spending, Space Force has not successfully replaced legacy systems that are vital to tracking and cataloging space objects.

DOD began the Space Command and Control (Space C2) program in 2018 as the most recent attempt to improve space command and control capabilities and replace legacy systems. Space C2 is a software-intensive program that plans to meet deferred requirements from past programs as well as develop and field advanced new capabilities through Agile software development. Agile principles emphasize iterative product development and delivery that is continuously evaluated for functionality, quality, and customer satisfaction.

Section 1613 of the National Defense Authorization Act (NDAA) for Fiscal Year 2020 included a provision for the Secretary of the Air Force to submit annual status reports to the congressional defense committees

¹The Air Force started the Space Command and Control program before statute established the Space Force within the Department of the Air Force in 2019. Space Force is tasked with consolidating leadership, planning, and managing DOD space programs, including Space Command and Control. 10 U.S.C. § 9081.

containing mandatory reporting elements.² This provision requires 5 years of reporting and for GAO to review the Space C2 reports and then present our findings to the defense committees. This is our second product under this provision.³ This report addresses (1) the challenges to Space C2's development efforts—including the Advanced Tracking and Launch Analysis System component—and how the program is addressing them; and (2) the extent to which the Air Force's 2022 annual report on Space C2 includes mandatory elements outlined in the NDAA for Fiscal Year 2020 and, with additional program reporting, provides information for congressional oversight.

To identify challenges to Space C2 development efforts and steps the program is taking to mitigate challenges, we analyzed the November 2021 program cost estimate and the program's implementation of Agile leading practices against GAO's Cost Estimating and Agile Guides.⁴ These analyses relied on program documents and interviews to assess the program against our criteria. To assess the extent to which the 2022 Space C2 annual report includes key elements and provides information for oversight, we assessed the annual report against requirements contained in the NDAA for Fiscal Year 2020. We also assessed the annual report and Space C2's program increment reports—which the program prepares after each planned segment of development work—against GAO's Agile Guide to address how the program is reporting performance information.

To support both of these objectives, we interviewed officials from DOD's Office of the Under Secretary of Defense for Acquisition and Sustainment (OUSD(A&S)); Office of Cost Assessment and Program Evaluation; the office of the Director, Operational Test and Evaluation (DOT&E); Department of the Air Force; Combined Forces Space Component Command; Combined Space Operations Center; National Space Defense Center; 18th Space Defense Squadron; and the Space C2 program office. We also interviewed subject matter experts from private industry. Appendix I provides additional details on our scope and methodology.

²National Defense Authorization Act for Fiscal Year 2020, Pub. L. No. 116-92 (2019).

³GAO, Space Command and Control: Opportunities Exist to Enhance Annual Reporting, GAO-22-104685 (Washington, D.C.: Dec. 22, 2021).

⁴GAO, *Agile Assessment Guide*, [GAO-20-590G](#) (Washington, D.C.: Sept. 28, 2020); and *Cost Estimating and Assessment Guide*, [GAO-20-195G](#) (Washington, D.C.: Mar. 12, 2020).

We conducted this performance audit from March 2022 through June 2023 in accordance with generally accepted 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.

Background

Space Command and Control Is Vital to All Warfighting Domains

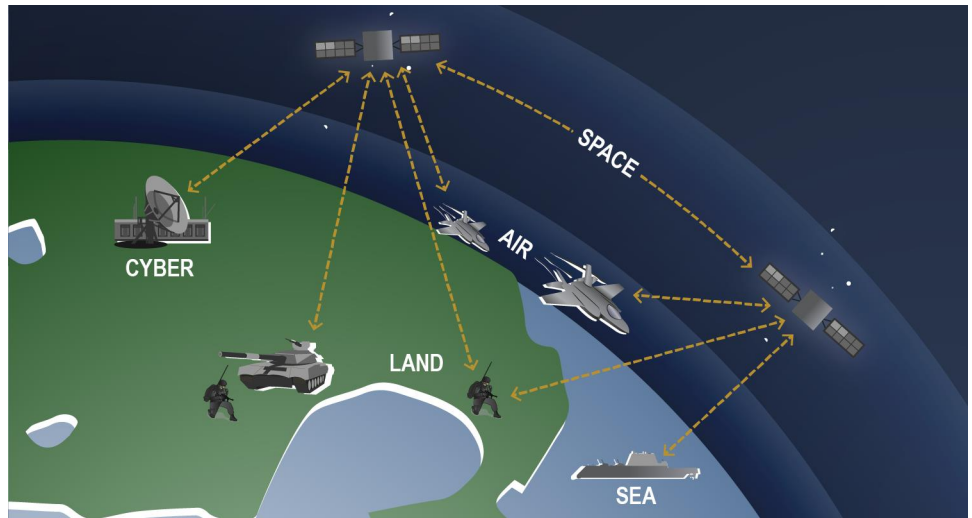
Space systems enable the U.S. to project combat power to areas of conflict and instability, and allow our armed forces to collect vital intelligence on foreign threats, to navigate and maneuver rapidly, and to communicate anywhere around the globe.⁵ The Defense Intelligence Agency identified several space capabilities that support military operations:

- Space-based remote sensing gathers data to support intelligence, such as monitoring military forces.
- Satellites support beyond-line-of-sight communications, as well as enable internet access to remote areas.
- Positioning, navigation, and timing capabilities support land, sea, air, and space navigation, along with precision weapons guidance.

DOD uses a variety of systems on the Earth and in space to provide these kinds of capabilities and needs to be able to command and control those systems. DOD currently conducts space command and control functions through multiple systems that are not all capable of sharing data. Without fast, automated data sharing, space command and control functions take longer and are vulnerable to data entry errors. Figure 1 shows how space capabilities intersect with other warfighting domains.

⁵Defense Intelligence Agency, *Challenges to Security in Space – 2022*, March 2022, https://www.dia.mil/Portals/110/Documents/News/Military_Power_Publications/Challenges_Security_Space_2022.pdf.

Figure 1: Space Capabilities Support Other Warfighting Domains



←--- Information flow to support command and control through navigation, communications, intelligence, etc.

Source: GAO representation of U.S. Space Force documents. | GAO-23-105920

Within the space domain, a key element of operations is space domain awareness, which generally refers to the current and predictive knowledge and characterization of space objects, including identification, characterization, and understanding of any factor associated with the space domain that could affect space operations.⁶ For example, space domain awareness of a satellite launch would show a satellite’s location during its movement into orbit and predict any potential collisions with debris. Data on the movements of objects in space are the foundation for space command and control because they provide the basis for predicting where an object will be at any given time, based on its orbit. DOD relies on computer systems to conduct these orbital analyses and assessments.

DOD Is Developing Space C2 to Replace Legacy Systems

DOD plans for the Space C2 acquisition program to deliver systems that conduct space object tracking and cataloging. A key requirement for the

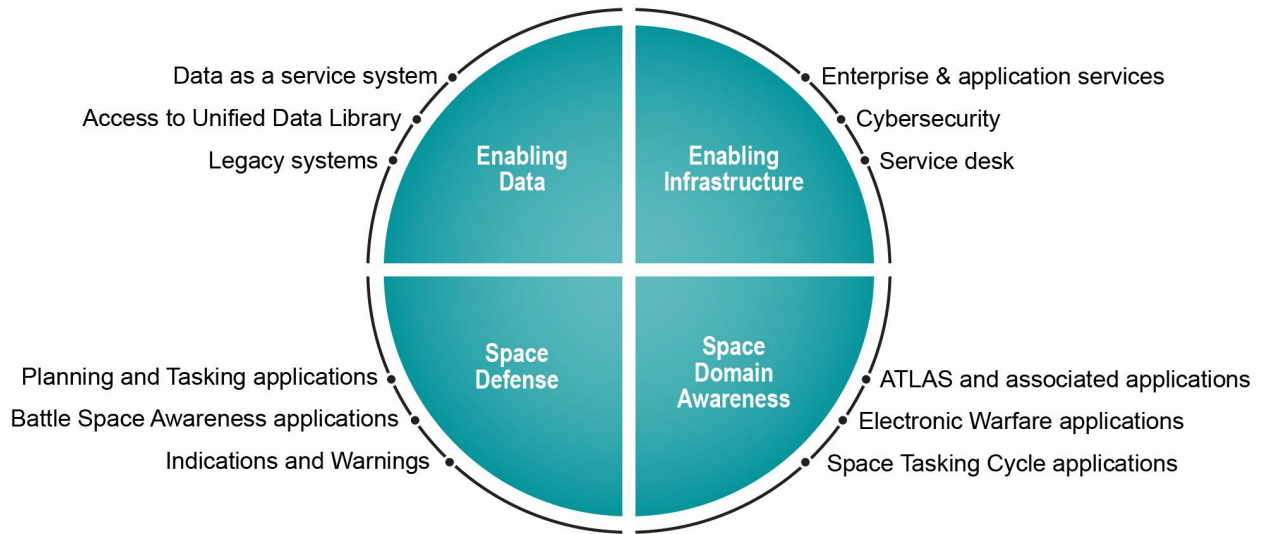
⁶DOD also conducts Space Situational Awareness—the requisite foundational, current, and predictive knowledge and characterization of space objects, and the environment upon which space operations depend. See GAO, *Space Situational Awareness: DOD Should Evaluate How it Can Use Commercial Data*, [GAO-23-105565](#) (Washington, D.C.: Apr. 24, 2023).

Space C2 program is to replace the decades-old space situational awareness system called the Space Defense Operations Center (SPADOC). The Air Force began development of SPADOC in 1979 and designed it to process space situational awareness data, maintain the catalog of space objects' orbital information, and share data with other systems. At that time, there were far fewer satellites and other space objects in orbit than there are today or are expected to be in the future. Space Force guardians continue to rely on this legacy system to conduct their missions because no other system provides these capabilities. However, SPADOC has limited processing capacity, which reduces the scope and number of analyses it can support, and it operates far more slowly than modern systems. In 2019, we reported that SPADOC was significantly beyond its estimated end-of-life.⁷

DOD designed the Space C2 program to consolidate operational-level command and control capabilities for DOD space assets into an integrated system, providing operators and decision makers a single point-of-access for timely, worldwide command and control of space assets. The Space C2 program is developing the Advanced Tracking and Launch Analysis System (ATLAS) in part as a replacement for SPADOC, particularly to automate its orbit determination, identify potential object collisions (called conjunction assessments), and enhance cross-system data-sharing capabilities. To that end, Space C2 is developing capabilities in addition to ATLAS that include a software-based infrastructure, operating platform, and applications. Space C2 plans to provide these capabilities with the program office, or government, as the lead systems integrator. Figure 2 shows the structure of the Space C2 acquisition program.

⁷GAO, *Space Command and Control: Comprehensive Planning and Oversight Could Help DOD Acquire Critical Capabilities and Address Challenges*, [GAO-20-146](#) (Washington, D.C.: Oct. 30, 2019).

Figure 2: Diagram of Space Command and Control Program through Late 2022



Source: GAO representation of U.S. Space Force documents. | GAO-23-105920

Text for Figure 2: Diagram of Space Command and Control Program through Late 2022

Enabling Data

- Data as a service system
- Access to Unified Data Library
- Legacy systems

Enabling Infrastructure

- Enterprise & application services
- Cybersecurity
- Service desk

Space Defense

- Planning and Tasking applications
- Battle Space Awareness applications
- Indications and Warnings

Space Domain Awareness

- ATLAS and associated applications
- Electronic Warfare applications
- Space Tasking Cycle applications

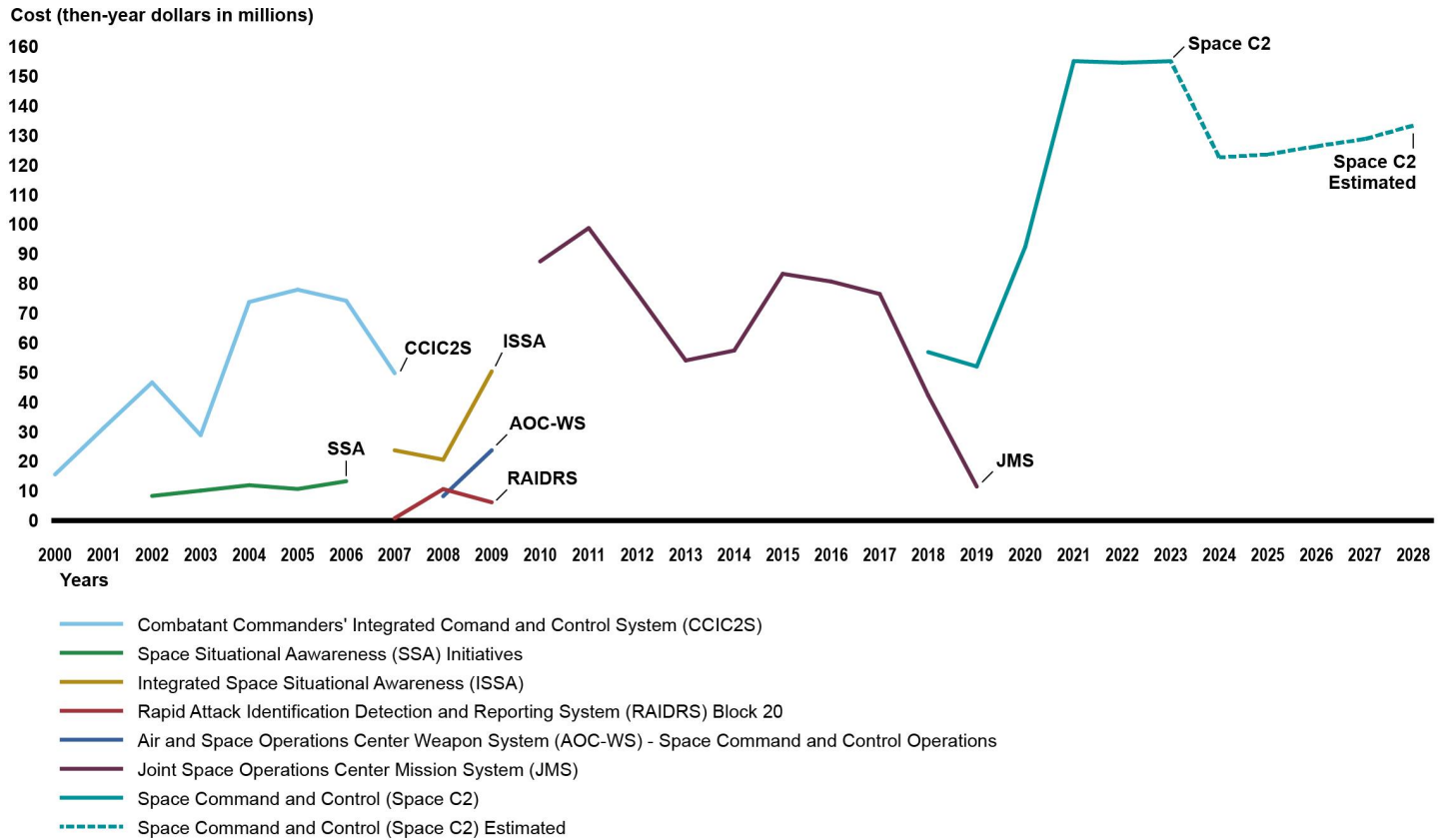
Source: GAO representation of U.S. Space Force documents. | GAO-23-105920

Note: In late 2022, Space Command and Control moved the Space Defense portfolio out of the acquisition program. The Program Executive Officer for Battle Management, Command, Control, and Communications within Space Systems Command still oversees acquisition for Space Defense capabilities.

DOD Has Struggled to Replace Space Command and Control Systems

DOD has struggled to upgrade or replace its older space command and control systems since 2000 and the current iteration—Space C2—projects spending over \$1.2 billion from fiscal year 2018 through fiscal year 2028. Excluding Space C2 costs to date, DOD spent at least \$1.2 billion on six other acquisition programs and projects, none of which delivered all the capabilities they promised. All of these efforts have been to modernize and consolidate DOD's space command and control systems as well as improve space domain awareness capabilities. Figure 3 shows DOD's investments from 2000 through 2022 and future estimated costs.

Figure 3: Department of Defense Investments in Space Command and Control Systems Since 2000



Source: GAO analysis of Department of the Air Force budget documents. | GAO-23-105920

Data for Figure 3: Department of Defense Investments in Space Command and Control Systems Since 2000

Year	CCIC2S	SSA	RAIDRS	AOC-WS	JMS	Space C2	Space C2(estimated)
2000	15.58						
2001	31.25						
2002	46.61	8.31					
2003	28.81	10.09					
2004	73.77	11.93					
2005	77.93	10.65					
2006	74.2	13.27					
2007	49.73		23.71	0.79			
2008			20.55	10.63	8.22		
2009			50.34	6.15	23.73		
2010						87.47	
2011						98.73	

Year	CCIC2S	SSA	RAIDRS	AOC-WS	JMS	Space C2	Space C2(estimated)
2012						76.68	
2013						54.03	
2014						57.39	
2015						83.28	
2016						80.67	
2017						76.47	
2018						42.19	56.85
2019						11.48	51.99
2020							92.41
2021							155.07
2022							154.53
2023							155.05
2024							122.58
2025							123.59
2026							126.33
2027							128.79
2028							133.37

Source: GAO analysis of the Department of the Air Force budget documents. | GAO-23-105920

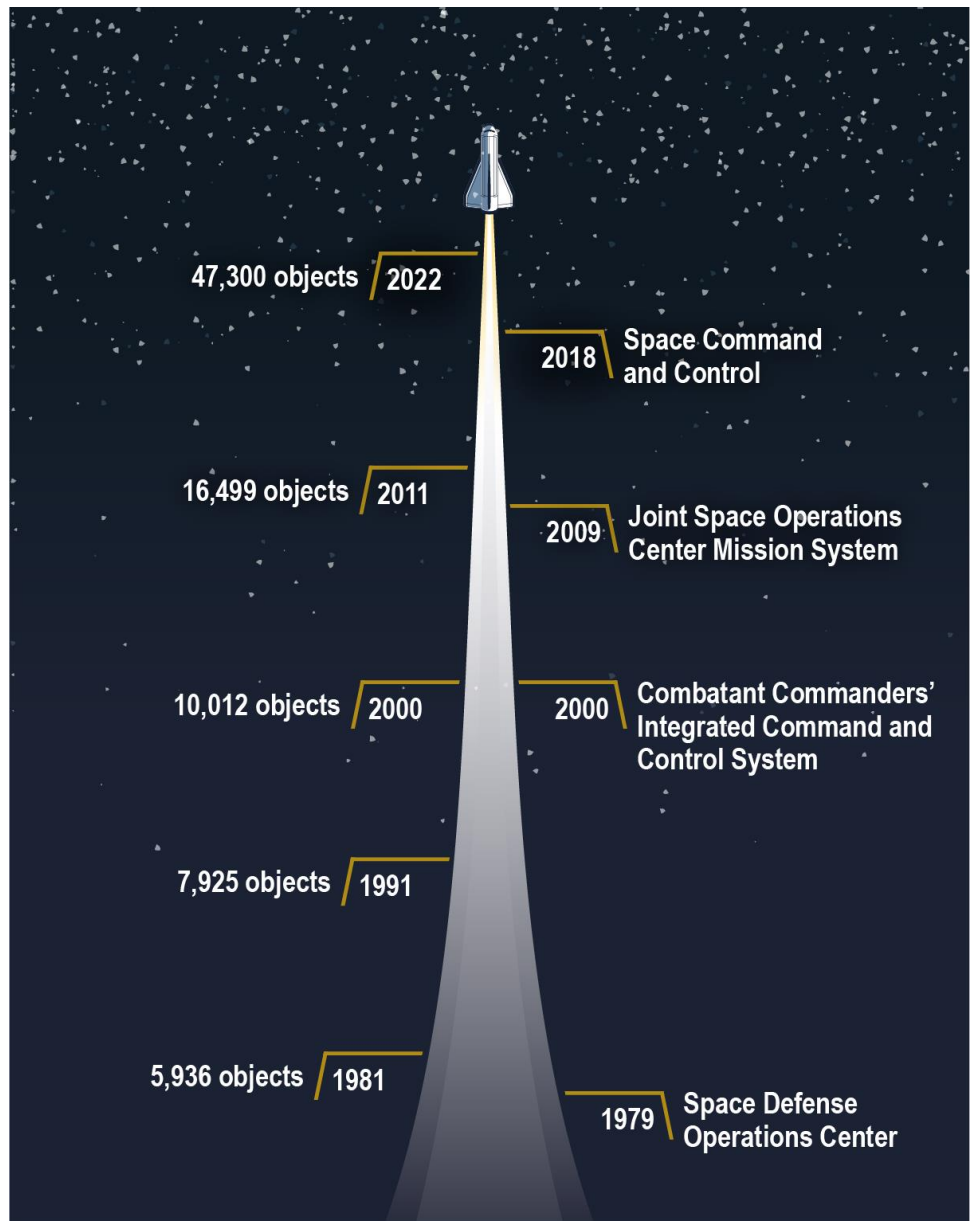
Note: To calculate past investments and future estimated amounts for space command and control efforts, we used Department of Defense (DOD) budget request documentation for fiscal years 2002 through 2024, which were publicly available on the Air Force financial management and comptroller website. Investments through fiscal year 2020 included only research, development, test and evaluation and procurement funds. In fiscal year 2021, Space C2 transitioned to Research, Development, Test & Evaluation Budget Activity-08 (Software and Digital Technology Pilot Programs), which includes development, procurement, and sustainment efforts.

Our prior work found that acquisitions to replace SPADOC suffered from deferred or poorly understood requirements that hampered development efforts. These programs faced problems with the complexity of software development and integration, which led to underestimating development resources. As a result, resources did not support sufficient software development activities to meet program requirements. For example, in 2006, we found that the Combatant Commanders’ Integrated Command and Control System was over cost and behind schedule because original estimates did not include the full scope of that program’s work.⁸ Figure 4 shows the timing of these past efforts and beginning of Space C2, as well

⁸GAO, *Defense Acquisitions: Further Management and Oversight Changes Needed for Efforts to Modernize Cheyenne Mountain Attack Warning Systems*, [GAO-06-666](#) (Washington, D.C.: July 6, 2006). We made eight recommendations to DOD to improve program management, with which DOD agreed. As of June 2023, DOD has implemented all of our recommendations.

as the exponential growth in cataloged space object observations across the same period.

Figure 4: Timeline of Department of Defense Space Command and Control Acquisitions Start Dates and Increasing Congestion of Cataloged Space Objects



Source: GAO representation of NASA data and U.S. Space Force documents. | GAO-23-105920

Text for Figure 4: Timeline of Department of Defense Space Command and Control Acquisitions Start Dates and Increasing Congestion of Cataloged Space Objects

Year	Acquisitions or Number of cataloged space objects
1979	Space Defense Operations Center
1981	5,936 objects
1991	7,925 objects
2000	Combatant Commanders' Integrated Command and Control System
2000	10,012 objects
2009	Joint Space Operations Center Mission System
2011	16,499 objects
2018	Space Command and Control
2022	47,300 objects

Source: GAO representation of NASA data and U.S. Space Force documents. | GAO-23-105920

Space C2 Is Using Agile Development Principles

In October 2020, DOD released DOD Instruction 5000.87 – *Operation of the Software Acquisition Pathway*.⁹ As part of the Adaptive Acquisition Framework, DOD intends this pathway be used for the timely acquisition of custom software capabilities using modern software development practices—such as Agile. Agile is an umbrella term for a variety of practices in software development. Agile emphasizes early and continuous software delivery, fast feedback cycles, rhythmic delivery cadence, the use of collaborative teams, and measuring progress in terms of working software. Table 1 defines some of the key terms associated with Agile development.

⁹Department of Defense (DOD) Instruction 5000.87, *Operation of the Software Acquisition Pathway* (Oct. 2, 2020). DOD also publishes and updates guidance for implementing the Software Acquisition Pathway at <https://aaf.dau.edu/aaf/software/>.

Table 1: Key Agile Terms for Space Command and Control (Space C2)

Term	Definition
User story	An individual user story captures the “who,” “what,” and “why” of a requirement in a simple, concise way, and can be limited in detail by what can be handwritten on a small paper notecard (also called “story”). User stories are not vehicles to capture complex system requirements on their own. Rather, full system requirements consist of a body of user stories. User stories are used in all levels of Agile planning and execution. Space C2 develops a set of user stories based on features that are resolved, over a given program increment, to deliver a minimum viable product or capability release.
Feature	A feature is a customer-understandable, customer-valued piece of functionality that serves as a building block for prioritizing, planning, estimating, and reporting. For example, Space C2 broke down Indications and Warnings development into features, including the Change Detection Alert feature.
Epic	An epic is a large user story that can span one or more releases that is progressively refined into features and then into smaller user stories that are at the appropriate level for daily work tasks and captured in the backlog. It is useful as a placeholder to keep track of and prioritize larger ideas. For example, Indications and Warnings is one of 13 Space C2 epics in the program’s February 2019 program increment report.
Release/program increment	A release is a planning segment of requirements (typically captured as features or user stories in the backlog) that deploys needed capabilities. Space C2 refers to releases as “program increments;” it has completed 17 90-day program increments since October 2018.
Road map	A road map is a high-level plan that outlines a set of releases and the associated features. The road map is intended to be continuously revised as the plan evolves. Space C2 compiles road maps for individual application development activities.
Backlog	The backlog is a list of features, user stories, and tasks to be addressed by the team, program or portfolio, and is ordered from the highest priority to the lowest priority. It includes user stories, features, or epics. If the program discovers new requirements or defects, those items go into the backlog. According to its draft acquisition strategy document, Space C2 addresses its backlog in accordance with its annual funding.
Minimum viable product/minimum viable capability release	The simplest version of a product that can be released. A minimum viable product should have enough value that it is still usable, demonstrates future benefit early on to retain customer buy-in, and provides a feedback loop to help guide future development. DOD also uses the term minimum viable capability release, which provides a minimum capability that an end user can employ operationally. For Space C2, a minimum viable product could be the initial version of an application, on which users provide feedback, while the minimum viable capability release would be an operational application.

Source: GAO Agile Assessment Guide, Department of Defense (DOD), and U.S. Space Force documents. | GAO-23-105920

When DOD began the Space C2 program in 2018, the department had not yet issued acquisition guidance for software-intensive programs that were implementing Agile principles. In May 2019, DOD approved Space C2 to be a pathfinder for Agile implementation so it could serve as one of the first acquisition programs to implement Agile principles and provide lessons learned to DOD. Space C2 remains in its Agile pathfinder status, though the program is planning to transition to the Software Acquisition Pathway. Program officials said they plan to request approval from the Under Secretary of Defense for Acquisition and Sustainment no earlier

than summer 2023, and have developed or are in the process of preparing the documentation listed in table 2.

Table 2: Status of Key Documents Required for Space Command and Control (Space C2) to Transition to the Software Acquisition Pathway

Document	Status	Notes
Acquisition Strategy	In progress	<ul style="list-style-type: none"> Draft is under review as of April 2023, according to program officials. Space C2 has never had an approved acquisition strategy. Requires approval from the Under Secretary of Defense for Acquisition and Sustainment.
Software Initial Capabilities Document	In progress	<ul style="list-style-type: none"> As of March 2023, under review with stakeholders. Requires Joint Staff approval.
Test and Evaluation Strategy	In progress	<ul style="list-style-type: none"> Draft approved in November 2022 by the Assistant Secretary of the Air Force for Space Acquisition and Integration and February 2023 by the Office of the Secretary of Defense's Director, Operational Test and Evaluation, and Director, Operational Test and Evaluation, according to program officials. Strategy still requires approval from the Under Secretary of Defense for Acquisition and Sustainment.
Requirements and Planning Council Charter	Approved	<ul style="list-style-type: none"> Updated version approved May 2022 by the Commander, Space Operations Command; Deputy Commander, U.S. Space Command; and Commander, Space Systems Command. Space C2 received approval from the Under Secretary of Defense for Acquisition and Sustainment to use this charter document in lieu of a User Agreement^a
Memorandum of Agreement of Cost Data Reporting	Approved	<ul style="list-style-type: none"> Approved in February 2022 by Air Force Cost Analysis Agency Technical Director and Space C2 Program Manager. Provides a summary of the total program cost and software data to Space C2.
Cost Estimate	Approved	<ul style="list-style-type: none"> Approved September 2021 by Air Force Deputy Assistant Secretary, Cost & Economics.

Source: U.S. Space Force documents. | GAO-23-105920

^aThe Software Acquisition Pathway requires a User Agreement to document a commitment between the sponsor and program manager for continuous user involvement, and assigns decision-making authority in the development and delivery of software capability releases.

Prior Reviews of Space C2 Found Program Challenges

Both GAO and the MITRE Corporation reviewed the Space C2 acquisition program in recent years and identified management challenges. In October 2019, we found that the program was still conceptualizing foundational elements of the program, including the infrastructure and software platform. We also found Space C2 had not fully developed its acquisition documents and recommended the program develop a

comprehensive acquisition strategy. We further recommended that DOD conduct periodic independent reviews of the Space C2 program. DOD concurred with both recommendations, but both remain open as of June 2023.¹⁰ In December 2021, we found that the 2020 and 2021 Space C2 annual reports did not contain key information to provide a complete picture of the Space C2 program. We recommended that future reports include (1) contextual information related to significant changes from prior reports and (2) user perspectives on the operational benefits of Space C2 efforts.¹¹ DOD agreed with both recommendations and addressed our recommendation to include user perspectives by adding the program's Value Assessment to the 2022 annual report.¹² We assess the 2022 annual report later in this report. In September 2021, MITRE issued an independent program assessment of Space C2. That study team reported that the Space C2 program had matured, but was not confident the program would be able to deliver effective capabilities within its required time frame and made 16 recommendations to help Space C2 implement lessons learned.¹³ Space C2 program documents describe plans to address MITRE's recommendations.

Too Soon to Tell If Recent Changes Will Address Program Management Challenges

Space C2 did not originally focus development activities on users' highest priority to replace SPADOC, while other management decisions resulted in schedule, organizational, and acquisition approach challenges. Further, our analysis found that the program managed the acquisition with an unreliable cost estimate. Space C2 is making changes to focus on efforts required to replace SPADOC, address identified challenges, and improve its cost estimate. But it is too soon to tell if these changes will lead to

¹⁰[GAO20146](#).

¹¹[GAO22104685](#).

¹²A Value Assessment is an outcome-based assessment of mission improvements and efficiencies realized from the delivered software capabilities, and a determination of whether the outcomes have been worth the investment.

¹³DOD had MITRE conduct this independent evaluation in response to a Senate report accompanying the NDAA for Fiscal Year 2020, which included a provision for the Under Secretary of Defense for Acquisition and Sustainment to enter into an agreement with a federally funded research and development center to review the Space C2 program and develop a report based on the independent evaluation.

overall program performance improvement—namely the decommissioning of SPADOC in late 2023.

Space C2's Management Decisions Did Not Originally Prioritize Critical User Requirements

Our work found the Space C2 program prioritized easier development activities during the early years of the program at the expense of higher user priorities, the highest of which was replacing SPADOC with ATLAS capabilities.¹⁴ Program documents showed that Space C2 did not assign sufficient resources to develop these more complex applications sooner. Further, we found the program did not begin to provide significant funding to ATLAS development until fiscal year 2021, the fourth year of the program. In discussing these decisions, DOD officials stated Space C2 took this approach to build experience with Agile principles and develop the program's role as integrator of new applications. They also said program managers focused on "quick wins," such as workflow applications, to deliver capability users could see and use relatively quickly. In addition, MITRE's 2021 assessment found that Space C2 underestimated the complexity of the effort to replace SPADOC with ATLAS. All of these factors contributed to users' continued reliance on SPADOC, as of June 2023.

Replacing SPADOC with a modernized system is a long-standing Space C2 requirement that dates back to its predecessor programs. Space C2 users, such as the 18th Space Defense Squadron, stated that a faster, more automated system will better support their operations. Key elements of this unit's mission include maintaining the catalog of space objects' orbital information, cross-system data sharing, and identifying potential object collisions (called conjunction assessments). Due to the high volume of data available, the 18th Space Defense Squadron said its guardians are focusing on routine space catalog management and have less time to analyze data in support of space defense operations.

The 18th Space Defense Squadron reassigned guardians with advanced orbital analysis skills to newly created roles to address mega-constellation

¹⁴"Easier" development activities are those Space Operations Command rated Category C: Application addresses a non-critical mission area or provides a non-essential support tool. Category B applications provide key functionality and Category A applications provide critical capabilities.

launches, such as when SpaceX launches up to 45 Starlink satellites into low Earth orbit.¹⁵ These guardians actively monitor the satellites for collision avoidance as they move away from the launch vehicle to their eventual positions in the constellation and enter the new satellites into the catalog. According to officials, automated tracking of objects like Starlink satellites would free guardians to focus on other parts of the 18th Space Defense Squadron mission that require more expertise.

Since 2018, Space C2 users have accepted 14 applications the program delivered, nearly all of which address a non-mission critical area or are non-essential support tools that improve analysts' workflows.¹⁶ For example, one application aggregates space object statuses into a single, web-based dashboard—a function that users stated they previously managed in a spreadsheet. Users reported that the dashboard's visualization capability is useful, but it is not changing how they conduct their mission or addressing some of the core challenges with replacing SPADOC. Other workflow applications that users accepted for operations provide similarly useful but not critical functions. Of the 14 applications Space C2 has delivered, only one, Space C2's data as a service capability, is mission critical, according to Space Operations Command. The 2022 DOT&E annual report stated that the Space Force conditionally accepted this capability for operations, pending additional cyber survivability testing.¹⁷ Users also noted an outstanding requirement to implement an operational support plan, including establishment of a 24-hour support capability. An outstanding user requirement means that this capability is not complete; therefore, it will still need program resources amidst other ongoing development.

Space C2 is making changes to its program and requirements management, including elevating ATLAS to be its top priority. However, it is too soon to tell if these efforts will result in delivery of new capabilities on Space C2's revised schedule. In 2021, the program shifted more resources to ATLAS to focus on delivering capabilities to decommission SPADOC by the end of 2022, a schedule the program did not meet. Space C2 reported 90 full-time equivalent personnel supporting ATLAS

¹⁵Low Earth orbit altitude is up to 1,200 miles above the Earth.

¹⁶Space Operations Command is responsible for Space C2 requirements and determines the criticality of the applications.

¹⁷The Director, Operational Test and Evaluation is DOD's operational test authority, responsible for ensuring operational test and evaluation is adequate to confirm the effectiveness and suitability of a system.

and the messaging development efforts during program increment 15 (May-July 2022). This is an increase from the 45 personnel the program reported in the November 2021 cost estimate. Also in program increment 15, the program introduced a test plan specifically for ATLAS and ATLAS-related software deliveries. The overall Space C2 development schedule shows the program is now focused on ATLAS and ATLAS-related capabilities. The program has not identified new milestone dates for remaining applications outside of ATLAS, labeling them as “to be determined,” but continues to work on a limited number of applications that remain a high priority for users.

While Space C2 assigned additional resources to ATLAS development, the program also de-scoped and delayed its initial ATLAS delivery. Space C2 now plans for this initial ATLAS delivery to provide fewer capabilities—eight of the 18 planned capabilities in the ATLAS suite. This plan may help the program decommission SPADOC in 2023, but still delays some of the program’s promised capabilities. Users will continue to rely on legacy systems integrated with new ATLAS capabilities until the program delivers the entire suite after SPADOC decommissioning. Furthermore, in February 2023, the Deputy Commander of Operations for Space Operations Command stated a low confidence that Space C2 would be ready to decommission SPADOC by fall of 2023 because the program has yet to deliver any useable ATLAS capabilities.

Reliance on legacy systems introduces additional risk. According to officials, these legacy systems are near or, in the case of SPADOC, at capacity and operate significantly more slowly than modern systems. They stated that legacy systems are in sustainment and therefore use operations and maintenance funding, not research, development, test and evaluation or procurement funding. The units or organizations that sustain these systems are unable to develop new capability while they wait for Space C2 to deliver replacement capabilities. Further, officials added that at least one of the legacy systems is supported by the operational community, including units like the 65th Cyberspace Squadron—which uses its operations and maintenance funds—and not the Space C2 program. The longer units have to wait for ATLAS capabilities, the longer they are paying to sustain an outdated system, which increases the risk of delays or disruptions to unit operations.

Earlier Management Decisions Created Additional Challenges That Space C2 Is Trying to Address

In addition to delaying ATLAS and other mission-critical capabilities, Space C2's earlier management decisions contributed to other program challenges.

Cost estimate challenges. Our analysis of the November 2021 Space C2 program office cost estimate determined that it did not fully reflect the characteristics of a high quality, reliable estimate, based on GAO's Cost Guide.¹⁸ According to GAO's Cost Guide, program managers can minimize the risk of cost overruns and unmet performance targets by ensuring the cost estimate is reliable based on four characteristics: comprehensive, well-documented, accurate, and credible. The November 2021 cost estimate did not provide a reliable basis for program decision-making, such as developing annual budgets, making requirement trade-offs, and gauging development progress. The issues affecting the November 2021 cost estimate introduced risks to the Space C2 program that persist today, particularly for the program's schedule. Program officials had insufficient or inaccurate information to make informed decisions and to support trade-offs among cost, schedule, and requirements management that continue to influence the program.

In December 2022, the program developed a new cost estimate. While it appears to address some of the shortfalls we found, such as incorporating prior years' actual cost data that Space C2 began collecting in 2021, it is too soon to tell if it will lead to program improvements.

Schedule challenges. Our analysis found that Space C2 does not have a standardized or consistent work breakdown structure, which affects the program's schedule. A work breakdown structure, or similar document (sometimes known as a road map or prioritized backlog), decomposes broader requirements into activities small enough to estimate the time and resources needed to complete each activity. In an outcome-based Agile environment, such as Space C2, the work breakdown structure or equivalent document shows how activities relate to one another and contains the total program scope. This enables program managers to build the schedule based on discrete pieces of work. Program officials

¹⁸[GAO-20-195G](#). For more detailed results of our analysis, see appendix II.

told us they did not develop an integrated master schedule because officials did not focus on program-wide development at the outset of Space C2. As a result, different development teams devised different schedules. Space C2 documents present schedule information in multiple formats that do not provide an integrated timeline or compare completed work to remaining work needed to meet requirements. None of these documents contains the total program scope based on discrete pieces of work.

The program has taken steps to develop a more reasonable near-term schedule, largely focused on delivering ATLAS and decommissioning SPADOC. However, it is too soon to tell whether these steps will help Space C2 avoid further delays. The program schedule now identifies program milestones, required documentation, and infrastructure time frames, as well as capability delivery timelines. However, key milestone dates for decommissioning SPADOC continue to be delayed. In January 2023, Space Force notified Congress that SPADOC decommissioning would occur no earlier than October 2023—10 months later than the program previously reported. Program officials stated that Space C2 is using its Agile software tools to build a more detailed program-level road map, including dependencies or relationships between development activities that is analogous to a master schedule.¹⁹ They did not provide a date when the program-level road map will be ready for use.

Organizational challenges. In its 2022 annual report, Space C2 acknowledged that program managers structured the organization around product lines that focused on delivering individual applications. This structure, however, did not initially support Space C2's ability to expand and integrate applications to meet key requirements. Space C2 has reorganized its internal program structure multiple times, changing terminology and realigning development teams.²⁰

¹⁹GAO's Agile Guide notes dependencies can occur between features, teams, related Agile and non-Agile programs, and with resources (e.g., equipment and data). For example, Space C2 delivered three modules in the C3PO Suite; however, the application cannot be used until all the modules are complete and interface with each other. [GAO20590G](#).

²⁰In addition to internal reorganizations, Space C2 had to navigate the challenges that come with external organizational changes, including the transition from the Air Force to the Space Force in 2019 and from the Space and Missile Systems Center to Space Systems Command in 2021.

Space C2 continues to revise its internal organizational structure. In April 2022, Space C2 established a systems engineering, integration and test team to focus on program priorities like ATLAS and manage software dependencies that affect integration. Our analysis of Space C2's Agile adoption practices found that program managers are focused on building up the Agile culture, removing roadblocks, and enabling access to collaboration tools. Working with an Agile coach, the portfolio team developing ATLAS documented its team members and their roles in detail. While Space C2 fully met the GAO Agile Guide's best practice "team composition supports Agile methods" for this portfolio team, it is too soon to tell if the positive steps Space C2 has taken with ATLAS will improve overall program performance to meet requirements and extend to other portfolios.

Acquisition approach challenges. Space C2 has been working to transition to the Software Acquisition Pathway for 2 years. In May 2021, the Under Secretary of Defense for Acquisition and Sustainment directed the Space C2 program to complete entrance criteria, including an acquisition strategy, a program road map, and other program documents, and return for a decision review within 5 months, to transition to the Software Acquisition Pathway. Space C2 still has not met all of the criteria. As a result, the program has been working from a draft acquisition strategy since 2018. Space C2's acquisition approach is under scrutiny within the Office of the Secretary of Defense. Specifically, during an August 2022 Space C2 in-process review, the Deputy Assistant Secretary of Defense, Strategic, Space, and Intelligence Portfolio Management directed Space Force to provide monthly progress updates to their office, to include the status of Space C2's Software Acquisition Pathway entrance criteria from May 2021.

Space C2 is starting to show signs of progress in its transition to the DOD Software Acquisition Pathway and is in the process of developing key documents needed to enter into the pathway. For example, Space Operations Command, U.S. Space Command, and Space Systems Command leadership approved an update to Space C2's version of the User Agreement in May 2022. Program officials drafted a new Software Initial Capabilities Document to replace Space C2's older Capability Development Document, bringing its requirements document in line with current acquisition policy, according to program officials. As of April 2023, program officials said they planned to submit the draft acquisition strategy to OUSD(A&S) by late June 2023.

Space C2’s 2022 Annual Report Met Statutory Requirements but Does Not Include Key Information on Overall Development Progress

Space C2 met statutory reporting requirements in its 2022 annual report, but this report and the program’s internal reporting does not clearly describe Space C2’s progress. Specifically, these reports do not help a reader understand how complete the program’s development may be or compare program performance against consistent metrics. We found this is at least in part because the program does not have a comprehensive, program-level backlog or comparable document to allow it to track how Space C2 development activities are meeting requirements. Without a prioritized backlog of deliverables, program managers also do not have a complete picture of Space C2’s development progress to report. As a result, Congress and DOD lack data to help make informed decisions about the program’s future or conduct comprehensive oversight.

Annual Report Addresses Statutorily Required Elements but Does Not Provide Context or Clear Performance Results

Our work found that the 2022 annual report addressed all eight statutorily required elements set forth in the NDAA for Fiscal Year 2020 (see table 3).

Table 3: Assessment of Space Command and Control (Space C2) 2022 Annual Report Inclusion of Statutorily Required Elements

National Defense Authorization Act for Fiscal Year 2020 Reporting Requirements	GAO assessment of 2022 Space C2 Annual Report
1. A description of any modification to the metrics established by the Secretary of the Air Force in the acquisition strategy for the program	Addressed
2. The short-term objectives for the subsequent fiscal year ^a	Addressed
3. A description of the ongoing, achieved, and deferred objectives for the preceding fiscal year	Addressed
4. The challenges encountered and lessons learned for the preceding fiscal year	Addressed
5. The modifications made or planned so as to incorporate lessons learned into subsequent efforts to address challenges for the preceding fiscal year	Addressed
6. The cost, schedule, and performance effects of such modifications for the preceding fiscal year	Addressed
7. A full survey of combatant command requirements, including Commanders’ Integrated Priorities Lists, and impacts with respect to the program for the preceding fiscal year	Addressed

National Defense Authorization Act for Fiscal Year 2020 Reporting Requirements

GAO assessment of 2022 Space C2 Annual Report

8. A description of potential future combatant command requirements being considered with respect to the program

Addressed

Source: GAO analysis of 2022 Space C2 Annual Report | GAO-23-105920

Note: The Space C2 program has submitted four annual reports, in August 2020, February 2021, April 2022, and March 2023. We assessed the first two annual reports in December 2021 ([GAO-22-104685](#)). We plan to assess the 2023 annual report in future work.

^aShort-term objectives consist of the top Space C2 objectives for the fiscal year. For the 2022 annual report, that was fiscal year 2022.

While the report met mandated elements, the 2022 annual report does not provide a clear picture of the program’s status or progress. Specifically, the report lacked context to inform decision-making and oversight, including results based on performance metrics. GAO’s Agile Guide states that programs implementing Agile principles should identify key metrics that align with and prioritize program-wide goals, as well as communicate performance information. The report described achieved, ongoing or incomplete objectives for its fiscal year 2021 program increments, but it did not assess those efforts against the program’s overall scope of work or performance results. For example, we compared the number of completed objectives for the 2021 program increments to the total work planned and found that the program completed about 46 percent of its planned work. However, the program did not report on this completion rate or on plans to complete the work scheduled for this period, or describe how much work remains following fiscal year 2021.²¹

In prior annual reports, Space C2 included performance results based on the five metrics the Secretary of the Air Force established in the program’s draft acquisition strategy. However, the program removed these data from the 2022 annual report. The report still described Space C2’s performance metrics, as noted in table 3 above, but removed the results the program included in the 2020 and 2021 annual reports. According to program officials, the reporting statute for Space C2’s annual reports does not require the program to include metrics-based performance results. Further, because these are annual reports, officials said the Department of the Air Force determined there is too much of a delay in performance results to provide meaningful information for oversight. With the removal of these performance data and a lack of reporting on how much work Space C2 completed during the prior year, the program’s 2022 annual report did not provide Congress a clear

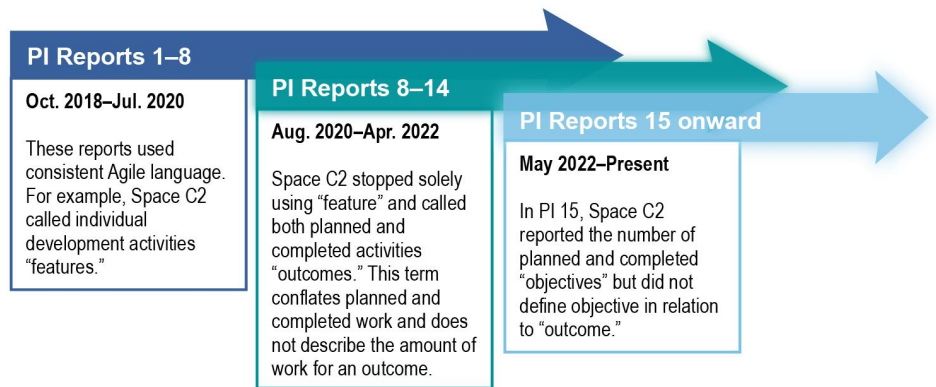
²¹As we were completing our review, Space C2 submitted its 2023 annual report in March 2023. We plan to assess this report in our future work.

picture of Space C2’s performance and prevented comparison across annual reports.

Program Increment Reports Provide Some Further Insight into Activities but Do Not Include Context or Metrics

In addition to its annual reports, Space C2 prepared retrospective reports on nearly all of its completed program increments, which it shares within DOD and with members of the congressional defense committees. These program increment reports provided details on the program’s work and results but did not use consistent language that would enable comparison between reports over the life of the program.²² GAO’s Agile Guide states that programs implementing Agile principles should identify key metrics that align with and prioritize program-wide goals, as well as communicate performance information. Since its first program increment report, Space C2 has changed its reporting format, terminology, and program organization multiple times over the 15 reports we reviewed. Over time, Space C2’s program increment reports became less clear in the terms the program uses to report results, as shown in figure 5.

Figure 5: Changes in Space Command and Control (Space C2) Program Increment (PI) Reports over Time



Source: GAO analysis of U.S. Space Force documents. | GAO-23-105920

²²Space C2’s program increment reports show the development work the program completed during the past 90-day program increment and the planned work for the next 90-day increment.

Text for Figure 5: Changes in Space Command and Control (Space C2) Program Increment (PI) Reports over Time

1) PI Reports 1–8

a) Oct. 2018–Jul. 2020

- i) These reports used consistent Agile language. For example, Space C2 called individual development activities “features.”

2) PI Reports 8–14

a) Aug. 2020–Apr. 2022

- i) Space C2 stopped solely using “feature” and called both planned and completed activities “outcomes.” This term conflates planned and completed work and does not describe the amount of work for an outcome.

3) PI Reports 15 onward

a) May 2022–Present

- i) In PI 15, Space C2 reported the number of planned and completed “objectives” but did not define objective in relation to “outcome.”

Source: GAO analysis of U.S. Space Force documents. | GAO-23-105920

Similar to prior annual reports, Space C2 previously included performance metrics and results in its program increment reports. For example, for program increments 3-10, Space C2 reported application metrics, like project length, in days or in the time needed to restore an application that went offline. Space C2 never reported program-wide performance metrics and after program increment 10, which ended in April 2021, Space C2 stopped reporting application results. According to program officials, organizational and priority changes in 2022 resulted in the program inconsistently collecting results against metrics. They also said that with new program management software, they will be able to more consistently collect metrics and report performance in future program increment reports. If Space C2 continues to omit these results, DOD stakeholders, oversight organizations, and Congress will not have information to help determine the program’s progress in developing capabilities that are long overdue to Space C2 users.

Further, none of the program increment reports described the work Space C2 completed during a given increment in terms of total development activities planned and completed. As we describe below, our analysis found that the program averaged completing about 62 percent of its reported work between program increments 1 through 16 from October 2018 to October 2022. It was not clear how the program planned to address deferred or delayed development activities from any given program increment. Moreover, without an overall program backlog, we could not determine how Space C2 was managing these performance shortfalls or the long-term implications of these delays. The Deputy Assistant Secretary of Defense for Strategic, Space, and Intelligence Portfolio Management also indicated that program increment reports lacked clear linkages to help assess progress and requested additional details in future reports. Including such information in program increment reports would help provide Congress a clearer picture of the Space C2 program's performance.

Space C2 Does Not Have an Overall Backlog to Track Requirements or Manage Development

Space C2 program documentation does not include a program-level backlog that reflects changes or additions to requirements. According to GAO's Agile Guide, programs should be managing any changes or additions to requirements, as well as tracing development activities back to requirements in a backlog or equivalent artifact.²³ Our analysis found that Space C2 does not maintain a backlog that shows the entirety of the program's development activities.²⁴ As a result, Space C2 is introducing additional risk to its development because the program lacks information that shows how it plans to address ongoing or incomplete work along with future work to meet requirements. This is a risk for two reasons: (1) Space C2 routinely underperformed during earlier program increments, and (2) the program is delivering incomplete applications that will need additional development work. The absence of a program-level Space C2 backlog increases the likelihood Space C2 will not deliver on priority requirements like decommissioning SPADOC in 2023.

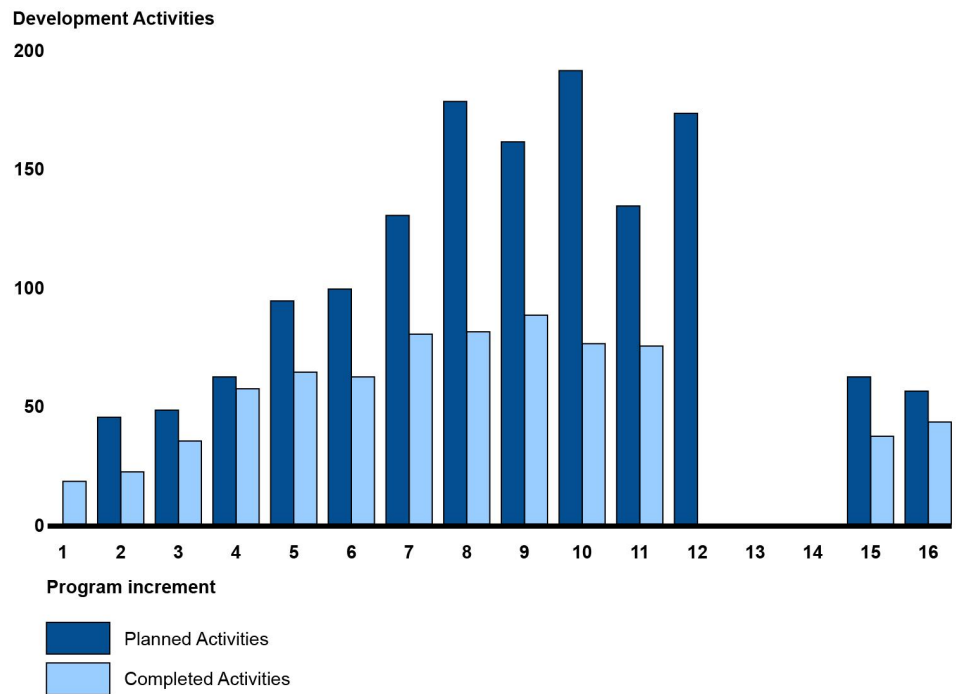
Our analysis of Space C2's program increment reports showed that for the increments the program reported specific results, Space C2

²³[GAO20590G](#).

²⁴For more detailed results of our analysis, see appendix III.

completed about 62 percent of its planned development work. Figure 6 shows these results for program increments 1-16. Space C2 temporarily stopped including these data in reports covering program increments 12 through 14.

Figure 6: Space Command and Control Planned versus Completed Development Activities: Program Increments 1-16 (October 2018 – October 2022)



Source: GAO analysis of U.S. Space Force documents. | GAO-23-105920

Data for Figure 6: Space Command and Control Planned versus Completed Development Activities: Program Increments 1-16 (October 2018 – October 2022)

Program Increment	Planned Activities	Completed Activities
1	-	18
2	45	22
3	48	35
4	62	57
5	94	64
6	99	62
7	130	80
8	178	81
9	161	88

Program Increment	Planned Activities	Completed Activities
10	191	76
11	134	75
12	173	-
13	-	-
14	-	-
15	62	37
16	56	43

Source: GAO analysis of U. S. Space Force documents. | GAO-23-105920

Note: Program increment 1 does not include planned activities because the program did not report how much work it planned to complete at the start of the increment. Space C2 did not report completed development activities for program increment 12 or any development activities for program increments 12-14.

What is not apparent from the program increment reports is how Space C2 planned to address development activities it did not complete in any given increment, or how the program addressed incomplete work in the context of the overall program development plan and schedule. This type of information is what is typically captured in a program-level backlog.

In addition, Space C2 users stated that they accepted initial versions of applications that did not provide capabilities fully meeting requirements so they could use the applications sooner, and to ensure Space C2 continued to develop or maintain the application. However, early acceptance allows Space C2 to report an incomplete application as complete, which misrepresents progress and introduces additional technical and schedule risk, such as the potential for future rework. For example, as discussed above, the single mission-critical application Space C2 delivered still has yet to satisfy all the open requirements identified when the Space Force conditionally accepted it.

Space C2's program documents do not clearly show how the program is managing development activities to meet requirements. Specifically, without a document like a program-level backlog, traceability from the simplest or lowest level of software development to the source requirement across the entire acquisition program is not possible for this program. Instead, Space C2 maintains separate backlogs for application development teams and a road map for high-level traceability. Program officials stated they never developed a program-level backlog to track and prioritize ongoing work but tracked program-level information informally through separate documents. However, these documents did not show hierarchical relationships of development activities and source requirements. According to program officials, Space C2 is in the process

of consolidating its separate backlogs into a program-level backlog, but they could not provide a timeline of when this effort would be ready for use.

Without a program-level backlog, Space C2 risks continuing to deliver applications that do not align to users' most critical needs and prevents program managers from having a holistic view of the program. As a result, Space C2 could continue to prioritize non-critical development activities and further delay completion of ATLAS. By tracing a lower level of development activity back to a higher-level requirement and aligning development activities to requirements, Space C2 can demonstrate to what extent managers are addressing development shortfalls from earlier program increments and report progress in meeting program goals.

Conclusions

In the more than 2 decades since the first effort to replace SPADOC began, DOD has cataloged over 30,000 new objects in orbit, and the need for new systems to manage DOD's space assets has become even more urgent. The \$1.7 billion DOD already spent to replace SPADOC and provide modern systems has not delivered needed capabilities to the warfighter and Space C2 continues to struggle. Space C2 is taking steps to refocus, but its plans still appear optimistic; and it is far from certain that Space C2 will deliver ATLAS by the fall of 2023. Further, Space C2's November 2021 program office cost estimate for these efforts is not reliable and raised concerns with the program's schedule that persist.

Given the struggle to develop critical systems, the reprioritization of development efforts, and delivery of incomplete capabilities, Space C2 needs to clearly communicate what work remains and report actual progress toward meeting requirements. A program-level backlog would provide a tool to more clearly track whether Space C2 is progressing toward SPADOC decommissioning through its ATLAS development efforts. A Space C2 program-level backlog would also support clearer reporting to Congress or within DOD, and answer basic oversight questions including a realistic presentation of how much work remains. While Space C2's 2022 annual report met mandated reporting elements, it did not clearly provide the status of the program's development effort, including the work completed or deferred to future development periods. Including such information in subsequent annual and program increment reports would provide Congress a more complete picture of the program's efforts.

Recommendations for Executive Action

We are making three recommendations to the Secretary of the Air Force.

The Secretary of the Air Force should ensure Space Force includes the following in Space C2's annual reports to Congress:

1. Metrics that are consistent across annual reports—for example, those metrics in the Space C2 draft acquisition strategy—and associated results;
2. Measures or metrics of the Space C2 backlog that show how much work remains for each development activity or application and the overall program; and
3. Assessment of risk in current and future program development. (Recommendation 1)

The Secretary of the Air Force should ensure Space Force includes the following in Space C2's program increment reports:

1. Metrics that are consistent across program increment reports—for example, those metrics in the Space C2 draft acquisition strategy—and associated results;
2. Measures or metrics of the Space C2 backlog that show how much work remains for each development activity or application and the overall program; and
3. Assessment of risk in current and future program development. (Recommendation 2)

The Secretary of the Air Force should ensure Space Force develops a prioritized program-level backlog to maintain traceability between development activities and Space C2 requirements, including any changes to the source requirements. (Recommendation 3)

Agency Comments and Our Evaluation

We provided a draft of this report to DOD for review and comment. In its written comments (reproduced in appendix IV) DOD concurred with all three of our recommendations. DOD also provided technical comments, which we incorporated as appropriate.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Defense, the Secretary of the Air Force, and the Chief of Space Operations. In addition, the report is available at no charge on the GAO 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 office 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 V.

A handwritten signature in black ink that reads "Jon Ludwigson". The signature is written in a cursive style with a long, sweeping underline.

Jon Ludwigson
Director, Contracting and National Security Acquisitions

List of Committees

The Honorable Jack Reed
Chairman
The Honorable Roger Wicker
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Jon Tester
Chair
The Honorable Susan Collins
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

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

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

Appendix I: Objectives, Scope, and Methodology

This report addresses (1) the challenges to Space Command and Control's (Space C2) development efforts—including the Advanced Tracking and Launch Analysis System (ATLAS) component—and how the program is addressing them; and (2) the extent to which the Air Force's 2022 annual report on Space C2 includes mandatory elements outlined in the National Defense Authorization Act (NDAA) for Fiscal Year 2020 and, with additional program reporting, provides information for congressional oversight.¹

To address our first objective, we conducted three analyses of the Space C2 program, based on GAO's Cost Estimating and Agile Guides:²

- We assessed Space C2's November 2021 program office cost estimate against GAO best practices, which comprise four characteristics—comprehensive, well documented, accurate, and credible. We reviewed cost estimate documentation, such as the Space C2 program cost estimate, briefs, memoranda, and other documents that contain cost, schedule and risk information, to conduct our initial analysis. We met with program officials responsible for preparing the cost estimate, as well as officials from the Air Force Cost Analysis Agency, to discuss the cost estimate and obtain any additional information relevant to our assessment. We then provided the draft analysis to Space C2 program officials for any additional comment or clarification. We incorporated new information as appropriate.
- Space C2 also provided its December 2022 cost estimate during our review period. We did not conduct a full assessment of this estimate against GAO best practices, but reviewed the documents and incorporated new information as appropriate.
- We assessed Space C2's implementation of Agile principles against GAO's best practices, namely chapter 3 of GAO's Agile Guide, which

¹National Defense Authorization Act for Fiscal Year 2020, Pub. L. No. 116-92, § 1613 (2019).

²GAO, *Cost Estimating and Assessment Guide*, [GAO20195G](#) (Washington, D.C.: Mar. 12, 2020); and *Agile Assessment Guide*, [GAO20590G](#) (Washington, D.C.: Sept. 28, 2020).

describes nine best practices for Agile adoption. These best practices are grouped into three functional areas: team dynamics and activities, program operations, and organization environment. As part of the Agile adoption review, we did not assess two best practices that we examined as part of the other reviews. Specifically, we did not assess the best practice “program controls are compatible with Agile” because this is covered in our assessment of the program’s cost estimate, discussed below. Additionally, we did not assess the requirements best practice because we assessed requirements as part of the Agile Guide review on chapter 5 “Requirements Development and Management in Agile,” discussed below. To conduct our initial analysis of Space C2’s Agile implementation principles, we reviewed Space C2 program documents, such as the draft acquisition strategy, and then met with program officials and leadership to obtain their perspectives on Agile adoption and any additional information relevant to our scoring. We then provided the draft analysis to Space C2 program officials for any additional comment or clarification. We incorporated new information as appropriate.

- We assessed Space C2’s implementation of Agile principles against chapter 5 of GAO’s Agile Guide, which describes eight best practices for requirements development and management in Agile. We reviewed Space C2 program documents, such as program increment reports, to conduct our initial analysis. Then, we met with program officials and leadership to obtain their perspectives on requirements management in an Agile environment and any additional information relevant to our scoring. We then provided the draft analysis to Space C2 program officials for any additional comment or clarification. We incorporated new information as appropriate.

To address our second objective, we assessed the 2022 Space C2 annual report against the required reporting elements in the NDAA for Fiscal Year 2020. Specifically, we compared information in the annual report to the eight reporting criteria and determined whether the report information addressed, partially addressed, or did not address a criterion. The NDAA requires the Space C2 annual report to address the following:

- A description of any modification to the metrics established by the Secretary of the Air Force in the acquisition strategy for the program.
- The short-term objectives for the subsequent fiscal year.
- A description of the ongoing, achieved, and deferred objectives for the preceding fiscal year.

- A description of the challenges encountered and lessons learned during the preceding fiscal year.
- A description of the modifications made or planned so as to incorporate such lessons learned into subsequent efforts to address challenges for the preceding fiscal year.
- A description of the cost, schedule, and performance effects of such modifications for the preceding fiscal year.
- A full survey of combatant command requirements, including Commanders' Integrated Priorities Lists, and impacts with respect to the program for the preceding fiscal year.³
- A description of potential future combatant command requirements being considered with respect to the program.

To determine the extent to which the Space C2 annual reports and program increment reports provide effective information for oversight, we leveraged part of the Agile analysis from our first objective and examined program reporting to see whether Space C2 communicated program-level performance information frequently and efficiently, in accordance with GAO's Agile Guide. We obtained reports for Space C2's program increments 1-16 during our review period. We calculated the rate of completed work using information in the Space C2 annual report and program increment reports and searched for information that described how the program addressed incomplete work.⁴ For program increments 1-16, we counted the number of planned and completed development activities, and then developed a bar chart comparing these figures. We also calculated the average percentage of completed work across these program increments. We did not count or calculate planned development activities for program increment 1, completed development activities for program increment 12, or any results for program increments 13-14 because results were not available or Space C2 did not report detailed results.

To support both of our objectives, we interviewed officials from the following organizations to discuss the Space C2 program: the Office of the Under Secretary of Defense for Acquisition and Sustainment; the

³Integrated priority lists outline each combatant commander's highest priority requirements, defining program shortfalls that could adversely affect the ability of the combatant commander's forces to carry out their missions.

⁴The Department of the Air Force provides Space C2 program increment reports to the congressional defense committees to provide additional information on the program.

Appendix I: Objectives, Scope, and Methodology

Office of Cost Assessment and Program Evaluation; the office of the Director, Operational Test and Evaluation; the Department of the Air Force; Combined Forces Space Component Command; Combined Space Operations Center; National Space Defense Center; 18th Space Defense Squadron; Space C2 Program Office; and the MITRE Corporation.

We conducted this performance audit from March 2022 through June 2023 in accordance with generally accepted 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.

Appendix II: Analysis of Space Command and Control Program Cost Estimate

To assess the reliability of the November 2021 Space Command and Control (Space C2) program office cost estimate, we determined the extent to which the estimate was consistent with cost estimating best practices, as identified in GAO's Cost Estimating and Assessment Guide.¹ This guide groups the best practices into four general characteristics: well-documented, comprehensive, accurate, and credible.²

After reviewing documentation the Space C2 program submitted for its cost estimate, conducting interviews, and reviewing relevant sources, we determined that the Space C2 cost estimate partially met three and minimally met one of the four characteristics of a reliable cost estimate. We determined the overall best practice by assigning each individual assessment rating a number:

- Not Met = 1,
- Minimally Met = 2,
- Partially Met = 3,
- Substantially Met = 4, and
- Met = 5.

Next, we calculated the average of the individual assessment ratings to determine the overall rating for each of the four characteristics. The resulting average becomes the overall assessment as follows:

- Not Met = 1.0 to 1.4,
- Minimally Met = 1.5 to 2.4,

¹GAO, *Cost Estimating and Assessment Guide*, [GAO-20-195G](#) (Washington, D.C.: Mar. 12, 2020).

²We assessed Space C2's cost estimate based on cost estimate documentation and interviews with program officials responsible for developing the estimate. For additional information on the methodology for this assessment, see appendix I.

Appendix II: Analysis of Space Command and Control Program Cost Estimate

- Partially Met = 2.5 to 3.4,
- Substantially Met = 3.5 to 4.4, and
- Met = 4.5 to 5.0.

A cost estimate is considered reliable if the overall assessment ratings for each of the four characteristics are substantially or fully met. If any of the characteristics are not met, minimally met, or partially met, then the cost estimate does not fully reflect the characteristics of a high-quality estimate and cannot be considered reliable. Table 4 provides our results of the program’s individual and overall assessment.

Table 4: Results of Space Command and Control November 2021 Cost Estimate Assessment

Characteristic	Overall assessment	Best practice	Individual assessment
Comprehensive	Minimally Met	Includes all life-cycle costs	Minimally Met
		Based on a technical baseline description that completely defines the program, reflects the current schedule, and is technically reasonable	Minimally Met
		Based on a work breakdown structure (WBS) that is product-oriented, traceable to the statement of work, and at an appropriate level of detail to ensure that cost elements are neither omitted nor double-counted	Minimally Met
		Documents all cost-influencing ground rules and assumptions	Partially Met
Well-documented	Partially Met	Shows the source data used, the reliability of the data, and the estimating methodology used to derive each element’s cost	Minimally Met
		Describes how the estimate was developed so that a cost analyst unfamiliar with the program could understand what was done and replicate it	Substantially Met
		Discusses the technical baseline description, and the data in the technical baseline are consistent with the cost estimate	Minimally Met
		Provides evidence that the cost estimate was reviewed and accepted by management.	Substantially Met
Accurate	Partially Met	Based on a model developed by estimating each WBS element using the best methodology from the data collected	Minimally Met
		Adjusted properly for inflation	Partially Met
		Contains few, if any, minor mistakes	Partially Met
		Regularly updated to ensure the estimate reflects program changes and actual costs	Partially Met
		Documents, explains, and reviews variances between planned and actual costs	Minimally Met

Appendix II: Analysis of Space Command and Control Program Cost Estimate

Characteristic	Overall assessment	Best practice	Individual assessment
		Based on a historical record of cost estimating and actual experiences from other comparable programs	Minimally Met
Credible	Partially Met	Includes a sensitivity analysis that identifies a range of possible costs based on varying major assumptions, parameters, and data inputs	Minimally Met
		Includes a risk and uncertainty analysis that quantifies the imperfectly understood risks and identifies the effects of changing key cost driver assumptions and factors	Partially Met
		Employs cross-checks—or alternate methodologies—on major cost elements to validate results	Partially Met
		Compared to an independent cost estimate that is conducted by a group outside the acquiring organization to determine whether other estimating methods produce similar results	Minimally Met

Source: GAO analysis of U.S. Space Force data. | GAO-23-105920

Appendix III: Analysis of Space Command and Control's Agile Adoption and Requirements Management

We evaluated the Agile development process against the best practices of chapters 3 "Agile Adoption Best Practices" and 5 "Requirements Development and Management in Agile" in GAO's Agile Assessment Guide as follows. ¹

Agile Adoption

To assess the success of Space Command and Control's (Space C2) Agile adoption, we determined the extent to which the program was consistent with best practices as identified in GAO's Agile Assessment Guide. This guide groups the Agile adoption best practices into three functional perspectives: team dynamics and activities, program operations, and organization environment.²

After reviewing documentation the Space C2 program submitted, conducting interviews, and reviewing relevant sources, we determined that Space C2 fully met one and substantially met two of the Agile adoption functional perspectives. We determined the individual assessment rating by assigning each individual best practice a number:

- Not Met = 1,
- Minimally Met = 2,
- Partially Met = 3,
- Substantially Met = 4, and

¹GAO, *Agile Assessment Guide*, [GAO-20-590G](#) (Washington, D.C.: Sept. 28, 2020).

²We did not evaluate the best practice related to requirements or the best practice related to program controls because we covered these in our Agile requirements and cost estimate assessments. For additional information on the methodology for this assessment, see appendix I.

Appendix III: Analysis of Space Command and Control's Agile Adoption and Requirements Management

- Met = 5.

Next, we calculated the average of the individual assessment ratings to determine the overall rating for each of the three functional perspectives. The resulting average becomes the overall assessment as follows:

- Not Met = 1.0 to 1.4,
- Minimally Met = 1.5 to 2.4,
- Partially Met = 2.5 to 3.4,
- Substantially Met = 3.5 to 4.4, and
- Met = 4.5 to 5.0.

Agile adoption is considered successful if the overall assessment ratings for each of the three functional perspectives are substantially or fully met. If any of the functional perspectives are not met, minimally met, or partially met, then the Agile adoption does not fully reflect the functional perspectives of effective Agile transition and more steps should be taken to fully transition to an Agile environment. Table 5 provides the results of our assessment of Space C2.

Table 5: Results of Space Command and Control Agile Adoption Assessment

Functional perspectives	Overall assessment	Best practice	Individual assessment
Team dynamics and activities	Fully Met	Team composition supports Agile methods.	Fully Met
		Repeatable processes are in place.	Substantially Met
		Work is prioritized to maximize value for the customer.	Did Not Evaluate
Program operations	Substantially Met	Staff are appropriately trained in Agile methods.	Substantially Met
		Technical environment enables Agile development.	Substantially Met
		Program controls are compatible with Agile.	Did Not Evaluate
Organization environment	Substantially Met	Organization activities support Agile methods.	Partially Met
		Organization culture supports Agile methods.	Substantially Met
		Organization acquisition policies and procedures support Agile methods.	Substantially Met

Source: GAO analysis of U.S. Space Force data. | GAO-23-105920

Our analysis found that the Space C2 program fully met the team dynamics and activities functional perspective. The program has self-

organized teams, with defined roles, that meet daily to review development actions, evaluate user needs, address roadblocks, and make updates. Space C2 uses modern digital engineering tools to support continuous integration; however, nonfunctional requirements are not tracked separately. The program completes a retrospective at the end of each 90-day iteration, which is documented in the program increment reports, and holds a demonstration at the end of its 3-week development cycle. However, the program does not have a complete program backlog.

Our analysis found that Space C2 substantially met the program operations functional perspective. Space C2 staff are appropriately trained in Agile methods and the program promotes a learning culture with a team dedicated to providing continuous access to educational opportunities. We found that Agile training was provided to the program office personnel. Space C2 primarily uses an Agile software program called Jira to manage the program. While Space C2 system design supports iterative delivery, the program continues to have issues with legacy code, which hinders Agile implementation.

Our analysis found that Space C2 substantially met the organization environment functional perspective. According to program officials, Space C2 leadership supports Agile; however, our analysis did not find evidence of incentives or rewards to further Agile development. While the program has yet to enter the Software Acquisition Pathway, the draft acquisition strategy indicates that it is following the principles of the pathway. Further, Space C2 hired an Agile coach to help program officials execute the program. Program officials stated that multi-year contracts the program awarded hampered their ability to implement Agile processes, which they said they took steps to address in their January 2023 contract modification. Our analysis also found that life-cycle activities are clearly defined for the Advanced Tracking and Launch Analysis System, though it is not clear if goals and objectives are aligned.

Agile Requirements Development and Management

To assess the success of Space C2's Agile requirements development and management implementation, we determined the extent to which the program was consistent with best practices, as identified in GAO's Agile Assessment Guide. Agile requirements management and development is considered successful if all assessment ratings for each best practice are substantially or fully met. If any of the best practices are not met, minimally met, or partially met, then the Agile requirements development

Appendix III: Analysis of Space Command and Control's Agile Adoption and Requirements Management

and management does not fully reflect an effective implementation of Agile and more steps should be taken. After reviewing documentation the Space C2 program submitted, conducting interviews, and reviewing relevant sources, we determined that the program substantially met two and partially met six of the requirements development and management best practices, as shown in table 6.

Table 6: Results of Space Command and Control Requirements Development and Management Assessment

Best practice	Individual assessment
Elicit and prioritize requirements	Substantially Met
Refine and discover requirements	Partially Met
Ensure requirements are complete, feasible, and verifiable	Partially Met
Balance customer needs and constraints	Substantially Met
Test and validate the system as it is being developed	Partially Met
Manage and refine requirements	Partially Met
Maintain traceability in requirements decomposition	Partially Met
Ensure work is contributing to the completion of requirements	Partially Met

Source: GAO analysis of U.S. Space Force data. | GAO-23-105920

Our analysis found that the Space C2 program substantially met best practices related to eliciting and prioritizing requirements as well as balancing customer needs and constraints. For example, the program routinely seeks customer feedback on needs, expectations, and constraints. Space C2 also employs user surveys to gather feedback; however, the program does not standardize surveys across development teams. Further, the program does not differentiate user requirements from non-functional requirements. According to program officials, the product owner—the customer representative—ensures all scope is covered and develops the stories.³ Officials also stated that any disagreements between the program and the customer are resolved during program increment events.

Our analysis found that Space C2 partially met the remaining requirements development and management best practices. The program has yet to complete a total program backlog, which hinders management's ability to make informed decisions and could result in

³Per Department of Defense (DOD) Instruction 5000.87, *Operation of the Software Acquisition Pathway* (Oct. 2, 2020), the product owner is a role on the program or development team that works closely with the user community to ensure that the requirements reflect the needs and priorities of the user community and align to the mission objectives.

Appendix III: Analysis of Space Command and Control's Agile Adoption and Requirements Management

schedule delays. While Space C2 is organized into cross-functional product teams with prioritized epics, the program will sometimes start development without an understanding of the end goal. Further, it is not clear how the product owner agrees to or accepts the definition of done for each user story. Program officials stated that requirements are a topic at the program increment meetings, though it is not clear how Space C2 manages or refines requirements. Space C2 documentation did not show that it uses continuous integration and automated testing in the build process. However, the Air Force recently approved a new Test and Evaluation Strategy that may address these shortfalls, according to program officials. Space C2 maintains a level of requirements traceability in program documents, but the traceability is not consistent from key performance parameters to user stories. Finally, Space Operations Command and U.S. Space Command completed a value assessment that determined Space C2-delivered capabilities are not considered mission critical.

Appendix IV: Comments from the Department of Defense



DEPARTMENT OF THE AIR FORCE
WASHINGTON DC

OFFICE OF THE ASSISTANT SECRETARY

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

25 May 2023

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 Department of Defense (DoD) response to the GAO Draft Report, GAO-23-105920, 'SPACE COMMAND AND CONTROL: Improved Tracking and Reporting Needed to Show a Clearer Picture of Progress amid Persistent Delays' (GAO Code 105920).

The Department concurs with the GAO recommendations in the draft report and looks forward to receiving the final report. Thank you for allowing the department to review the draft report and we look forward to continuing collaboration with the GAO and other stakeholders to improve Space C2 for our warfighters and the nation.

Sincerely,

A handwritten signature in blue ink, appearing to read "SPW".

STEVEN P. WHITNEY, Maj Gen, USSF
Military Deputy, Office of the Assistant
Secretary of the Air Force
(Space Acquisition and Integration)

GAO DRAFT REPORT DATED APRIL 27, 2023
GAO-23-105920 (GAO CODE 105920)

“SPACE COMMAND AND CONTROL: IMPROVED TRACKING AND REPORTING
NEEDED TO SHOW A CLEARER PICTURE OF PROGRESS AMID PERSISTENT
DELAYS”

DEPARTMENT OF DEFENSE COMMENTS
TO THE GAO RECOMMENDATIONS

RECOMMENDATION 1: The GAO recommends that the Secretary of the Air Force should ensure Space Force includes the following in Space C2’s annual reports to Congress:

1. Metrics that are consistent across annual reports—for example, those metrics in the Space C2 draft acquisition strategy—and associated results;
2. Measures or metrics of the Space C2 backlog that show how much work remains for each development activity or application and the overall program; and
3. Assessment of risk in current and future program development.

DoD RESPONSE: Concur.

RECOMMENDATION 2: The GAO recommends that the Secretary of the Air Force should ensure Space Force includes the following in Space C2’s program increment reports:

1. Metrics that are consistent across program increment reports—for example, those metrics in the Space C2 draft acquisition strategy—and associated results;
2. Measures or metrics of the Space C2 backlog that show how much work remains for each development activity or application and the overall program; and
3. Assessment of risk in current and future program development.

DoD RESPONSE: Concur.

RECOMMENDATION 3: The GAO recommends that the Secretary of the Air Force should ensure Space Force develops a prioritized program-level backlog to maintain traceability between development activities and Space C2 requirements, including any changes to the source requirements.

DoD RESPONSE: Concur.

Text for Appendix IV: Comments from the Department of Defense

DEPARTMENT OF THE AIR FORCE
WASHINGTON, DC
OFFICE OF THE ASSISTANT SECRETARY

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

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Director, Contracting and National Security Acquisitions
U.S. Government Accountability Office
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Sincerely,

Steven P. Whitney, Maj Gen, USSF
Military Deputy, Office of the Assistant
Secretary of the Air Force
(Space Acquisition and Integration)

GAO DRAFT REPORT DATED APRIL 27, 2023, GAO-23-105920 (GAO CODE 105920)

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DoD RESPONSE: Concur.

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DoD RESPONSE: Concur.

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DoD RESPONSE: Concur.

Appendix V: GAO Contact and Staff Acknowledgments

GAO Contact

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

Staff Acknowledgments

In addition to the contact named above, Laura Hook (Assistant Director), Burns C. Eckert (Analyst in Charge), Pete Anderson, Jennifer Echard, Richard Horiuchi, Min-Hei (Michelle) Kim, Jennifer Leotta, Mary Anne S. Sparks, and Adam Wolfe made key contributions to this report.

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