United States Government Accountability Office

Report to Congressional Committees

JUNE 2024

Weapon Systems Annual Assessment

DOD Is Not Yet Well-Positioned to Field Systems with Speed

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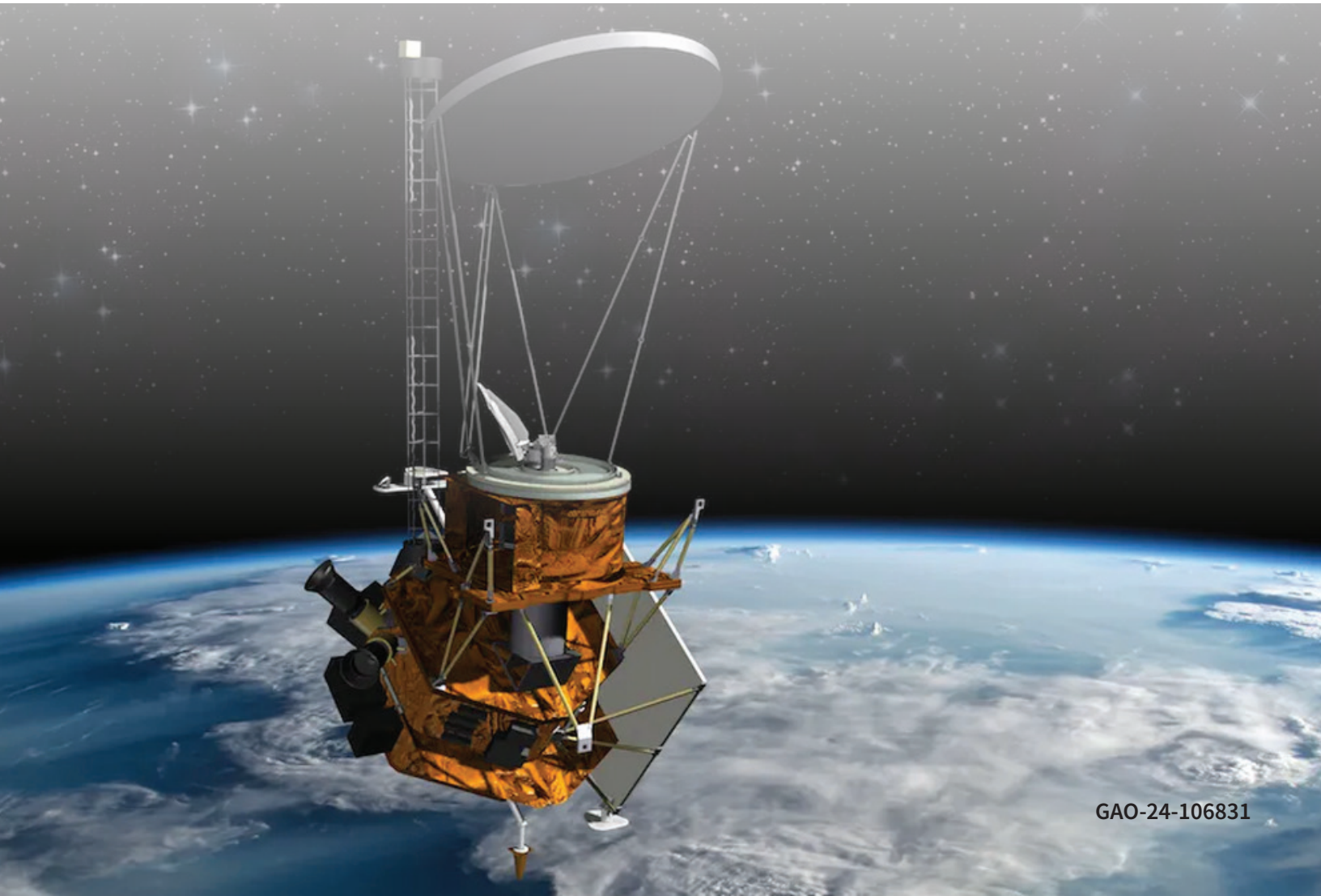

GAO-24-106831

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A Report to Congressional Committees June 2024

Weapon Systems Annual Assessment

DOD Is Not Yet Well-Positioned to Field Systems with Speed

GAO Highlights

Highlights of GAO-24-106831

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Source: Copyright © Boeing; U.S. Army; and U.S. Navy, respectively. | GAO-24-106831

Why GAO Did This Study

To deliver more timely and effective solutions to the warfighter, DOD revamped its department-wide acquisition policies in 2020. These policy changes responded to long-standing concerns that the defense acquisition process was overly bureaucratic and too slow.

As part of these changes, DOD established the Adaptive Acquisition Framework, which offers a variety of pathways for acquisition programs. This framework includes the major capability acquisition pathway to acquire and modernize unique DOD programs that provide enduring capability. MDAPs, some of the costliest programs, follow the major capability pathway.

The framework also includes the MTA pathway for rapid prototyping and rapid fielding. This pathway for programs is intended to be completed in 5 years.

This report, GAO's 22nd annual assessment, responds to a provision Congress included in statute for GAO to annually review selected DOD acquisition programs and efforts. It assesses the characteristics and performance of 108 of DOD's costliest weapon programs.

What GAO Found

While the Department of Defense (DOD) plans to invest more than $2 trillion to develop and acquire its costliest weapon programs, it continues to struggle with delivering innovative technologies quickly. Weapon systems are more complex and driven by software than ever before. Recent reforms were intended to lead to faster results, but slow, linear development approaches persist. In July 2023, GAO found that leading commercial companies deliver complex, innovative products with speed through iterative cycles of design, development, and production.

Cost and schedule performance for DOD's costliest weapon programs. Combined total estimates decreased slightly by $1.7 billion in the past year for the 31 major defense acquisition programs (MDAP) that GAO assessed in depth this year and last year. This decrease was the result of several factors, including quantity reductions and changes in inflation assumptions. However, several large programs plan to update their cost estimates because of a statutory unit cost growth breach or other program performance changes, which may result in future cost growth.

Factors That Drove 1-Year Cost Changes for 31 Major Defense Acquisition Programs (fiscal year 2024 dollars in billions)

Source: GAO analysis of Department of Defense (DOD) data. | GAO-24-106831

The average MDAP that has yet to deliver initial capability plans to take over 10 years to do so—slightly longer than last year. This continues a trend of increased cycle times. GAO also found that, for MDAPs that have delivered capability, the average amount of time it took to do so increased from 8 years to 11 years—an average increase of 3 years from their original planned date.

GAO also assessed 20 of DOD's largest middle tier of acquisition (MTA) programs, with a combined estimated total cost of over $35 billion. GAO found that five MTA programs continue to report delays to a key milestone intended to demonstrate capability.

It further analyzes selected programs' implementation of leading practices for product development, as described in GAO-23-106222, as well as modern software development approaches, and cybersecurity practices. Finally, it assesses DOD's efforts to address challenges related to the software acquisition workforce; including steps DOD has taken to establish a congressionally directed software cadre.

GAO identified programs for review based on cost and acquisition status; reviewed relevant legislation and policy; collected program documents; used a questionnaire to obtain data from program offices; and interviewed DOD officials.

What GAO Recommends

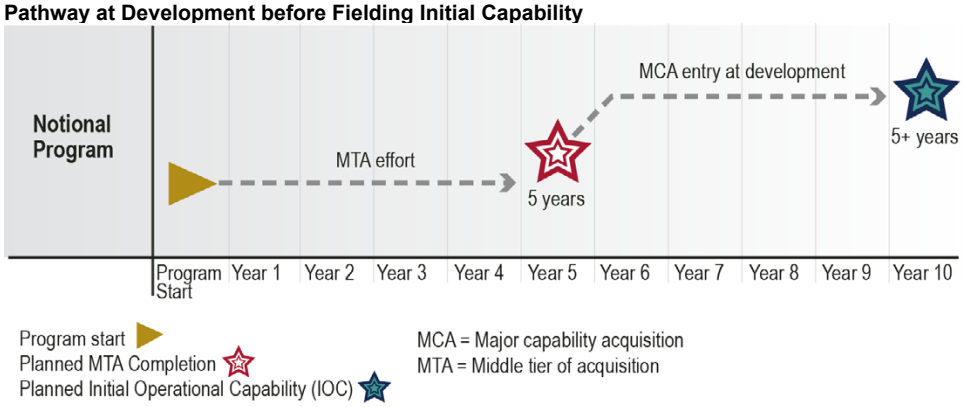
GAO is making three recommendations to DOD, including that DOD address how MTA programs implement leading practices for product development; define goals for its software cadre; and identify strategies and resources need to achieve those goals. DOD concurred with the software workforce recommendations and partially concurred with the remaining recommendation. DOD stated that, to facilitate effective implementation, the recommendation should be focused on updating policy rather than guidance. GAO agreed with DOD's rationale and revised its recommendation accordingly.

View GAO-24-106831. For more information, contact Shelby S. Oakley at (202) 512-4841 or oakleys@gao.gov.

Although the MTA pathway was designed for speed, GAO found most MTA programs do not plan to implement leading practices to facilitate that speed. For example, most MTA acquisition strategies do not outline how programs plan to leverage leading practices to develop and deliver an initial fieldable capability—the goal of an iterative approach—within 5 years.

Some programs continue to expect to deliver capability after following lengthy, linear development schedules, such as 5 years for rapid prototyping followed by another development effort of 5 or more years. Employing leading practices to deliver capability with speed provides programs with an opportunity to follow an iterative approach to development.

Example of a Middle Tier of Acquisition Program Transitioning to the Major Capability Pathway at Development before Fielding Initial Capability



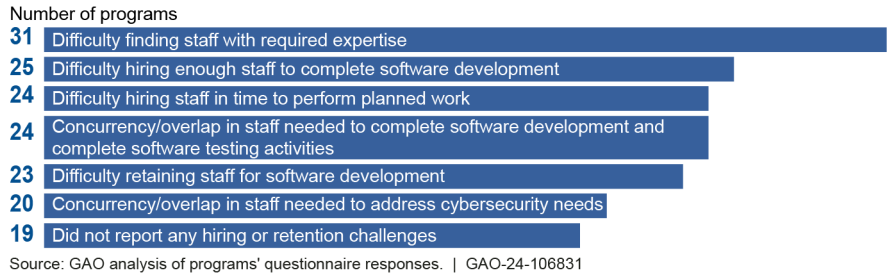
Source: GAO analysis of Department of Defense data. | GAO-24-106831

Software development approaches and cybersecurity practices. Since 2021, more programs have reported using modern software development approaches. But programs continued to lag in implementing key practices, such as using a software factory and modular contracting, to accelerate software development.

Most MDAP and MTA programs GAO reviewed did not consistently report scheduling key cybersecurity assessments at appropriate stages of development or before planned transition dates, respectively. Conducting such assessments early is critical to identifying and fixing vulnerabilities with less effect on program schedule. In 2023, we issued a restricted report that includes recommendations related to early cybersecurity testing.

Software workforce challenges. DOD programs have struggled to hire and retain a workforce with sufficient software expertise. Most of the 53 software-intensive programs GAO reviewed reported contractor-led software development efforts, underscoring the importance of capable acquisition staff for oversight.

Most of the 53 Software-Intensive Acquisition Programs GAO Reviewed Reported Challenges Related to Hiring and Retaining the Software Workforce



Source: GAO analysis of programs' questionnaire responses. | GAO-24-106831

DOD has taken initial steps to establish a cadre of personnel with software expertise, but its efforts are in early stages. While DOD expects to request more funding, as of March 2024, the cadre consisted of one federal employee with limited assistance. Without planning for key aspects of how it will expand the cadre and defining the cadre's goals, DOD may face challenges providing its acquisition programs with the software acquisition expertise they need.

Contents

Tables

Figures

Abbreviations

AAF	Adaptive Acquisition Framework
ACAT	acquisition category
DAES	Defense Acquisition Executive Summary
DAU	Defense Acquisition University
DAVE	Defense Acquisition Visibility Environment
DOD	Department of Defense
MCA	major capability acquisition
MDAP	major defense acquisition program
MTA	middle tier of acquisition
NDAA	National Defense Authorization Act
OSD	Office of the Secretary of Defense
RDT&E	research, development, test, and evaluation
TRL	technology readiness level
USD(A&S)	Under Secretary of Defense for Acquisition and Sustainment
USD(R&E)	Under Secretary of Defense for Research and Engineering

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U.S. GOVERNMENT ACCOUNTABILITY OFFICE
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June 17, 2024

Congressional Committees

I am pleased to present our annual assessment of the Department of Defense's (DOD) acquisition of weapon systems. This report, GAO's 22nd annual assessment, examines DOD's most expensive weapon system acquisition programs—an area on GAO's High-Risk List since 1990.[1] We offer observations on the performance of 108 acquisition programs that DOD expects will cost more than $2.096 trillion in total. These programs include 76 major defense acquisition programs (MDAP), 20 programs using the middle tier of acquisition (MTA) pathway, and 12 future major weapon acquisitions.

DOD remains alarmingly slow in delivering new and innovative weapon system capabilities, even as national security threats continue to evolve. As the 2022 National Security Strategy and the unclassified 2022 National Defense Strategy make clear, the acquisition processes used to deliver capabilities in the past are too slow to address emerging threats of the future. China has greatly strengthened its military capabilities over the last 20 years and its stated goal is to have a "world-class" military by the end of 2049, according to DOD.[2] China will continue to modernize its military into one that can challenge the United States across the spectrum of conventional and unconventional capabilities. The 2022 DOD strategies further note that Russia is increasing its military capability and seeks to expand control over portions of the former Soviet empire, underscored by its unprovoked, full-scale invasion of Ukraine in February 2022. The number of threats in space also continues to grow, including adversarial development of ways to target U.S. space assets and communications. Rapid advancements in technology and innovation are shared worldwide, and other threats will continue to emerge—such as our adversaries' access to artificial intelligence and autonomous systems, and their ability to conduct malicious cyber activity.

These and other threats require DOD to focus on speed and innovation in acquiring weapon systems. While DOD has made efforts to identify

[1]GAO, *High Risk Series: Efforts Made to Achieve Progress Need to Be Maintained and Expanded to Fully Address All Areas,* GAO-23-106203 (Washington, D.C.: Apr. 20, 2023).

[2]U.S. Department of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China* (Washington, D.C.: 2023).

efficiencies, the speed of technological change outpaces the responsiveness of the current acquisition structure. Weapon systems are increasingly cyber-physical—complex networks of hardware and software—with software driving programs more than ever before. Our recent work on leading practices for product development identified that delivering these complex systems with speed requires new, iterative approaches for development.[3] Commercial breakthroughs in design and development tools—such as digital twinning—enable rapid iterative development cycles of design, development, and delivery.

Still, many DOD programs continue to use a slow and linear development approach and fall short of delivering capabilities quickly and at scale. The average expected time for MDAPs in DOD's portfolio to deliver even an initial capability to the warfighter is 10 years—a time frame incompatible with maintaining military advantage in an environment shaped by the need for technological advantage.

DOD has acknowledged the limitations of the current acquisition system and is working to improve how fast it develops and delivers its weapon systems. For example, in January 2024, the Secretary of the Navy directed Navy leadership to conduct a comprehensive analysis of the Navy shipbuilding portfolio to assess the challenges in fielding ships critical to the nation's defense. Among other things, the analysis is intended to recommend actions for providing combat capabilities that warfighters need, when they need them.

DOD's adaptive acquisition framework, established in January 2020, is intended to deliver solutions to the end user in a timely manner. The MTA pathway provides a streamlined process that programs can use to achieve more efficient acquisitions that are intended to be completed in 5 years from MTA program start. The MTA pathway offers certain flexibilities that can facilitate speed. For example, programs using the pathway are not subject to the traditional requirements process and the pathway has tiered thresholds for data reporting.

However, we found that MTA programs would benefit from implementing iterative practices. For example, this report shows that most MTA acquisition strategies do not outline how programs plan to leverage leading practices to develop and deliver an initial fieldable capability—the

[3]GAO, *Leading Practices: Iterative Cycles Enable Rapid Delivery of Complex, Innovative Products,* GAO-23-106222 (Washington, D.C.: July 27, 2023).

goal of an iterative approach—within 5 years. Although programs have the potential to use the pathway to gain efficiencies, some programs still plan to finish their 5-year MTA efforts only to require significant additional development before providing any operational capability to the warfighter.

The MTA programs we reviewed that intend to transition to the major capability acquisition pathway at development start plan to take an average of 10 years after the start of the MTA effort to deliver initial capability to the warfighter. The major capability acquisition pathway provides a structured process designed to support certain complex acquisitions. Even at that length, these estimates are likely optimistic. Programs on the major capability acquisition pathway we reviewed that have delivered capability experienced an average increase in cycle time of 3 years from their original estimate to initial capability. While MTA programs might plan to achieve marginal improvements in cycle time, planning for a decade of development and procurement, while technology continues to evolve at a tremendous pace, may mean that the provided capability is no longer as relevant and responsive to warfighter needs as initially planned. Therefore, it is troubling to see programs, including MTA programs, pursue ambitions of developing complex, cyber-physical systems, without planning to implement leading practices that will enable them to do so with speed.

As evidence of the importance of software for providing critical capabilities continues to mount, we are also concerned about DOD's continued challenges with equipping its software workforce. These challenges also apply to DOD's development of a congressionally mandated software cadre to improve the effectiveness of DOD's software development, acquisition, and sustainment programs and activities. DOD has taken some steps to address these challenges, but they are in early stages.

Continued efforts by DOD to mitigate such concerns are essential to staying ahead of our adversaries in delivering effective capabilities in an environment increasingly shaped by advanced technological competition. DOD cannot afford to rely on changes at the margin. The threat environment requires a wholesale shift in its approach to developing weapon systems. Thoughtful implementation of leading practices can help DOD speed its approach to weapon system development to maintain a military advantage.

Gene L. Dodaro
Comptroller General of the United States

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June 17, 2024

Congressional Committees

In response to title 10, section 3072 of the United States Code, this report provides insight into 108 of the Department of Defense's (DOD) most costly weapon programs.[4]

Specifically, this report covers the following sets of programs:

- 76 major defense acquisition programs (MDAP),
- 20 programs currently using the middle tier of acquisition (MTA) pathway,
- and 12 future major weapon acquisitions.[5]

This report assesses (1) the characteristics of DOD's portfolio of its costliest weapon programs and how selected programs have performed over time; (2) the extent to which selected programs followed leading product development practices; (3) the extent to which programs implemented modern software development approaches and recommended cybersecurity practices; and (4) challenges reported by DOD with the software workforce in acquisition program offices and the extent to which DOD has implemented related changes.

To conduct our work, we analyzed cost and schedule data from a variety of sources, including DOD's December 2022 Selected Acquisition Reports (the latest available at the time of our review), 2023 Defense Acquisition Executive Summaries (DAES), MTA Program Identification

[4]Title 10, section 3072 of the U.S. Code includes a provision for us to submit to the congressional defense committees an annual assessment of selected DOD acquisition programs and efforts by March 30 of each year from 2020 through 2026. Our assessment of the performance of DOD's IT programs is included in a separate report, which we also prepared in response to title 10, section 3072 of the U.S. Code. That report will issue later this year.

[5]Throughout this report, we refer to programs currently using the MTA pathway as "MTA programs," although some of these programs may also currently use or plan to subsequently use one or more other pathways before fielding an eventual capability. For the purposes of this report, we use the word "effort" to refer specifically to the activities undertaken using a single Adaptive Acquisition Framework (AAF) pathway or any of the paths provided by an AAF pathway (for example, the rapid prototyping path of the MTA pathway). Our use of the word "effort" excludes other paths or pathways that a program may be using simultaneously, or may plan to use in the future, to field an eventual capability.

Data, and cost data provided by program offices.[6] We determined that the December 2022 Selected Acquisition Report data, the 2023 DAES data, and MTA program cost data were sufficiently reliable for the purposes of reporting program cost and schedule information.

We also provided a questionnaire to 70 programs to obtain information on

- the extent to which programs were using leading acquisition practices;
- programs' schedule performance;
- programs' approach to software development and cybersecurity practices; and
- any challenges associated with the software workforce in program offices.

These 70 programs represent a subset of the overall 108 programs included in our portfolio analysis.[7] Specifically, it includes the 12 future major acquisitions, the 20 programs using the MTA pathway, and 38 MDAPs and MDAP increments, for which we completed more detailed program assessment (see appendix I).[8]

To further examine DOD's recent efforts to address challenges related to the software workforce in program offices, we identified and summarized relevant provisions signed into law from fiscal year 2018 to fiscal year 2023. We also reviewed DOD plans and other relevant documents and conducted interviews with officials from the Office of the Under Secretary of Defense for Acquisition and Sustainment (USD(A&S)), among other offices, to identify changes DOD implemented or is in the process of implementing. Further, we assessed DOD's planning to implement one of

[6]Department of Defense, *Operation of the Middle Tier of Acquisition (MTA)* DOD Instruction 5000.80 (Dec.30, 2019). DOD Instruction 5000.80 requires components to submit updated program identification data with the President's Budget and Program Objective Memorandum submissions to the Office of the Secretary of Defense. This data includes the program's capability requirement, quantity, schedule, technology, and budget, among other things.

[7]We did not complete a 2-page assessment for the remaining 38 MDAPs because those programs have already reached full-rate production or, if there is no full-rate production milestone, initial operational capability.

[8]While we assessed 20 MTA efforts, we completed 19 assessments. One assessment provides combined information on two programs—the Space Force's Tranche 1 and Tranche 2 Transport MTA efforts.

its efforts, a software cadre, as compared to leading practices for evidence-based policymaking.[9]

For all objectives, we also conducted interviews with program officials from the 70 programs for which we completed individual or combined assessments.

Appendix II provides additional information on our objectives, scope, and methodology.

We conducted this performance audit from May 2023 to June 2024 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Defense Acquisition Principles and Authorities

DOD generally acquires its weapon systems through a management process known as the Defense Acquisition System, governed by the overarching principles described in DOD Directive 5000.01 and DOD Instruction 5000.02.[10] According to DOD Directive 5000.01, the objective of the defense acquisition system is to support the National Defense Strategy through the development of a more lethal force based on U.S. technological innovation and a culture of performance that yields a decisive and sustained U.S. military advantage. Further, delivering performance "at the speed of relevance" is one of the overarching policies governing the defense acquisition system. DOD Directive 5000.01 states that the defense acquisition system will be designed to acquire products

[9]GAO, *Evidence-Based Policymaking: Practices to Help Manage and Assess the Results of Federal Efforts*, GAO-23-105460 (Washington, D.C.: July 12, 2023).

[10]Department of Defense, *The Defense Acquisition System*, DOD Directive 5000.01 (Sept. 9, 2020) (incorporating change 1, July 28, 2022); and *Operation of the Adaptive Acquisition Framework*, DOD Instruction 5000.02 (Jan. 23, 2020) (incorporating change 1, June 8, 2022).

and services that satisfy user needs with measurable and timely improvements to mission capability.

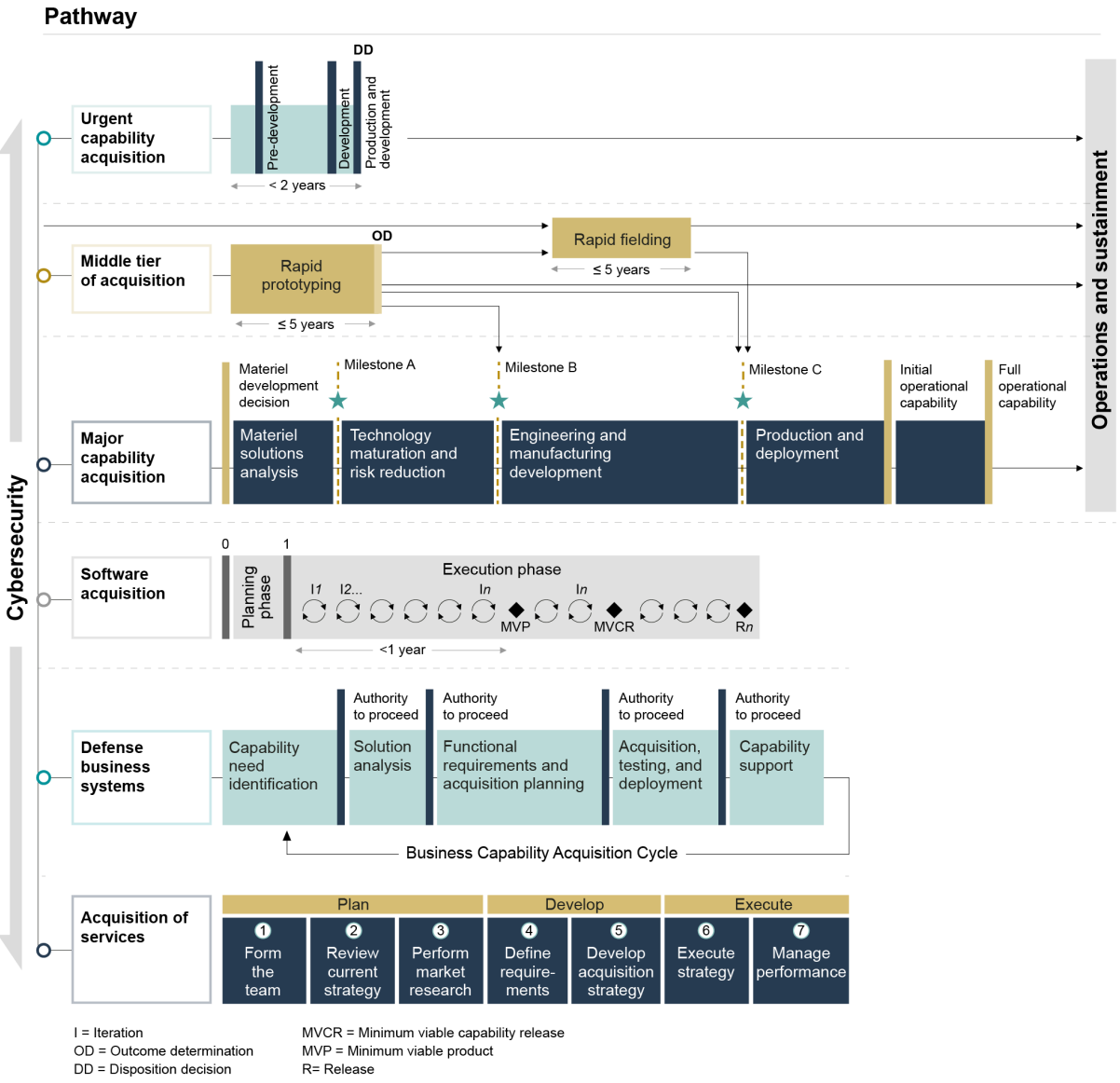
To deliver effective, suitable, survivable, sustainable, and affordable solutions to the warfighter in a timely manner, DOD established the Adaptive Acquisition Framework (AAF) in January 2020. The AAF emphasizes several principles that include simplifying acquisition policy, tailoring acquisition approaches, and conducting data-driven analysis. Oversight of the department's costliest weapon systems is shared between several entities within the Office of the Secretary of Defense (OSD) and the military departments. Appendix III provides more detail on oversight responsibilities for DOD weapon systems.

DOD Instruction 5000.02 establishes the groundwork for the operation of the AAF. The AAF is comprised of six acquisition pathways, each with processes, reviews, documentation requirements, and metrics that program managers can match to the characteristics and risk profile of the capability being acquired. Programs, with approval from the decision authority or the milestone decision authority, may leverage a combination of acquisition pathways to provide value not otherwise available through use of a single pathway.[11] DOD has issued policy documents to address each of these six acquisition pathways as well as additional functional policy documents in areas such as engineering and test and evaluation.[12] Figure 1 shows the AAF pathways.

[11]According to DOD Instruction 5000.02, the milestone decision authority is the program decision authority and specifies the decision points and procedures for assigned programs. Milestone decision authorities for MDAPs and major systems will approve, as appropriate, the acquisition strategy at all major decision points.

[12]Additional functional policy documents include DOD Instruction 5000.88,*Engineering of Defense Systems* (Nov. 18, 2020)*;* DOD Instruction 5000.89, *Test and Evaluation* (Nov. 19, 2020); and DOD Instruction 5000.73, *Cost Analysis Guidance and Procedures* (Mar. 13, 2020).

Figure 1: Adaptive Acquisition Framework Pathways



Source: GAO analysis of Department of Defense (DOD) data. I GAO-24-106831

In this report, we focus on selected programs using the (1) major capability acquisition (MCA) pathway, used by MDAPs, and (2) MTA pathway, used for rapid prototyping and rapid fielding efforts. We also make broad observations regarding the software acquisition pathway.

MDAPs

Under DOD Instruction 5000.02, DOD's MCA pathway is designed to support certain complex acquisitions such as MDAPs.[13] DOD Instruction 5000.85, released in August 2020 and updated in November 2021, established the policy and prescribed procedures that guide acquisition programs using the MCA pathway. Within this pathway, programs generally proceed through several phases, the following three of which are most relevant to this report:

- technology maturation and risk reduction,
- engineering and manufacturing development, and
- production and deployment.

In this report, we refer to these three phases as technology development, system development, and production, respectively. Programs typically complete a series of milestone reviews and other key decision points that authorize entry into a new acquisition phase.

Our body of work on MDAPs shows that attaining high levels of knowledge before programs make significant commitments during product development drives positive acquisition outcomes.[14] We have found that, to reduce risk, there are three key points at which programs should demonstrate critical levels of knowledge before proceeding to the next acquisition phase: development start (milestone B), system-level

[13]MDAPs generally include those programs that are not a highly sensitive classified program and that are either (1) designated by the Secretary of Defense as a MDAP; or that are (2) estimated to require an eventual total expenditure for research, development, test, and evaluation, including all planned increments or spirals, of more than $525 million in fiscal year 2020 constant dollars or, for procurement, including all planned increments or spirals, of more than $3.065 billion in fiscal year 2020 constant dollars. See 10 U.S.C. § 4201(a); DOD Instruction 5000.85, *Major Capability Acquisition* (Aug. 6, 2020) (incorporating change 1, Nov. 4, 2021) (reflecting statutory MDAP cost thresholds in fiscal year 2020 constant dollars). Certain programs that meet these thresholds, including programs using the MTA pathway, are not considered MDAPs. See 10 U.S.C. § 4201(b).

[14]GAO, *Best Practices: DOD Can Achieve Better Outcomes by Standardizing the Way Manufacturing Risks Are Managed*, GAO-10-439 (Washington, D.C.: Apr. 22, 2010); *Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding*, GAO-09-322 (Washington, D.C.: May 13, 2009); *Defense Acquisitions: A Knowledge-Based Funding Approach Could Improve Major Weapon System Program Outcomes*, GAO-08-619 (Washington, D.C.: July 2, 2008); *Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes*, GAO-02-701 (Washington, D.C.: July 15, 2002); *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*, GAO-01-288 (Washington, D.C.: Mar. 8, 2001); and *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO/NSIAD-99-162 (Washington, D.C.: July 30, 1999).

critical design review, and production start (milestone C). Appendix IV provides additional details about key practices we recommend programs follow at each of the knowledge points.

MTA Pathway

The National Defense Authorization Act (NDAA) for Fiscal Year 2016 required DOD to establish guidance for an alternative acquisition process, now referred to as MTA, for programs intended to be completed in a period of 2 to 5 years. In response, in April 2018, the USD(A&S) issued interim guidance that provided DOD components with the authority to implement MTA programs on an interim basis.[15] The guidance encouraged DOD components using the MTA pathway to develop specific implementation processes and procedures for the interim authority.

In December 2019, DOD issued Instruction 5000.80, Operation of the Middle Tier of Acquisition, which formally established the department's MTA policy, assigned responsibilities, and prescribed procedures for the management of the MTA rapid prototyping and rapid fielding paths. The policy states that the MTA pathway is intended to fill a gap in the Defense Acquisition System for capabilities with a level of maturity that allows them to be rapidly prototyped within an acquisition program or fielded within 5 years of MTA program start. The pathway may be used to accelerate capability maturation before transitioning to another acquisition pathway or to minimally develop a capability before rapid fielding.[16] DOD Instruction 5000.80 also outlines the distinctions between the two MTA paths as described in statute:

- The **rapid prototyping** path provides for the use of innovative technologies to rapidly develop fieldable prototypes to demonstrate new capabilities and meet emerging military needs. The objective of a program using the rapid prototyping path is to field a prototype that meets defined requirements, which can be demonstrated in an

[15]Department of Defense, Under Secretary of Defense (Acquisition and Sustainment), *Middle Tier of Acquisition (Rapid Prototyping/Rapid Fielding) Interim Authority and Guidance* (Apr. 16, 2018).

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

operational environment and provide for residual operational capability within 5 years of the MTA program start date.[17]

- The **rapid fielding** path provides for the use of proven technologies to field production quantities of new or upgraded systems with minimal development required. The objective of a program using the rapid fielding path is to begin production within 6 months and complete fielding within 5 years of the MTA program start date.[18]

DOD policy states that, for programs designated on or after December 30, 2019, the MTA program start date is the date that the program was designated. The designation date is when an acquisition decision memorandum initiating the effort as an MTA program is signed by a decision authority. MTA programs designated before December 30, 2019, generally maintain their MTA program start date as the date that funds were first obligated.

Programs using the MTA pathway are generally exempt from the documentation requirements in DOD Directive 5000.01 and the Chairman of the Joint Chiefs of Staff Instruction 5123.01, which outline processes to implement DOD's traditional requirements process. At program initiation, DOD's MTA policy requires MTA programs that are major systems to submit documentation to USD(A&S), including an acquisition decision memorandum, approved requirements, a cost estimate, and an acquisition strategy.[19] Our prior work shows that this type of information helps to establish a program's business case and is important to help

[17]DOD Instruction 5000.80 states that for rapid prototyping programs, residual operational capability is any military utility for an operational user that can be fielded. Virtual prototypes can meet this requirement if they result in a residual operational capability that can be fielded.

[18]The statutory objectives for MTA efforts are outlined in section 804 of the National Defense Authorization Act for Fiscal Year 2016. See Pub. L. No. 114–92, § 804(b) (2015).

[19]Major systems generally refer to a combination of elements that will function together to produce the capabilities required to fulfill a mission need, including hardware, equipment, software, or any combination thereof, but excluding construction or other improvements to real property. A DOD system is considered a major system if (1) the milestone decision authority designates it as a major system; (2) it is estimated to require an eventual total expenditure for research, development, test, and evaluation of more than $200 million in fiscal year 2020 constant dollars, or for procurement of more than $920 million in fiscal year 2020 constant dollars. See 10 U.S.C. § 3041(a)-(c); DOD Instruction 5000.85 (reflecting statutory major system cost thresholds in fiscal year 2020 constant dollars).

decision-makers make well-informed decisions about MTA program initiation.[20]

For each MTA program using the rapid prototyping path, DOD Instruction 5000.80 states that DOD components will develop a process for transitioning successful prototypes to new or existing acquisition programs for production, fielding, and operations and sustainment. Programs have numerous options for transition, such as transitioning into the rapid fielding path or another acquisition pathway, including the MCA pathway at development start or production start. For each MTA program using the rapid fielding path, DOD Instruction 5000.80 states that DOD components will develop a process for transitioning successful programs to operations and sustainment. DOD Instruction 5000.80 also requires both rapid prototyping and rapid fielding MTA programs to develop an acquisition strategy that includes a transition plan with a timeline for completing all necessary documentation required for the transition within 2 years of program start. DOD provides a transition plan template within its guidance on provisions for programs to include in the plan.

While the MTA pathway offers DOD programs a useful tool to develop and deliver innovative capabilities with speed, we identified factors that hinder effective implementation and oversight of these programs in a February 2023 report.[21] For example, an unclear data framework—including undefined data requirements and partially implemented data reliability measures—and reporting guidance for required reporting from the military departments to USD(A&S) limit the visibility of USD(A&S) into MTA program structures, scope, and technical data. As a result, the oversight role of USD(A&S) regarding the MTA pathway is diminished. We also found that DOD components provided USD(A&S) with inaccurate data. These issues complicate DOD's efforts to conduct data-driven oversight of the MTA pathway.

We recommended that USD(A&S) improve its MTA data framework and reporting guidance to better capture program structure and changes in MTA programs' scopes. DOD partially concurred, stating that it is reviewing the existing framework and reporting procedures to determine

[20]GAO, *DOD Acquisition Reform: Leadership Attention Needed to Effectively Implement Changes to Acquisition Oversight*, GAO-19-439 (Washington, D.C.: June 5, 2019).

[21]GAO, *Middle-Tier Defense Acquisitions: Rapid Prototyping and Fielding Requires Changes to Oversight and Development Approaches,* GAO-23-105008 (Washington, D.C.: Feb. 7, 2023).

whether changes are needed. We also recommended that the Air Force, Army, Navy, and U.S. Special Operations Command identify and implement additional actions needed to improve the reliability of MTA program data submitted to USD(A&S). DOD concurred with these recommendations. These recommendations remained open as of March 2024.

Leading Practices for Product Development

In a March 2022 report, we found that leading companies prioritize developing and delivering new, innovative products to customers with speed.[22] To achieve this objective, leading companies rely on four key principles that underpin leading practices in product development. These principles help position leading companies to deliver innovative products that satisfy their customers' needs and correspondingly retain or grow their market share. Figure 2 below outlines these four principles, which also comprise several related sub-principles, detailed in appendix V.

Figure 2: Leading Companies Rely on Four Principles to Deliver Innovative Products to Market with Speed

Principle 1
Attain a sound business case that is informed by research along with collaboration with users

Principle 2
Use an iterative design approach that results in minimum viable products

Principle 3
Prioritize schedule by off-ramping capabilities when necessary

Principle 4
Collect user feedback to inform improvements to the minimum viable product

Source: GAO analysis of company information; GAO (icons). | GAO-24-106831

Our March 2022 report also found that DOD's primary, department-wide acquisition policies do not fully implement product development principles and most of their corresponding sub-principles. Our work found that DOD policies include multiple examples of language that emphasize attaining a sound business case, iterating on design, prioritizing schedule through a realistic assessment of product development activities, and collecting end-user feedback. However, in many cases, we found that this policy

[22]GAO, *Leading Practices: Agency Acquisition Policies Could Better Implement Key Product Development Principles,* GAO-22-104513 (Washington, D.C.: Mar. 10, 2022).

language was limited to certain product types—such as software—and did not generally apply across all acquisition programs.

We made four recommendations that DOD update its acquisition policies to fully implement the four principles throughout development. DOD concurred with our recommendations and noted that it will consider implementing the leading product development principles when it next updates its acquisition policies, which it estimates it will complete in June 2024.

In February 2023, we similarly found that component-level MTA policies from the Air Force, Army, Navy, and U.S. Special Operations Command partially implement some of the aforementioned principles.[23] We recommended that the Air Force, Army, Navy, and U.S. Special Operations Command update their policies to fully implement these four leading principles throughout development. DOD concurred with these recommendations, which remain open as of March 2024.

Additionally, in July 2023, we reported that leading companies use iterative cycles to design, validate, and deliver complex cyber-physical products with speed.[24] Cyber-physical systems—sometimes called hybrid systems—are co-engineered networks of hardware and software that combine computation, communication, sensing, and actuation with physical systems. For example, software in a car's cyber-physical system would receive information about the environment through sensors (such as temperature and tire pressure), and then use these data to instruct physical hardware (such as motors or pumps). Major DOD acquisitions increasingly reflect this close interaction between digital and physical environments. For example, satellites, uncrewed vehicles, and aircraft are cyber-physical systems. The rise of cyber-physical systems in product development has also led to new iterative development approaches. Iterative development allows companies to evolve and define requirements based on demonstrated achievement, with development focused on user needs and mission effect. Table 1 describes some of the

[23]GAO-23-105008.

[24]GAO, *Leading Practices: Iterative Cycles Enable Rapid Delivery of Complex, Innovative Products,* GAO-23-106222 (Washington, D.C.: July 27, 2023). We identified 14 leading product development companies based on rankings in well-recognized lists and awards; recognition as successfully being innovative or having disruptive approaches to product development; records of financial stability and success; and industry type.

differences between traditional linear development and modern iterative development.

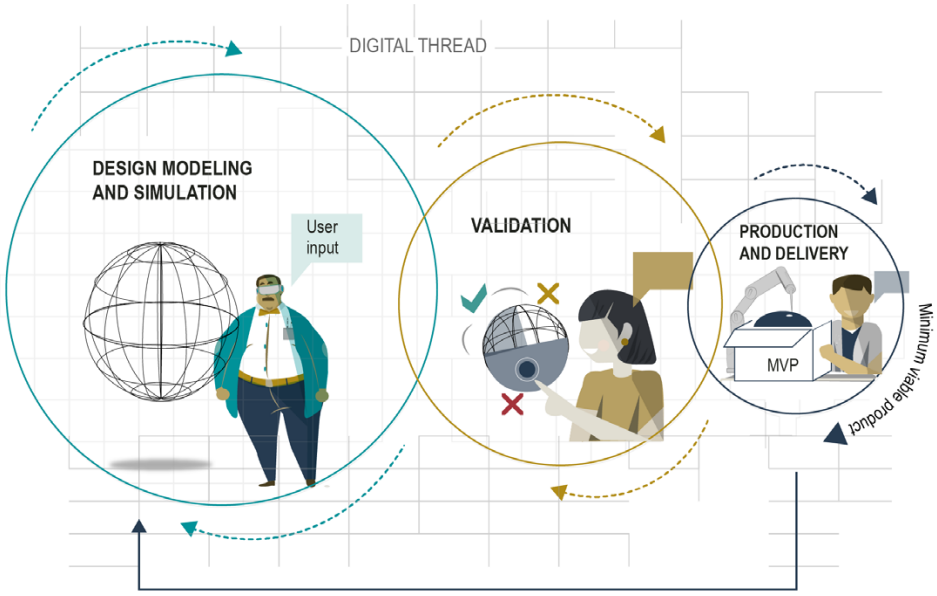
Table 1: Comparison of Linear Development and Iterative Development

	Linear development	Iterative development
Requirements	Requirements are fully defined and fixed up front.	Requirements evolve and are defined in concert with demonstrated achievement.
Development	Development is focused on compliance with original requirements.	Development is focused on user needs and mission effect.
Performance	Performance is measured against an acquisition cost, schedule and performance baseline.	Performance is measured through multiple value assessments—a determination of whether the outcomes are worth continued investment.

Source: GAO analysis. I GAO-24-106831

Activities in these iterative cycles often overlap as the design undergoes continuous user engagement and testing. As the cycles proceed, product teams refine the design to achieve a minimum viable product—one with the initial set of capabilities needed for customers to recognize value that is suitable to be fielded and can be followed by successive iterations. These companies use modern design and manufacturing tools and processes to produce and deliver the product in time to meet their customers' needs. Figure 3 depicts key elements of this approach.

Figure 3: Leading Companies Progress through Iterative Design, Validation, and Production Cycles to Develop a Minimum Viable Product



Source: GAO analysis of leading company information; GAO (illustration). | GAO-24-106831

Key concepts within iterative development of cyber-physical systems include the following:

- **Iteration:** a predefined, time-boxed, and recurring period of time in which product teams develop a working solution.
- **Digital twins:** virtual representations of physical products. Digital twins incorporate dynamic data regarding a physical object or a system—meaning the model changes and updates in real-time as new information becomes available.
- **3D models:** static visualizations of a physical aspect. They cannot be updated without someone manually inputting new data. 3D models are similar to digital versions of paper design drawings.
- **Digital threads:** a common source of information that connect stakeholders with real-time data across the product life cycle to help inform decisions.

Appendix V further details leading practices that leverage knowledge gained throughout iterative development. These practices provide important context for understanding the analyses included in this report.

Software Development and Acquisition

Modern Software Development Approaches

Software has become one of the most important components of DOD systems. DOD's ability to respond to evolving threats and compete with countries, such as Russia and China, is increasingly determined by its ability to rapidly develop and deploy software-intensive weapon and IT systems. Our past work found that DOD acquisition programs employ a wide range of software development approaches, including Agile frameworks and various incremental models.[25] Table 2 provides descriptions of selected modern software development approaches employed by DOD acquisition programs.

Table 2: Selected Modern Software Development Approaches Employed by Department of Defense Acquisition Programs

Software development approach	Description
Agile	This approach breaks a product into components where, in each cycle or iteration, a working model of a component is delivered. The approach produces ongoing releases, each time adding small changes to the previous release. During each iteration, as the product is being built, it is also tested to ensure that at the end of the iteration the product is usable. Agile emphasizes collaboration, as the customers, developers, and testers work together throughout the project.
DevOps	DevOps combines "development" and "operations," emphasizing communication, collaboration, and continuous integration between software developers and users.
DevSecOps	DevSecOps is an iterative software development approach that combines "development," "security," and "operations" as key elements in delivering useful capability to the user of the software.

Source: GAO-24-105506 and GAO analysis of Department of Defense and software industry documentation. I GAO-24-106831

Our recent work found that DOD has made numerous efforts to modernize its software acquisition and development approaches over the past several years.[26] For example, the department has taken steps to improve its software development approach, such as:

[25]GAO, *Weapon Systems Annual Assessment: Limited Use of Knowledge-Based Practices Continues to Undercut DOD's Investments*, GAO-19-336SP (Washington, D.C.: May 7, 2019).

[26]GAO, *Defense Software Acquisitions: Changes to Requirements, Oversight, and Tools Needed for Weapon Programs*, GAO-23-105867 (Washington, D.C.: July 20, 2023); and *Software Acquisition: Additional Actions Needed to Help DOD Implement Future Modernization Efforts*, GAO-23-105611 (Washington, D.C.: Apr. 5, 2023).

- issuing a Software Modernization Strategy in February 2022 and an accompanying implementation plan in March 2023;
- establishing the Software Modernization Senior Steering Group in December 2021; and
- finalizing guidance in October 2020 for the software acquisition pathway, which includes streamlined processes for programs using the software acquisition pathway.[27]

However, we have also highlighted that DOD continues to face challenges in executing modern approaches and rapidly delivering software to users, which senior DOD leaders have acknowledged.[28] According to DOD, software modernization will entail a cohesive department-wide effort that will take time. The department noted, in its 2022 Software Modernization Strategy, that this major digital transformation requires significant changes to processes, policies, workforce, technology, and the establishment of partnerships across the department—all of which will require sustained engagement over many years.[29]

End User Feedback

Modern software development approaches emphasize fast feedback cycles so that software is continuously evaluated on functionality, quality, and user satisfaction. Our previous work—as well as other DOD and industry studies—has found that user involvement is critical to successful software development efforts because it helps programs to detect deficiencies early. It is also linked to reducing risk, enhancing customer commitment, and improving technical staff motivation.[30] Continual

[27]Department of Defense, *Operation of the Software Acquisition Pathway*, DOD Instruction 5000.87 (Oct. 2, 2020).

[28]GAO-23-105611 and GAO-23-105867.

[29]Department of Defense, *Software Modernization Strategy* (Washington, D.C.: Feb. 1, 2022).

[30]GAO, *Information Technology Reform: Agencies Need to Improve Certification of Incremental Development*, GAO-18-148 (Washington, D.C.: Nov. 7, 2017); *Software Development: Effective Practices and Federal Challenges in Applying Agile Methods*, GAO-12-681 (Washington, D.C.: July 27, 2012); and *Information Technology: Critical Factors Underlying Successful Major Acquisitions*, GAO-12-7 (Washington, D.C.: Oct. 21, 2011). See also Department of Defense, Office of the Under Secretary of Defense for Research and Engineering, Defense Science Board, *Design and Acquisition of Software for Defense Systems* (Washington D.C.: February 2018); and Software Engineering Institute, *Scaling Agile Methods for Department of Defense Programs*, Technical Note CMU/SEI-2016-TN-005 (December 2016).

involvement on a regular, recurring basis throughout development is a characteristic of effective user engagement.[31]

Practices Recommended by the Defense Science Board

A February 2018 Defense Science Board study found that DOD can, and should, leverage today's commercial software development leading practices to its advantage, including on its weapon systems.[32] The Defense Science Board made seven recommendations to help DOD modernize its software development and acquisition approach. The recommendations included—but were not limited to—several software development practices, as listed in table 3.

Table 3: GAO Summary of Selected Software Practices Recommended by the Defense Science Board in February 2018

Recommended practice	Description
Creation of a software factory as a key source selection criteria	Development of a software factory as a factor in evaluating proposals for a potential government contractor.
Use of software factory[a]	Cloud-based computing used to assemble a set of software tools enabling developers, users, and management to work together on a daily tempo.
Delivery of minimum viable product[b]	Development technique in which a new product or website is developed with sufficient features to satisfy early adopters, followed by a successive next viable product.
Continuous iterative development	Way of developing software in smaller blocks that can be incrementally evaluated by a user community. This incremental approach allows updates and improvements to be rapidly incorporated into the software.
Iterative development training for program managers and staff	Development of a training curriculum to create and train a cadre of software-informed program managers, sustainers, and software acquisition specialists.
Software documentation provided to the Department of Defense at each production milestone	Delivery of software documentation includes all documentation, test files, coding, application programming interfaces, design documents, results of fault and performance tests conducted using the framework, and tools developed during the development, as well as the software factory framework.

Source: GAO analysis of Defense Science Board report. I GAO-24-106831

[a]The Defense Science Board recommended that all current programs plan a transition to the use of a software factory.

[b]Department of Defense Instruction 5000.87 defines a minimum viable product as an early version of the software to deliver or field basic capabilities to users to evaluate and provide feedback.

In April 2023, we reported that DOD had partially implemented each of the Defense Science Board's seven recommendations. The department

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

[32]Defense Science Board, *Design and Acquisition of Software for Defense Systems* (Washington, D.C.: Feb. 14, 2018).

had taken actions such as issuing new policies and guidance and developing training for DOD's software workforce.[33] We noted, however, that DOD had yet to take certain actions outlined in the recommendations, such as creating a cadre of software development experts. In this report, we assess the extent to which selected DOD weapon programs implemented the software development practices encouraged by the Defense Science Board's recommendations.

Modular Contracting Strategies

The use of a modular contracting strategy—a procurement strategy in which one or more contracts are used to acquire IT systems in successive, interoperable increments—can help an organization achieve the compressed time frames envisioned when using Agile development practices.[34] Modular contracting can eliminate the delay between when the government defines its requirements and when the contractor begins delivering workable solutions.[35] Achieving timely results requires the contracting cycle to be in alignment with the technology cycle.

Modular contracting is intended to reduce risk and incentivize contractor performance while meeting the government's need for timely access to rapidly changing technology.[36] As a result, it can enable delivery of capabilities more rapidly and permit easier adoption of newer and emerging technologies. DOD's software acquisition pathway instruction states that a key element of an acquisition strategy is a flexible and modular contracting strategy that enables software development teams to rapidly design, develop, test, integrate, deploy, and support software capabilities.[37] Although generally associated with the acquisition of IT

[33]GAO-23-105611. We also found that DOD had made progress in implementing, but had not fully implemented, software acquisition recommendations made by the Defense Innovation Board in 2019. These recommendations emphasized, among other things, speed and delivery time, hiring and retaining qualified staff, and focusing on continuous improvement throughout the software life cycle. Defense Innovation Board, *Software Is Never Done: Refactoring the Acquisition Code for Competitive Advantage* (May 3, 2019).

[34]For each increment, contracting officers are required to choose an appropriate contracting technique that facilitates the acquisition of subsequent increments. Pursuant to the Federal Acquisition Regulation, contracting officers are required to select the contract type and method appropriate to the circumstances (e.g., indefinite delivery, indefinite quantity contracts, single contract with options, successive contracts, multiple awards, task order contracts). Federal Acquisition Regulation (FAR) 39.103.

[35]GAO-24-105506.

[36]FAR 39.103. Modular contracting was established in title 41, section 2308 of the U.S. Code.

[37]DOD Instruction 5000.87.

systems or software, modular contracting practices can also be used for other types of acquisitions.

According to the Defense Acquisition University, a modular contracting strategy for one program is likely to look different from that of another program. The strategy should be tailored to the unique needs of the program to enable development of a collection of contracts with different objectives to meet different requirements that support the overall program objectives. The collection of contracts should be expected to change and evolve throughout the program life cycle, especially as scaling occurs and more development activities are added.

Software Acquisition Pathway

As discussed above, in January 2020, DOD introduced the software acquisition pathway as part of the AAF.[38] This pathway is governed by DOD Instruction 5000.87 and is intended to facilitate rapid and iterative delivery of software capability, including software-intensive systems, to users. The pathway involves the use of small cross-functional teams that include operational users, developmental and operational testers, software developers, and cybersecurity experts to deliver software rapidly and iteratively to meet highest priority user needs. It is intended to address recommendations made by the Defense Science Board to enable DOD to deploy software quickly and adopt continuous iterative development, among other things. As of November 2023, DOD was tracking 66 programs using the software acquisition pathway.

According to a 2020 DOD report to Congress, DOD's software acquisition pathway represents a significant component of modernizing the department's software development capabilities.[39] The pathway requires several features of modern software development, such as the use of modern software development methodologies, as well as early and frequent end user feedback. In addition, our previous work found DOD's software acquisition pathway aligned with key product development principles.[40] However, these requirements apply only to efforts using the software acquisition pathway, and not to programs using another AAF

[38]Prior to the publication of DOD Instruction 5000.87, the department had an interim policy in effect. Department of Defense, *Software Acquisition Pathway Interim Policy and Procedures* (Washington, D.C., Jan. 3, 2020).

[39]Department of Defense, *Report to Congress on Implementation of Defense Science Board Report Recommendations, "Design and Acquisition of Software for Defense Systems" Section 868 of the National Defense Authorization Act for Fiscal Year 2019 (P.L. 115-232)* (Apr. 16, 2020).

[40]GAO-22-104513.

pathway, even if those programs are software intensive. Further, DOD policy does not require programs to use the software acquisition pathway when they develop software.

Cybersecurity in DOD Weapon Programs

Cybersecurity for weapon systems has increasingly been recognized as a critical area in which DOD must improve. We have previously reported that cyberattacks can target any weapon system that is dependent on software, potentially leading to an inability to complete military missions or even loss of life.[41]

In November 2020, DOD issued DOD Instruction 5000.89, which establishes policy and procedures for test and evaluation across five of the six AAF pathways—including the MCA and MTA pathways—that addresses cybersecurity planning and execution.[42] In particular, the instruction requires all DOD acquisition programs and systems, regardless of acquisition pathway, to execute an iterative cybersecurity test and evaluation process detailed in the DOD *Cybersecurity Test and Evaluation Guidebook* throughout the program's life cycle, including for new increments of capability.[43] Table 4 outlines the DOD cybersecurity test and evaluation phases from the guidebook.

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

[42]Department of Defense, *Test and Evaluation*, DOD Instruction 5000.89 (Nov. 19, 2020). The sixth pathway, defense acquisition of services, does not require test and evaluation policy and procedures.

[43]Department of Defense, *Cybersecurity Test and Evaluation Guidebook 2.0, Change 1* (February 2020).

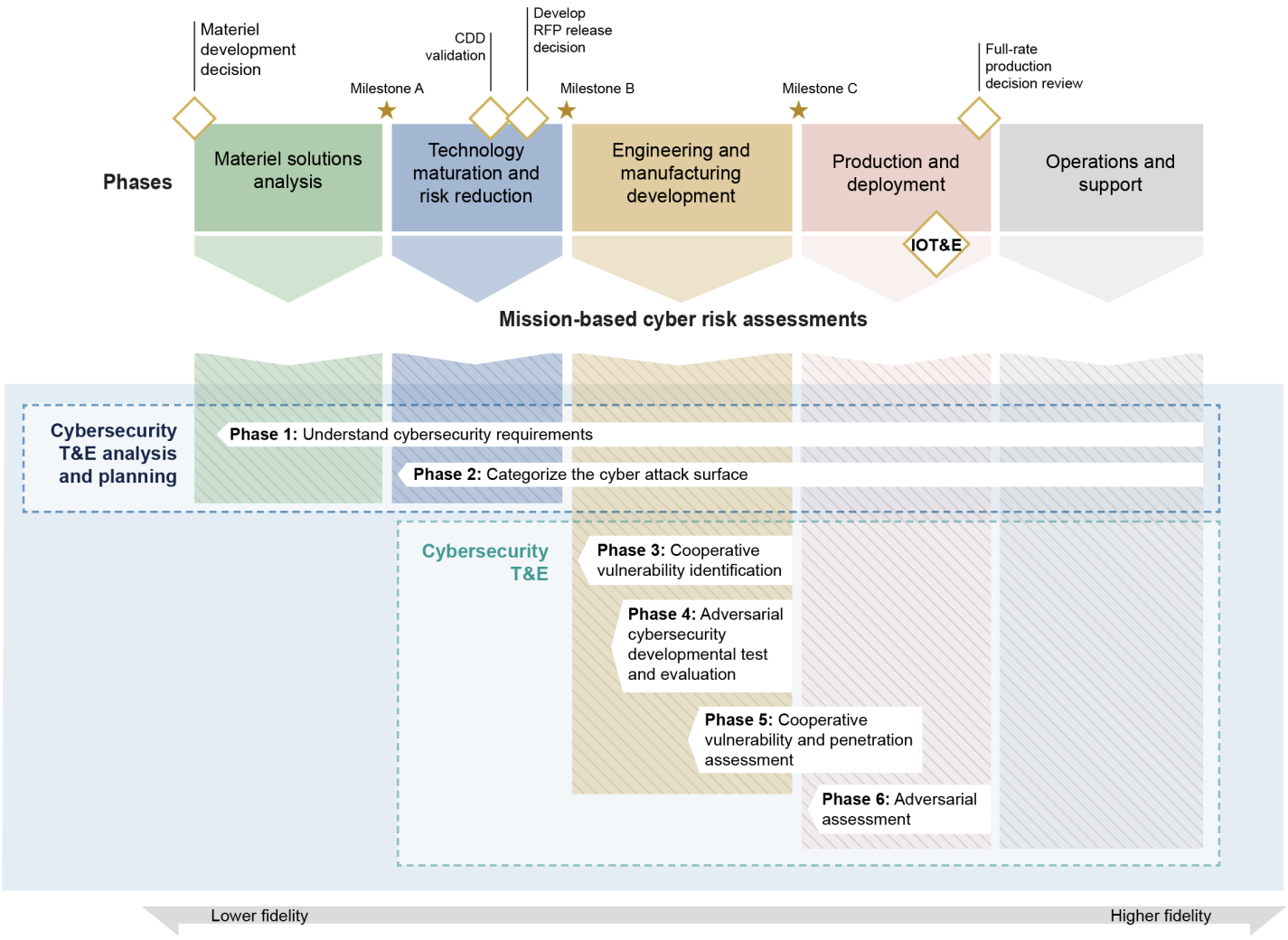
Table 4: Department of Defense Cybersecurity Test and Evaluation Phases

Cybersecurity test and evaluation phase	Description
Phase 1: Understand cybersecurity requirements	Examine cybersecurity, system cyber survivability, and other requirements for developing approaches and plans for conducting test and evaluation.
Phase 2: Characterize the attack surface	Identify vulnerabilities of attack an adversary may use and make plans to evaluate impacts to the mission. This may include a cyber tabletop exercise—an intellectually intensive exercise to introduce and explore potential threats.
Phase 3: Cooperative vulnerability identification	Conduct early cyber vulnerability tests to identify known cybersecurity vulnerabilities, assess the risks associated with those vulnerabilities, and determine appropriate mitigations.
Phase 4: Adversarial cybersecurity developmental test and evaluation	Conduct tests of a system's cyber survivability and operational resilience in a mission context, using realistic threat exploitation techniques, while in a representative operating environment.
Phase 5: Cooperative vulnerability and penetration assessment	Conduct tests during operational test and evaluation to assess the system's ability to execute critical missions and tasks in the expected operational environment.
Phase 6: Adversarial assessment	Conduct tests to characterize the operational effects on critical missions caused by threat-representative cyber activity against a unit training and equipped with a system as well as the effectiveness of the defensive capabilities.

Source: GAO analysis of Department of Defense Cybersecurity Test and Evaluation Guidebook. I GAO-24-106831

Early and regular discovery of system vulnerabilities makes it easier to fix them and reduces risk to the schedule. According to the DOD *Cybersecurity Test and Evaluation Guidebook*, late testing can make it much more difficult to fix due to lack of time and funding before fielding or deployment. Figure 4 provides an illustrative example of how DOD guidance applies to programs using the MCA pathway.

Figure 4: DOD Guidance for Cybersecurity Test and Evaluation Activities during the Acquisition Life Cycle for Programs Using the Major Capability Acquisition Pathway



CDD = Capabilities development document
IOT&E = Initial operational test and evaluation
RFP = Request for proposal
T&E = Test and evaluation

Source: GAO analysis of Department of Defense (DOD) Cybersecurity Test and Evaluation Guidebook. I GAO-24-106831

Additionally, DOD issued a policy on cybersecurity in December 2020, which establishes policy and procedures to manage cybersecurity risk.[44] The policy also highlights the need to incorporate cybersecurity into all aspects of the defense acquisition system and operations.

DOD guidance also generally states that MDAPs are to develop a cybersecurity strategy by milestone A (technology development start) and update the strategy at subsequent milestones.[45] The strategy is expected to detail the cybersecurity practices the program will use to address cybersecurity risks and reduce the likelihood of severe impacts from a cyberattack. DOD guidance for MTA programs requires components to develop processes, resulting in a test strategy or assessment of test results in the acquisition strategy. This test strategy or assessment of test results should document the evaluation of the demonstrated operational performance, to include validation of required cybersecurity.[46]

DOD Software Workforce

Many people in DOD's workforce are involved in the development and implementation of software, including those whom DOD relies on for expertise in acquiring software and those who deliver software to end users. For the purposes of this review, we refer to the software workforce, which DOD defined in a 2021 report to Congress.[47] According to DOD, the software workforce comprises two broad groups of professionals:

- **Software acquisition professionals.** DOD defines a software acquisition professional as any member of the DOD acquisition workforce who provides expertise in the procurement, management,

[44]Department of Defense, *Cybersecurity for Acquisition Decision Authorities and Program Managers*, DOD Instruction 5000.90 (Dec. 31, 2020).

[45]The Defense Acquisition University Adaptive Acquisition Framework Document Identification tool identifies statutory and regulatory program information requirements for programs using certain AAF pathways, including the MCA pathway, as referenced in DOD Instruction 5000.85. The information requirements include milestone and phase information requirements, statutory program breach definitions, recurring program reports, and other requirements. See https://www.dau.edu/aafdid.

[46]DOD Instruction 5000.80.

[47]Department of Defense, *Report to Congress on FY20 NDAA Section 862(b)(1)(B) Software Development and Software Acquisition Training and Management Programs* (January 2021). We found during our review that DOD sometimes uses "software workforce" synonymously with the term "software acquisition workforce." For example, officials from USD(A&S) generally agreed that the term "software acquisition workforce" encompasses the two categories of individuals used by DOD for the definition of "software workforce."

or development of software intensive processes and systems.[48] This category includes roles such as program managers, financial managers, contracting officers, and logisticians.

- **Software practitioners.** DOD defines software practitioners as personnel who implement software and deliver capability to users. This category includes roles such as software developers, software engineers, product managers, cloud architects, and user experience specialists. Software practitioners can exist outside of the acquisition workforce.

According to DOD, an individual in the software workforce may fulfill multiple roles, in line with industry best practices within organizations that adopt modern software practices such as Agile and DevSecOps. For example, in our Agile Assessment Guide, we noted that team members on an Agile team should have cross-functional skills that allow them to be capable of performing all the work rather than a single specialty.[49]

USD(A&S) is primarily responsible for overseeing acquisition personnel within DOD. According to DOD Directive 5135.02, USD(A&S) is responsible for establishing policies on and supervising all elements of DOD related to acquisition, and for establishing policies and procedures for the effective management of DOD officials serving in acquisition positions. According to USD(A&S) officials, their office leads hiring, retention, and training initiatives for acquisition personnel. Training is offered to acquisition professionals through the Defense Acquisition University (DAU). Other offices within OSD and the military departments also perform specific duties related to the software workforce:

- The Office of the Under Secretary of Defense for Research and Engineering and the Office of the Chief Digital and Artificial Intelligence Officer have responsibilities related to defining and identifying the software workforce.
- The military departments play a role in hiring and retaining their acquisition personnel, as well as providing department-specific

[48]DOD's acquisition workforce is composed of multiple communities and roles. DOD initiated the "Back-to-Basics" for Defense Acquisition Workforce framework in February 2022 to reorganize 14 legacy career fields into six "functional areas," which include Business, Financial Management, and Cost Estimating; Contracting; Engineering and Technical Management; Life Cycle Logistics; Program Management; and Test and Evaluation. DOD does not specifically track software acquisition personnel and software practitioners working on acquisitions programs.

[49]GAO-24-105506.

training. Additionally, Directors for Acquisition Career Management and Acquisition Talent Management within the military departments provide acquisition career and training expertise for their departments.

DOD's 2021 report to Congress detailed the current state of the software acquisition workforce and its challenges.[50] Key findings from the report included the following:

- Acquisition professionals often have limited familiarity with modern software development practices. Further, existing software expertise is scattered throughout the workforce.
- Software expertise is not systematically identified, tracked, or developed within the department.[51]
- Ongoing challenges regarding hiring, training, and retaining professionals with software development and acquisition expertise add risk to achieving the department's goals.[52]

Our prior work also identified challenges with DOD's management of the software workforce. In April 2023, we found that DOD had yet to conduct strategic planning to ensure it has the needed skill sets to implement planned software modernization efforts across the department.[53] We reported that, in part, this lack of planning was because DOD had yet to identify the makeup of its software workforce. We recommended that, once DOD identifies the makeup of its workforce, it should use the results to develop a strategic workforce plan for the software workforce. DOD

[50]Section 862 of the National Defense Authorization Act for Fiscal Year 2020 directed the Secretary of Defense, acting through USD(A&S) and in consultation with certain other officials, to establish software development and software acquisition training and management programs for all software acquisition professionals, software developers, and other appropriate individuals, to earn a certification in software development and software acquisition. This provision also directed the Secretary of Defense to report to the congressional defense committees on the status of implementing these training and management programs. See National Defense Authorization Act for Fiscal Year 2020, Pub. L. No. 116–92, § 862 (2019).

[51]In 2020, RAND reported that DOD lacks a workforce model that properly supports a software acquisition workforce, such as an official software career field or a system for identifying or tracking software professionals in the department. See RAND Corporation, *Software Acquisition Workforce Initiative for the Department of Defense* (Santa Monica, Calif.: 2020).

[52]Department of Defense, *Report to Congress on FY20 NDAA Section 862(b)(1)(B) Software Development and Software Acquisition Training and Management Programs* (Jan. 2021).

[53]GAO-23-105611.

stated it would develop the recommended plan but has yet to do so as of February 2024.

Congress has also enacted legislation relevant to the software workforce. For example, the NDAA for Fiscal Year 2022 directed DOD to establish a software cadre to improve the effectiveness of DOD's software development, acquisition, and sustainment programs or activities.[54] The statute directed USD(A&S) to ensure that the cadre has the appropriate number of experts and to develop a career path for the cadre.

[54]Specifically, the NDAA for Fiscal Year 2022 directed the Secretary of Defense, acting through USD(A&S), to establish a cadre of personnel who are experts in software development, acquisition, and sustainment to improve the effectiveness of DOD's software development, acquisition and sustainment programs or activities. See National Defense Authorization Act for Fiscal Year 2022, Pub. L. No. 117–81. § 836 (2021), For the purposes of this report, we refer to this cadre as the software cadre.

MH-139A Grey Wolf Helicopter (MH-139A)

Source: U.S. Air Force. | GAO-24-106831

OVERVIEW

DOD Weapon Portfolio for 2024

DOD plans to spend more than $2 trillion to develop and acquire its costliest weapon programs.

The weapon systems portfolio we assessed is larger than last year both in cost and number of programs. It consists of 76 MDAPs, 20 MTA programs, and 12 future major weapon acquisitions not currently on an AAF pathway (see table 5). This is an increase of one MDAP, one MTA program, and five future efforts from last year. Our reporting does not include total life-cycle sustainment costs or classified programs, which constitute a substantial portion of military department spending.

Table 5: Department of Defense Planned Acquisition Investments in Selected Weapon Programs GAO Reviewed (fiscal year 2024 dollars in billions)

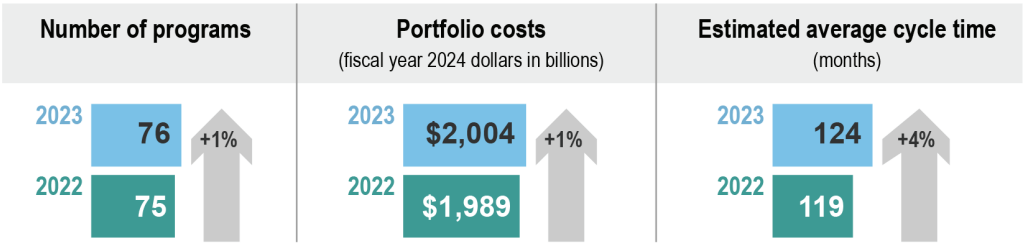
Type of program	Number of programs reviewed	Total planned investment	Air Force	Army	Navy and Marine Corps	Space Force	Joint DOD
Major defense acquisition programs	76	$2,004.5	15	15	36	7	3
Middle tier of acquisition programs	20	$36.0	3	7	2	8	0
Future major weapon acquisitions	12	$55.5	0	4	7	1	0
Total	**108**	**$2,096.0**	**18**	**26**	**45**	**16**	**3**

Source: GAO analysis of Department of Defense (DOD) data. | GAO-24-106831

Note: Planned middle tier of acquisition investment amounts reflect the current costs reported by those programs, many of which are planning follow-on efforts that are not included in these costs. Similarly, the planned investment amounts for future major weapon acquisitions reflect current costs reported by those programs, which may not include the costs of later development and procurement efforts.

Figure 5 highlights 1-year changes in DOD's MDAP portfolio. Three programs—**B-52 Commercial Engine Replacement Program**, **Next Generation Overhead Persistent Infrared Space Polar**, and **Next Generation Overhead Persistent Infrared Geosynchronous Earth Orbit Satellites**—recently transitioned to the MCA pathway and have yet to provide official cost estimates. As such, the full cost of the MDAP portfolio is likely substantially higher. Further, the planned time for programs to deliver initial capability to the warfighter increased, continuing a trend we have reported on in prior years. There are various factors driving these schedule slips, which we explore in more detail later in the report. We also found that, for programs that have delivered initial capability, the average amount of time it took to do so increased from nearly 8 years to 11 years—an average increase of 3 years—from their original planned date.

Figure 5: Key Metrics from DOD's 2023 Major Defense Acquisition Program Reporting Compared to DOD's 2022 Reporting



Source: GAO analysis of Department of Defense (DOD) data. | GAO-24-106831

Note: Portfolio costs do not include costs for three programs—B-52 Commercial Engine Replacement Program, Next Generation Overhead Persistent Infrared Space Polar, and Next Generation Overhead Persistent Infrared Geosynchronous Earth Orbit Satellites—that recently transitioned to the major capability acquisition pathway and have yet to provide official cost estimates. The estimated average planned cycle time includes data only for programs that have yet to achieve initial operational capability.

DOD MDAP Portfolio

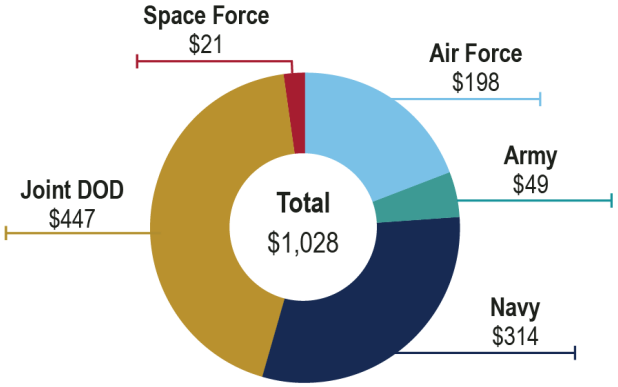
OVERVIEW OF COST CHANGES

Subset of MDAP costs declined slightly since last year due to quantity decreases and changed inflation assumptions.

We conducted in-depth analysis on the 34 MDAPs for which we produced 2-page assessments in this report. Combined total planned investment for these programs was $1.028 trillion (see figs. 6 and 7 for breakdowns by military service and commodity). These programs represent a subset of the 76 MDAPs that comprise DOD's MDAP portfolio. The 34 programs are generally in development or early stages of production.[1]

Sixteen programs reported a cost decrease this year, while 14 programs reported an increase. One program reported no change. Of the 14 programs that reported an increase, two were due to increased quantities. Increases for the remaining 12 programs were the result of development issues, obsolescence, and production issues, among other factors.

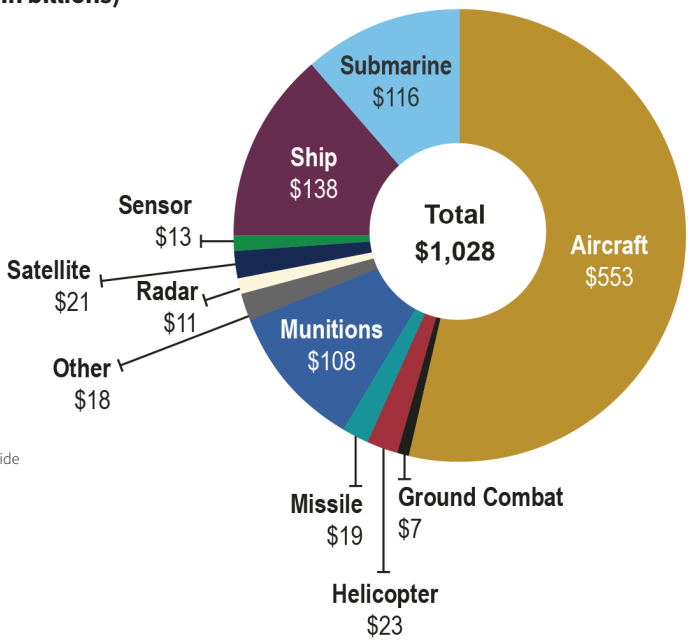
Figure 6: Estimated Cost by Military Service of 31 Current Major Defense Acquisition Programs GAO Assessed (fiscal year 2024 dollars in billions)



Source: GAO analysis of Department of Defense (DOD) data. | GAO-24-106831

Note: Two Space Force satellite programs and one Air Force aircraft program assessed by GAO have yet to provide official cost estimates and are not included in this figure.

Figure 7: Estimated Cost by Commodity for 31 Major Defense Acquisition Programs GAO Assessed (fiscal year 2024 dollars in billions)



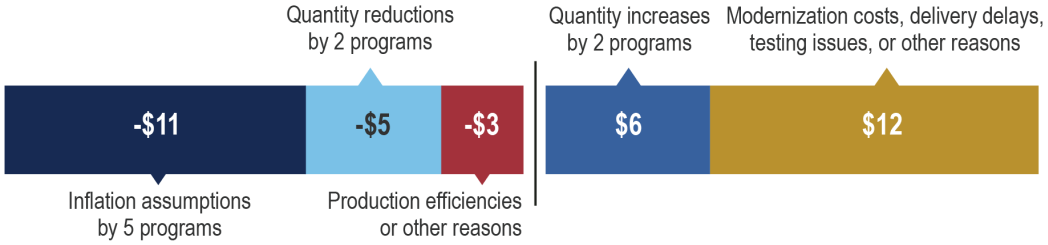
Source: GAO analysis of Department of Defense (DOD) data. | GAO-24-106831

Note: Two Space Force satellite programs and one Air Force aircraft program assessed by GAO have yet to provide official cost estimates and are not included in this figure.

Combined total cost estimates decreased slightly by $1.7 billion—0.17 percent—in the past year for the 31 MDAPs that we also assessed last year. This decrease was the result of several factors (see fig. 8), including reductions in quantities and out of date inflation assumptions in program cost estimates.

In addition to the cost changes outlined here, the Air Force reported a Nunn-McCurdy breach to Congress after the **LGM-35A Sentinel** program experienced acquisition unit cost growth of at least 37 percent. Sentinel program costs are as of July 2023 and do not reflect this breach as its costs are under review as the program undergoes a re-baselining. As a result, DOD's current cost estimates do not fully reflect expected 1-year cost changes across the portfolio.

Figure 8: Factors Contributing to 1-Year Cost Changes across 31 Major Defense Acquisition Programs Assessed by GAO (fiscal year 2024 dollars in billions)



Source: GAO analysis of Department of Defense (DOD) data. | GAO-24-106831

Note: Subdivisions of cost changes do not sum to the total due to rounding.

[1]GAO assessed 34 MDAPs but cost information is available for only 31 of those programs. Three new MDAPs have have yet to provide official cost estimates.

DOD MDAP Portfolio

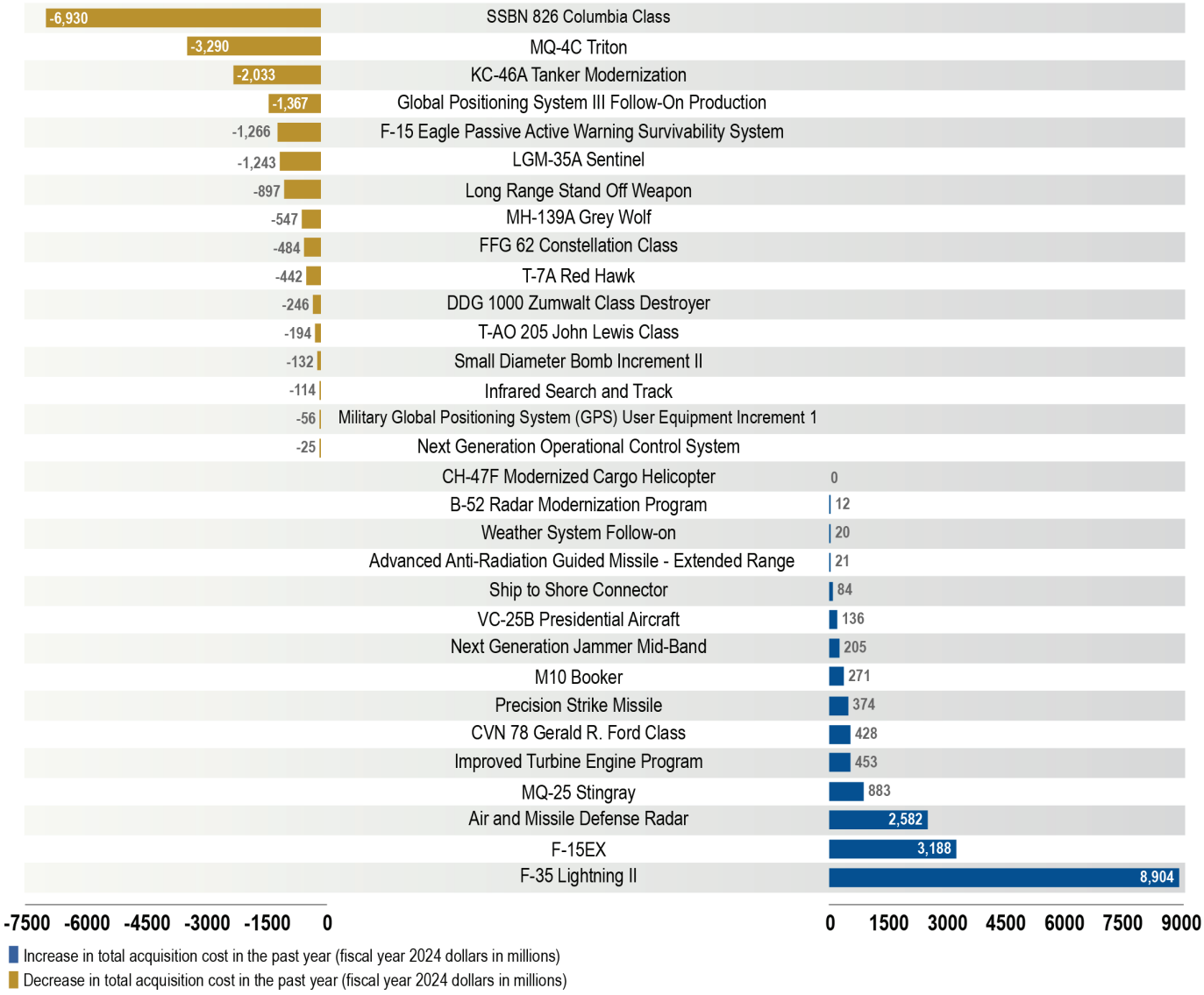
COST

Nearly half of MDAPs reported cost increases.

Nearly half of MDAPs that were also included in last year's report—14 of 31—reported cost increases. These increases totaled more than $17.5 billion. This total increase was offset, however, by 16 programs that reported cost decreases, which totaled slightly more than $19 billion. Outdated Iinflation assumptions for two programs that had among the largest reported cost decreases since last year likely mask the true cost of the MDAP portfolio.

Figure 9 details 1-year cost changes by program.

Figure 9: 1-Year Reported Cost Changes in Major Defense Acquisition Programs GAO Reviewed (fiscal year 2024 dollars in millions)



Source: GAO analysis of Department of Defense data. | GAO-24-106831

Note: Program costs for LGM-35A Sentinel are under review following a Nunn-McCurdy breach reported to Congress in January 2024, which is not reflected in the figure above.

Factors Driving the Largest Cost Changes Not Related to Quantity since Our Prior Report

Continued changes to the way the **Navy's *Columbia* Class ballistic missile submarine's (SSBN 826)** total cost is calculated complicated tracking the program's cost performance. The program stated that calculations to account for inflation assumptions resulted in a reported decrease of almost $7 billion. This is despite our analysis showing consistently lower than expected cost performance for the program from January 2022 to May 2023. The Navy planned to revise the cost estimate to better reflect the effects of inflation and program performance, which may result in the Navy needing to request more funding than currently planned to complete construction.

Outdated inflation assumptions were also responsible for the cost decrease reported by the **Air Force's KC-46A Tanker Modernization** program. Even though the Air Force plans to procure four additional aircraft in fiscal year 2027, and costs increased due to boom redesign and retrofitting aircraft, the program's inflation assumptions resulted in the program's reported cost estimate decreasing by 4 percent—$2 billion—since our previous review.

DOD's F-35 Lightning II's (F-35) total cost grew an additional $8.9 billion since last year, in part due to increasing modernization costs and rising procurement costs driven by delayed aircraft deliveries.

DOD MDAP Portfolio

SCHEDULE PERFORMANCE

Schedule delays persist for more than half of selected MDAPs.

FFG 62 *Constellation* Class Frigate (FFG 62)
Source: Fincantieri Marinette Marine (FMM). | GAO-24-106831

Factors Contributing to the Two Largest Delays to Initial Operational Capability since Our 2023 Report

21 months: Improved Turbine Engine Program (Army). Delays in the contractor receiving parts from suppliers delayed flight testing. Further, the program reported that staffing issues with critical manufacturing positions have led to production delays.

15 months: Ship to Shore Connector Amphibious Craft (Navy). Ongoing delays to developmental testing forced further delays to achieving initial operational capability.

Examples of Factors Contributing to Delays of Unknown Duration since Our 2023 Report

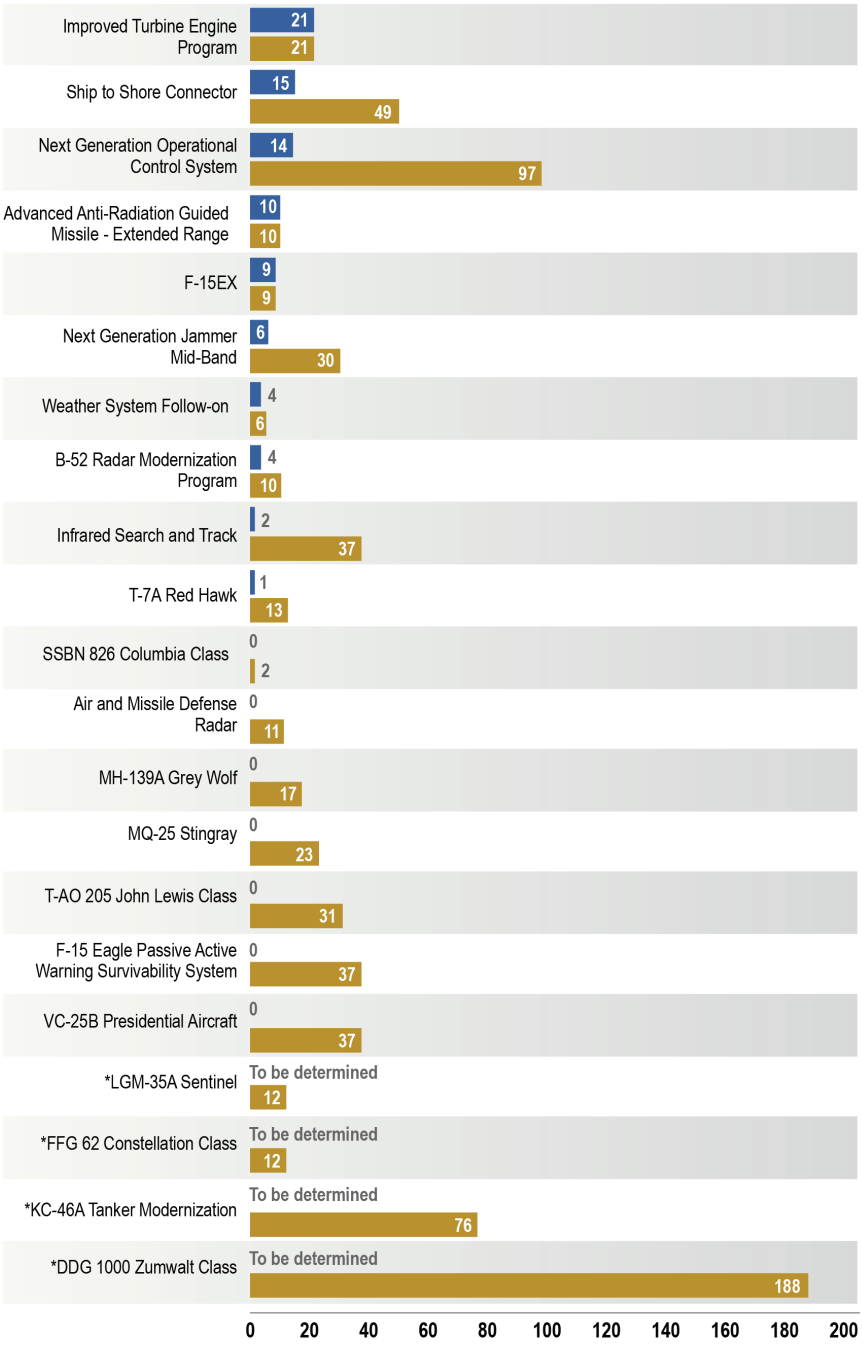
The Air Force's **KC-46A Tanker Modernization Program** has further delayed planned initial capability due to issues with delivering wing aerial refueling pods. The program, which was already 76 months delayed, plans to complete a schedule assessment to establish a new date.

As a result of ongoing delays, the Navy's **FFG 62 *Constellation* Class Frigate** program reported the shipbuilder will not meet its planned lead ship delivery date. The Navy will not confirm a date for initial capability until it completes an ongoing schedule assessment.

The Navy's **DDG 1000 *Zumwalt* Class Destroyer** program has further delayed planned initial capability due to delays in completing the acceptance trial for the lead ship. The program stated that its planned date for initial capability is under review.

MDAPs continue to experience delays to planned initial operational capability dates. Of the 25 programs we assessed that have yet to declare initial operational capability, more than half—15 of 25—experienced schedule delays in the past year. Figure 10 shows the length of delay for programs that have provided estimates for when they plan to deliver initial capability. Three of these programs delayed plans to deliver initial capability by 12 months or more. These schedule slips were due to test delays and production issues. The schedules for 10 programs remained stable over the past year. However, several of these programs have previously experienced delays, including five programs with delays of 12 months or more.

Figure 10: Programs Reporting Cumulative or 1-Year Delays to Planned Initial Operational Capability (months)



Source: GAO analysis of Department of Defense (DOD) data. | GAO-24-106831

Note: Three programs—the Air Force's KC-46A program and the Navy's FFG 62 and DDG 1000 programs—which reported delays last year, continue to delay their initial capability since our last review but told us they have yet to establish new dates. The Air Force's Sentinel program declared a schedule breach and its schedule is under review. In addition, since 2022, the Army's CH-47F Block II program has reported that its initial capability date is to be determined. Finally, three programs—the Army's M10 Booker and PrSM programs and the Air Force's LRSO program—have not reported any delays.

DOD MTA Portfolio

SCHEDULE

Programs continue to report delays to a key event intended to demonstrate capability.

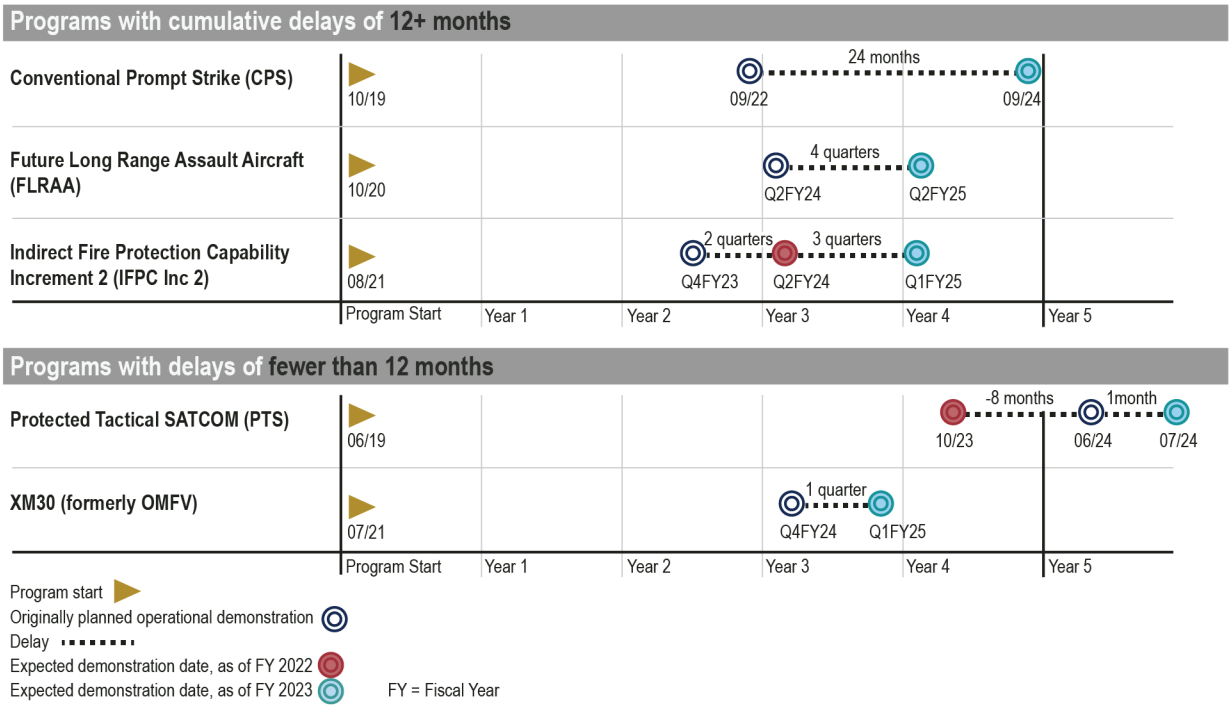
Programs continue to report delays to planned operational demonstration, a key event to demonstrate capability. Of the 12 rapid prototyping efforts included in both our current and 2023 assessments:

- one program—the Army's **Indirect Fire Protection Capability Increment 2 (IFPC Inc 2)**—previously reported a delay and reported further delays in the past year,
- one program—the Army's **XM30**—reported a delay in the past year but had not previously reported a delay, and
- two programs—the Army's **Future Long Range Assault Aircraft (FLRAA)** and the Navy's **Conventional Prompt Strike (CPS)**—previously reported a delay but reported no further delays in the past year.

In addition, one program—the **Space Force's Protected Tactical SATCOM (PTS)** program—reported plans in August 2022 to expedite their operational demonstration. In the past year, however, it reported delaying this event until July 2024, one month after it was originally planned, and 9 months later than reported in 2022 (see fig. 11).

Beyond the MTA efforts, programs plan to take significant additional time to deliver actual capability. We found that rapid prototyping MTA programs that transition to the MCA pathway at development start plan to take an average of 5 additional years before providing initial capability, for a planned total of 10 years from MTA initiation.

Figure 11: Delays to Planned Operational Demonstrations for Selected Middle Tier of Acquisition (MTA) Rapid Protoyping Programs



Source: GAO analysis of Department of Defense (DOD) data. | GAO-24-106831

Note: According to DOD Instruction 5000.80, MTA efforts may not exceed 5 years after the start date without a waiver from the Defense Acquisition Executive. The program start date for MTA programs designated on or after December 30, 2019, is generally the date an acquisition decision memorandum was signed initiating an MTA rapid prototyping or rapid fielding program. MTA programs designated before December 30, 2019, generally maintain their MTA program start date as the date funds were first obligated. The Army's FLRAA program plans to transition to the major capability acquisition pathway at development start in fiscal year 2024, approximately 4 years after beginning its MTA effort.

The Army's Indirect Fire Protection Increment 2 (IFPC Inc 2) Further Delayed Operational Demonstration

Since our last assessment, the Army's **IFPC Inc 2** program further delayed its operational demonstration to align its schedule with the Army's air and missile defense fire control system. We previously reported the program planned to conduct operational tests with whichever version of the fire control system was available at the time of the tests. The program initiated with an ambitious timeline, with an initial goal to hold operational demonstration approximately 2 years after the program's initiation. IFPC Inc 2 now plans to conduct this demonstration more than 3 years after the program's initiation; however, this is still within the 5-year time frame established by DOD policy for MTA efforts.

DOD MTA Portfolio

TECHNOLOGY DEVELOPMENT

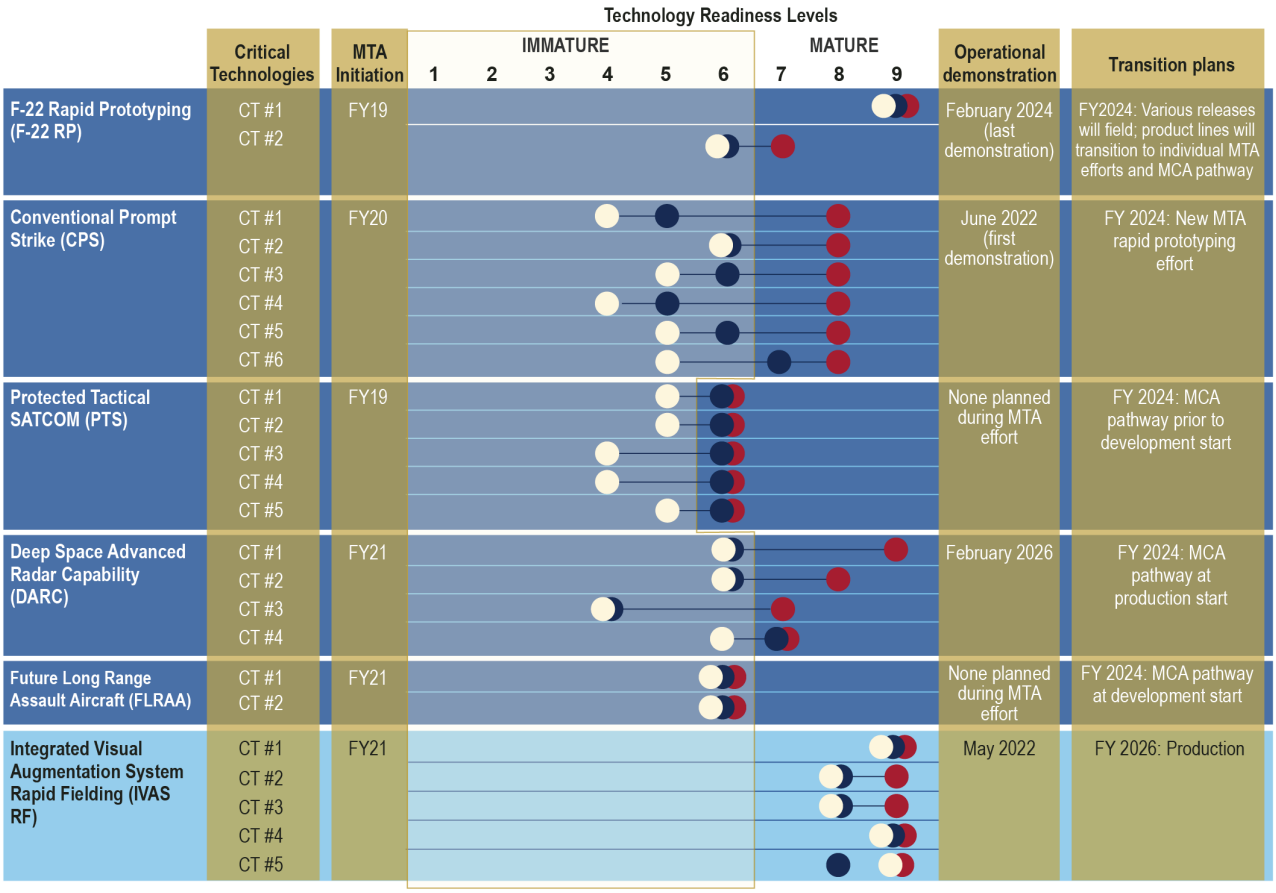
Several MTA programs' capabilities require substantial work to reach maturity.

MTA programs reported varying progress maturing critical technologies since our last assessment. Six of the 13 MTA programs that were also included in last year's review had previously identified critical technologies and provide a basis on which to compare progress made in maturing those technologies. These programs reported plans to mature their critical technologies before the end of their current MTA effort. However, some programs have significant work—defined as making two or more levels of progress on multiple critical technologies to reach their TRL goals—and limited time to do so.

Our prior work has shown that increasing even one TRL can take multiple years and becomes more challenging as the technology approaches maturity. MTA programs transitioning with immature technologies may risk additional costly and time-intensive redesign work for the overall effort. See appendix VI for additional information on TRLs.

The Navy's **Conventional Prompt Strike (CPS)** program plans to conclude its MTA effort in fiscal year 2024 but made limited progress in the last year maturing its five critical technologies. The Space Force's **Protected Tactical SATCOM (PTS)** program and the Army's **Future Long Range Assault Aircraft (FLRAA)** program do not plan to complete operational demonstrations prior to transitioning from the MTA effort. Figure 12 summarizes MTA programs' current and planned technology readiness levels, as compared with our 2023 report.

Figure 12: Selected MTA Programs' Progress in Maturing Critical Technologies



Source: GAO analysis of Department of Defense (DOD) data. | GAO-24-106831

Note: Technologies are generally considered mature at a technology readiness level 7, except for satellite programs, which are generally considered mature at a TRL 6.

Several MTA programs not included in our prior assessment also plan to significantly mature critical technologies as a part of their MTA effort. The Air Force's **Hypersonic Attack Cruise Missile (HACM)** program and the Army's **M-SHORAD Inc 3** program each reported technologies with current readiness levels as low as 4—corresponding with component validation in a laboratory environment. Both programs plan to fully mature their technologies to TRL 7 or 8 before transitioning to the MCA pathway in fiscal year 2028. In addition, the Space Force's **MGUE Increment 2** program identified a critical technology this year. The program plans to mature its critical technology from a TRL 5 to a TRL 8 before transitioning production-ready receiver card capability for the departments to procure through separate efforts in early fiscal year 2026. We will continue to monitor these programs' efforts to mature critical technologies.

DOD MTA Portfolio

COST

DOD plans to invest at least $35 billion in 20 of its largest MTA programs.

For the 13 MTA programs we reviewed in both this year and last year's assessments, estimated combined costs decreased by more than 8 percent ($2.1 billion) from last year's assessment. However, most of this decrease—$1.5 billion—was due to quantity decreases for the Army's **Integrated Visual Augmentation System Rapid Fielding (IVAS RF)** program. Similar to prior years, MTA programs reported inconsistent cost data—complicating DOD's efforts to maintain oversight of MTA programs' costs.

Combined cost estimates totaled more than $35.7 billion for the 20 MTA programs we reviewed (see fig. 13). This amount includes costs only for the programs' 5-year MTA efforts and does not include any further investments DOD may make to develop or acquire a capability after the MTA effort concludes, which as we have previously reported, can require substantial costs.

Factors Driving Selected Estimated Cost Changes Since Our Last Assessment

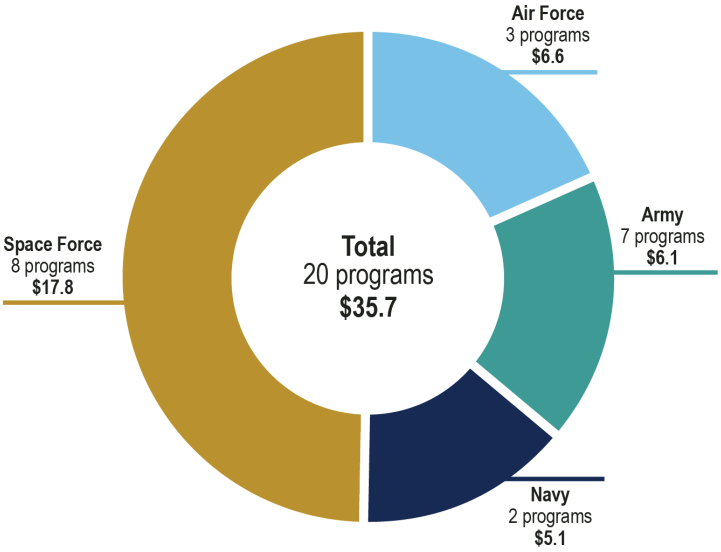
The Space Force's **MGUE Increment 2** program reported a $310 million (27 percent) cost increase over our prior assessment, in which it reported a 14 percent decrease. Program officials attributed this variation to budget constraints at the time of the fiscal year 2023 budget request.

The Space Force's **Protected Tactical SATCOM (PTS)** program reported a cost increase of $111 million (12 percent) over what it reported for our prior assessment. Program officials attributed this to the program's errors last year in allocating costs between the end of the MTA effort and the planned transition to the major capability acquisition pathway in fiscal year 2024.

The Army's **IVAS RF** program reported a $1.5 billion (50 percent) decrease in its MTA costs, as the program plans to procure 75 percent fewer units due to receiving less funding in fiscal year 2023 than planned (from about 55,000 to 13,500 units). However, the program also reported increases in unit costs compared to our last assessment, which could result in higher costs across the program's lifecycle.

The Space Force's **Future Operationally Resilient Ground Evolution (FORGE)** program reported a $232 million decrease from what it reported for our prior assessment. Program officials attributed the decrease to revised software costs and an improved understanding of contracts.

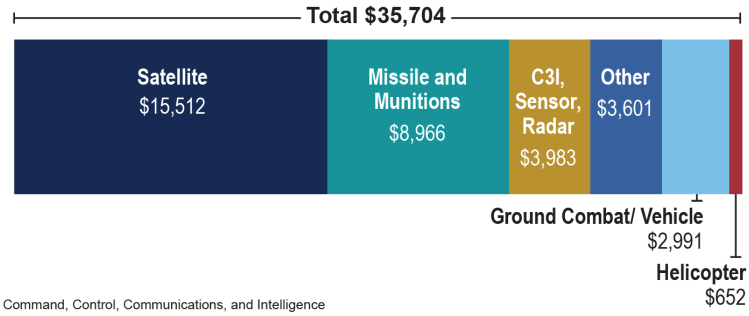
Figure 13: Estimated Cost of 20 Current Middle Tier of Acquisition Efforts GAO Reviewed (fiscal year 2024 dollars in billions)



Source: GAO analysis of Department of Defense data. | GAO-24-106831

Space Force MTA programs account for about half of all MTA costs. Six of the Space Force's eight MTA programs are satellite programs, and these programs account for 43 percent of all MTA costs (see fig. 14).

Figure 14: Estimated Costs of Current Middle Tier of Acquisition Efforts GAO Reviewed by Commodity (fiscal year 2024 dollars in millions)



C3I = Command, Control, Communications, and Intelligence
Source: GAO analysis of Department of Defense (DOD) data. | GAO-24-106831

DOD MTA Portfolio

TRANSITION PLANS

Thirteen MTA programs plan to transition in fiscal years 2024 or 2025.

Over half (13 of 20) of the MTA programs we reviewed plan to transition to a follow-on effort in fiscal years 2024 or 2025, as shown in figure 15. Five programs plan to transition prior to or at development start and may require significant additional work and investment before reaching production. As stated earlier, the average expected time between program start and initial operational capability for MDAPs in DOD's portfolio is estimated to be more than 10 years. If starting as an MTA does not shorten that duration, these programs could take more than 15 years to deliver capability, given work remaining to mature technologies and the potential impact of delayed operational tests. We will continue to monitor these transitions in our future assessments to provide insight on the effects of the MTA pathway on the overall timeliness of capability delivery.

Figure 15: Expected Transition Date for Selected Middle Tier of Acquisition Programs GAO Reviewed

Source: GAO analysis of Department of Defense data. | GAO-24-106831

Note: "New MTA effort" indicates the program is transitioning to a new MTA rapid prototyping or rapid fielding effort after the end of the current MTA effort. "Other outcome" indicates the program plans to take a combination of outcomes listed in our questionnaire or an outcome not included in our questionnaire. The F-22 Rapid Prototyping effort plans to transition most selected capabilities as individual programs to different pathways. The PTS program plans to transition to the MCA pathway at technology development—a pre-system development phase for program definition and risk-reduction activities. The CPS program plans to transition the rapid prototyping hypersonic missile system effort to the rapid fielding pathway to be onboard the DDG 1000 *Zumwalt* Class, followed by a transition to the major capability acquisition pathway at production start to mature the system and field onboard SSN 74 *Virginia* Class submarines. MGUE Increment 2 is developing receiver cards that the individual military services will then procure and field. The Air Force plans to transition the HACM rapid fielding effort to the major capability acquisition pathway at either development start or production start in 2027, depending on what capabilities the Air Force is willing to accept and whether production facilities are ready. One additional program we reviewed plans to transition in fiscal year 2025 but we did not list it in this figure due to sensitivity concerns.

Future Major Weapon Acquisitions

EFFORTS OUTSIDE OF AAF PATHWAYS

DOD continues to inconsistently track efforts not currently on AAF pathways.

We assessed 12 future major weapon acquisitions—which include certain efforts not currently using an AAF pathway. These included:

- six efforts that plan to use the major capability acquisition pathway,
- four efforts that plan to use other pathways, and
- two programs that have completed their MTA efforts but have yet to complete their planned transitions to the MCA pathway.

DOD plans to invest at least $55.5 billion in the 12 efforts we reviewed. These efforts are intended to provide a range of capability needs for the warfighter—from conducting forward-based resupply and repair operations for deployed submarines to providing enhanced capabilities for reconnaissance, attack, and aerial security. Figure 16 highlights plans for two future major weapon acquisitions we reviewed.

Figure 16: Examples of Future Major Weapon Acquisitions GAO Reviewed (fiscal year 2024 dollars in billions)

Source: U.S. Space Force. | GAO-24-106831

Resilient Missile Warning (MW)/Missile Tracking (MT) Medium Earth Orbit (MEO) - Epoch 1

Military service: Space Force

Estimated cost: $3.606 (represents fiscal years 2021 to 2030)

Current quantity: 9 (represents fiscal years 2021 to 2030)

Description: MTC Epoch 1 is a new effort by the Space Force that intends to provide missile warning, tracking, and defense data to legacy and future missile warning and tracking space systems.

Current acquisition approach: Epoch 1 is the first of at least three planned satellite Epochs and is focused on delivering the latest Overhead Persistent Infrared sensing into medium Earth orbit.

Adaptive Acquisition Framework transition plan: DOD is expected to approve MTC Epoch 1 for initiation on the middle tier of acquisition rapid prototyping path by the end of the second quarter of fiscal year 2024.

Source: U.S. Navy. | GAO-24-106831

E-6B Recapitalization (E-XX)

Military service: Navy

Estimated cost: $4.090 (represents fiscal years 2023 to 2029)

Current quantity: 31

Description: E-XX is intended to augment and eventually replace aging E-6B aircraft performing airborne nuclear command, control, and communications between the U.S. National Command Authority and U.S. strategic forces.

Current acquisition approach: Plans to award a development contract in November 2024 for the integration of mission systems into C-130J-30 aircraft.

Adaptive Acquisition Framework transition plan: The program plans to transition to the major capability acquisition pathway at development start in the fourth quarter of fiscal year 2024.

Source: GAO analysis of Department of Defense data. | GAO-24-106831

Although DOD has taken steps to improve its acquisition reporting, it continues to lack a consistent approach to tracking efforts planning to use a pathway in the AAF.[1] Many of DOD's future efforts are not tracked until they start on an AAF pathway, meaning DOD lacks insight into costly programs planning until they are formally initiated. This lack of tracking occurs even though the military departments plan to expend significant resources and may plan to deliver operational capability before formal initiation on a pathway. We will continue to monitor these efforts.

[1]GAO, *Defense Acquisitions: Additional Actions Needed to Implement Proposed Improvements to Congressional Reporting*, GAO-22-104687 (Washington, D.C.: Feb. 28, 2022). We recommended that USD(A&S) fully implement leading reform practices in the areas of leadership focus, attention, and managing and monitoring reforms while developing the reporting system to replace Selected Acquisition Report requirements.

Leading Practices for Product Development

USE OF LEADING PRACTICES

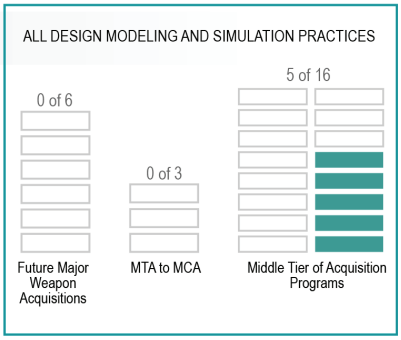
Programs report iterative approaches but lack related practices to fully realize benefits.

Most future major weapon acquisitions (6 of 10), programs using or planning to use the MCA pathway that began on the MTA pathway (3 of 7), and MTA programs (16 of 20) reported using an iterative development approach. However, we found that these programs do not plan to fully implement related product development practices. As discussed earlier in this report, our recent work found that leading companies use these practices in concert to design, validate, and deliver complex cyber-physical products—co-engineered networks of hardware and software—with speed (see fig. 17).[1]

Figure 17: Programs that Report Following an Iterative Approach to Development Plans to Implement Leading Practices Throughout Product Development

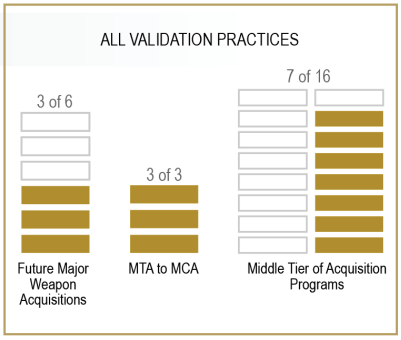
DESIGN MODELING AND SIMULATION: *Ensures design meets essential user needs*

- Refine the minimum set of capabilities to be included in the final minimum viable product (MVP) design based on user feedback
- Incorporate architecture that supports software updates that modify hardware functionality in future iterations
- Formalize a user agreement to ensure collaboration with and incorporation of feedback from users during design modeling and simulation
- Allow for updating requirements to reflect changes in user needs, operational environment, threats, or understanding of the system

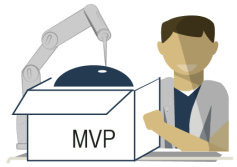


VALIDATION: *Verifies the MVP*

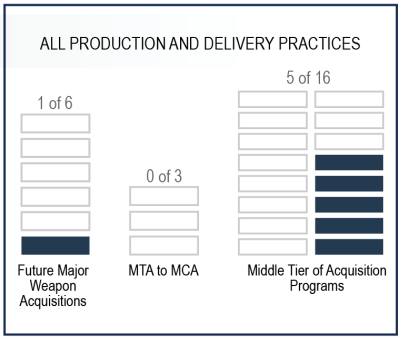
- Conduct integrated, system-level prototype testing with users and stakeholders in a digital environment, physical environment, or both
- Incorporate feedback from users during validation testing
- With schedules as a key driver, evaluate the most critical functions and off-ramp (to include subsequent iterations) product capabilities that are not essential and could delay the delivery of the MVP
- Prepare MVP for production, recognizing that additional functionality can be added through software updates later



PRODUCTION AND DELIVERY: *Identifies efficiencies and prepares for next iteration*



- Use digital models to maximize efficient production processes to prepare for subsequent design iterations
- Formalize a user agreement to ensure collaboration with and incorporation of feedback from users after deployment of the MVP
- Collect feedback from users on the MVP and incorporate the feedback into development plans for the next iteration or a new system



Source: GAO analysis of programs' questionnaire responses, GAO (illustrations). | GAO-24-106831

Note: The Middle Tier of Acquisition to Major Capability Acquisition (MTA to MCA) number includes two programs—ERCA and LTAMDS—that have completed their MTA efforts but have yet to transition to the MCA pathway as planned. In total, six of 10 future efforts, three of seven MTA to MCA programs, and 16 of 20 MTA programs reported taking an iterative approach to development. One MTA to MCA program—the Army's M10 Booker program—initially reported not using an iterative approach to development and, as a result, is not included in this analysis. However, after our cutoff date for new information, the program subsequently reported using an iterative approach to update prototype design following developmental testing.

[1]GAO, *Leading Practices: Iterative Cycles Enable Rapid Delivery of Complex, Innovative Products*, GAO-23-106222 (Washington, D.C.: July 27, 2023).

Leading Practices for Product Development

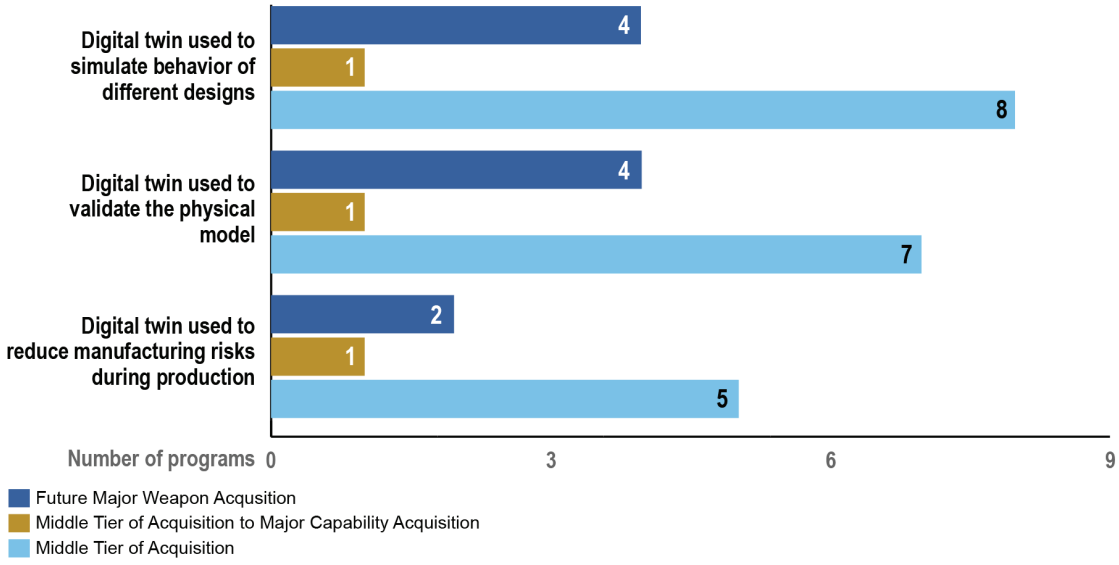
DIGITAL ENGINEERING

Digital twins enable speed in iterative development, but few programs are using them.

Digital engineering models are a key component of iterative development. Digital twins, in particular, enable iterative cycles of design, development, and production. Programs reported using or planning to use digital twins during iterative cycles of development (see fig. 18). However, just 2 of 6 future major acquisitions, 1 of 3 programs using or planning to use the MCA pathway that began on the MTA pathway, and 5 of 16 MTA programs that reported using an iterative approach to development are using or plan to use digital twins throughout all cycles of development.

As discussed earlier in this report, digital twins are different from 3D digital modeling, which is a static visualization of a physical object—meaning it cannot be updated without manually inputting new data. In contrast, digital twins are virtual representations of physical products; the model incorporates automated updates as new information becomes available. Digital twins enable real-time collaboration and informed decisions throughout a product's lifespan and allow for informed decision-making with stakeholders and users to deliver products with speed.

Figure 18: Programs' Reported Use of Digital Twins



Source: GAO analysis of programs' questionnaire responses. | GAO-24-106831

Note: The Middle Tier of Acquisition (MTA) to Major Capability Acquisition (MCA) number includes two programs—ERCA and LTAMDS—that have completed their MTA efforts but have yet to transition to the MCA pathway as planned. In total, six of 10 future efforts, three of seven MTA to MCA programs, and 16 of 20 MTA programs reported taking an iterative approach to development. One MTA to MCA program—the Army's M10 Booker program—initially reported not using an iterative approach to development and, as a result, is not included in this analysis. However, after our cutoff date for new information, the program subsequently reported using an iterative approach to update prototype design following developmental testing.

According to program officials, the Army's **Future Long Range Assault Aircraft (FLRAA)** program plans to develop a digital twin that will evolve from one that represents the system in development to eventually support production and sustainment, consistent with leading practices. The program plans to use data from digital modeling, sensors, and simulations to develop the digital twin.

Source: Bell Textron, Inc. | GAO-24-106831

One future effort—the Navy's **Submarine Tender Recapitalization Program (AS(X))**—reported plans to use 3D modeling to help stakeholders review designs and provide feedback, and to inform production models and ship assembly, rather than using digital twins. The Military Sealift Command intends to develop digital twins for novel or high-risk ship designs but does not consider the AS(X) design to meet this condition.

Source: CACI. | GAO-24-106831

Leading Practices for Product Development

FUTURE MAJOR WEAPON ACQUISITIONS

More than half of future major weapon acquisitions have started to use some leading practices.

Six of the 10 future major weapon acquisitions we assessed reported taking an iterative approach to development.[1] Several of these future acquisitions reported implementing or planning to implement some leading practices for product development. These efforts are early enough in development that there are opportunities to further implement leading practices before they begin a pathway, such as the MTA or MCA pathway. By implementing leading practices, these efforts could take advantage of the full benefits the practices provide.

Program officials responsible for future major weapon acquisitions identified potential challenges to employing leading practices for product development. For example, officials cited possible issues with balancing and prioritizing requirements and delays with software integration, among other things. These programs are early in their life cycles; it is too soon to know whether these challenges will be realized. We will continue to monitor these programs to better understand their progress in identifying challenges and efficiencies from implementing leading practices for product development.

Several efforts have begun implementing some practices, including those in figure 19.

Figure 19: Examples of Future Major Weapon Acquisitions' Use or Planned Use of Leading Product Development Practices

Source: U.S. Space Force. | GAO-24-106831

Resilient Missile Warning (MW)/Missile Tracking (MT) Medium Earth Orbit (MEO) - Epoch 1

Military service: Space Force

Planned pathway: Middle tier of acquisition

Use of leading practices: Epoch 1 is the first of at least three planned satellite Epochs. Each successive Epoch will have a key capability to deliver to the user based on user-defined requirements. Program officials stated they regularly engage the user community to define and implement program requirements, such as data types and tasking procedures. The program reported it uses modeling and simulation and continued interaction with warfighter groups to present capabilities to stakeholders.

Although the program is using a model-based systems engineering tool for digital design of its payloads and platforms, program officials acknowledged challenges with leveraging the tool to gain efficiencies.

Source: Alion Science and Technology. | GAO-24-106831

MK 54 MOD 2 Advanced Lightweight Torpedo (ALWT)

Military service: Navy

Planned pathway: Major capability acquisition

Use of leading practices: The Navy's MK 54 MOD 2 program is developing an advanced lightweight torpedo for use by U.S. surface ships, fixed-wing aircraft, and helicopters in anti-submarine warfare. Program officials reported they are employing several leading practices for product development. For example, according to program officials the Navy deferred the high altitude and vertical launch capabilities for the program to deliver a minimum viable product faster. The program also reported it is using a modular open systems approach and an architecture that supports software updates for its torpedo programs.

Program officials stated they are using digital modeling to help develop the MK 54 MOD 2 physical prototype; however, they acknowledged that the lack of accreditation for the virtual prototype limits how the program can use it.

Source: GAO analysis of Department of Defense data. | GAO-24-106831.

[1]We did not evaluate as future major weapon acquisitions the two programs that have completed their MTA efforts but have yet to complete their planned transitions to the MCA pathway. Instead, these programs, for this analysis, were included in the MTA to MCA group of programs.

Leading Practices for Product Development

MIDDLE TIER OF ACQUISITION

Most MTA programs report taking an iterative approach to development, but few are fully implementing leading practices.

Sixteen of the 20 MTA programs and three of the seven MTA to MCA programs we assessed reported taking an iterative approach to development. However, none of the MTA to MCA programs and only two MTA programs reported using all of the leading practices that support the iterative approach. As discussed elsewhere in this report, we found that leading companies use these practices to deliver a minimum viable product (MVP) and then further develop those capabilities in subsequent iterations. The MVP represents the initial set of capabilities suitable to be fielded to an operational environment. Without planning to implement these practices throughout design, validation, and delivery, programs will miss opportunities to deliver capability with speed and enable the program for further innovation.

MTA programs reported challenges to employing leading practices. These include complications in ensuring open, adaptable, and secure digital engineering tools; and difficulty ensuring user and stakeholder involvement, among other things.

Several MTA programs have begun implementing some practices, including those in figure 20.

Figure 20: Examples of Middle Tier of Acquisitions' Use or Planned Use of Leading Product Development Practices

Source: Lockheed Martin with edits from U.S. Army RCCTO. | GAO-24-106831

Mid-Range Capability (MRC)

Military service: Army

Transition plan: Middle tier of acquisition rapid fielding

Use of leading practices: The MRC system is an offensive, ground-based weapon system. Each MRC battery consists of an operations center, missiles, missile launcher, and support vehicle. The MTA effort is expected to leverage and build upon the battery 1 prototype through technology insertion points for batteries 2 through 4. Program officials stated that these insertion points will add improvements that are driven, in part, by soldier feedback. Program officials also expect MRC to conduct joint flight tests—up to two per year—with the Navy to prove out new technology insertions that require firing a missile from MRC.

Program officials stated the MRC weapon system is also utilizing modularity using a shared architecture for Navy-developed canisters that enable the firing of multiple missile types. To make adjustments to accommodate the unique requirements of the MRC, which requires transport of the canisters with munitions loaded, the program changed cabling locations, missile orientation within the canister, and software.

Source: Boeing Defense, Mobility, Bombers and Surveillance. | GAO-24-106831

E-7A Rapid Prototyping (E-7A RP)

Military service: Air Force

Transition plan: Major capability acquisition pathway at production start

Use of leading practices: The E-7A program intends to modify an existing aircraft design while developing and integrating advanced detection, tracking, identification, and targeting capabilities. The program has a systems user embedded with the development team to provide continuous feedback and is integrating users and maintainers into the development process to ensure maintainability.

Program officials said that the program's iterative approach will be directed more at software development than modifying the aircraft design. Officials stated that one of their primary goals for software development is to re-architect existing mission systems software to better support future upgrades and new capabilities—such as new sensors—while also easing maintenance.

Source: U.S. Navy. | GAO-24-106831

Conventional Prompt Strike (CPS)

Military service: Navy

Transition plan: Middle tier of acquisition rapid fielding

Use of leading practices: The Navy's CPS program aims to develop an intermediate-range, hypersonic missile in phases. The program established a process to strategically prioritize capabilities through technology insertions every 2 years that are informed by factors such as technology maturity, affordability, and evolving user needs. This process is used to inform requirements for the current effort and subsequent phases.

Program officials stated that CPS has used a 3D model for the entire weapon. However, there have been challenges bringing the various subsystem models together to create a digital representation of the weapon system and with not having data from a successful end-to-end flight test to help anchor their models.

Source: GAO analysis of Department of Defense data. | GAO-24-106831.

Leading Practices for Product Development

MIDDLE TIER OF ACQUISITION

Most MTA programs' acquisition strategies do not identify delivering capability with speed.

We previously recommended that DOD fully implement key principles for product development in its high-level policies.[1] DOD concurred with our recommendations and is taking steps to implement them. For example, USD(A&S) officials told us their office is working to update DOD's MTA policy to address our leading principles. Our leading practices further identified having an iterative structure that enables delivering complex cyber-physical systems with speed. As discussed earlier in this report, the goal of an iterative approach is to develop an MVP—the initial set of capabilities suitable to be fielded in an operational environment—and further develop those capabilities in subsequent iterations.

B-52 Commercial Engine Replacement Program (B-52 CERP)
Source: U.S. Air Force. | GAO-24-106831

The MTA pathway seeks to accelerate capability maturation and provide capabilities within 5 years of an acquisition program's start date. As previously noted in this report, most MTA programs reported following an iterative approach to development. According to the Defense Acquisition University, acquisition strategies describe a program manager's plan to achieve program execution and programmatic goals across a program's entire life cycle, and provide a basis for more detailed planning. However, we found that most MTA acquisition strategies do not outline how programs plan to leverage leading practices to develop and deliver an initial fieldable capability—the goal of an iterative approach —within 5 years.

Current DOD MTA policy does not require MTA programs to incorporate leading practices in their acquisition strategies, and USD(A&S) officials told us that their office has not issued policy that calls for MTA programs to incorporate leading practices in their acquisition strategies. However, without identifying how programs using the MTA pathway plan to implement these leading practices in their acquisition strategies, programs will miss an opportunity to consider incorporating approaches that can help them develop and deliver capability quickly, as intended.

Some programs using the MTA pathway are experiencing challenges with completing rapid prototyping and rapid fielding activities within 5 years of the MTA program start date. Other programs plan to finish the 5-year MTA effort and complete additional development before providing fieldable capability to the warfighter, as discussed below.

Several programs plan significant additional development after the completion of their MTA effort before delivering initial fieldable capability. For example:

- Space Force's **Protected Tactical SATCOM (PTS)** program does not intend to demonstrate a prototype until after completing its 5-year MTA effort and transitioning to the MCA pathway prior to development start.
- The Army initiated the **XM30 Mechanized Infantry Combat Vehicle** program in 2018 to replace existing Bradley Infantry Fighting Vehicles but revised its acquisition plan in 2020 after experiencing difficulties with the desired capabilities and time frames. The Army plans to transition the program to the MCA pathway with entry at development start, at which point it expects to subsequently select one contractor for a low-rate production contract.
- The Air Force's **B-52 Commercial Engine Replacement Program (B-52 CERP**) delivered a virtual prototype in August 2023 before the program transitioned to the MCA pathway prior to development start, after which it plans to spend an additional 9 years developing and testing physical protypes. The program does not anticipate delivering initial capability until mid-fiscal year 2033, almost 15 years after its MTA initiation.

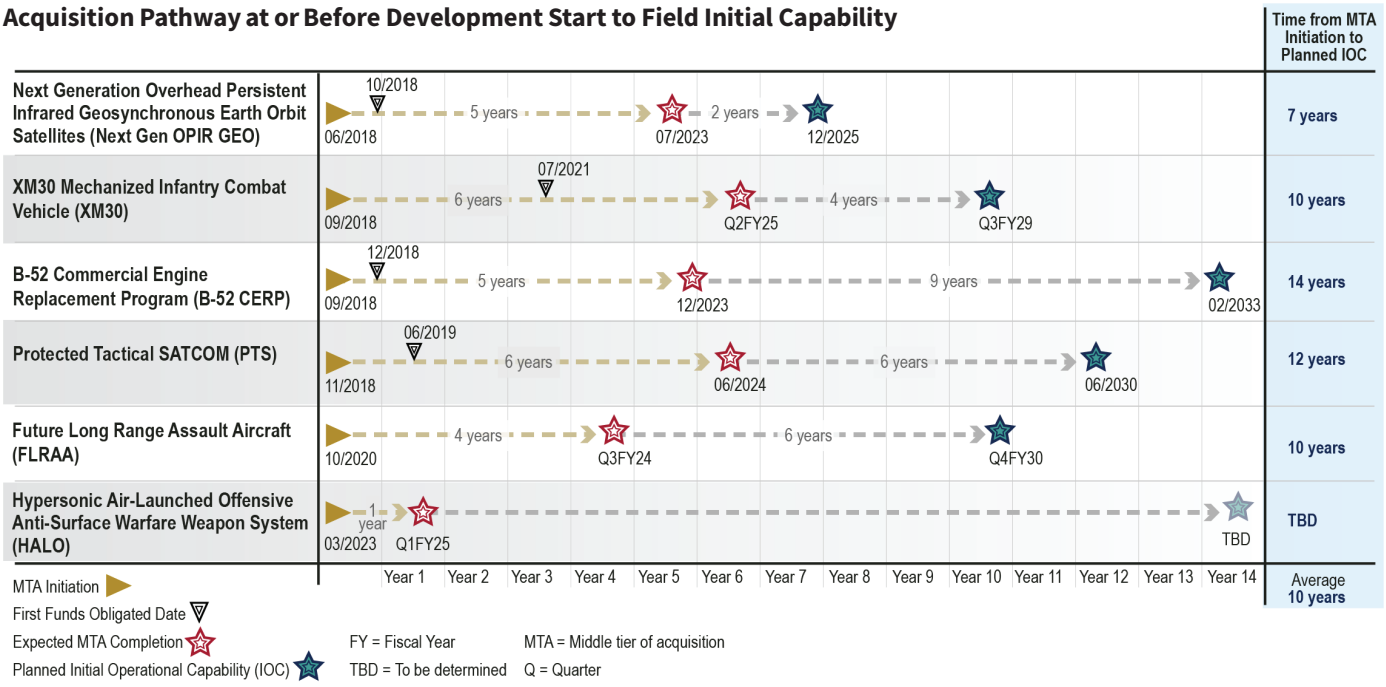
[1]GAO, *Leading Practices: Agency Acquisition Policies Could Better Implement Key Product Development Principles*, GAO-22-104513 (Washington, D.C.: Mar. 10, 2022).

MIDDLE TIER OF ACQUISITION

Middle tier of acquisition efforts are not delivering capability quickly.

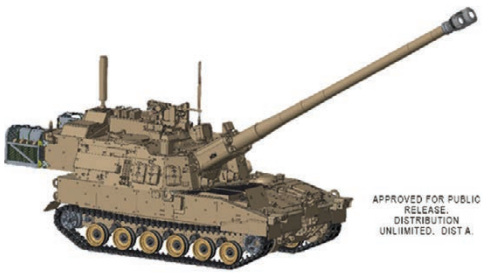
The MTA pathway offers certain flexibilities to the acquisition process. For example, programs using the pathway are not subject to the Joint Requirements Oversight Council's policies and procedures, and the pathway has tiered documentation and data reporting requirements. These flexibilities are meant to help the acquisition process deliver effective, secure, supportable, and affordable solutions in a timely manner. While some programs that plan to transition at development start may have shorter timeframes to reach initial capability, most MTA programs will continue to deliver capabilities in the form of linear development schedules, including plans that allot 5 years for rapid prototyping followed by another multi-year development effort (see fig. 21). Employing leading practices to deliver capability with speed provides programs with an opportunity to follow an iterative approach to development, enabling DOD to be more responsive to the warfighter's needs.

Figure 21: Time Required for Selected MTA Programs Transitioning to the Major Capability Acquisition Pathway at or Before Development Start to Field Initial Capability



Source: GAO analysis of Department of Defense (DOD) data. | GAO-24-106831

Note: According to DOD Instruction 5000.80, MTA efforts may not exceed 5 years after the start date without a waiver from the Defense Acquisition Executive. For this analysis, we calculated the time period from the MTA initiation date. The MTA initiation date is generally the date that the program was designated, which is the date that an acquisition decision memorandum was signed initiating an MTA rapid prototyping or rapid fielding program. According to DOD Instruction 5000.80, MTA programs designated before December 30, 2019, generally maintain their MTA program start date as the date funds were first obligated, which may differ from the MTA initiation date. This figure shows both the initiation and the first funds obligated dates for these programs. The program start date for MTA programs designated on or after December 30, 2019 is generally the same as the MTA initiation date.



Source: U.S. Army. | GAO-24-106831

The Army initiated the **Extended Range Cannon Artillery (ERCA)** program in September 2018. The program was one of the Army's top modernization efforts. The ERCA program was unable to transition to the major capability acquisition pathway at production start as planned within the 5-year MTA time frame due to technical challenges that forced the Army to pause development. Program officials stated that the 5-year window was too short to develop a system as innovative as ERCA.

The program's initial acquisition strategy, released in August 2019, did not identify the planned use of an iterative approach to development or the leading practices for product development associated with that approach. Given program officials' statements regarding the innovative nature of ERCA, an acquisition strategy that included leading practices to achieve speed in delivery could have provided additional direction for how the program planned to achieve its development goals during its MTA effort.

Program officials stated that the ERCA rapid prototyping effort has concluded and the program is exploring a range of options to deliver operational capabilities identified in an Army portfolio-level study of long-range precision fire systems.

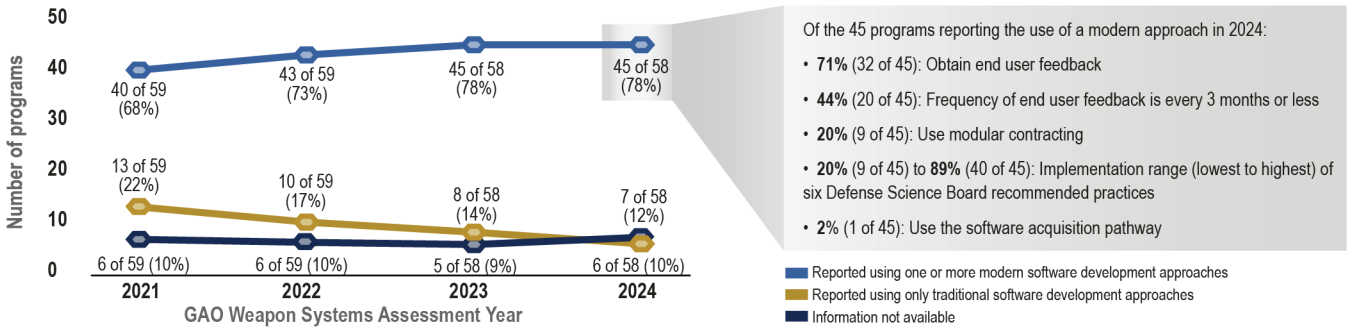
DOD Software Development

IMPLEMENTATION OF MODERN APPROACHES

More programs reported use of modern software development approaches, but programs have yet to effectively implement related practices.

Compared with our 2021 review, more weapon programs in this review reported the use of modern software development approaches while fewer programs reported using only traditional approaches (see fig. 22).[1] However, the 45 programs using a modern approach continued to lag in implementing several key aspects of those approaches that could enable them to deliver software more quickly and reduce risk, as compared to traditional approaches. Programs also reported limited use of modular contracting and use of the software acquisition pathway, approaches that have the potential to improve software development.

Figure 22: Number of Programs GAO Reviewed Reporting Use of Modern Software Development Approaches since 2021



Source: GAO analysis of programs' questionnaire responses. | GAO-24-106831

Note: We considered programs to be using a modern software development approach if they reported the use of Agile, DevOps, DevSecOps, or an iterative (other than Agile) approach. "Information not available" includes, among other responses, instances in which a program did not report a software development effort or had yet to start its software development effort.

Table 6: Implementation of 2018 Defense Science Board Recommended Practices by Programs GAO Reviewed That Reported Using a Modern Software Development Approach

Defense Science Board recommendations

Program implementation of three practices is less than 50 percent (see table 6). These practices are intended to help programs leverage commercial software development approaches to deploy software quickly.

	GAO Weapon Systems Assessment Year				
Recommended practice	**2021**	**2022**	**2023**	**2024**	**Change from 2023**
Creation of a software factory as a key source selection criterion	N/A[a] N/A	N/A N/A	11% 5 of 45	20% 9 of 45	Improved
Use of software factory	20% 8 of 40	26% 11 of 43	20% 9 of 45	38% 17 of 45	Improved
Delivery of minimum viable product, followed by next viable products	53% 21 of 40	58% 25 of 43	51% 23 of 45	62% 28 of 45	Improved
Continuous iterative development	80% 32 of 40	81% 35 of 43	89% 40 of 45	89% 40 of 45	Unchanged
Iterative development training for program manager(s) and staff	25% 10 of 40	33% 14 of 43	27% 12 of 45	44% 20 of 45	Improved
Software documentation provided to DOD at each production milestone	58% 23 of 40	65% 28 of 43	60% 27 of 45	76% 34 of 45	Improved

Source: GAO analysis of programs' questionnaire responses. | GAO-24-106831

[a]The questionnaires for our assessments in 2021 and 2022 did not ask programs about the "creation of a software factory as a key source selection criterion."

Software acquisition pathway

One program we reviewed—the **Army's XM30 Mechanized Infantry Combat Vehicle**—is using the software acquisition pathway for its software development and the MTA pathway for its hardware development. The limited use of the software acquisition pathway—and the lack of corresponding policies and guidance for programs using Agile on other AAF pathways—emphasizes the importance of our open recommendation for DOD to incorporate Agile principles into policy and guidance for all programs using Agile for software development.[2]

[1]Programs were considered to be using a modern software development approach if they reported the use of either Agile, DevOps, DevSecOps, or an iterative (other than Agile) approach.

[2]GAO, *Defense Software Acquisitions: Changes to Requirements, Oversight, and Tools Needed for Weapon Programs*, GAO-23-105867 (Washington, D.C: July 20, 2023).

DOD Cybersecurity

CYBERSECURITY ASSESSMENTS

Programs generally plan for cybersecurity but have yet to consistently execute timely cybersecurity testing.

The extent to which programs planned for cybersecurity has generally not changed since our last assessment. All programs we assessed this year reported having an approved cybersecurity strategy or planning to have one in the future. Further, a majority of programs included cybersecurity provisions in key requirements documents.

However, MDAPs and MTAs did not consistently complete or plan to complete key cybersecurity assessments before certain program events occurred, as recommended by DOD guidance.

Cybersecurity strategies

Consistent with our reviews since 2021, all 58 programs—38 MDAPs and 20 MTAs for which we produced 1- or 2-page assessments—reported either having an approved cybersecurity strategy or planning to have one in the future.

Cybersecurity requirements

Most programs—48 of 58 (83 percent)—reported that a key performance parameter, key system attribute, or MTA requirements document addressed cybersecurity.

Cybersecurity assessments—MDAPs

As discussed in our 2023 report, MDAPs did not consistently report the completion of cybersecurity assessments in line with DOD's *Cybersecurity Test and Evaluation Guidebook* (see table 7). Early and regular discovery of mission-impacting system vulnerabilities is used to make informed program decisions, makes it easier to fix vulnerabilities, and reduces risk to schedule. In 2023, we released a restricted report that includes recommendations related to early cybersecurity testing for MDAPs.[1]

Table 7: Number of Major Defense Acquisition Programs Completing Key Cybersecurity Assessments Before Applicable Program Event

		GAO Weapon Systems Assessment Year		
Cybersecurity assessment	Applicable program event	2023	2024	Change from 2023
Cooperative Vulnerability Identification	Start of production (Milestone C)	82% 9 of 11	73% 8 of 11	Declined
Adversarial Cybersecurity Developmental Test and Evaluation	Start of production (Milestone C)	25% 1 of 4	57% 4 of 7	Improved
Cooperative Vulnerability and Penetration Assessment	Initial operational test and evaluation	82% 9 of 11	67% 6 of 9	Declined
Adversarial Assessment	Full-rate production decision	100% 7 of 7	100% 5 of 5	Unchanged

Source: GAO analysis of programs' questionnaire responses. | GAO-24-106831

Note: Results shown are for programs that reported relevant dates for comparison. The analysis excludes program events that occurred before the Department of Defense originally published its *Cybersecurity Test and Evaluation Guidebook* on July 1, 2015.

Cybersecurity assessments—MTA programs

MTA rapid prototyping programs planning to transition to production on the major capability acquisition pathway or to a rapid fielding MTA did not consistently complete or plan to complete key cybersecurity assessments before planned transition dates, as recommended by DOD guidance (see table 8).[2] We will continue to evaluate MTA program progress and challenges in implementing cybersecurity test and evaluation guidance, among other topics, as part of our ongoing work reviewing weapon system cybersecurity.

Table 8: Number of Middle Tier of Acquisition Rapid Prototyping Programs Completing or Planning to Complete Key Cybersecurity Assessments Before Planned Transition Date

Transition plan	Recommended cybersecurity assessments to be completed before transition	Number of programs reported completing or planning to complete all recommended assessments before transition
To MDAP production start (Milestone C)	CVI, ACD	33% (1 of 3)
To MTA rapid fielding	CVI, ACD, CVPA, AA	0% (0 of 2)
To operations and sustainment	CVI, ACD, CVPA, AA	100% (2 of 2)

CVI: Cooperative Vulnerability Identification ACD: Adversarial Cybersecurity Developmental Test and Evaluation CVPA: Cooperative Vulnerability and Penetration Assessment AA: Adversarial Assessment
MDAP: Major defense acquisition program MTA: Middle tier of acquisition

Source: GAO analysis of programs' questionnaire responses. | GAO-24-106831

Note: Results shown are for programs that reported relevant dates for comparison.

[1]GAO, *Weapon Systems Cybersecurity: DOD Should Increase Testing during Development*, GAO-23-105654SU (Washington, D.C.: Sept. 26, 2023). We made three recommendations, which remain open as of March 2024.
[2]The one MTA rapid fielding program in our assessment did not provide sufficient information in its questionnaire to determine whether recommended assessments for rapid fielding programs had occurred or are planned to occur before the planned transition date and, therefore, we did not assess it.

Plans to Address Software Workforce Hiring and Retention Challenges in DOD Acquisition Programs Have Been Limited

Most Weapon Programs Reported Challenges Related to Hiring and Retaining the Software Workforce

DOD has recognized that it cannot deliver quality software capabilities without a skilled workforce. But most weapon programs reported experiencing challenges related to hiring or retaining the software workforce. The ability to deliver quality software capabilities is critical, since DOD is increasingly investing in cyber-physical systems—co-engineered networks of both hardware and software, such as aircraft and uncrewed vehicles—to achieve the capabilities it needs.

Thirty-four out of the 53 MDAP and MTA programs with software development efforts also reported experiencing at least one challenge related to hiring and retaining software staff in the program office.[55] Twenty-eight of those 34 programs reported two or more challenges concurrently. Programs most frequently reported that finding staff with the required expertise was a challenge for their software workforce (see fig. 23).

[55]In a report to the congressional defense committees, DOD defined the software workforce as consisting of both software acquisition professionals and software practitioners. Software acquisition professionals may include roles such as program managers, financial managers, contracting officers, and logisticians. Software practitioners may include roles such as software developers, software engineers, product managers, cloud architects, and user experience specialists. See Department of Defense, *Report to Congress on FY20 NDAA Section 862(b)(1)(B) Software Development and Software Acquisition Training and Management Programs*, (January 2021). For questions specific to the software workforce, we reviewed responses from 53 programs—35 MDAPs and 18 MTA programs. We asked these questions of all 58 MDAPs and MTA programs that we sent questionnaires to for this report, but excluded data from five of these programs for this section because they reported not having significant software development efforts.

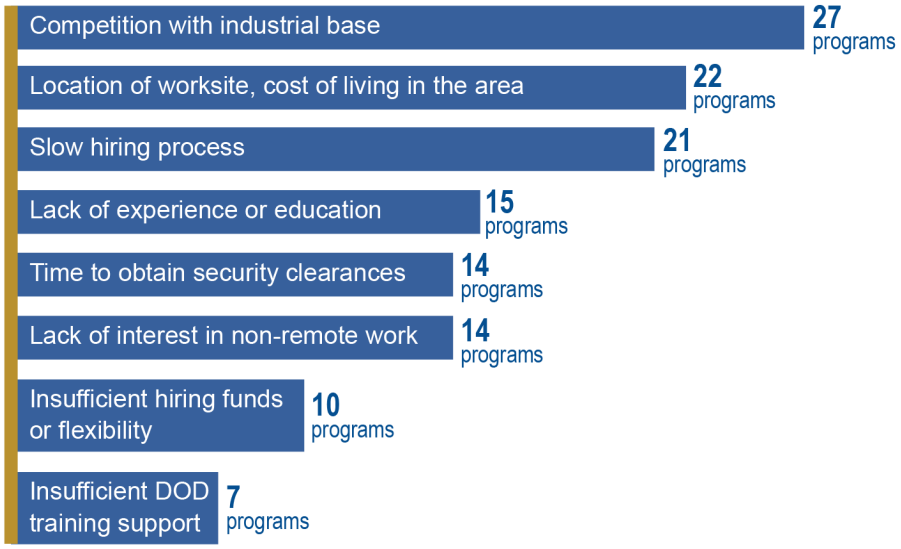
Figure 23: Software Workforce Hiring and Retention Challenges, as Reported by 53 Department of Defense Weapon Programs

Source: GAO analysis of programs' questionnaire responses. | GAO-24-106831

Note: Programs could select more than one response.

Additionally, weapon programs identified contributing factors to hiring and retention challenges. The most frequently reported factor was competition with the industrial base (see fig. 24).

Figure 24: Factors Contributing to Software Workforce Hiring and Retention Challenges, as Reported by 53 Department of Defense Weapon Programs

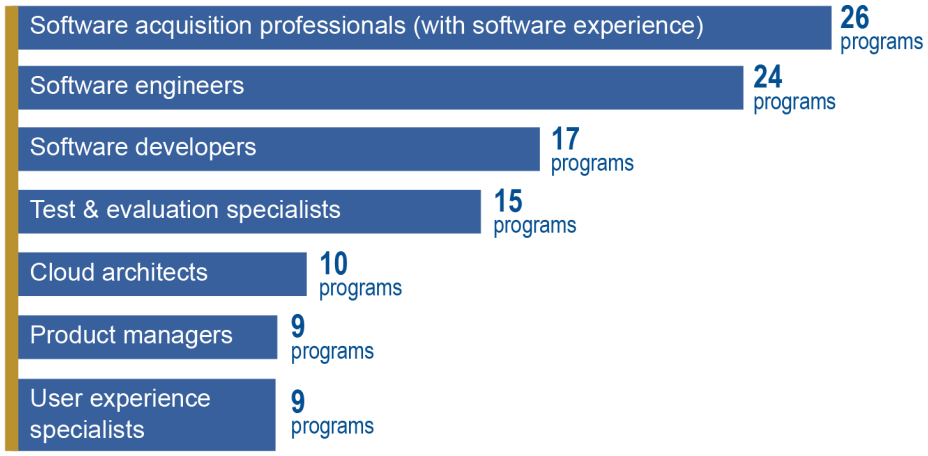


Source: GAO analysis of programs' questionnaire responses. | GAO-24-106831

Note: Programs could select more than one response.

Programs also identified the most difficult areas of expertise for hiring, with the most frequently cited being software acquisition professionals (with software experience), as shown in figure 25.

Figure 25: Areas of Expertise in the Software Workforce Most Difficult to Hire, as Reported by 53 Department of Defense Weapon Programs



Source: GAO analysis of programs' questionnaire responses. | GAO-24-106831

Note: Programs could select more than one response.

Selected Program Responses About a Lack of Software Experience in DOD's Software Workforce

"In terms of software oversight, the government has no specialized people to do that. As a development environment, nobody in government has that expertise and the program relies on contractor support."

"Software engineers are in high demand which results in high turnover. Not having sufficient expertise and software engineers results in schedule impacts to the program."

Source: GAO analysis of programs' questionnaire responses. | GAO-24-106831

Software acquisition professionals play a key role in overseeing contractor software development efforts. Thirty-eight out of the 53 programs reported that their software development efforts were led by contractors, heightening the importance of software acquisition professionals with software experience to provide the necessary oversight. The Office of the USD(A&S) reported to Congress in January 2021 that existing civilian and military software experience is scattered through DOD's workforce and not systematically identified, tracked, and developed.[56] Programs also emphasized in written responses to our questionnaire that there is a general lack of software expertise in the software workforce.

USD(A&S) officials told us that they hear similar challenges regarding the software workforce through their interactions with program offices, such as when consulting with programs interested in using the software acquisition pathway. In its January 2021 report to Congress, USD(A&S)

[56]Department of Defense, *Report to Congress on FY20 NDAA Section 862(b)(1)(B) Software Development and Software Acquisition Training and Management Programs*, (January 2021). According to DOD Directive 5135.02, USD(A&S) is responsible for establishing policies on and supervising all elements of DOD related to acquisition, and for establishing policies and procedures for the effective management of DOD officials serving in acquisition positions.

stated that there are few career paths and minimal room for job growth available to software acquisition professionals within DOD. As a result, DOD struggles to attract new talent or take advantage of existing talent.

DOD Has Yet to Effectively Plan to Expand a Congressionally Directed Software Cadre

DOD has taken steps to establish a congressionally mandated software cadre, in part to help alleviate challenges with the software workforce, but it lacks specific plans on how to expand the cadre. As discussed earlier in this report, the NDAA for Fiscal Year 2022 directed DOD to establish a software cadre to improve the effectiveness of DOD's software development, acquisition, and sustainment programs or activities.[57] The statute directed USD(A&S) to ensure that the cadre has the appropriate number of experts and to develop a career path for the cadre, including development opportunities, exchanges, talent management programs, and training.

According to USD(A&S) officials, DOD is still in the early stages of implementing the cadre, which it established in January 2023. USD(A&S) officials added that their office had already been performing activities in support of the legislation, such as educating the workforce and department leadership on modern practices for software acquisition. As of March 2024, the cadre consisted of one federal employee with limited assistance from Federally Funded Research and Development Center employees, according to USD(A&S) officials.[58] USD(A&S) officials referred to the current composition of the cadre as a minimum viable product and noted that it is not the desired end state.[59]

[57]National Defense Authorization Act for Fiscal Year 2022, Pub. L. No. 117–81 § 836 (2021).

[58]According to USD(A&S) officials, the software cadre is supported by three staff years of technical effort from Federally Funded Research and Development Center employees. Staff years of technical effort is a measure of available resources approximately equal to the work of one employee for 1 year.

[59]GAO-23-106222.

GAO Leading Practices that Support Evidence-Based Policymaking

Define Goals

Goals communicate the results that an organization seeks to achieve. Goals cover both long-term outcomes and near-term results. To ensure progress can be assessed, each long-term outcome is broken down into one or more performance goals, which have quantitative targets and time frames against which performance can be measured.

Identify Strategies and Resources

After a federal organization has identified its goals, it identifies how it plans to achieve them. This involves strategies along with related resources. Strategies are planned actions to achieve each goal, while resources are required items for each strategy to help achieve its goals.

Assess the Environment

Factors within and outside an organization, such as statutory requirements and organizational culture, can affect its ability to achieve its goals. Our past work has found that successful organizations monitor their internal and external environments continually and systematically.

Source: GAO. | GAO-24-106831

USD(A&S) officials told us they intend to expand the number of personnel in the cadre to have a greater capacity to help more programs. They added that, as a starting point for this expansion, they have submitted a request to USD(A&S) leadership for funding for two additional personnel as part of the fiscal year 2025 budget request. They noted that longer-term, they would like to assemble a well-rounded team comprised of staff with expertise in contracting, test and evaluation, cost estimation, and cybersecurity requirements. They stated that there is currently no specific timeline for expanding the cadre, as they are waiting for funding for additional positions.

Although USD(A&S) officials told us they are awaiting funding for additional positions, DOD's planning for the cadre does not provide a clear path toward successfully achieving this expansion and thus meeting the goals of the cadre. According to prior GAO work on evidence-based policymaking, organizations can have a clearer picture of how they will achieve their goals when they (1) define specific goals with measurable results; (2) identify strategies and resources needed to meet those goals; and (3) assess factors that may affect achievement of those goals.[60] USD(A&S) officials defined a long-term goal of meeting more demand for the cadre's services and a short-term goal of continuing to help programs use best practices and lessons learned for software acquisition. However, DOD has yet to determine other key aspects of how it would operationalize an expanded software cadre. For example:

- **Defining goals.** Although planning documentation indicates the cadre's high-level goals, USD(A&S) has yet to establish specific outcomes or near-term performance goals. Further, the cadre's high-level goals do not contain performance goals such as quantitative targets or time frames. These types of goals could better position DOD to assess the performance of the cadre in supporting weapon systems programs on software acquisition and sustainment.
- **Identifying strategies and resources.** While USD(A&S) officials told us that more staff with a variety of expertise would help the cadre's efforts, DOD has yet to create a formal strategy with specific actions to achieve its goals. Additionally, it has yet to define what specific resources it needs to meet the goals of the cadre, such as identifying the appropriate number of staff with specific skill sets needed to implement the cadre's goals.

[60]GAO, *Evidence-Based Policymaking: Practices to Help Manage and Assess the Results of Federal Efforts*, GAO-23-105460 (Washington, D.C.: July 12, 2023).

- **Assessing the environment.** USD(A&S) officials told us that the success of the cadre could be affected by factors such as the availability of resources and the awareness of the cadre among acquisition programs. However, DOD's planning documentation does not include an assessment of how these or other internal or external factors, such as organizational culture, could affect the cadre's ability to achieve its goals, and how it could mitigate potential challenges. The documentation also does not address how DOD would monitor these types of factors in the future.

Officials told us that they had yet to determine the specifics of how the cadre would be expanded because they were waiting for additional funding. However, until DOD undertakes more detailed planning, it will not be well positioned to effectively leverage any additional funding to expand the cadre and improve the effectiveness of software development, acquisition, and sustainment within DOD acquisition programs.

DOD's Other Efforts to Address Software Workforce Challenges Are Also in Early Stages

USD(A&S) and other offices within OSD have initiated additional efforts beyond the software cadre to address challenges with the software workforce, although it is too soon to measure the extent to which these efforts will succeed.

- **New curricula for software acquisition.** DOD has begun work on addressing a statutory requirement related to software acquisition training. Section 835 of the James M. Inhofe NDAA for Fiscal Year 2023 directed the President of the Defense Acquisition University to supplement existing training curricula related to software acquisitions and cybersecurity software or hardware acquisitions.[61] It further directed the Secretary of Defense to submit to Congress a comprehensive plan to implement the supplemental curricula, including a comparison with similar existing training curricula, among other items. The Secretary of Defense submitted this plan to Congress in August 2023. The plan proposed new training aimed at increasing the digital literacy of software acquisition professionals to identify, critically evaluate, and synthesize data and information related to software acquisitions, among other topics. The plan included a comparison between new and existing training curricula, curricula content and costs, and a schedule for implementation.

  Section 835 also directed the President of the Defense Acquisition University to offer the supplemental curricula to covered individuals—

[61]James M. Inhofe National Defense Authorization Act for Fiscal Year 2023, Pub. L. No. 117-263, § 835 (2022).

individuals working in designated acquisition positions who are regularly consulted for software acquisitions or cybersecurity software or hardware acquisitions. It also directed the Secretary of Defense, in consultation with the President of the Defense Acquisition University, to submit to Congress a report assessing the costs and benefits of requiring all covered individuals to complete the supplemental curricula. The Defense Acquisition University plans to offer the first part of its supplemental curricula to students and submit its report to Congress in August 2024. The curricula's first part, *Digital Literacy Basics*, is a collection of five courses designed to ensure all acquisition professionals are given a basic level of awareness and understanding of digital acquisition. Courses in *the Digital Literacy Basics* curricula include *IT Foundations, Industry Best Practices, Introduction to Digital Acquisition, Data, and Emerging Technology*.

- **Expanded credential opportunities.** In September 2020, DOD began implementing the Back-to-Basics talent management framework, which expanded credential opportunities for the acquisition workforce, including software acquisition professionals.[62] For example, DAU launched the *Foundational Software Acquisition Management* credential in December 2022. The credential, designed to provide the DOD acquisition workforce with skills to successfully develop and acquire better software products, includes courses such as *Software Literacy Fundamentals and Introduction to Agile Software Acquisition*. This credential is optional, and as of January 2024, 33 students had completed it, while 244 enrollees were in progress toward completion.[63]
- **Identification of the software workforce.** DOD is in the process of identifying the composition of and the individuals in its software workforce, although it still has significant work to perform on this initiative. Our prior work recognized identification of the software workforce as a crucial step in both supporting the workforce and successfully adopting department-wide reforms.[64] An official from the Office of the Under Secretary of Defense for Personnel and

[62]Specifically, the Back-to-Basics talent management framework was intended to streamline certification requirements, expand job relevant credential opportunities, and facilitate continuous learning for the acquisition workforce.

[63]According to Defense Acquisition University officials, defense acquisition credentials are optional, though this does not prevent a supervisor, organization, component, or functional area leader from directing selected groups of individuals to obtain a particular credential.

[64]GAO-23-105611.

Readiness, which was tasked with identifying segments of the workforce for work role identification, noted as part of our prior work that identifying the software workforce is a challenge for DOD because software professionals work across many occupational series.

DOD began the identification process in September 2022 by defining work roles based on each role's required knowledge, skills, and abilities, according to USD(A&S) officials. As of January 2024, OSD had approved eight software engineering work roles and added them to DOD's existing framework, which was already being used for identifying and tracking work performed by the cyber workforce.[65] OSD also issued a memorandum in January 2024 to inform DOD components of the intention to collaborate to prepare a plan and guidance for assigning these work roles. OSD plans to begin coding the workforce—that is, assigning software-related work role codes to civilian and military staff in the workforce—in fiscal year 2024, and intends to complete this phase within 2 years.

- **Efforts to improve the hiring, training, and retention of the software workforce.** DOD has also recently taken other steps to improve the hiring, training, and retention of the software workforce. For example, DOD initiated the congressionally mandated Defense Civilian Training Corps as a pilot program in September 2023.[66] According to USD(A&S) officials, this program is expected to help build the technology workforce at DOD, including the software workforce.

  Specifically, this program helps DOD recruit university-level talent, including in areas such as acquisition-related fields. It provides selected university students with a full tuition scholarship that includes DOD-related classroom training and a summer internship with a DOD organization. Upon graduation, participants will be placed in a job with a DOD organization. According to USD(A&S) officials, the pilot program intends to place about 90 students from across four universities participating in the fall 2023 cohort into internships or

[65]Department of Defense Directive 8140.01 established the Defense Cyber Workforce Framework as the authoritative reference for the identification, tracking, and reporting of DOD's cyberspace positions. The framework serves as the Department's coding structure for authoritative manpower and personnel systems for the work performed by the full spectrum of the cyber workforce.

[66]National Defense Authorization Act for Fiscal Year 2020, Pub. L. No. 116–92, § 860, (2019).

other opportunities within DOD. They also plan to recruit another round of students in fall 2024.

Additionally, USD(A&S) officials stated that DOD employs teleworking flexibilities when allowed, which has helped them recruit and retain some members of the acquisition workforce including software acquisition professionals. However, they noted that DOD follows executive branch policies on telework and any changes to those policies may affect DOD's ability to offer this flexibility. As noted above, several weapon programs identified that a preference for remote work and the high cost of living in some work areas were factors contributing to hiring and retention challenges with their software workforces.

Conclusions

DOD weapon systems are increasingly complex cyber-physical systems that require new, iterative development approaches to achieve speed in delivery. However, achieving the positive outcomes associated with leading practices requires programs to plan for iterative approaches from their inception, such as refining a minimum viable product based on continuous user feedback, and adopting modern digital engineering tools that facilitate rapid iterations of design, development, and delivery. While the MTA pathway offers flexibilities to create efficiencies in the acquisition process, the warfighter may continue to wait years—if not more than a decade—for a solution that may ultimately no longer be relevant or responsive to the most urgent needs by the time it is delivered. Additional policy that calls for program acquisition strategies to include how programs plan to implement leading practices to deliver capability with speed will provide an opportunity for programs to be more responsive to the warfighter's needs.

Further, DOD's ability to rapidly deliver complex cyber-physical products to the warfighter is inextricably linked to the capacity of its software workforce, both in terms of having enough personnel and having personnel with the right skill sets. Yet weapons programs reported numerous challenges related to hiring and retaining qualified personnel for software workforce roles. The congressionally mandated software cadre provides an opportunity for DOD to start building needed software expertise to support acquisition programs. However, until DOD improves planning for the cadre, such as by fully defining goals, identifying strategies and resources needed to achieve those goals, and assessing the internal and external factors that could affect success of the cadre, it will not be well positioned to ensure it is providing the critical support programs need.

Recommendations for Executive Action

We are making three recommendations to the Department of Defense.

The Secretary of Defense should direct the USD(A&S) to issue policy calling for MTA program acquisition strategies to include how the program plans to implement leading practices for product development to deliver fieldable capability with speed, within 5 years. (Recommendation 1)

The Secretary of Defense should ensure the USD(A&S) fully defines goals for DOD's software cadre, to include long-term outcomes and near-term measurable results with time frames. (Recommendation 2)

The Secretary of Defense should ensure the USD(A&S) identifies strategies and resources needed to achieve DOD's goals for its software cadre, including assessing the internal and external factors that could affect achievement of DOD's goals for its software cadre and how to mitigate them. (Recommendation 3)

Agency Comments and Our Evaluation

We provided a draft of this report to DOD for review and comment. We received written comments, which are reproduced in appendix VIII and summarized below. DOD also provided technical comments, which we incorporated as appropriate.

In its written comments, DOD concurred with the two recommendations concerning the software acquisition workforce and partially concurred with the one recommendation concerning leading practices in MTA programs. As initially written, our recommendation called for the Secretary of Defense to direct USD(A&S) to update the MTA transition plan template to ensure that it provides guidance for transition plans included in MTA acquisition strategies to address how the program plans to implement leading practices for product development.[67]

DOD generally agreed with this recommendation but suggested we direct it to require programs to document in their acquisition strategies (rather than in the transition plan template) how they will implement leading practices for product development to deliver fieldable capabilities with speed, within 5 years. DOD stated that transition plans include a timeline for completion within 2 years of all necessary documentation required for

[67]The Office of USD(A&S) has developed a transition plan template, available on the Defense Acquisition University's website, that programs may use to develop their transition plans.

transition, but that those plans are not always included at MTA program start.

We agree that directing changes to the acquisition strategy would ensure leading practices are documented at the start of development and have amended our recommendation accordingly.

We are sending copies of this report to the appropriate congressional committee and offices; the Secretary of Defense; the Secretaries of the Army, Navy, and Air Force; and the Director of the Office of Management and Budget. In addition, the report will be made available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions concerning this report, please contact me at (202) 512-4841 or oakleys@gao.gov. Contact points for our offices of Congressional Relations and Public Affairs may be found on the last page of this report. Staff members making key contributions to this report are listed in appendix IX.

Shelby S. Oakley
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

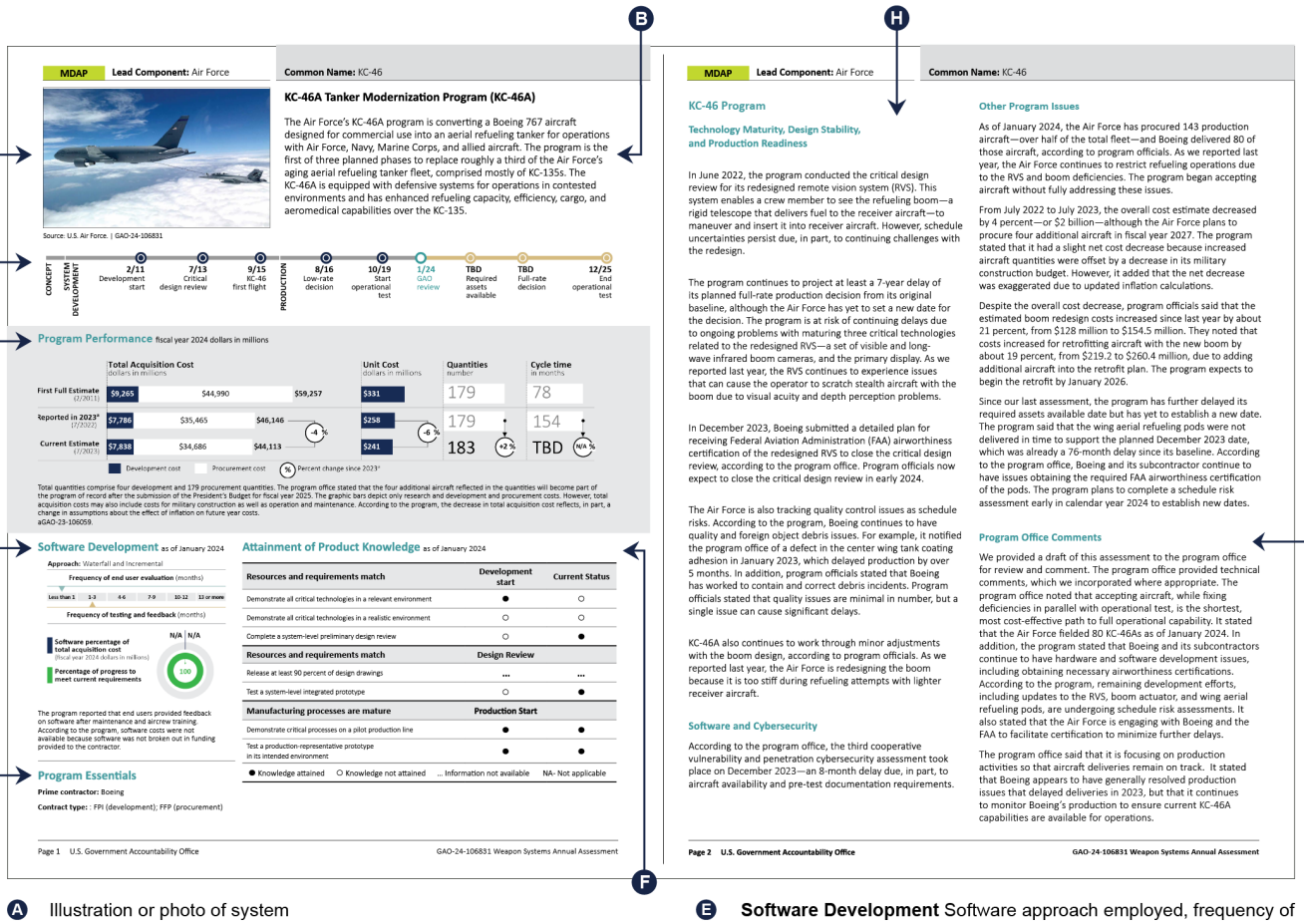
Appendix I: Program Assessments

This section contains 69 assessments of weapon programs.[68]

For 34 MDAPs, we produced two-page assessments discussing cost and schedule performance, software and cybersecurity efforts, and other program issues. For 29 of these MDAPs, we also assessed program attainment of selected knowledge-based acquisition practices. For the remaining five MDAPs, which recently transitioned from the MTA pathway, we began exploring the extent to which they are incorporating the iterative product development practices that our prior work found were employed by leading companies. See figure 26 for an illustration of the layout of each two-page assessment.

[68]We reviewed 70 total programs. The Space Force's Tranche 1 (T1) Transport and Tranche 2 (T2) Transport MTA efforts were reviewed together in one assessment. The assessments also contain basic information about the program, including the prime contractor(s) or other identified contractors and contract type(s). We abbreviated the following contract types: cost reimbursement (CR), cost-plus-award-fee (CPAF), cost-plus-fixed-fee (CPFF), cost-plus-incentive-fee (CPIF), firm-fixed-price (FFP), fixed-price-award-fee (FPAF), fixed-price incentive (FPI), and indefinite delivery/indefinite quantity (IDIQ). For some FPI contracts, we distinguished between their forms: firm target (FPIF) and successive targets (FPIS).

Figure 26: Illustration of Two-Page Major Defense Acquisition Program Assessment



- **A** Illustration or photo of system
- **B** Program description
- **C** Timeline identifying key dates for the program including, the start of development, major decision reviews, production decision and planned operational capability. Where applicable, "major capability transition" indicates when the program transitioned to the major capability acquisition pathway.
- **D** **Program Performance** Cost, quantity, and schedule data as of the program's first full estimate (baseline), one year ago (GAO's 2023 assessment), and current estimate. We depict only the program's main element of acquisition cost – research and development and procurement. However, total program costs also include military construction and acquisition operation and maintenance. Schedule data is presented as a cycle time comparison of planned number of months from program start to initial capability.
- **E** **Software Development** Software approach employed, frequency of end user evaluation, frequency of testing and feedback, percentage of total program cost accounted for by software development, and percentage of progress to meet current requirements
- **F** **Attainment of Product Knowledge** Depiction of selected knowledge-based practices and the program's progress in attaining that knowledge
- **G** **Program Essentials** Programmatic information including prime contractor (or other identified contractors) and contract type
- **H** Assessment of program's technology, design, and production maturity, as well as software, cybersecurity, and other program issues.
- **I** **Program Office Comments** General comments provided by the cognizant military service or program office

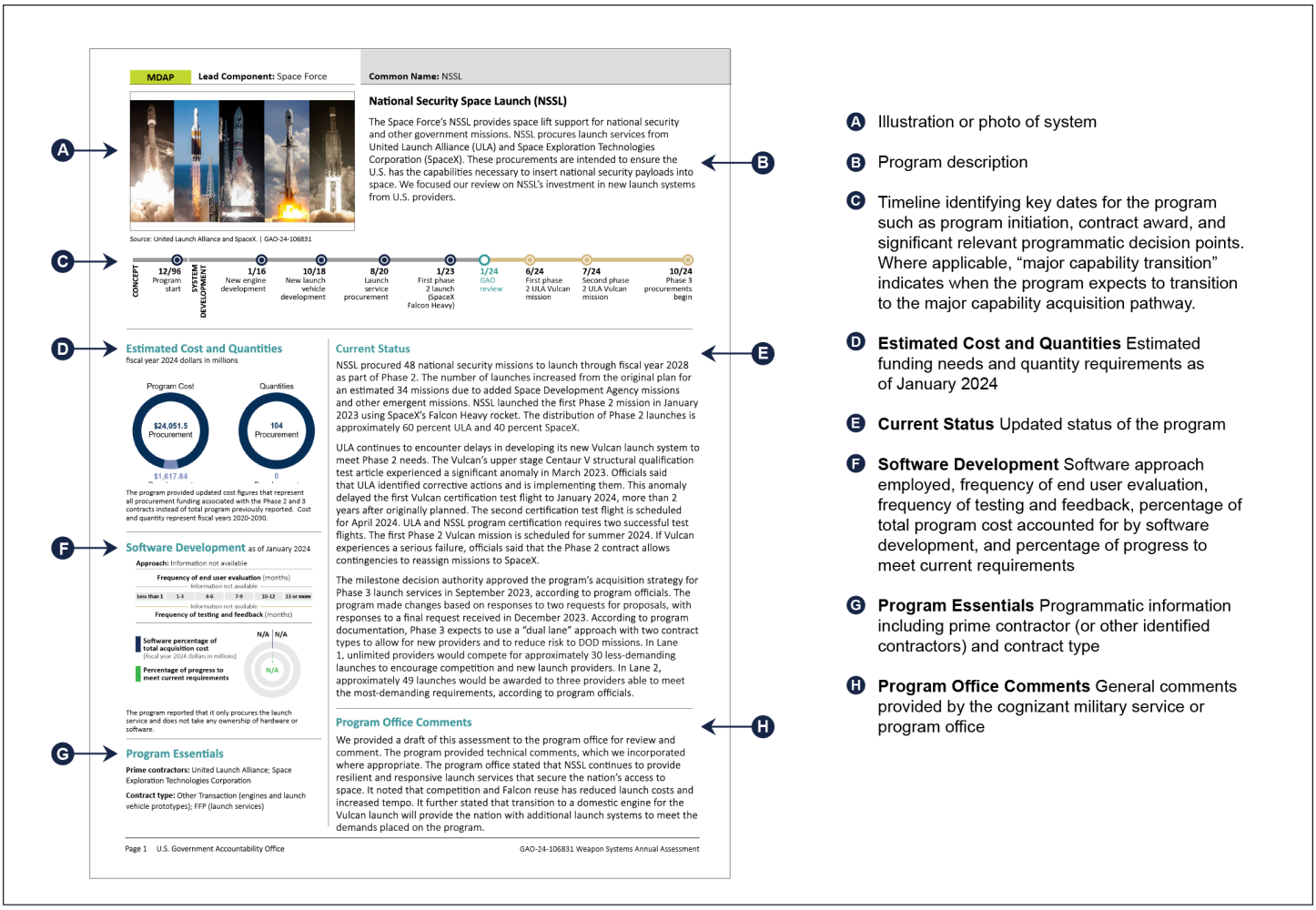
Source: GAO. | GAO-24-106831

In addition, we produced one-page assessments for 16 efforts and programs:

- twelve future major weapon acquisitions and
- four MDAPs that were well into production, but planned to introduce new increments of capability, which we refer to as MDAP increments.

See figure 27 for an illustration of the layout of each one-page assessment.

Figure 27: Illustration of One-Page Future Major Weapon Acquisition or Major Defense Acquisition Program Increment Assessment



Source: GAO. | GAO-24-106831

We produced 19 two-page assessments for 20 programs using the MTA pathway. These two-page assessments discuss program background and transition plans, completion of or updates to key business case elements, software and cybersecurity efforts, employment of leading product

development practices, as well as other program issues. See figure 28 for an illustration of the layout of each two-page MTA program assessment.

Figure 28: Illustration of Two-Page Assessment of Programs Using the Middle Tier of Acquisition Pathway

- **A** Illustration or photo of system
- **B** Program description
- **C** Timeline identifying key dates for the program such as program initiation, funds obligation, contract award, expected MTA completion, and significant relevant programmatic decision points. Where applicable, "major capability transition" indicates when the program expects to transition to the major capability acquisition pathway.
- **D** **Estimated Middle Tier of Acquisition Cost and Quantities** Comparison of current and 2023 cost, quantity and schedule program estimate as of January 2024
- **E** **Program Background and Transition Plan**
- **F** **Software Development** Software approach employed, frequency of end user evaluation, frequency of testing and feedback, percentage of total program cost accounted for by software development, and percentage of progress to meet current requirements
- **G** **Attainment of Business Case Knowledge** Depiction of key knowledge programs should attain prior to program initiation and the program's progress in attaining that knowledge
- **H** **Program Essentials** Programmatic information including prime contractor (or other identified contractors) and contract type
- **I** Assessment of program's performance and business case, software and cybersecurity, use of key product development principles, and other program issues
- **J** **Program Office Comments** General comments provided by the cognizant military service or program office

Source: GAO. | GAO-24-106831

For 49 of the 70 programs we assessed, we used scorecards to depict the extent of knowledge that a program has gained. These scorecards display key knowledge-based practices that should be implemented by certain points in the acquisition process to reduce risk.[69]

For each scorecard, we used the following scoring conventions:

- A closed circle to denote a knowledge-based practice the program implemented.
- An open circle to denote a knowledge-based practice the program did not or has yet to implement.
- A dashed line to denote that the program did not provide us with enough information to make a determination.
- NA to denote a practice that was not applicable to the program. For example, a practice may be marked "NA" for a program if it has yet to reach the point in the acquisition cycle when the practice should be implemented.

We included notes beneath the figures to explain information not available, or NA scores, and added other explanatory notations for the scorecards where appropriate. Appendix II provides additional detail on our scorecard methodology. Figures 29 and 30 provide examples of the knowledge scorecards we used in our assessments.

[69]We used knowledge scorecards for 29 MDAPs and 20 MTA programs. We did not use scorecards for the four MDAP increments we assessed, because these programs are well into production; or for the 12 future major weapon acquisitions, because these programs were early in their life cycles. Additionally, for the five MDAPs we assessed that transitioned from the MTA pathway, we described how program acquisition approaches compared to our leading product development practices; however, we did not provide a scorecard for this information. We have ongoing work to refine our leading product development practices, which we expect will enable a more detailed assessment of knowledge attainment for these types of programs in future reports. See GAO, *Leading Practices: Iterative Cycles Enable Rapid Delivery of Complex, Innovative Products,* GAO-23-106222 (Washington, D.C.: July 27, 2023). We assessed different knowledge-based practices for shipbuilding programs than for other types of programs. These shipbuilding practices were informed by our prior work and focus on leading practices for achieving ship design maturity at key points for the programs, such as at the point ship fabrication starts. See GAO, *Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding*, GAO-09-322 (Washington, D.C.: May 13, 2009).

Figure 29: Examples of Knowledge Scorecards on Two-Page Major Defense Acquisition Program Assessments

Non-shipbuilding program

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current status
Demonstrate all critical technologies in a relevant environment	●	●
Demonstrate all critical technologies in a realistic environment	○	●
Complete a system-level preliminary design review	●	●
Product design is stable	**Design review**	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production start**	
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	○	●

● Knowledge attained ○ Knowledge not attained ••• Information not available NA- Not applicable

Source: GAO analysis of DOD data. | GAO-24-106831

Shipbuilding program

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Detail Design Contract Award	Current status
Demonstrate all critical technologies in a relevant environment	○	○
Demonstrate all critical technologies in a realistic environment	○	○
Complete a system-level preliminary design review	●	●
Product design is stable	**Fabrication start**	
Complete 100 percent of basic and functional design using computer-aided modeling	○	●

● Knowledge attained ○ Knowledge not attained ••• Information not available NA- Not applicable

Figure 30: Example of Knowledge Scorecards for Assessments of Programs Using the Middle Tier of Acquisition Pathway

MTA

Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case	Status at Initiation	Current status
Approved requirements document	●	●
Approved middle tier of acquisition strategy	●	●
Formal technology risk assessment	●	●
Cost estimate based on independent assessment	●	●
Formal schedule risk assessment	●	●

● Knowledge attained ○ Knowledge not attained ••• Information not available NA- Not applicable

Source: GAO analysis of DOD data. | GAO-24-106831

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AIR FORCE

Program Assessments

▲ T-7A Red Hawk (T-7A)

Assessment type	Program name
MDAPs	B-52 Commercial Engine Replacement Program (B-52 CERP)
	B-52 Radar Modernization Program (B-52 RMP)
	F-15 Eagle Passive Active Warning Survivability System (F-15 EPAWSS)
	F-15EX
	KC-46A Tanker Modernization (KC-46A)
	LGM-35A Sentinel (Sentinel)
	Long Range Standoff (LRSO)
	MH-139A Helicopter (MH-139A)
	Small Diameter Bomb Increment II (SDB II)
	T-7A Red Hawk (T-7A)
	VC-25B Presidential Aircraft Recapitalization (VC-25B)
MTA Programs	E-7A Rapid Prototyping (E-7A RP)
	F-22 Rapid Prototyping
	Hypersonic Attack Cruise Missile (HACM)

Source (previous page image): Boeing Corporation. | GAO-24-106831

MDAP | Lead Component: Air Force

Common Name: B-52 CERP

Source: U. S. Air Force. | GAO-24-106831

B-52 Commercial Engine Replacement Program (B-52 CERP)

The B-52 CERP plans to support nuclear and conventional operations by replacing the aircraft's engine with military-configured commercial engines. Along with the new engines, the B-52 CERP will replace associated subsystems, such as engine struts, the electrical power generation system, and cockpit displays for the B-52H fleet. In December 2023, B-52 CERP transitioned from the MTA pathway to the MCA pathway. The transition from the former effort, known as the B-52 CERP rapid virtual prototype, occurred prior to the start of system development.

Program Performance fiscal year 2024 dollars in millions

	Total Acquisition Cost (dollars in millions)	Unit Cost (dollars in millions)	Quantities (number)	Cycle time (in months)
First Full Estimate (1/2024)	Program has not developed formal cost or schedule estimates			
Reported in 2023[a]	Not a Major Defense Acquisition Program in GAO's 2023 assessment			
Current Estimate (1/2024)	Program has not developed formal cost or schedule estimates			

[a]GAO-23-106059.

Software Development as of January 2024

Approach: Agile and Incremental

Frequency of end user evaluation (months)

Information not available

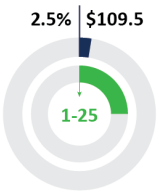
Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that evaluation of the software by end users is expected to begin in August 2024.

Program Essentials

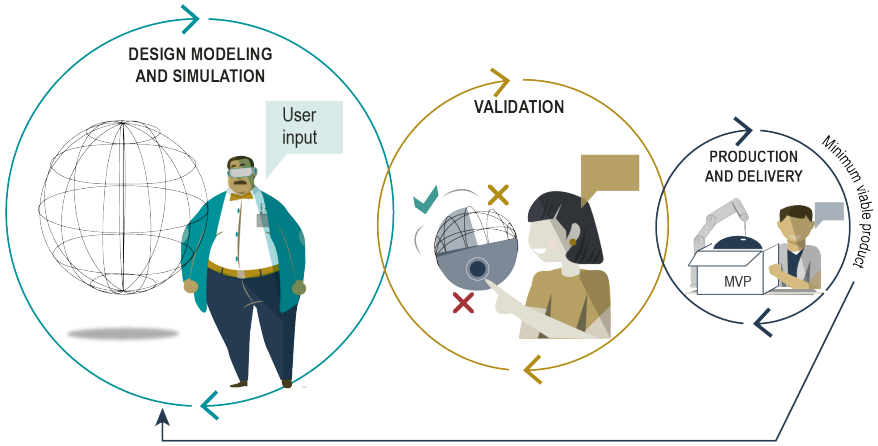
Prime contractor: Boeing; Rolls Royce

Contract type: CPIF; FFP

Attainment of Product Knowledge as of January 2024

Plan for leading product development practices

We have ongoing work to refine our leading product development practices associated with iterative development. We plan to use this space in the future to assess program implementation of leading practices, including those programs transitioning from the middle tier of acquisition to major capability acquisition pathway. These leading practices criteria include plans to use tools and approaches that refine requirements into a minimum viable product (MVP) with users through iterative cycles of development, as depicted in the figure below. The MVP is the initial set of warfighting capabilities suitable to be fielded in an operational environment that provides value to the warfighter in a rapid timeline.



Source: GAO analysis of leading company information; GAO (illustration). | GAO-24-106831

B-52 CERP

Program Performance

In March 2022, the Air Force revised its B-52 CERP acquisition strategy and extended the B-52 CERP rapid prototyping effort by more than a year to enable transition to the MCA pathway. In December 2023, the program received Air Force approval to transition to the MCA pathway. Although the program transitioned pathways, officials stated that the development contract would still not be awarded until completion of the critical design review, now planned for August 2025, nearly 2 years later than previously planned. In the meantime, officials stated that they plan to complete design work under an extension to the virtual prototyping contract.

According to program officials, delays to critical design are a result of underestimating the level of funding needed to complete the detailed design activities. Specifically, as the B-52 prototyping effort was extended from preliminary design to critical design, program officials received a proposal for the detailed design work. Program officials stated that the proposal cost exceeded the program's available funding, and that they asked Boeing to slow its level of work to align with available funding. They also noted that an associated materials contract could not be awarded, causing additional delays.

Leading Product Development Practices

While the program office stated that it is not using iterative development for its engine replacement effort, the program is employing some practices in line with leading practices for product development. For example, we previously found that leading companies repeatedly obtain feedback from users to ensure the product specifications meet user needs. Leading companies also collect user feedback after delivery of the first iteration to identify new features to include in subsequent iterations or new products. As part of the B-52 CERP MTA effort, the program solicited feedback from end users, including pilots and maintainers, during design and development of the virtual prototype. Program officials noted that this feedback led to design changes, such as a redesign of service panel hinges to improve maintainer access. As we previously found, collaboration with a wide range of stakeholders—such as users, engineers, and manufacturers—helps leading companies identify potential problems early.

However, the program does not plan to conduct integrated, systems-level testing in an operational environment prior to production, which could provide additional knowledge into how key systems will perform and reduce production risk. Our prior work found that conducting fully integrated testing prior to production allows users to verify performance and can uncover problems that were not apparent when subsystems were tested earlier. Specifically, the program plans to begin flight testing a production representative prototype with users about 6 months after the first low-rate initial production decision. Officials stated that this approach presents cost risk, but they are willing to trade off cost risk in order to maintain schedule. They stated that component and lab testing will allow them to mitigate technical risks prior to the first production decision. Additionally, they stated that they are managing risk by implementing decision points for each lot, to allow decision-makers additional opportunities to evaluate hardware maturity and production readiness. Even so, our prior work has shown that leading companies rely on prototyping results to help assess whether the product will remain within expected cost and schedule parameters, and whether the product will still meet user needs. Without this testing, the program faces increased risk of costly and time-intensive design changes and retrofits if issues are discovered in flight testing.

Software and Cybersecurity

Software coding began in November 2022 with the initial software deliveries expected to occur in late fiscal year 2024, according to program officials. The program's cybersecurity strategy was approved in July 2023 and the program plans to hold a cybersecurity tabletop exercise in April 2024.

Program officials stated that they utilized direct hiring authorities and offered hiring bonuses to mitigate software workforce staffing challenges. Program officials noted that Boeing was also experiencing staffing challenges with its software workforce.

Program Office Comments

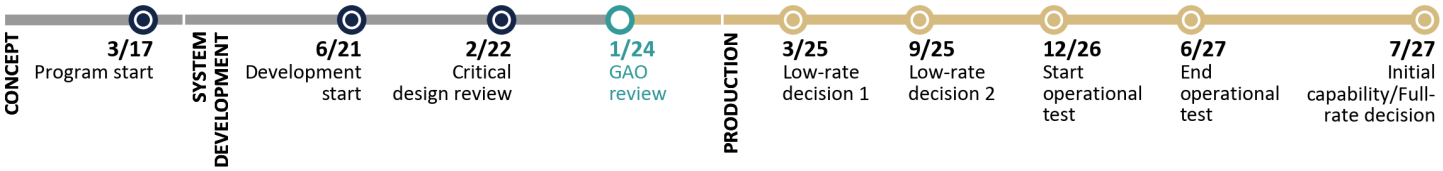
We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

The program office stated that the B-52 CERP successfully delivered a virtual system prototype in August 2023 under the MTA pathway and transitioned to the MCA pathway in December 2023. It stated that it continues to refine schedule and cost maturity. The program noted that there have been program delays in part due to funding shortfalls to complete the detailed design, but that it has worked with the contractors and submitted budget requests to support critical design review in August 2025 and initial operational capability in mid-fiscal year 2033. It also stated that the B-52 CERP acquisition strategy strikes a balance between risk and capability delivery and that extensive component and subsystem testing in integration labs, augmented by digital modeling, is structured to reduce technical risk prior to production. It stated that the production decision is planned to occur after two test aircraft are delivered, and that flight testing is expected be underway for 18 months prior to beginning the first production aircraft modification.

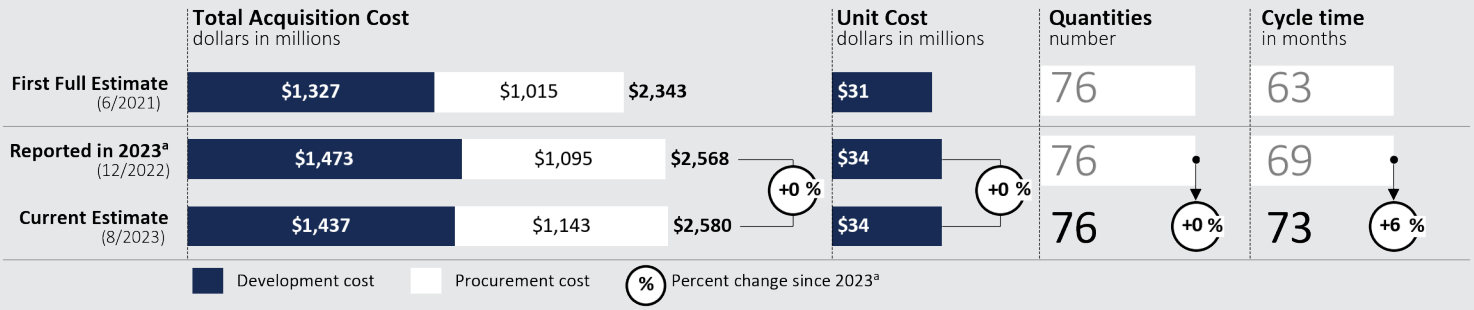
Source: Copyright © Boeing. | GAO-24-106831

B-52 Radar Modernization Program (B-52 RMP)

The Air Force's B-52 RMP plans to replace the current APQ-166 radar on all 76 B-52H aircraft with a modern off-the-shelf Active Electronically Scanned Array radar. The new radar is expected to provide improved functionality and reliability to support both nuclear and conventional B-52H missions while allowing for mission-essential aircraft navigation and weather avoidance. The Air Force plans for continued B-52H operations through the year 2050.



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise two development quantities and 74 procurement quantities. B-52 RMP declared a cost breach in September 2023 due to issues with lab testing. The program plans to update its cost estimate by March 2025.
[a]GAO-23-106059.

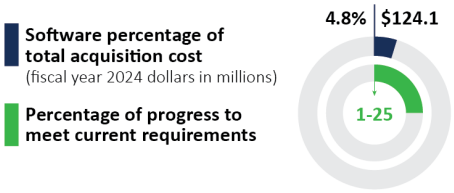
Software Development as of January 2024

Approach: Agile and Incremental

Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)



The program office revised its reported frequency of testing and feedback from last year to include releases to the development laboratories.

Program Essentials

Prime contractor: Boeing

Contract type: CPIF

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	NA	NA
Demonstrate all critical technologies in a realistic environment	NA	NA
Complete a system-level preliminary design review	●	●
Product design is stable	Design Review	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	○
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

We did not assess B-52 RMP critical technologies because the program office reported that the system does not have any. We also did not assess manufacturing maturity because the program has yet to reach production start.

B-52 RMP

Technology Maturity and Design Stability

B-52 RMP reported it has no critical technologies. According to program officials, all planned technologies are fully mature because the program is using off-the-shelf components.

The program has met one key practice for design stability—releasing at least 90 percent of design drawings—but not the second practice, testing a system-level integrated prototype. The program considers integration testing to be one of its top risks. Previously, the program stated that it was not performing a test of a system-level integrated prototype. This year, it stated that it plans to conduct this test in 2024—well after the program's 2022 critical design review. It also noted that it has already tested prototypes of some components. Our prior work has shown that testing a system-level integrated prototype before critical design review helps demonstrate that a system's design meets requirements.

Further, while the program currently meets the practice related to design drawings, we updated our Attainment of Product Knowledge graphic to reflect that the program had less than 90 percent of releasable drawings at critical design review. Since last year, the program increased the number of design drawings by 35 (about 10 percent of total drawings). Program officials stated that the increase was due to the need to update historical drawings to match the current aircraft configuration and that they do not expect additional drawings.

Production Readiness

Since our last assessment, the program delayed its low-rate production dates by an additional 6 months and other future dates by an average of 3 months. The program has moved its two low-rate production decisions to the baseline threshold—placing the program at risk for a schedule breach. Decision point 1, planned for March 2025, would approve procurement for the first 11 units. Decision point 2, planned for September 2025, would approve all remaining units. Program officials stated that delays with the display and sensor processor are the primary cause. Specifically, the processor's fiber optic converter—which provides communication between processors—did not work in testing. Program officials stated that the contractor expected to rectify the issue by October 2023 and deliver processors by November 2023.

The program stated that it is using two integration and development labs to test developmental hardware. It noted that developmental units are intended to be airworthy and complete full environmental qualification testing as entry criteria to the first decision point, and that any critical design defects will result in a delay of that decision point. It also stated that a planned production readiness review will account for any critical findings prior to decision point 2. Even so, it does not plan to test a production representative prototype until June 2025, after the first low-rate production decision in March 2025. Our prior work has shown that testing a production prototype after making the production decision increases the risk of costly and time-intensive design changes if the program discovers hardware issues later during integration with legacy systems.

Software and Cybersecurity

B-52 RMP continues to track software completion and integration as a moderate schedule risk. Program officials stated that they will not test version 1.0 capabilities in a realistic environment until after they order the first B-52 RMP production units. According to program officials, software version 0.5, which will support decision point 1, will provide minimal capability required to display imagery from the radar; decision point 2 will be supported by version 1.0, which will provide additional capabilities. The program office noted that the first decision point concerns hardware suitability, and that software immaturity has no bearing on that decision. However, the program's plan to approve low-rate production of 11 units at decision point 1—at a cost of $156 million—will be based on less mature software functionality, increasing the risk of costly and time-intensive software fixes if the program discovers issues later.

Further, the program plans to conduct key cybersecurity testing after the time frame recommended by DOD guidance. Specifically, it plans to conduct cybersecurity vulnerability and survivability developmental testing in June and October 2025, respectively—both after the first production decision. Program officials stated that they decided to conduct these cybersecurity tests after decision point 1 because the testing requires software capability that will not be available until between decision points 1 and 2. However, our past work has shown that early and regular discovery of mission-impacting system vulnerabilities makes it easier to fix vulnerabilities and reduces risk to schedule.

Other Program Issues

B-52 RMP declared a cost breach in September 2023 due to issues with lab testing. Costs grew by 12.6 percent since the program's initial estimate in 2021 due to additional hardware and labor for three integration labs, installation of test equipment, and an additional year of contractor support. The program plans to update its baseline with new costs by decision point 1.

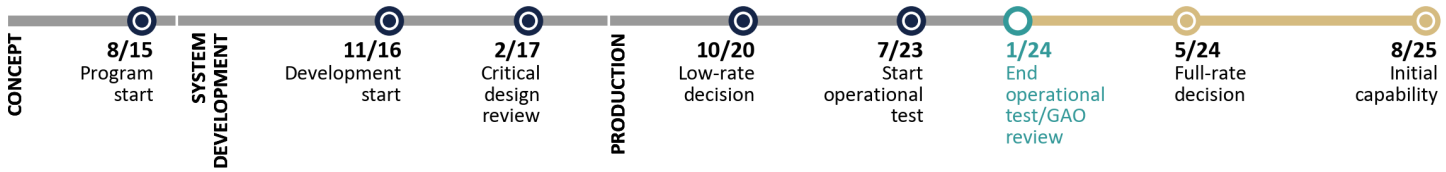
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

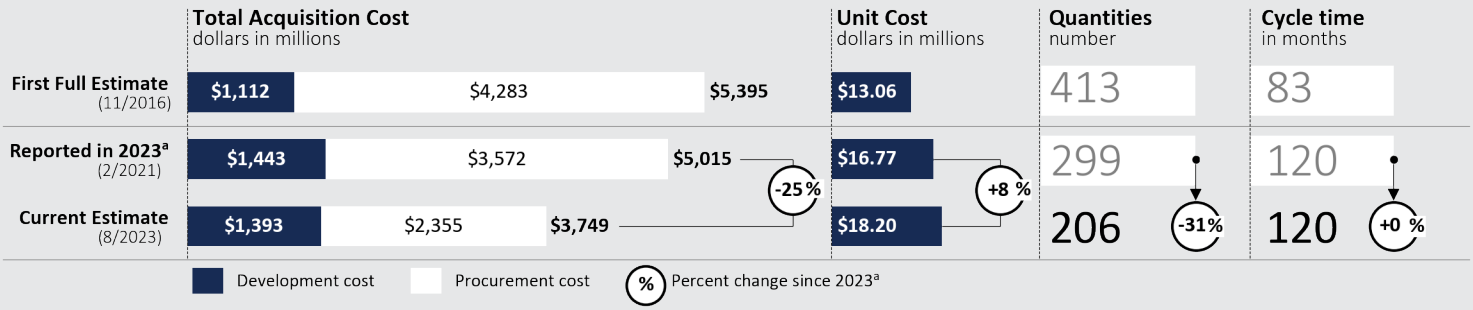
F-15 Eagle Passive Active Warning Survivability System (F-15 EPAWSS)

The Air Force's F-15 EPAWSS program plans to modernize the onboard F-15 electronic warfare system used to detect and identify threat radar signals, employ countermeasures, and jam enemy radars. The program uses reconfigured hardware and software from other military aircraft to address current electronic warfare threats. The Air Force developed EPAWSS to replace the F-15 legacy electronic warfare system, but is also incorporating it into the new F-15EX model, which the Air Force is procuring to replace its F-15C/D fleet.

Source: U.S. Air Force. | GAO-24-106831



Program Performance fiscal year 2024 dollars in millions



The current estimate total quantity includes three development units, 99 F-15E and 104 F-15EX production units. Five of the F-15E production units will start as development units and be upgraded to a production configuration during full-rate production.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Agile, Iterative (other than Agile), Waterfall, and Incremental

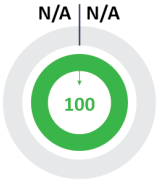
Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that it does not track software costs and that software development was completed in January 2022.

Program Essentials

Prime contractor: Boeing

Contract type: CPIF/CPFF/FFP (development); CPFF/FFP/FPI (low-rate initial production)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	●	●
Demonstrate all critical technologies in a realistic environment	○	●
Complete a system-level preliminary design review	●	●
Product design is stable	Design Review	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	○	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

F-15 EPAWSS Program

Technology Maturity, Design Stability, and Production Readiness

The F-15 EPAWSS critical technologies are mature and its design is stable, as we previously reported. Since our last assessment, the program tested a production-representative prototype. This testing occurred almost 3 years after production start, much later than recommended by leading practices to minimize risk of cost and schedule growth. The program is also tracking three production-related risks.

The first risk concerns hardware fabrication delays that the program experienced during low-rate initial production since our last assessment. The EPAWSS supplier has not met the planned production delivery schedule due to manufacturing capacity bottlenecks and the need to supply both F-15EX production and F-15E modification efforts with EPAWSS hardware. This supplier took measures to increase its production capacity that are expected to help it make timely deliveries of remaining low-rate production hardware.

Secondly, the prime contractor is under pressure to maintain the EPAWSS modification line schedule, as the entry of additional F-15E aircraft into its facility is subject to possible delays if more time is spent completing modification work on aircraft already in process. According to program officials, the contractor is making process improvements to benefit follow-on aircraft and support the achievement of initial capability in August 2025. To mitigate delays, the Air Force is also planning to set up a second EPAWSS modification line at Robins Air Force Base during low-rate production.

Lastly, the program aims to proceed to the full-rate production (FRP) decision before October 2024—which is within its approved baseline—to avoid a potential break in production between low-rate production and the start of FRP. This decision is currently planned for May 2024. To avoid any production breaks, the program considered awarding an undefinitized contract action for the start of FRP. However, according to the program, an undefinitized contract action is now unlikely because EPAWSS modification line delays are resulting in more time to make this award than originally planned.

Software and Cybersecurity

While the program reported completing software development, the start of operational testing was delayed by approximately 3 months to address software issues identified in prior testing and improve the software's reliability.

The program originally planned to conduct two operational cybersecurity tests in 2023 using a lab-based cybersecurity testing environment. However, the Air Force's testing organization decided to conduct these tests on aircraft with production-representative hardware and software installed, which delayed the start of testing until the required test assets were available. It completed these two cybersecurity tests in November and December 2023, a few months later than anticipated but still prior to the FRP decision.

Other Program Issues

In July 2023, the Air Force notified Congress of a Nunn-McCurdy breach resulting from a decrease of more than 200 aircraft due to force structure changes made since development start. For example, in 2017, the Air Force decided not to upgrade the F-15C with EPAWSS, but added the F-15EX, resulting in a net decrease of 52 aircraft. The Air Force made some additional changes to the mix of F-15E and F-15EX aircraft in the years that followed. Those made over the past year were the most significant and include a decrease of 118 F-15E aircraft while adding only 24 to the F-15EX quantity. This latest reduction pushed the program acquisition unit cost increase past the threshold for required congressional notification. The program does not anticipate any significant cost, schedule, or performance effects related to the breach.

The program has tracked diminishing manufacturing sources (DMS) as a risk for several years and expects it to remain a long-term risk. As of October 2023, over 50 different DMS notifications have been received from suppliers. Program officials stated that mitigation strategies are in place to address the loss of parts that will no longer be produced. The program also proactively manages emerging DMS issues by meeting regularly with the prime contractor and EPAWSS supplier, engaging with subject matter experts, and utilizing third-party monitoring services to estimate the continued availability of at-risk parts.

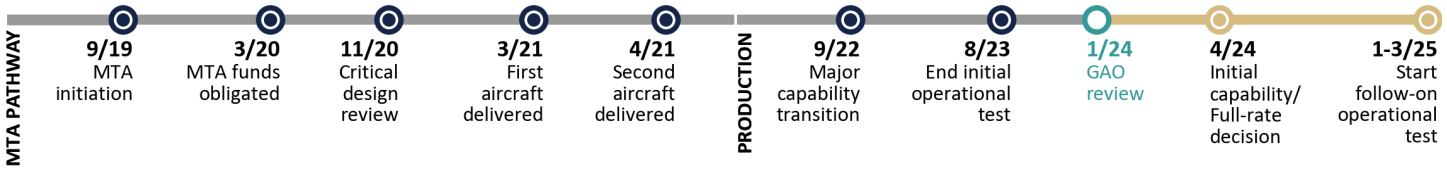
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office stated that during 2023, it began installing EPAWSS on the first four F-15E aircraft and completed a significant portion of planned operational testing and remaining development work. The program office acknowledged that software instability, production challenges, and aircraft modification delays hindered it from making further progress but stated that the prime contractor addressed the root causes of these issues. The program anticipates that the prime contractor will make substantial improvements in 2024 to its timing of EPAWSS modifications and achieve production stability for the EPAWSS hardware. The program office added that in 2024 it expects to (1) close the development contract, (2) award the FRP contract as planned, and (3) deliver the first eight EPAWSS-equipped F-15E aircraft. It stated that it remains on-track to meet its approved baseline date for achieving initial capability.

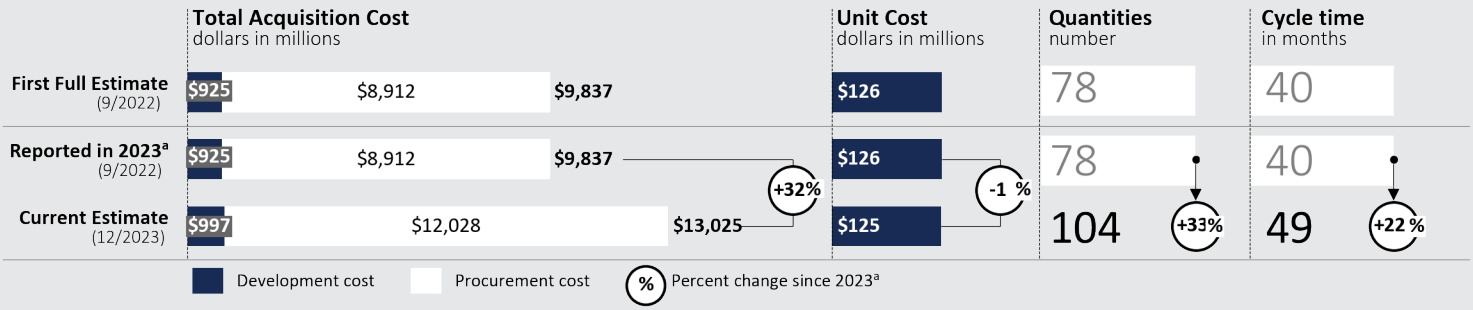
F-15EX

The Air Force's F-15EX program is intended to address F-15C/D readiness challenges and eventually replace the F-15C/D fleet. The program began as a middle tier of acquisition effort. The F-15EX, based on a current foreign military sales aircraft design, will be upgraded with capabilities unique to the U.S., including operational flight program software and Eagle Passive Active Warning and Survivability System (EPAWSS) upgrades. EPAWSS is assessed separately in this report. The F-15EX is planned to be a complementary platform to fifth-generation F-35 and F-22 stealth aircraft operating in highly contested environments.

Source: U. S. Air Force. | GAO-24-106831



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise two development quantities and 102 procurement quantities. Total acquisition cost includes the program's MTA rapid fielding effort. We measured cycle time from the start of the MTA rapid fielding effort to the date the program plans to achieve initial operational capability.
[a]GAO-23-106059.

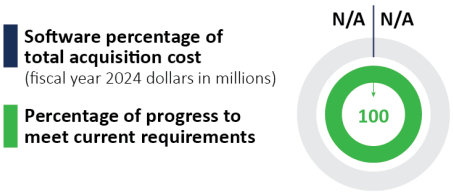
Software Development as of January 2024

Approach: Agile

Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)



The program reported that dedicated software development for F-15EX was completed under the MTA effort. The program stated that software development for all F-15 models was shifted to the overall F-15 program in January 2022.

Program Essentials

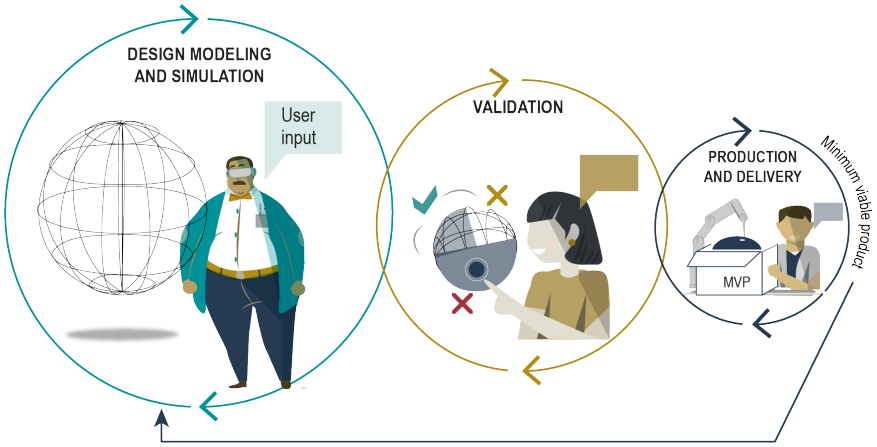
Prime contractor: Boeing

Contract type: IDIQ; FPI Lot 1-4 definitized production orders; CPFF/CPIF/FPI/FFP (development and production support)

Attainment of Product Knowledge as of January 2024

Plan for leading product development practices

We have ongoing work to refine our leading product development practices associated with iterative development. We plan to use this space in the future to assess program implementation of leading practices, including those programs transitioning from the middle tier of acquisition to major capability acquisition pathway. These leading practices criteria include plans to use tools and approaches that refine requirements into a minimum viable product (MVP) with users through iterative cycles of development, as depicted in the figure below. The MVP is the initial set of warfighting capabilities suitable to be fielded in an operational environment that provides value to the warfighter in a rapid timeline.



Source: GAO analysis of leading company information; GAO (illustration). | GAO-24-106831

F-15EX Program

Program Performance

Since our last assessment, the Air Force increased its planned procurement quantities from 78 to 104 as it continues to refine investment priorities. The increased procurement quantities contributed to a higher cost estimate than what we reported in last year's assessment.

Program officials stated that they finalized the terms and conditions for the Lot 2 and Lot 3 production orders and placed a definitized Lot 4 production order in September 2023. They stated that they engaged in Lot 4 negotiations with Boeing at the same time as Lots 2 and 3 to leverage their buying power. The program reported granting Boeing relief from meeting Lot 1 contractual delivery dates in exchange for better pricing on aircraft in Lots 2 to 4, among other things. Program officials said the contracts for Lots 2 to 4 incentivize Boeing to improve performance and cut costs.

Boeing delivered two F-15EX test aircraft—Lot 1A—in early 2021 and four Lot 1B aircraft between mid-December 2023 and early January 2024. Boeing initially planned to deliver the first Lot 1B aircraft in December 2022, but subsequently delayed those deliveries due to production-related issues. Boeing now plans to deliver the remaining two Lot 1B aircraft by April 2024. Boeing also delayed delivery of each Lot 2 aircraft by 2 to 3 months due to Lot 1B production issues. These delays caused planned initial operational capability to slip from July 2023 to April 2024 and the full-rate production decision to slip from November 2023 to April 2024.

Program officials said the recent production issues are because of Boeing's new forward fuselage manufacturing process. Boeing is using new, automated manufacturing processes to drill holes prior to assembling the forward fuselage. Korea Aerospace Industries built the forward fuselage for earlier aircraft. According to program officials, Boeing has experienced increased quality deficiencies after switching to this new manufacturing process, including improperly installed tubing and wires that required time-consuming rework.

While Boeing developed quality improvement plans for specific risk items, officials noted that rework continued in other areas of the forward fuselage. Recent Boeing data suggest that the cost of rework has more than quadrupled over the past year. Boeing is still refining the forward fuselage's new, automated manufacturing process, which could result in increased rework costs and additional schedule delays. To mitigate future rework costs, program officials stated that Boeing plans to increase training and transfer experienced manufacturing staff from other product lines, such as the F-18.

DOD's Director, Operational Test and Evaluation reported in November 2023 that the program successfully completed initial operational and live fire testing, indicating that the F-15EX was operationally effective and suitable. Program officials said that they still expect to conduct follow-on operational testing in the second quarter of fiscal year 2025 with four Lot 3 F-15EXs—after the program has contracted for all 104 aircraft. The program office characterized the possibility of hardware-related, post-testing retrofits as a low likelihood. However, if the testing uncovers unexpected issues, the program may have to retrofit aircraft that it already contracted to buy.

Leading Product Development Practices

Program officials said they did not adopt an iterative development approach because F-15EX required minimal development and had limited opportunities to iterate. However, we found that leading companies view delivery as a springboard for the next iteration of the product. After product delivery, product teams collect user feedback to inform the next iteration of the product or the design of a new product.

Cybersecurity

The program continues to track cybersecurity as its primary risk. The original aircraft design—used in foreign military sales—was not required to meet Air Force cybersecurity requirements, according to the program. The program added that, as a result, there is a risk that the F-15EX design does not meet these requirements. The DOD Director, Operational Test and Evaluation told the program that it should complete additional cybersecurity testing on Lot 2 or later aircraft since the Lot 1 aircraft are not fully representative of the production cybersecurity architecture.

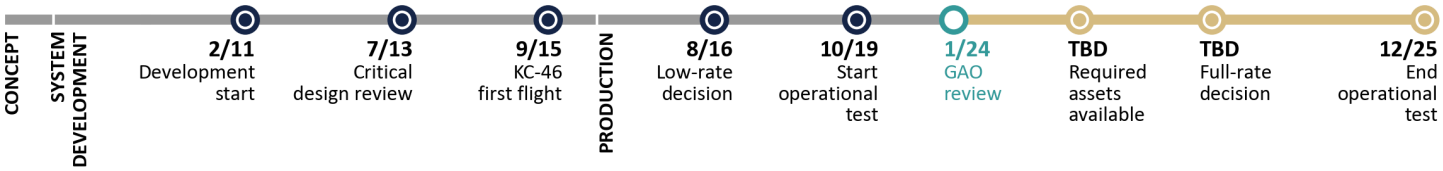
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

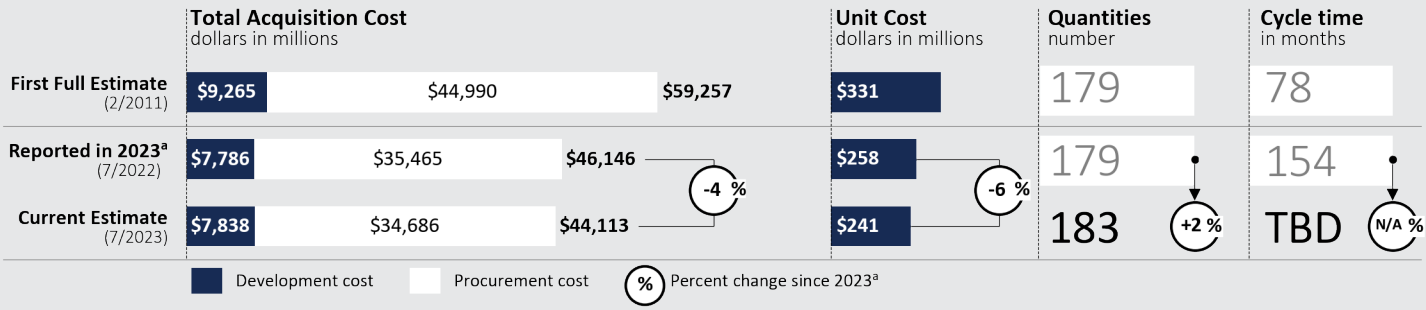
Source: U. S. Air Force. | GAO-24-106831

KC-46A Tanker Modernization Program (KC-46A)

The Air Force's KC-46A program is converting a Boeing 767 aircraft designed for commercial use into an aerial refueling tanker for operations with Air Force, Navy, Marine Corps, and allied aircraft. The program is the first of three planned phases to replace roughly a third of the Air Force's aging aerial refueling tanker fleet, comprised mostly of KC-135s. The KC-46A is equipped with defensive systems for operations in contested environments and has enhanced refueling capacity, efficiency, cargo, and aeromedical capabilities over the KC-135.



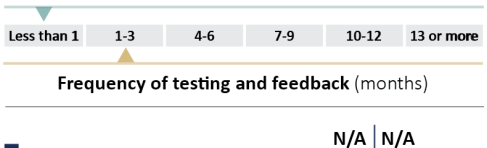
Program Performance fiscal year 2024 dollars in millions

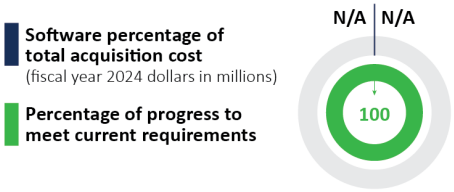


Total quantities comprise four development and 179 procurement quantities. The program office stated that the four additional aircraft reflected in the quantities will become part of the program of record after the submission of the President's Budget for fiscal year 2025. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance. According to the program, the decrease in total acquisition cost reflects, in part, a change in assumptions about the effect of inflation on future-year costs.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Waterfall and Incremental





The program reported that software costs were not tracked. The program reported that testing and feedback is more frequent than last year due to the reduction in the quantities of software being tested, as well as an increase in meetings with the contractor.

Program Essentials

Prime contractor: Boeing

Contract type: FPI (development); FFP (procurement)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	●	○
Demonstrate all critical technologies in a realistic environment	○	○
Complete a system-level preliminary design review	○	●
Product design is stable	Design Review	
Release at least 90 percent of design drawings	…	…
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	●	●

● Knowledge attained ○ Knowledge not attained … Information not available NA - Not applicable

We could not assess the status of design drawings at the KC-46A design review or currently because the program no longer tracks drawings; therefore, there is no total number of drawings against which to measure the program's knowledge.

KC-46A Program

Technology Maturity, Design Stability, and Production Readiness

In June 2022, the program conducted the critical design review for its redesigned remote vision system (RVS). This system enables a crew member to see the refueling boom—a rigid telescope that delivers fuel to the receiver aircraft—to maneuver and insert it into receiver aircraft. However, schedule uncertainties persist due, in part, to continuing challenges with the redesign.

The program continues to project at least a 7-year delay of its planned full-rate production decision from its original baseline, although the Air Force has yet to set a new date for the decision. The program is at risk of continuing delays due to ongoing problems with maturing three critical technologies related to the redesigned RVS—a set of visible and long-wave infrared boom cameras, and the primary display. As we reported last year, the RVS continues to experience issues that can cause the operator to scratch stealth aircraft with the boom due to visual acuity and depth perception problems.

In December 2023, Boeing submitted a detailed plan for receiving Federal Aviation Administration (FAA) airworthiness certification of the redesigned RVS to close the critical design review, according to the program office. Program officials now expect to close the critical design review in early 2024.

The Air Force is also tracking quality control issues as schedule risks. According to the program, Boeing continues to have quality and foreign object debris issues. For example, Boeing notified the program office of a defect in the center wing tank coating adhesion in January 2023, which delayed production by over 5 months. In addition, program officials stated that Boeing has worked to contain and correct debris incidents. Program officials stated that quality issues are minimal in number, but a single issue can cause significant delays.

KC-46A also continues to work through minor adjustments with the boom design, according to program officials. As we reported last year, the Air Force is redesigning the boom because it is too stiff during refueling attempts with lighter receiver aircraft.

Software and Cybersecurity

According to the program office, the third cooperative vulnerability and penetration cybersecurity assessment took place in December 2023—an 8-month delay due, in part, to aircraft availability and pre-test documentation requirements.

Other Program Issues

As of January 2024, the Air Force has procured 143 production aircraft—over half of the total fleet—and Boeing delivered 80 of those aircraft, according to program officials. As we reported last year, the Air Force continues to restrict refueling operations due to the RVS and boom deficiencies. The program began accepting aircraft without fully addressing these issues.

From July 2022 to July 2023, the overall cost estimate decreased by 4 percent—or $2 billion—although the Air Force plans to procure four additional aircraft in fiscal year 2027. The program stated that it had a slight net cost decrease because increased aircraft quantities were offset by a decrease in its military construction budget. However, it added that the net decrease was exaggerated due to updated inflation calculations.

Despite the overall cost decrease, program officials said that the estimated boom redesign costs increased since last year by about 21 percent, from $128 million to $154.5 million. They noted that costs increased for retrofitting aircraft with the new boom by about 19 percent, from $219.2 million to $260.4 million, due to adding more aircraft to the retrofit plan. The program expects to begin retrofits by January 2026.

Since our last assessment, the program has further delayed its required assets available date but has yet to establish a new date. The program said that the wing aerial refueling pods were not delivered in time to support the planned December 2023 date, which was already a 76-month delay since its baseline. According to the program office, Boeing and its subcontractor continue to have issues obtaining the required FAA airworthiness certification of the pods. The program plans to complete a schedule risk assessment early in calendar year 2024 to establish new dates.

Program Office Comments

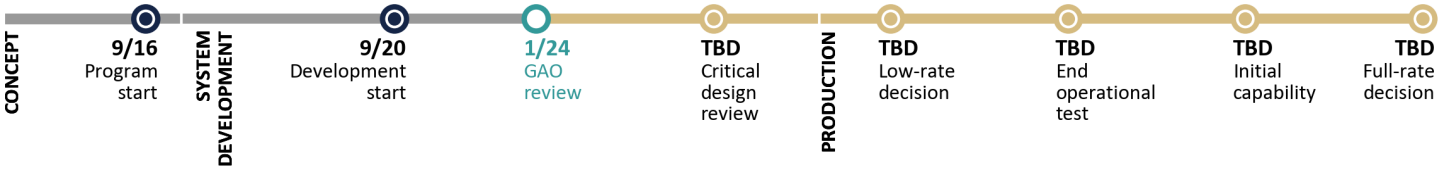
We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office noted that accepting aircraft, while fixing deficiencies in parallel with operational testing, is the shortest, most cost-effective path to full operational capability. It stated that the Air Force has fielded 80 KC-46As as of January 2024. In addition, the program stated that Boeing and its subcontractors continue to have hardware and software development issues, including obtaining necessary airworthiness certifications. According to the program, remaining development efforts, including updates to the RVS, boom actuator, and wing aerial refueling pods, are undergoing schedule risk assessments. It also stated that the Air Force is engaging with Boeing and the FAA to facilitate certification to minimize further delays.

The program office stated that it is focusing on production activities so that aircraft deliveries remain on track. It further stated that Boeing appears to have generally resolved production issues that delayed deliveries in 2023, but that it continues to monitor Boeing's production to ensure current KC-46A capabilities are available for operations.

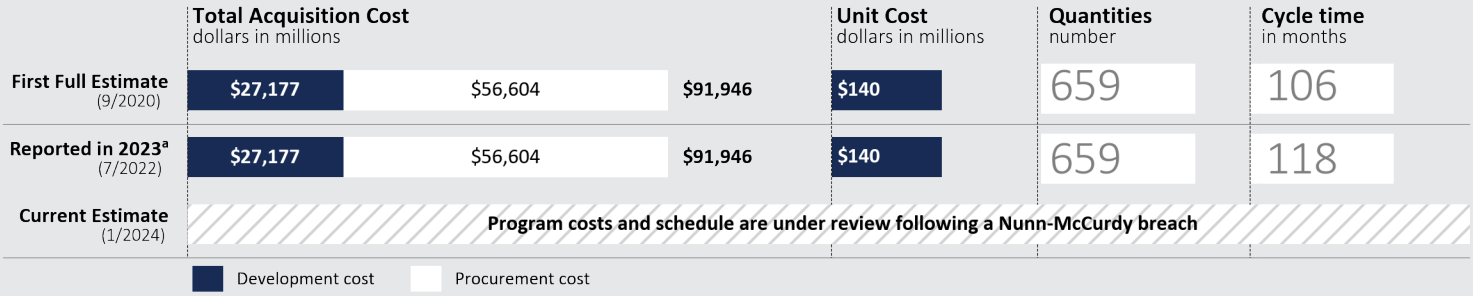
Source: U.S. Air Force. | GAO-24-106831

LGM-35A Sentinel (Sentinel)

The Air Force's Sentinel, formerly the Ground Based Strategic Deterrent, is intended to replace the Minuteman III (MMIII) intercontinental ballistic missile system. Sentinel's large program scope and size includes the development of a new missile and command and control and ground systems, as well as modernization of MMIII infrastructure. Sentinel is expected to enhance the capability, security, and reliability of the land-based portion of the nuclear triad. Sentinel is employing digital engineering tools and is being designed with an open systems architecture to allow for improvements throughout the life of the weapon system.



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise 25 development quantities and 634 procurement quantities. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance. Program costs and schedule events are under review following a cost and schedule breach reported in December 2023, and are not reflected in the timeline or program performance graphic.
[a]GAO-23-106059.

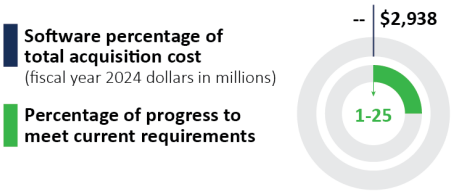
Software Development as of January 2024

Approach: Agile and DevSecOps

Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)



The program reported that the software costs provided last year were the cumulative software costs as of August 2022. This year, the program provided the same cost percentage but revised the dollar amount to represent the total estimated costs for software development and procurement. Software percentage of total acquisition cost is not presented because program costs are under review following a cost and schedule breach reported in December 2023.

Program Essentials

Prime contractor: Northrop Grumman Systems Corp.

Contract type: CPIF

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	○	●
Demonstrate all critical technologies in a realistic environment	○	○
Complete a system-level preliminary design review	●	●
Product design is stable	Design Review	
Release at least 90 percent of design drawings	NA	NA
Test a system-level integrated prototype	NA	NA
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

We did not assess Sentinel's design stability or manufacturing maturity because the program has yet to reach, respectively, critical design review or production.

Sentinel Program

Technology Maturity and Design Stability

According to the program, three of its 18 critical technologies are mature, while the remaining 15 are approaching maturity. The program plans to mature and demonstrate most of the technologies during its first flight and full system functional tests. However, development is ongoing, and prior to the recent announcement of a cost and schedule breach, the Air Force had planned to begin testing and production in fiscal year 2026. Our prior work found that starting development before technologies are mature and starting production before design is stable can increase the risk of cost and schedule growth later in the program.

We are unable to assess Sentinel's design stability because, for a second year in a row, program officials were unable to provide expected and completed design drawing data, the ratio of which is a key indicator of design stability. Sentinel program officials did not provide an alternate approach for overseeing design maturation. Officials stated that the program is in the midst of a replan and that they would provide design status information when the replan is complete.

Challenges with Sentinel's construction design stability are slowing the development of other weapon system features. Ongoing launch facility design changes and persistent launch center design delays are contributing to the immaturity of the command and launch segment design and are slowing down the development of training equipment.

In June and August 2023, the program completed two of the 26 subsystem critical design reviews originally planned for fiscal year 2023—for the post-boost altitude control module and the delta flight test vehicle. Program officials stated they could not provide updates on the 24 remaining events due to ongoing program replanning activities.

Software and Cybersecurity

Sentinel's software development, which began in January 2021, is progressing more slowly than anticipated and the program office lacks appropriate metrics to determine the overall status of the effort. The program office and contractor have yet to finalize software development metrics and are replanning the delivery schedule. In addition, the contractor is rebuilding its software development environment due to instability.

Software development has also been delayed by Sentinel's unique safety, security, and classification requirements—namely, the lack of Air Force and National Security Agency approval to conduct data transfer between networks of different security classifications. Sentinel is actively working to secure approval.

Sentinel's combined test force, an independent test advisory and oversight body, conducted two cooperative vulnerability cybersecurity assessments in 2023. The combined test force continues to recommend that the contractor adopt a holistic cyber test strategy.

Other Program Issues

In December 2023, the Sentinel program filed a deviation report—an official notification of a cost and schedule breach—with the Air Force. In January 2024, the Air Force reported to Congress that the program had experienced at least a 37 percent increase to the program's acquisition unit cost, an amount that exceeds the statutory critical cost growth threshold.

Sentinel is undergoing a program replan, prompted by significant delays to its aggressive development schedule. The program continues to see technical challenges and schedule slips because of staffing, supply chain, and program management issues. In March 2023, Sentinel's milestone decision authority approved an updated acquisition strategy aimed at maintaining the weapon system's initial operational capability date. According to program documentation, this strategy includes approval to pursue contract actions for early construction activities and advanced procurement of missile assets. The program office expects a new schedule baseline in spring 2024 and to conclude negotiations related to added scope in fiscal year 2025.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. It provided technical comments, which we incorporated where appropriate.

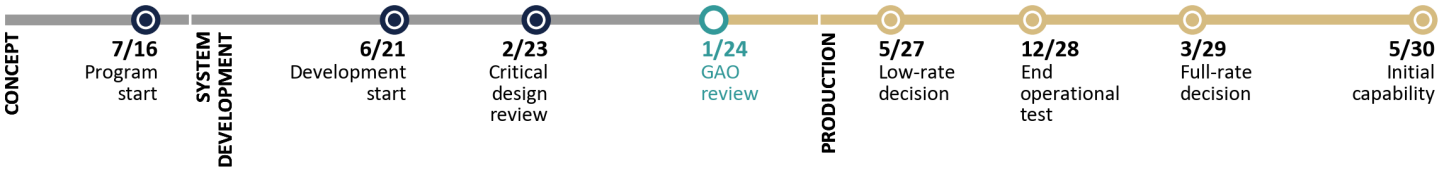
The program stated that Sentinel is unique in size and scope, with no recent comparisons, and is one of the largest, most complex programs that the Air Force has ever undertaken. The program noted that its December 2023 draft cost estimate indicated that most cost growth is in the command and launch segment that consists of 450 launch facilities, thousands of miles of fiber optic network, real estate easement acquisitions with hundreds of landowners, and operational site activation efforts to support the workforce. The program noted that maturing infrastructure designs are providing it with a better understanding of the transition process and re-usability of the existing MMIII infrastructure.

The program added that the Air Force and Office of the Secretary of Defense are actively mitigating risks to ensure there are no capability gaps during the MMIII to Sentinel transition. Sentinel will provide the nation with a significantly more capable defense system with modular capacity to adapt as threats and technology evolve, according to the program.

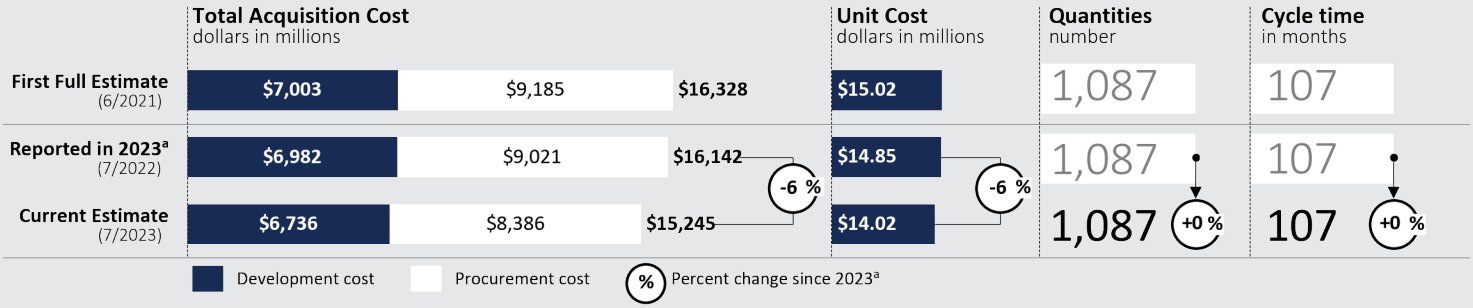
Long Range Standoff (LRSO)

The Air Force is designing the LRSO weapon as a long-range, survivable, nuclear cruise missile to penetrate advanced threat air defense systems. LRSO is slated to replace the Air Launched Cruise Missile. The LRSO's nuclear warhead—the W80-4—is managed by the Department of Energy (DOE) and is undergoing a life-extension program in parallel with the missile's development. Coupled with a legacy and a future bomber, the LRSO is expected to help modernize the bomber segment of the nuclear triad.

Source: U.S. Air Force. | GAO-24-106831



Program Performance fiscal year 2024 dollars in millions



Total quantities include 67 development and 1,020 procurement missiles. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance.
[a]GAO-23-106059.

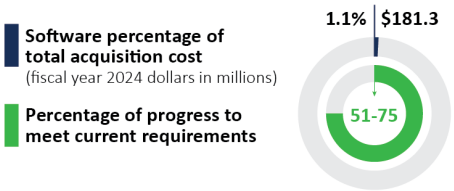
Software Development as of January 2024

Approach: Agile, Waterfall, Incremental, and DevSecOps

Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)



Program Essentials

Prime contractor: Raytheon Missiles & Defense

Contract type: CPFF

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	○	○
Demonstrate all critical technologies in a realistic environment	○	○
Complete a system-level preliminary design review	●	●
Product design is stable	Design Review	
Release at least 90 percent of design drawings	●	●
Test a system-level integrated prototype	●	●
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

We assessed technology maturity and design stability metrics for the LRSO missile. We did not assess manufacturing maturity because LRSO has yet to reach production start.

LRSO Program

Technology Maturity and Design Stability

LRSO has six critical technology areas—three are mature, two are approaching maturity, and one is still immature, more than 2½ years after development start. The program plans to complete testing of the remaining immature technology, nuclear hardness, in a relevant environment by June 2024. DOE officials separately identified critical warhead technologies, 36 percent of which are still approaching maturity—an improvement from our last assessment, which found that 77 percent remained immature. DOE does not expect maturity of these technologies to reach leading practice levels until about the end of fiscal year 2025. Our prior work found that beginning development without mature technologies increases the risk that issues may arise later in development.

The LRSO missile program met our knowledge metrics associated with a stable design, as we previously reported. DOE's warhead program, however, has released only 49 percent of its design drawings as of December 2023—well below the 90 percent that is considered a key indicator of design maturity. The warhead program does not expect to reach 90 percent until late 2025. However, based on our prior work, if the maturity of warhead technologies does not progress as now planned, design changes remain possible.

DOE officials acknowledged that warhead design immaturity increases the risk that rework may be required later in the development process. Officials also stated that this design immaturity has contributed to delays in overall development and may delay warhead test asset availability. However, officials stated that they are expecting to mitigate potential warhead test asset availability delays by using surrogate test warheads.

Production Readiness

The Air Force continues to report plans to meet our leading practices for production readiness for the missile prior to the production decision planned in 2027, as we noted in our last assessment. Warhead manufacturing readiness is not as far along, as the program reported that 60 percent of the critical components identified have not achieved manufacturing maturity at this point. This manufacturing immaturity and the previously mentioned warhead design immaturity are the reasons the warhead program officially moved the expected date of the first warhead production unit from fiscal year 2025 to fiscal year 2027.

While DOE program officials acknowledge the new date for initial production, they stated that they do not expect this new date to hold up the planned fielding in 2030, because they now plan to produce more warheads in the first few years of production. The program is taking steps to facilitate this plan, such as buying more tooling earlier.

Software and Cybersecurity

The program plans 12 incremental software deliveries during development—five of which have been delivered so far. Nuclear certification of the software is a program watch area, but officials stated that it is being mitigated by allowing an independent software verification organization to conduct reviews designed to improve the software.

The LRSO program plans to conduct multiple cybersecurity risk assessments prior to a full system cybersecurity assessment in 2025. To date, the program conducted three assessments, in which it identified potential vulnerabilities and developed mitigations. Program officials stated that these assessments provided expected results to support remaining system design work as planned.

Other Program Issues

The Air Force reported a production cost decrease of $635 million from last year. Officials stated that the reduction is due to inflation rate updates since the cost estimate was approved. Also, as we previously reported, the program's two existing production cost estimates are significantly different. Specifically, the Office of the Secretary of Defense (OSD) estimate for missile production exceeded the Air Force estimate by $1.9 billion. Program officials stated that as test missile manufacturing data become available, this will allow for more accurate production cost estimates. OSD agreed to conduct annual production cost estimate updates using these new data, but to date, too few missiles have been built to enable a new estimate. The first annual estimate is planned for the third quarter of fiscal year 2024.

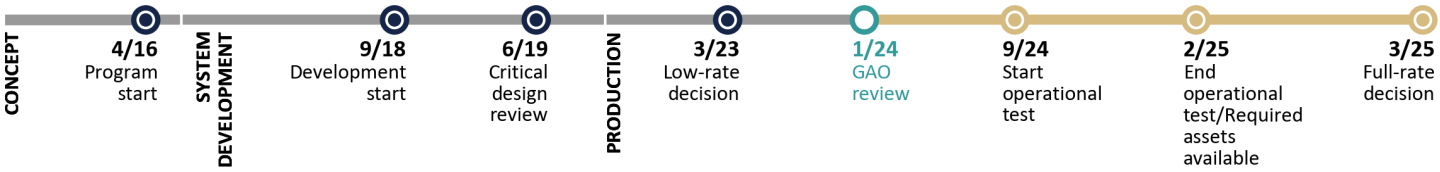
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. It provided technical comments, which we incorporated where appropriate. The program stated that LRSO remains on track to complete development for planned production and on-time fielding; that LRSO's technical approach exceeds leading acquisition practices; and that it implemented mitigation steps to ensure that maturation supports production and fielding. It also stated that software development and cybersecurity efforts continue to mature as planned. The program noted that the warhead is on track for its first production unit in fiscal year 2027, and that it has matured warhead technologies and manufacturing to support production. It stated that the warhead continues to progress through final system development testing ahead of a planned fiscal year 2026 system final design review. The program also stated that DOE's focus is on warhead qualification via joint and system tests, producibility improvement, and mitigating production risks.

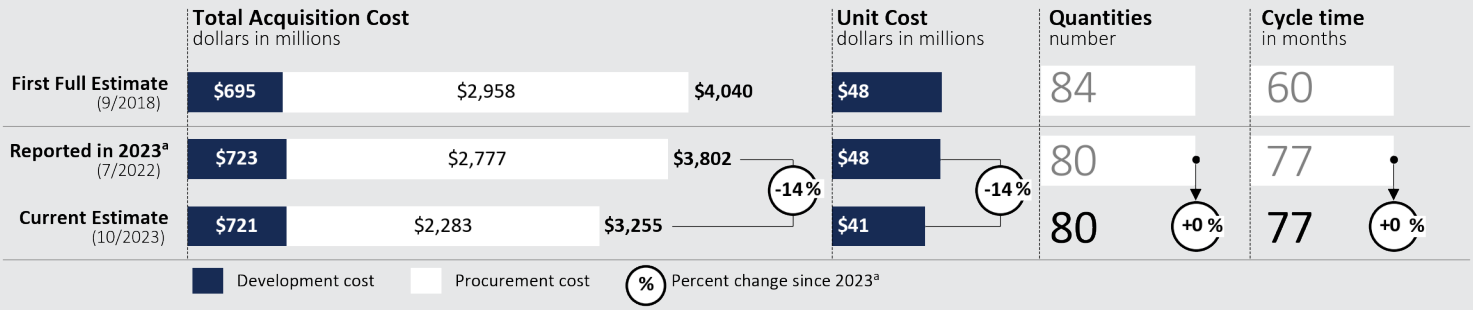
MH-139A Grey Wolf Helicopter (MH-139A)

Source: U.S. Air Force. | GAO-24-106831

The MH-139A program will replace the Air Force's fleet of 63 UH-1N utility helicopters. The MH-139A helicopter's missions will include securing intercontinental ballistic missile sites and convoys and transporting senior government officials in the National Capital Region. The MH-139A program is acquiring a militarized version of a commercial helicopter to be integrated with previously developed systems. In addition to the helicopters, the Air Force plans to acquire an integration laboratory, a training system, and support and test equipment as part of the program.



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise six development quantities and 74 procurement quantities. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Agile

Frequency of end user evaluation (months)

Information not available

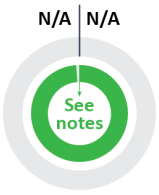
Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that it does not have insight on software costs since they are included in the overall firm-fixed-price contract. The program also reported that software for the aircraft was complete and the software for the training systems is 99 percent complete.

Program Essentials

Prime contractor: Boeing

Contract type: FFP (development)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	NA	NA
Demonstrate all critical technologies in a realistic environment	NA	NA
Complete a system-level preliminary design review	NA	NA
Product design is stable	Design Review	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	NA	NA
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	●	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

We did not assess MH-139A critical technologies because the program office reported it does not have any. We also did not assess completion of a preliminary design review or system-level integrated prototype testing because the program office reported these were not applicable.

MH-139A Program

Technology Maturity, Design Stability, and Production Readiness

The program entered production in March 2023 after successfully completing some of the supplemental certification testing required by the Federal Aviation Administration. At the time the program entered production, the program reported awarding a production contract for 13 aircraft, including training systems. Program officials said that Boeing is on schedule to meet the terms of that contract.

The program completed additional supplemental certifications in May 2023. Program officials stated that there were delays to these certifications that the prime contractor was working to resolve with the Federal Aviation Administration. This resulted in a delay for two aircraft, which were delivered in September and October 2023.

The program continues to assume some schedule risk in starting low-rate initial production while still finishing additional rounds of testing for supplemental certifications, such as the ability to identify friendly forces. Officials stated that testing for one supplemental certification was completed in 2023, and testing for additional certifications will occur in 2024 and 2025. Officials told us they do not think this testing will identify significant issues because they do not think the supplemental testing will require modifications to the aircraft. Specifically, program officials said the remaining capabilities that are being tested would not require design modifications to the aircraft even if challenges are identified during testing.

Program officials said the program plans to begin initial operational testing in September 2024. They added that they are still working to resolve some outstanding deficiencies, but do not expect a delay with initial operational testing. For example, the program is addressing some deficiencies related to the aircraft's intercommunication system. Program officials added that the aircraft's military systems have been flight tested and early results indicate a low risk of design changes.

Software and Cybersecurity

The program developed a quality assurance process related to Agile incremental software development, according to the program office. Boeing contractor employees are part of the MH-139A software development team. As each software defect is addressed, at least one software teammate conducts a peer review. The program office noted that the frequency of this review process is based on the increments of Agile development and defects identified and completed.

Program officials also noted that they completed testing for the software used to train users on cockpit procedures in July 2023, with positive user feedback. The development of software needed to train users on operational flying is ongoing. Once development is complete, this software will undergo government testing. Officials also stated that the program completed developmental adversarial cybersecurity testing in October 2022, and plans to conduct operational cybersecurity testing in the future, although the program has yet to identify dates for the testing.

Other Program Issues

The program is working to mitigate risks as it moves into production. For example, program officials identified delivery of contractually required data related to the supplemental certification testing during production as a potential challenge. The program has reported experiencing delays in getting this type of data from Boeing since 2020. The program stated that the lack of available data could affect access to sustainment data and the program's ability to document a technical baseline. To mitigate this risk, the program developed a technical delivery plan that includes criteria for data delivery tied to each low-rate initial production lot.

The program office also noted that the Air Force Cost Analysis Agency estimating methodology for the MH-139A was updated in fiscal year 2023 to reduce costs associated with several program risks that were not realized. The MH-139A budget was similarly adjusted to better align with the Air Force Cost Analysis Agency estimate. These updates resulted in a cost decrease since our prior assessment.

Program Office Comments

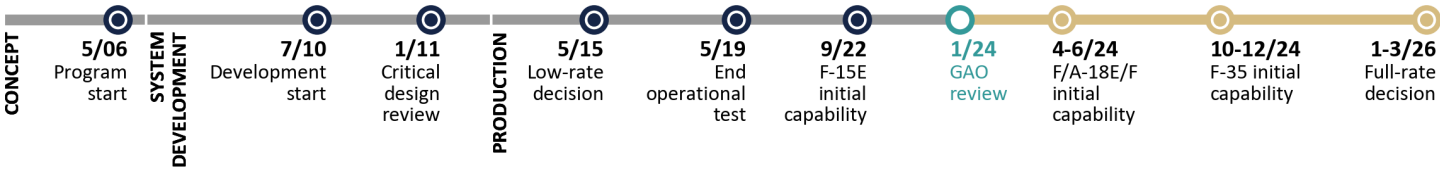
We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

According to the program, production start was approved in March 2023, and the initial aircraft from the first low-rate production lot are expected to be delivered on schedule in the fourth quarter of fiscal year 2024. The program noted that the developmental testing phase remains on track for completion in February 2024, followed by planned fielding to Malmstrom and Maxwell Air Force Bases in March 2024. The program further stated that the second low-rate production lot was approved for contract award pending passage of the fiscal year 2024 budget appropriations. After our January 2024 cut-off date for new information, the program stated it is delaying its full rate production decision from March 2025 to September 2025.

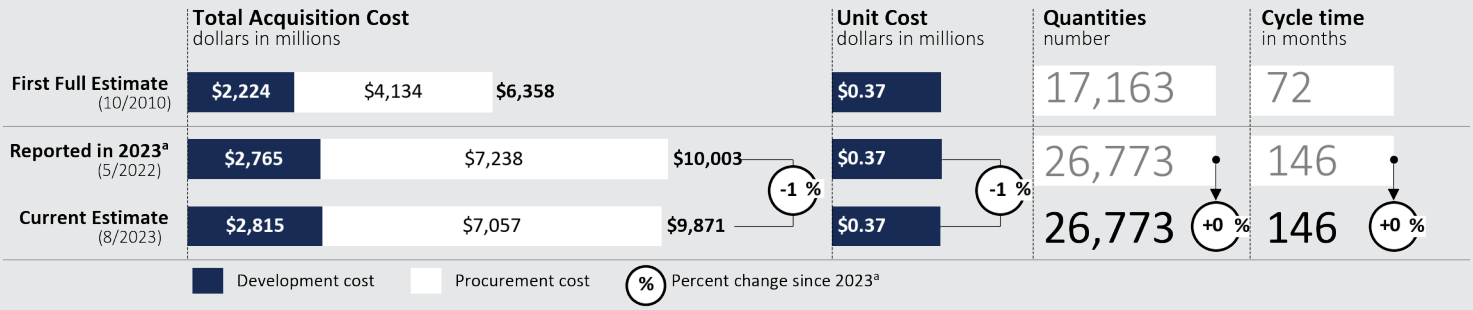
Small Diameter Bomb Increment II (SDB II)

Source: © 2009 Raytheon Company. | GAO-24-106831

The Air Force's SDB II StormBreaker is a joint-interest program with the Navy that is designed to provide attack capability against stationary and mobile targets in adverse weather from extended range. It combines radar, infrared, and semiactive laser sensors to acquire, track, and engage targets. It uses airborne and ground data links to update target locations, as well as a GPS and an inertial navigation system to ensure accuracy. SDB II will be integrated with various Air Force and Navy aircraft.



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise 163 development quantities and 26,610 procurement quantities. Cycle time is calculated using the F-15E initial capability date of September 2022.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Agile, Iterative (other than Agile)

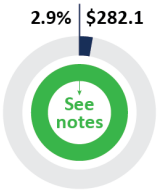
Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that initial software development was completed for fielding on the F-15E. Software is continually being updated for enhanced capability and fielding on other aircraft.

Program Essentials

Prime contractor: Raytheon Missiles and Defense

Contract type: FPI/FFP (procurement)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	●	●
Demonstrate all critical technologies in a realistic environment	○	●
Complete a system-level preliminary design review	●	●
Product design is stable	Design Review	
Release at least 90 percent of design drawings	…	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	●	●

● Knowledge attained ○ Knowledge not attained … Information not available NA - Not applicable

We could not assess SDB II design drawing stability at design review because the program implemented design changes after this event, but did not track these changes in such a way that we could assess the effect on design stability at the program's design review.

SDB II Program

Technology Maturity, Design Stability, and Production Readiness

The Air Force determined that it needed to increase the inventory of SDB II weapons from 17,163 to 26,773 based on user needs. As a result, the program is pursuing technology refresh efforts for several components. To meet the new procurement quantity, the program must find another supplier or redesign some components because of parts obsolescence, such as the control actuation system that guides the bomb. The program office stated that it awarded a $6.17 million contract in November 2023 to begin work on a redesign of the control actuation system, which is expected to be incorporated into SDB II in lot 12.

Production of the GPS military code (M-code) receiver—which provides a stronger, encrypted GPS signal intended to help military users overcome signal jamming—presents challenges. The program is ramping up production of the receivers in 2024 to meet low-rate production requirements. These receivers are expected to incorporate M-code for weapon deliveries in 2028. The program office stated it is working to procure additional test equipment for the receivers in 2024. SDB II will be the first Raytheon weapon with M-code capability, according to program officials.

Deliveries of 1,228 lot 6 units began in July 2022 and delivery of 1,100 lot 7 units is scheduled to begin in the third quarter of fiscal year 2024. Both lots have experienced production delays. The program reported that the supplier is not able to produce enough parts due to workforce shortages and sub-tier supplier shortfalls. The program established a new supplier that is expected to be fully qualified by spring 2024 to make up delivery time and minimize further delays. The program expects to resolve delivery delays by the end of lot 8 production in the third quarter of fiscal year 2025.

Software and Cybersecurity

The program continues to work with the National Security Agency to correct quality and timeliness issues with receiving modernized cryptographic keys, according to officials. These keys help to improve information security. The program successfully tested cryptographic modernization using test keys on the F-15E, F/A-18E/F, and F-35B/C aircraft.

Officials stated that the program completed four phases of DOD's Cybersecurity Test and Evaluation process. For example, the program completed vulnerability identification testing. As of October 2023, the program continues to work with the Director of Operational Test and Evaluation and the Navy to define future cybersecurity test requirements.

Other Program Issues

Initial capability on the F/A-18E/F is delayed by over a year since our last assessment due to issues discovered during aircraft operational testing, according to officials. While integrating SDB II capabilities, officials noted that it took longer to correct the errors because the aircraft did not have priority on the test range for flight testing.

SDB II is ready for testing on the F-35, but the F-35 program is still working through aircraft software development issues that continue to delay the completion of SDB II integration and testing. The program updated its baseline in May 2022 due to the F-35 delays. Program officials stated that the revised schedule accounts for the F-35 delays, and as of December 2023, SDB II is on track to meet the new dates.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

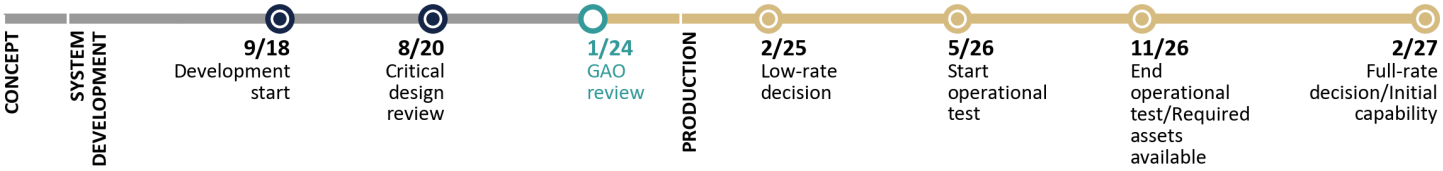
According to the program office, the SDB II program had significant events in 2023. Specifically, the program stated that it awarded both the lot 9 and lot 10 contracts. It also stated that it completed five developmental and operational tests for the F/A-18E/F and expects initial capability to occur by the end of June 2024.

Integration efforts on the F-35A/B/C are ongoing, according to the program office. It stated that it completed developmental testing for the F-35B but delayed operational testing to the end of March 2024 due to aircraft software integration issues. The program stated that it completed some flight tests in 2023 for the F-35C. It expects initial capability for F-35B/C to occur by the end of December 2025.

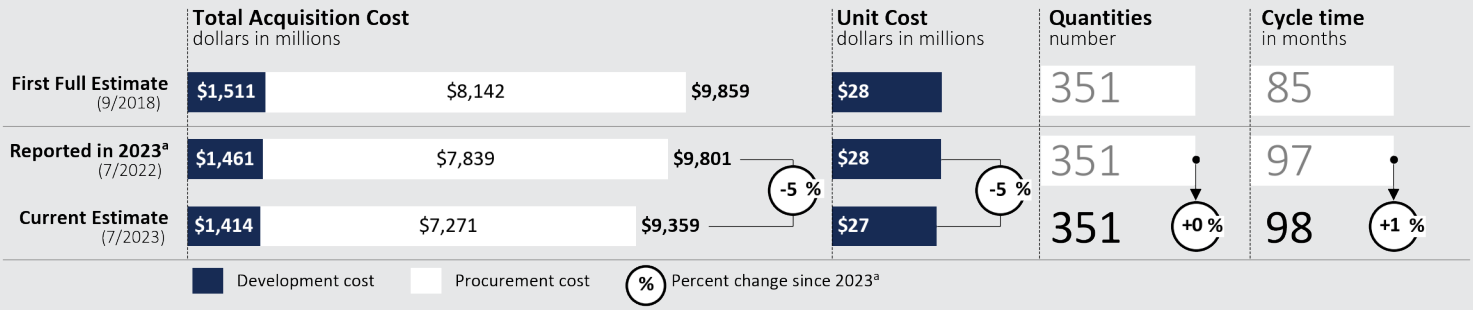
Source: Boeing Corporation. | GAO-24-106831

T-7A Red Hawk

The Air Force's T-7A Red Hawk program, formerly the Advanced Pilot Training program, is expected to replace the Air Force's legacy T-38C trainer fleet and related ground equipment. To field newer, more technologically advanced trainer aircraft, the program is developing two major components for the T-7A—the air vehicle, and an associated Ground-Based Training System. The T-7A program seeks to address the Air Force's advanced fighter pilot training needs and close training gaps that the T-38C cannot fully address.



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise five development quantities and 346 procurement quantities. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance. Acquisition cycle times for our current and prior assessment are calculated using required assets available dates.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Agile

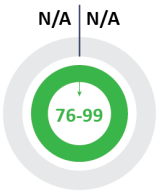
Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that difficulties in developing and testing flight control software resulted in a decrease in the frequency of testing and feedback. The program reported that it does not track software costs because the contract is fixed price.

Program Essentials

Prime contractor: Boeing

Contract type: FPI; FFP (development)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	●	●
Demonstrate all critical technologies in a realistic environment	○	○
Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	●	●
Test a system-level integrated prototype	○	○
Manufacturing processes are mature	**Production Start**	
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

We did not assess T-7A's manufacturing maturity because the system has yet to reach production.

T-7A Program

Technology Maturity and Design Stability

The Air Force rebaselined the schedule in April 2023 after declaring a schedule breach in June 2022 when it determined the low-rate production schedule was unachievable. We reported on these schedule challenges in our last assessment. Program officials stated that the rebaselined schedule remains optimistic, as it is predicated on favorable test outcomes with little margin for discovery of issues.

Safety and test concerns with the escape system continue to drive program delays and the potential for design changes. The program reported the canopy fracturing system as mature because it functioned as expected when tested in a relevant environment. However, while testing over the past year showed safety improvements, the program is still addressing the issue that ejecting from the aircraft continues to pose risks to smaller, lighter pilots. This includes the risk of concussion, body acceleration that could result in spinal injury, and eye and neck injury.

T-7A is testing changes to elements of the escape system to reduce the risk of injury. These include changes to the timing of parachute deployment and the explosive charge pattern on the canopy glass. A fully integrated system test is planned for February 2024. Several additional tests are also needed, which will likely put continued pressure on the schedule.

The program's other critical technology, the 8K projector for the Ground-Based Training System, is still approaching maturity. Program officials stated that while a production-representative projector is on track for delivery in 2024, integration work with prototype projectors has been slower than expected. Once the projector is delivered, the officials said that they plan to work with the user to mitigate risks and correct any lingering issues while still moving forward with the planned production decision.

Production Readiness

The Air Force accepted delivery of the first three developmental aircraft between September 2023 and December 2023 and expects delivery of the remaining two aircraft in the first half of 2024. We reported in May 2023 that the contractor began producing parts and plans to begin assembling the first production aircraft by early 2024, even though the Air Force has yet to place any orders for those aircraft. Beginning production at this point increases the risk of overlap between development, testing, and production, and the likelihood that the Air Force may face challenges from potential issues and retrofit work following the low-rate production decision, planned for February 2025. Overlap increases the consequences of rework because an issue discovered in testing may require redevelopment and retesting and then need to be retrofit on dozens of aircraft.

Because there is no production contract in place—or corresponding aircraft specifications—the Air Force cannot conduct comprehensive oversight of current production through its quality management plan delegated to the Defense Contract Management Agency (DCMA). To mitigate these risks, program officials stated that they executed agreements with Boeing and DCMA to enable limited oversight of production activities at Boeing and some subcontractors. However, DCMA officials noted that because this oversight is based on specifications that are likely to change, there is still significant risk that costly and time-consuming inspections will be needed before the Air Force can accept production aircraft.

Software

Delivery of the final software version—which is used by both the aircraft and the Ground-Based Training System—was expected in 2023, but it is now delayed until June 2024. Program officials stated that efforts to address flight-control issues under stressing maneuvers is adding time to development and further compressing testing plans. Because the Ground-Based Training System also relies on this software, the program cannot conduct integrated testing of the aircraft and simulators until the flight control software is delivered.

Other Program Issues

Program costs decreased by about 5 percent since last year. According to program officials, the program decreased the amount of risk reserve in its estimate since it determined it would not be needed as the program is approaching production.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

The program office stated that it is focused on delivering the T-7A Red Hawk to the Air Force Air Education and Training Command for training the Air Force's future fighter and bomber pilots. It also noted that it continues to partner with Boeing to prioritize schedule throughout all aspects of system development.

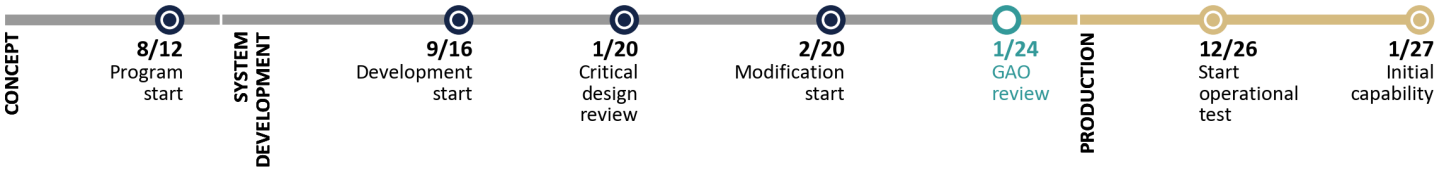
MDAP | Lead Component: Air Force

Common Name: VC-25B

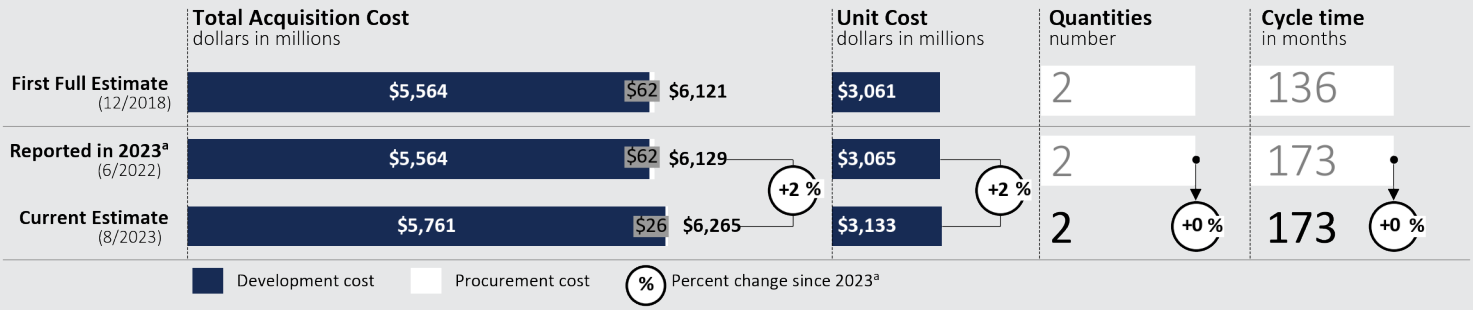
Source: The Boeing Company. | GAO-24-106831

VC-25B Presidential Aircraft Recapitalization (VC-25B)

Through its VC-25B program, the Air Force is replacing the current two VC-25A presidential aircraft with two modified Boeing 747-8 aircraft. The Air Force plans to modify the commercial aircraft to provide the U.S. president, staff, and guests with safe and reliable air transportation, with the same level of security and communications available in the White House. Aircraft modifications will include structural modifications, electrical power upgrades, a mission communication system, military avionics, executive interiors, and other systems.



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise two development quantities and zero procurement quantities. Cycle time is calculated using the required assets available date. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance. Program officials noted that the cost increase over the past year is primarily related to product support contract efforts, such for as initial spares and support equipment, that have yet to be awarded and may cost more than initially estimated in 2018 due to subsequent economic changes.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Agile, Iterative (other than Agile), and Waterfall

Frequency of end user evaluation (months)

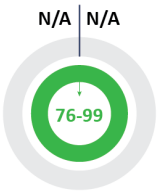
Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that it does not track software costs under the firm-fixed-price contract.

Program Essentials

Prime contractor: Boeing

Contract type: FFP (development)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	NA	NA
Demonstrate all critical technologies in a realistic environment	NA	NA
Complete a system-level preliminary design review	○	●
Product design is stable	Design Review	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	○
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

We did not assess VC-25B critical technologies because the program stated that the system does not have any. We also did not assess manufacturing maturity because the program stated that it has no formal production phase and that its two modified aircraft are the final delivered products.

VC-25B Program

Technology Maturity, Design Stability, and Production Readiness

VC-25B program officials stated that Boeing continued to make incremental progress during 2023 with wiring and interior design refinement, and in other areas. For example, according to VC-25B officials, Boeing started producing wiring bundles that will be incorporated into the aircraft's racks, panels, and cabinets. Also, program officials stated that Boeing fully definitized the new interior supplier contract in December 2023, and the supplier completed designs for several areas of the aircraft, such as the passenger seat layout. We previously reported that Boeing had completed major structural modifications and begun preparations for wiring installation on the first aircraft.

Boeing continues to make progress on addressing four major schedule risks that we reported on previously. However, incorporating interiors and wiring design changes led to structural design changes and modification rework, because Boeing was working on the design of the wiring as the aircraft was being built, according to program officials.

More specifically on the four schedule risks:

- Boeing is addressing issues related to decompression and the environmental control system that contribute to excess noise in the aircraft cabin, among other things. Program officials expect Boeing to present proposed design solutions in January 2024.
- Boeing is continuing to develop its wire installation plans. According to program officials, delays in wiring the aircraft due to wiring design changes contributed to modification rework and affected the timely completion of other work on the aircraft. Program officials expect the wiring installation plan to be completed in September 2024.
- Boeing continues to face challenges hiring and retaining aircraft mechanics. It achieved peak staffing requirements in 2022, according to program officials. However, they said Boeing fell below these requirements in 2023 due to mechanic attrition. They explained that aircraft design and build inefficiency decreased the amount of work available, making it difficult to retain mechanics. Boeing is continuing to focus on hiring additional mechanics and improving mechanic performance to increase quality levels and reduce rework, according to program officials. They added that finding qualified mechanics who can acquire necessary clearances continues to be a hiring challenge.
- Boeing will not complete flight test plans for the two aircraft until their first flight dates, which are projected to occur in October 2024 and October 2025, respectively, according to program officials. They stated that Boeing engineers who develop the flight test plans have been working on higher-priority issues including wiring redesign instead. Delays in flight test plans could delay first flight, which increases the risk of testing delays and Boeing's ability to meet other program milestones. VC-25B officials said that Boeing added 4 months to the end of developmental testing to provide additional time to address any discoveries made during developmental testing, currently planned to start in October 2024.

Software and Cybersecurity

According to program officials, the commercial derivative aircraft are required to meet Federal Aviation Administration cyber standards to obtain certification. A team within the program office plans to monitor cybersecurity and will determine a path forward to address any identified vulnerabilities.

Other Program Issues

In June 2023, Boeing updated its integrated master schedule to reflect delays in wiring design and fabrication and modification rework. Program officials stated that Boeing plans to update the integrated master schedule in the second quarter of fiscal year 2024, to cover activities up to first flight of the first aircraft. They also said that it has yet to be determined when Boeing will provide the remainder of the schedule through aircraft delivery to the program office. As of September 2023, Boeing reported a loss of over $2.4 billion related to modifying the two aircraft.

Officials stated that repairs of VC-25B stress-corrosion cracks on certain aircraft support structures are ongoing. The cracks were originally discovered on the 747-8 commercial fleet in 2019. Program officials anticipate that VC-25B repairs will be completed by summer 2024, a year later than the program reported for our last assessment, due to challenges with a redesigned repair and Boeing's ongoing workforce limitations.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

The program office stated that it will continue to work with Boeing to manage all program risks to modify, test, and deliver presidential mission-ready VC-25B aircraft.

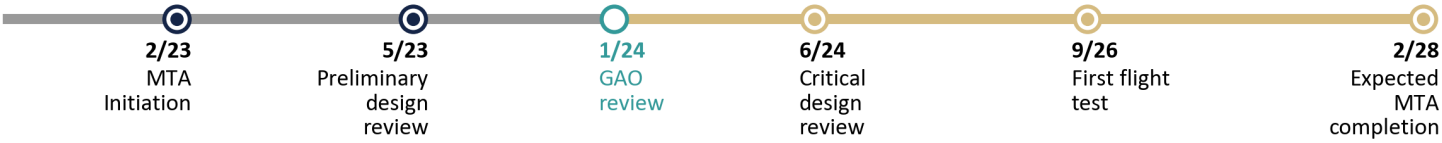
MTA | Lead Component: Air Force

Common Name: E-7A RP

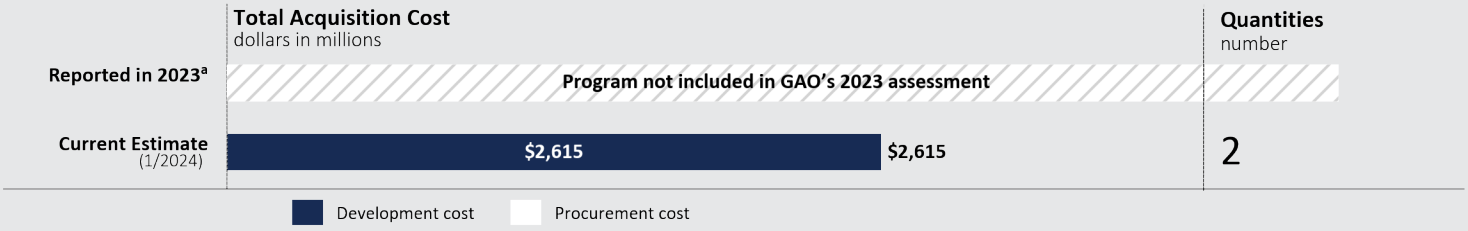
Source: Boeing Defense, Mobility, Bombers and Surveillance. | GAO-24-106831

E-7A Rapid Prototyping (E-7A RP)

The Air Force's E-7A program, using the MTA rapid prototyping pathway, intends to modify an existing aircraft design to replace the aging E-3 Sentry aircraft. The resulting prototype is expected to demonstrate an enhanced airborne warning and control system aircraft with advanced detection, tracking, identification, and targeting capabilities—while enabling faster delivery of production aircraft.



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2024 dollars in millions



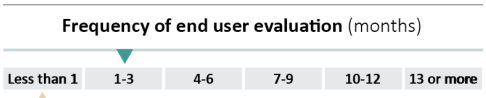
[a]GAO-23-106059.

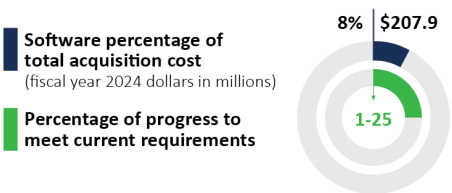
Program Background and Transition Plan

The Air Force initiated E-7A RP as an MTA effort in February 2023. Program officials stated that the MTA effort is to modify an existing design used by international partners to meet U.S. requirements—such as those related to Federal Aviation Administration certification. The program aims to build two prototype aircraft, support flight testing, and deliver a residual capability, while enabling faster delivery of production aircraft. Officials plan to begin production efforts by August 2025, prior to rapid prototyping completion, through a follow-on program using either the MTA rapid fielding or major capability acquisition pathway. Officials stated that production activities are planned to occur concurrently with the rapid prototyping effort to offset the multiyear lead time associated with acquiring a new commercial aircraft to modify for military use.

Software Development as of January 2024

Approach: Agile and DevSecOps





Program Essentials

Prime Contractor: Boeing

Contract type: CPIF/CPFF

Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case	Status at Initiation	Current Status
Approved requirements document	●	●
Approved middle tier of acquisition strategy	●	●
Formal technology risk assessment	●	●
Cost estimate based on independent assessment	●	●
Formal schedule risk assessment	●	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

E-7A RP Program

Key Elements of Program Business Case

The E-7A RP program had all elements of its business case approved before program initiation in February 2023. This includes program requirements, an acquisition strategy, schedule risk assessment, and technology risk assessment. The cost estimate was independently assessed in February 2023; however, program officials noted that it is currently being updated to support the fiscal year 2025 President's budget based on design and supply chain considerations.

Leading Product Development Practices

E-7A RP program officials stated that they are using an iterative design approach for certain components of the system, such as software and other mission systems. However, other components that already meet requirements are being reused from an existing design. These components—such as the radar—will not be iterated on during the MTA effort. Additionally, program officials explained that iterating on certain program requirements—such as those related to Federal Aviation Administration certifications—would not be practical.

The program is incorporating several additional practices that we found leading companies employ to deliver innovative products rapidly, including the use of digital models and involving users and stakeholders in design and testing to incorporate feedback. For example, in addition to recurring meetings with user representatives and stakeholders, the program has an air battle manager (the systems user) embedded with the development team to provide continuous feedback. The program is integrating both users and maintainers into the software development process to provide regular design feedback and to ensure maintainability. Program officials also stated that while they currently use model-based systems engineering and 3D models, they would like to move toward more advanced digital models in the future.

Software and Cybersecurity

Program officials stated that one of their primary goals for software development is to refactor and re-architect the existing mission systems software to better support future upgrades and new capabilities—such as new sensors—while also easing maintenance. For example, program officials stated that the existing software is based on a tightly coupled architecture, but that they intend to independently validate that the newly refactored software is modular, open, and compliant with a government reference architecture to support future development using a software factory.

The program's cybersecurity strategy was approved in February 2023 and the program plans to conduct cybersecurity assessments including adversarial assessments, among others, prior to MTA completion. The program office intends for these assessments to help evaluate that the system design will meet cybersecurity requirements.

Other Program Issues

Program officials identified significant funding shortfalls for the rapid prototyping effort. These officials stated that the shortfalls are driven by higher-than-expected estimates for updating hardware and software to provide U.S. Air Force-required program and cybersecurity capabilities, address supply chain issues, and resolve other issues.

Program Office Comments

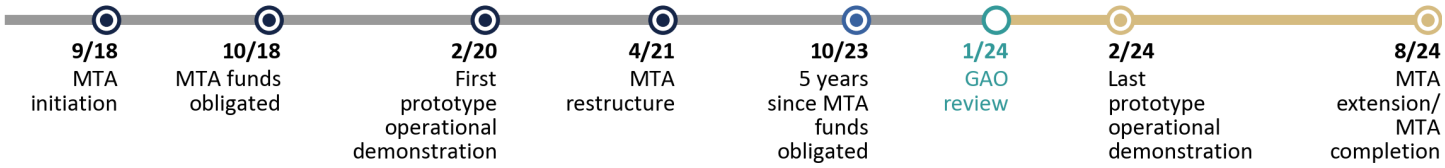
We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

The program office stated that fiscal year 2024 and 2025 budget decisions may impact its ability to complete the program within the 5-year MTA statutory objective and delay the program's production decision. The program also stated that it directed the contractor to slow execution and deliver a plan to mitigate schedule impacts. It noted that the assessment of these alternatives is ongoing and will be reported once final budget decisions have been made.

Source: Defense Visual Information Distribution Service. | GAO-24-106831

F-22 Rapid Prototyping

The F-22 program, utilizing the MTA rapid prototyping and fielding pathways, intends to develop, integrate, and deliver hardware and software capabilities to F-22 aircraft. This assessment focuses on the rapid prototyping effort, which is expected to develop enhanced capabilities, including for tactical information transmission, combat identification, navigation, sensors, fuel tanks, and electronic protection.



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2024 dollars in millions

	Total Acquisition Cost (dollars in millions)	Quantities (number)
Reported in 2023[a]	Not approved for public release by the Air Force	4
Current Estimate (1/2024)	Not approved for public release by the Air Force	5 (+25 %)

Quantities represent the planned number of prototype demonstrations during the MTA effort.
[a]GAO-23-106059.

Program Background and Transition Plan

F-22 Rapid Prototyping partly replaced a prior MTA effort, the F-22 Capability Pipeline. The Air Force restructured the Capability Pipeline in April 2021 into separate rapid prototyping and rapid fielding efforts. F-22 Rapid Prototyping expected to demonstrate four prototypes to enhance six capabilities by the end of its 5-year MTA effort in October 2023. However, DOD approved an extension of the effort through August 2024 to add and demonstrate a fifth prototype and conduct follow-up analysis. The program plans for most demonstrated capabilities to transition as individual programs to the major capability acquisition pathway, though the program is considering the rapid fielding pathway for some capabilities under development.

Software Development as of January 2024

Approach: Agile, DevOps, and DevSecOps

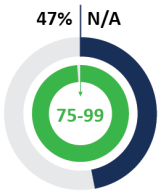
Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The Air Force did not approve the public release of the software cost in dollars.

Program Essentials

Prime Contractor: Lockheed Martin

Contract type: CPFF/CPAF/FFP (development)

Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case	Status at Initiation	Current Status
Approved requirements document	●	●
Approved middle tier of acquisition strategy	●	●
Formal technology risk assessment	○	●
Cost estimate based on independent assessment	○	●
Formal schedule risk assessment	○	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

F-22 Rapid Prototyping Program

Updates to Program Performance and Business Case

The program expected to complete its 5-year MTA effort in October 2023. However, program officials stated that DOD approved their request to extend the MTA effort through August 2024 to finish work on the sensors enhancements capability. According to the officials, the extension helps to manage risk and meet defined user requirements. Officials stated that they are planning a fifth demonstration under the MTA during the extension that will feature the sensors enhancements capability.

Prior to the extension, the program reported that it completed a fourth prototype demonstration in March 2023. During the demonstration, the program ran government-sourced software, enabled by its Open Systems Architecture critical technology, to process F-22 mission system data in real time. According to program officials, this demonstration furthered their confidence that open systems allow the government to apply its own software on F-22 aircraft. In June 2023, we reported that program officials stated that open systems could increase innovation and lead to more affordable capability deliveries in the future.

Leading Product Development Practices

The program reported that it is using an iterative approach for development, and cited practices that we found leading companies employ to successfully develop and deliver products to users with speed. For example, the program incorporates feedback from stakeholders across multiple decision-making phases to refine requirements, and it is planning to field a minimum viable product with subsequent releases. In addition, the program has a long-established use of modularity in both hardware and software, which officials stated has resulted in multiple outside products being integrated into the jet.

The program has not used digital twins (virtual representations of physical products) or digital threads (a common source of digital information), but officials say they may for future efforts. We found that leading companies use digital twins of an integrated prototype—including all hardware and software—to test the product's functionality and uncover problems as design requirements change. The use of digital threads could also inform decision-making by connecting stakeholders with real-time data.

Software and Cybersecurity

The program continued to report software development as a high risk. According to the program, requirement changes have resulted in additional software development efforts, which is a new factor contributing to software development risk this year. For example, program officials stated that changes in fielding requirement dates for some software content affected the composition of development teams as key personnel transitioned to other efforts.

Other Program Issues

Program officials stated that F-22 modernization has been hampered without the ability to fully demonstrate the tactical information transmission capability that was originally planned for the first prototype. Officials stated that conducting a full demonstration has been the primary challenge during the MTA effort and required the program to defer the planned capability. They do not expect a full demonstration until fiscal year 2025, even though some F-22 aircraft have been ready to test the capability since fiscal year 2021.

As we reported in June 2020, the program continues to face testing capacity challenges. Program officials stated that they made efforts to relieve pressure on testing labs by working with the F-22 contractor to develop simulated environments. They stated that they have incentivized the contractor to improve software-based testing. According to officials, Air Combat Command has required the use of simulators for testing; however, the program still needs to integrate simulator systems to use them. Officials stated that the program could start using these simulators in 2027 or 2028.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

According to the program office, over the past year it successfully transitioned five of the six approved capabilities out of the F-22 Rapid Prototyping MTA effort and into separate major capability acquisition programs. The program stated that the F-22 Rapid Prototyping MTA effort was extended through August 2024 to accommodate completion of the remaining sensors enhancement demonstration and determination of a follow-on acquisition strategy.

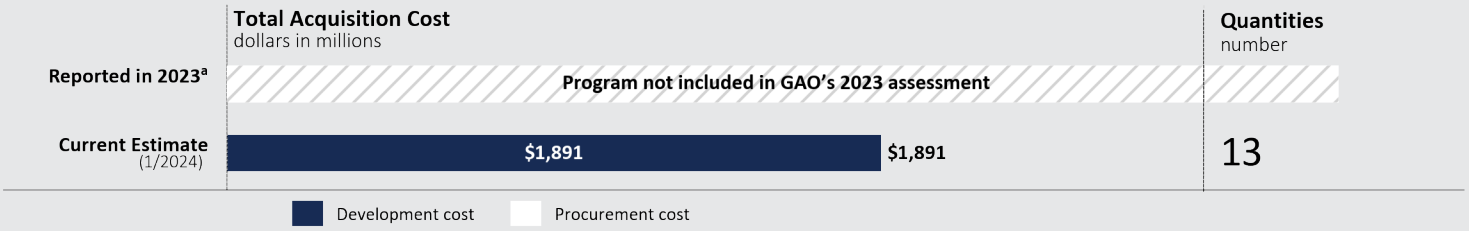
Common Name: HACM

Source: Raytheon. | GAO-24-106831

Hypersonic Attack Cruise Missile (HACM)

The Air Force's HACM program, a rapid prototyping MTA effort, is developing a conventional, air-launched hypersonic missile that can be carried by an F-15 tactical aircraft. According to officials, the missile consists of two stages, a rocket booster and a scramjet cruiser, which separates from the booster and eventually dives toward its target. The Air Force plans to produce 13 missiles during the rapid prototyping effort, including test assets, spares, and rounds for a residual operational capability.

Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2024 dollars in millions



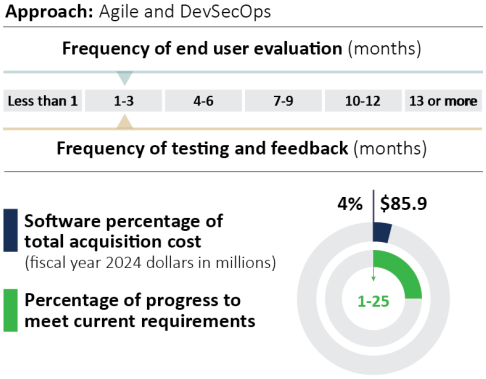
[a]GAO-23-106059.

Program Background and Transition Plan

The Air Force initiated HACM as an MTA rapid prototyping effort in 2022 based on a Defense Advanced Research Projects Agency scramjet demonstrator, known as the Hypersonic Air-breathing Weapon Concept. This hypersonic demonstrator served as the basis for the HACM cruiser. According to officials, the launch aircraft, booster, payload, and guidance system, along with an interstage that connects the cruiser and booster, are new to HACM and make it operationally capable. The program completed subsystem critical design reviews of the initial design and plans to complete a review of the final design in 2025. The Air Force plans to transition HACM to the major capability acquisition pathway at either development start or production start in 2027, depending on what capabilities the Air Force is willing to accept and whether production facilities are ready.

Software Development as of January 2024

Approach: Agile and DevSecOps



Program Essentials

Prime Contractor: Raytheon Missiles and Defense

Contract type: CPFF

Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case	Status at Initiation	Current Status
Approved requirements document	●	●
Approved middle tier of acquisition strategy	●	●
Formal technology risk assessment	●	●
Cost estimate based on independent assessment	●	●
Formal schedule risk assessment	○	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

HACM Program

Key Elements of Program Business Case

The HACM program did not have one key element of its business case—a formal schedule risk assessment—at the time of initiation in September 2022. The schedule risk assessment has since been approved. Our prior work has shown that this type of information is important to help decision-makers make well-informed decisions about MTA program initiation. This includes whether the program is likely to meet the statute-based objective of fielding a prototype that can be demonstrated in an operational environment and provide for a residual operational capability within 5 years of program start. The program completed its first schedule risk assessment in June 2023 with the contractor. According to program officials, HACM has direction from Air Force leadership to move as quickly as possible, and schedule risk assessments would likely note that higher level of risk.

The program completed the other four key elements of its business case—approved requirements, an approved acquisition strategy, formal technology risk assessment, and independent cost estimate—before initiation. The HACM requirements were approved by the Air Force in November 2021. The DOD-level Joint Requirements Oversight Council has yet to validate those requirements, but program officials expect that to occur before HACM transitions to the major capability acquisition pathway. From a technology perspective, the program reported that the critical technologies underpinning HACM design were either immature or nearing maturity at initiation. The program expects them to be fully mature by the end of the rapid prototyping effort. The Air Force Cost Analysis Agency completed an independent cost estimate in advance of initiation and updates it annually.

Leading Product Development Practices

The HACM program reported that it is using an iterative approach for development, and cited practices that we found leading companies employ to successfully develop and deliver products to users with speed. For example, the program is attempting to leverage digital design tools, up to and including fully digital design reviews. The program stated, however, that there are challenges to conducting these reviews, including the sheer number of tools, licensing restrictions, limited computing power, and the logistics of doing so in a way that is accessible to the large number of program stakeholders.

The program is not planning to use digital twins—which are virtual representations of physical systems and more dynamic than the 3D models HACM uses. According to the program office, it is still working to create a digital foundation that would allow it to build a digital twin in a future phase of the effort. Digital twins can help development teams iterate on the system's design to meet the most important user needs.

In terms of validation and testing, HACM will physically test integrated prototypes as it iterates the design. According to officials, the program will conduct an incremental critical design review on an initial configuration prior to flight testing in 2025. Officials stated that the program will then continue to develop and improve the design until it can conduct a system-level design review and flight test on the final, operational configuration.

Program officials stated that breaking the design and demonstration processes into incremental steps is part of their strategy to speed the development of the system. This approach could be improved by incorporating continuous user feedback throughout these types of iterative development cycles to determine if the design meets user needs, but HACM does not have plans to solicit this type of feedback. Program officials did state that users could provide some feedback during operational testing, but this would primarily serve to facilitate users learning the system, rather than informing the design.

Software and Cybersecurity

According to program officials, software development has not been identified as a risk for HACM. The first of five software deliveries is scheduled to start qualification testing in July 2024.

As of October 2023, the program reported that its final cybersecurity strategy was in the process of being signed and approved. HACM does not have any top-level performance requirements for cybersecurity, but according to program officials, cybersecurity is part of the criteria for major design reviews.

Other Program Issues

Test range availability and limitations have been an issue for hypersonic programs. To alleviate this issue, the HACM program is integrated with the Southern Cross Integrated Flight Research Experiment, a joint U.S.-Australian effort. Through this joint effort, several of HACM's planned flight tests will occur in Australia using Australian Air Force F/A-18s.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

ARMY

Program Assessments

▲ Future Long Range Assault Aircraft (FLRAA)

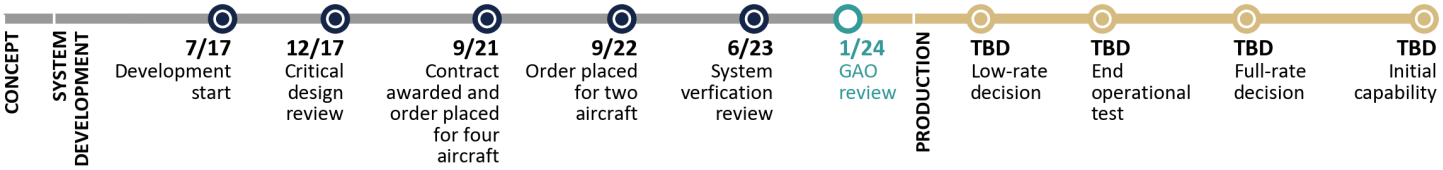
Assessment type	Program name
MDAPs	CH-47F Block II Modernized Cargo Helicopter (CH-47F Block II)
	Improved Turbine Engine Program (ITEP)
	M10 Booker
	Precision Strike Missile (PrSM)
MTA Programs	Future Long Range Assault Aircraft (FLRAA)
	High Accuracy Detection and Exploitation System (HADES)
	Indirect Fire Protection Capability Increment 2 (IFPC Inc 2)
	Integrated Visual Augmentation System Rapid Fielding (IVAS)
	Maneuver Short Range Air Defense Increment 3 (M-SHORAD Inc 3)
	Mid-Range Capability (MRC)
	XM30 Mechanized Infantry Combat Vehicle (XM30)
Future Major Weapon Acquisitions	Extended Range Cannon Artillery (ERCA)
	Future Attack Reconnaissance Aircraft Program (FARA)
	Long Range Hypersonic Weapon System (LRHW)
	Lower Tier Air and Missile Defense Sensor (LTAMDS)

Source (previous page image): Bell Textron, Inc. | GAO-24-106831

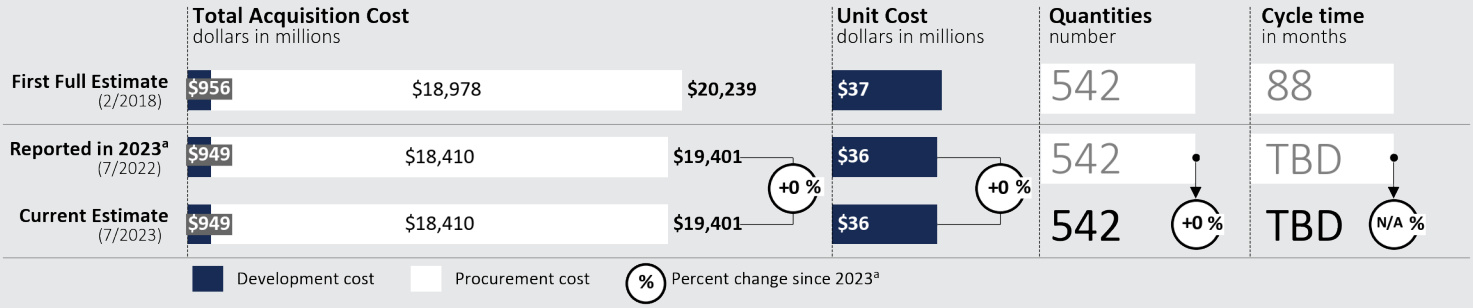
Source: U.S. Army. | GAO-24-106831

CH-47F Block II Modernized Cargo Helicopter (CH-47F Block II)

The Army's CH-47F Block II program upgrades the CH-47F aircraft and is intended to provide additional capability, greater reach, and increased payload capacity. Improvements include a strengthened airframe and drive train, improved flight controls, and upgraded fuel and electrical systems to increase lift in all weather conditions. The Army expects the CH-47F Block II fuel and rotor system improvements to reduce operating and support costs. CH-47F helicopters provide the Army's only heavy-lift capability and are scheduled to remain in service through 2060.



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise three development quantities and 539 procurement quantities, including 69 MH-47G Block II aircraft for Special Operations Forces. Program performance data may change because of the ongoing rebaselining effort, which the program expects to complete after the Army's decision about the future of the program. The program did not report an initial capability date and, as a result, the cycle time could not be calculated. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Agile, Iterative (other than Agile), and DevSecOps

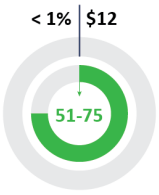
Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



Program Essentials

Prime contractor: Boeing

Contract type: CPIF (development); FPI/IDIQ (production before low-rate production decision)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	●	●
Demonstrate all critical technologies in a realistic environment	○	●
Complete a system-level preliminary design review	●	●
Product design is stable	Design Review	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

We did not assess CH-47F Block II manufacturing maturity because the program has yet to reach the production phase. The program stated that, in response to direction by congressional conferees, it contracted to procure Block II aircraft prior to the production decision.

CH-47F Block II Program

Technology Maturity and Design Stability

The CH-47F Block II program reported that its one critical technology is fully mature, but the program continues to face related uncertainties based on the industrial base and alternate suppliers. The technology relies on proprietary components provided by a single supplier. According to program documentation, the prime contractor has not conducted an industrial base capability assessment, which includes a study of supplier capacity and output to assess the supplier's production capability. The prime contractor identified an alternative supplier to use in case the original supplier cannot meet production needs. According to the program, the industrial base capability assessment can be conducted once a path forward decision has been made and low-rate initial production quantities are determined.

As we previously reported, the fuel system was redesigned as a result of test failures. The redesigned system passed the first phase of testing. The program plans to conduct more tests in the first quarter of fiscal year 2025 to confirm survivability.

Production Readiness

The time frame for the low-rate production decision, originally planned for the fourth quarter of fiscal year 2021, continues to slip. As we previously reported, the decision was delayed due to technical concerns found in testing as well as funding shortfalls. The program now anticipates a production decision approximately 18 months after the Army's path forward determination. Army officials stated in November 2023 that they anticipate this decision in the near-term. They added that multiple factors are being considered, including industrial base health and future fleet readiness and force structure.

According to the program, an advanced procurement order for long lead items for a third lot was placed in September 2022. Program officials stated that the number of Lot 3 aircraft will be determined during negotiations. As we previously reported, to maintain the production line, the Army reported placing orders with Boeing in 2021 and 2022 for six aircraft in total.

A production readiness review was conducted in support of the systems added after a congressionally mandated increase in program funding. The review stated that the program could produce quantities of less than seven per year but did not meet the criteria to support the larger quantities associated with low-rate production. The Army stated that the review identified manageable risks related to the requirements for the added systems and low-rate production.

The review recommended that an additional production readiness assessment be conducted prior to the low-rate decision to ensure risks have been mitigated. Low-rate production would require ramping up to a production rate higher than seven aircraft per year and moving from a pilot production line to a main production line. According to the Army, Boeing's transition plan for Block II includes moving from the pilot line to the main production line for foreign military sales production, which it stated provides enough production volume (12 aircraft per year) to necessitate the move.

The review further noted risks related to tooling, staffing levels, and the supply chain. According to the program, the contractor has mitigation plans in place to address these risks. Even so, as the review noted, these issues could limit or delay production until the program addresses them.

Software and Cybersecurity

The program reported an increase in software costs due to changes necessary to support rotor blade, electrical system, and fuel system configuration changes. However, according to the Army, the CH-47 software is common and shared across the CH-47 fleet. The Army stated that, as a result of these shared costs, the software costs will not increase the CH-47F Block II program costs.

As we reported last year, cybersecurity continues to pose a medium risk to the program due to findings from vulnerability penetration testing conducted in 2021. The Army stated that the program is working with the contractor to implement mitigation plans.

Other Program Issues

The program office identified several consequences arising from ongoing production decision delays. For example, due to their age, many aircraft were identified to be upgraded to Block II capabilities after production start. If these Block II upgrades are further delayed, the Army will have to undertake a recapitalization program to ensure these aging aircraft continue to meet readiness requirements. According to officials, if the industrial base is not maintained, the program will lose suppliers and manufacturing knowledge and the program would face increased schedule delays and costs due to production stops and restarts.

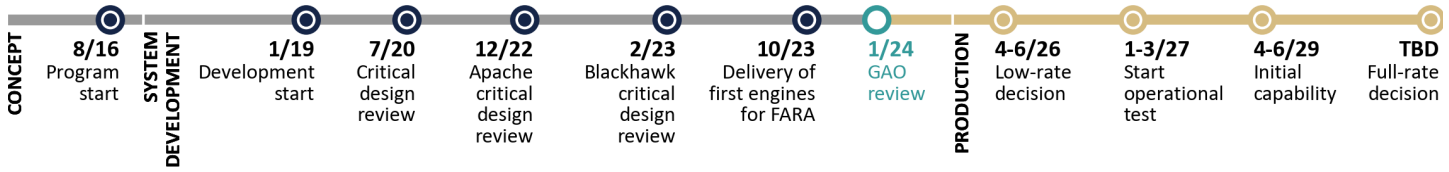
Program Office Comments

We provided a draft of this assessment to the Army for review and comment. It provided technical comments, which we incorporated where appropriate. The Army stated that it is procuring three additional CH-47F Block II aircraft under Lot 3 with fiberglass rotor blades. It also stated that developmental testing was completed to validate key troop and cargo-carrying capabilities under operationally-relevant high and hot conditions. According to the Army, the program's path forward decision is pending formal approval and release.

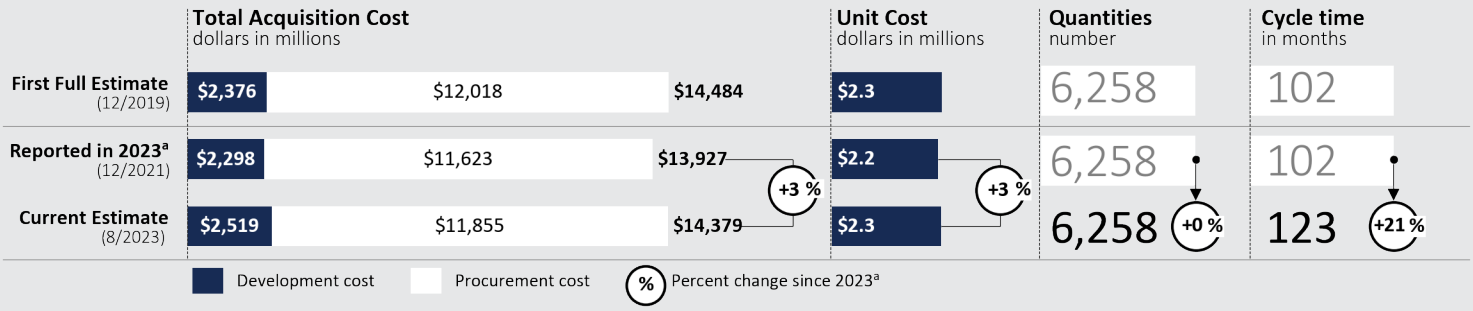
Improved Turbine Engine Program (ITEP)

The Army's ITEP is developing a next generation turbo-shaft engine for the Black Hawk, Apache, and Future Attack Reconnaissance Aircraft (FARA) fleets. The program includes engine development, manufacturing, platform integration, and qualification. According to requirements approved by the Army, the improved turbine engine needs to fit inside the existing engine compartments of Black Hawk and Apache helicopters; be compatible with FARA; and provide power, fuel efficiency, reliability, and sustainment improvements.

Source: U.S. Army. | GAO-24-106831



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise 69 development quantities and 6,189 procurement quantities. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Agile and Incremental

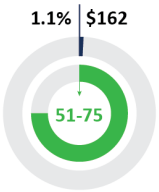
Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that costs increased from last year due to the inclusion this year of software costs related to integration of the engines with the Black Hawk and Apache helicopters. Prior reported software costs included only engine software development costs.

Program Essentials

Prime contractor: GE Aerospace

Contract type: CPIF

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	●	●
Demonstrate all critical technologies in a realistic environment	○	○
Complete a system-level preliminary design review	●	●
Product design is stable	Design Review	
Release at least 90 percent of design drawings	●	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

We did not assess ITEP's manufacturing maturity because the program has yet to reach production.

ITEP

Technology Maturity and Design Stability

ITEP's three critical technologies are approaching maturity, with no progress reported since our last assessment. As we noted last year, further maturation is not expected until the engine completes substantial flight testing in an operational environment.

The engine design meets leading design stability practices. Nevertheless, until the program fully matures its technologies, it risks issues emerging during testing that could require redesigns, further disrupt testing and aircraft integration, and delay engine qualification.

Acceptance testing of the first two prototype FARA engines concluded in October 2023. Both engines were delivered to the FARA program in October 2023, a delay to the originally planned date of January 2022. As we reported last year, the Army attributed this delay to parts manufacturing challenges, which persist.

The delays in GE Aerospace receiving parts from suppliers delayed the start of preliminary flight rating testing for other engines by 3 months, to September 2023. If these delays continue, program officials expect them to delay additional engine assemblies intended for Apache and Black Hawk platforms, which in turn could delay flight testing in early fiscal year 2025 and engine qualification in 2026 on both platforms. According to program documentation, the program originally anticipated completing engine qualification testing prior to production start.

Despite these delays, ITEP continues to make progress on platform integration. It completed the critical design review for Black Hawk integration in February 2023, and Apache laboratory risk reduction activities are ongoing.

Production Readiness

According to program officials, GE Aerospace and its suppliers have struggled with staffing critical manufacturing positions. Specifically, insufficient staff and experience levels combined with new manufacturing processes have contributed to parts quality issues, resulting in rework and delays. Program officials have developed corrective actions for at-risk vendors and are implementing mitigations, such as identifying alternate vendors and assessing the cost and schedule impacts of alternate sourcing.

Engine production start is currently scheduled for the third quarter of fiscal year 2026, but, as described above, GE Aerospace is behind schedule in completing activities required prior to production start. GE Aerospace's ability to meet the planned date is dependent on the above discussed management of their immature manufacturing processes, including additive manufacturing, and quality performance of GE Aerospace and its suppliers.

Software and Cybersecurity

Multiple software releases planned for 2022, 2023, and 2024 were delayed. The primary driver was the delay of engine control hardware that required software rework. According to program officials, ITEP is experiencing challenges hiring and retaining software professionals, including software engineers with specialized airworthiness experience. Additionally, they noted a significant turnover of contractor software staff due to the competitive nature of the industry.

Two developmental cybersecurity tests of the engine, originally scheduled for 2023, are now planned for the end of fiscal year 2024 and start of fiscal year 2025. These delays could make it harder to address any issues discovered during testing. Our past work has shown that early discovery of vulnerabilities makes them easier to fix and reduces schedule risk.

Other Program Issues

In March 2023, the milestone decision authority approved ITEP's new program baseline following Army Contracting Command's letter of concern regarding GE Aerospace's schedule slips and cost growth. ITEP's new baseline moved initial operational capability from 2027 to 2029.

In June 2023, in its response to the letter of concern, GE Aerospace acknowledged its role in the delays and cost growth but stated that the government directly contributed to cost and schedule growth by expansion of in-scope effort, risk-inducing contract modifications, and an unwillingness to accept industry test analysis standards. In June 2023, GE Aerospace submitted a new schedule, designed to address the continued schedule degradation, that is currently under review by the program. According to program officials, ITEP is currently on track to meet the revised baseline set in March, but continued hardware delays could likely shift developmental testing and subsequent major milestones by an additional 6 to 12 months.

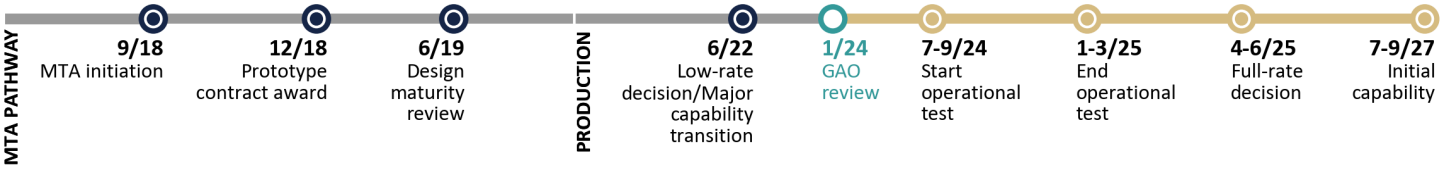
Program Office Comments

We provided a draft of this assessment to the Army for review and comment. The Army provided technical comments, which we incorporated as appropriate. The Army stated that it continues to manage cost, schedule, and performance of ITEP to field the new engine for platforms by fiscal year 2027. It added that engine testing to date has achieved maximum power and validated performance and operability model predictions. According to the Army, the Aviation Turbine Engines program office continues to aggressively assess the delivery dates amid global supply chain issues.

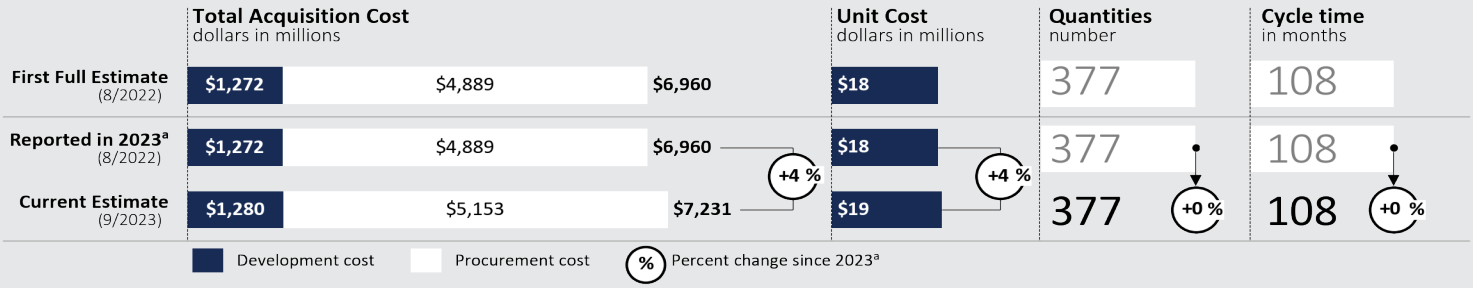
Source: U.S. Army. | GAO-24-106831

M10 Booker

The Army intends for the M10 Booker combat vehicle, formerly the Mobile Protected Firepower (MPF), to provide a new direct fire capability for support of infantry units across a range of military operations. One key program requirement is that the M10 Booker be air-transportable to enable initial entry operations. In June 2022, the M10 Booker transitioned from the MTA rapid prototyping pathway to the major capability acquisition pathway for production. The Army developed 24 prototype vehicles with two vendors during the MTA effort.



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise 27 development quantities and 350 procurement quantities. Total acquisition cost includes the program's MTA rapid prototyping effort. We measured cycle time from the start of the MTA rapid prototyping effort to the date the program plans to achieve initial operational capability. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance.
[a]GAO-23-106059.

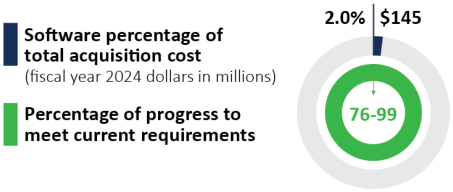
Software Development as of January 2024

Approach: Iterative (other than Agile) and Incremental

Frequency of end user evaluation (months)
Other frequency (see notes)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)



The program reported that there will be an interval between contract award and vehicle delivery before soldier feedback can resume. According to the program, the change in the frequency of testing and feedback from last year is due to changes in the timing of vehicle delivery.

Program Essentials

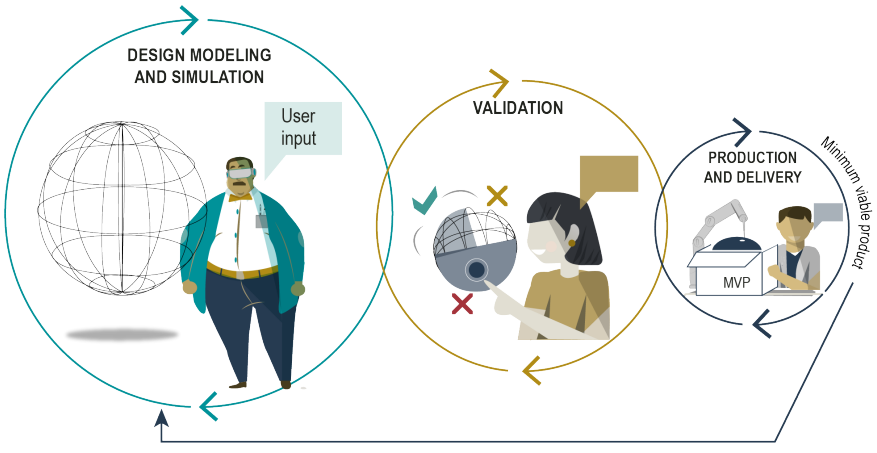
Prime contractor: General Dynamics Land Systems

Contract type: FFP; FPIF; CPFF

Attainment of Product Knowledge as of January 2024

Plan for leading product development practices

We have ongoing work to refine our leading product development practices associated with iterative development. We plan to use this space in the future to assess program implementation of leading practices, including those programs transitioning from the middle tier of acquisition to major capability acquisition pathway. These leading practices criteria include plans to use tools and approaches that refine requirements into a minimum viable product (MVP) with users through iterative cycles of development, as depicted in the figure below. The MVP is the initial set of warfighting capabilities suitable to be fielded in an operational environment that provides value to the warfighter in a rapid timeline.



Source: GAO analysis of leading company information; GAO (illustration). | GAO-24-106831

M10 Booker Program

Program Performance

As of the second quarter of fiscal year 2024, the Army has ordered the production or retrofitting of up to 60 vehicles.

- The initial 26 low-rate production vehicles are on track to start delivery in fiscal year 2024.
- In June 2023, the Army exercised the second low-rate production contract option. The option authorized the purchase of up to an additional 26 vehicles, scheduled to begin delivery in the first quarter of fiscal year 2025.
- In addition, eight prototype vehicles are currently being retrofitted to the low-rate production configuration to support operational testing, planned to begin in the fourth quarter of fiscal year 2024.

Program officials stated that the root causes of two key technical issues were identified in developmental testing. They added that while additional testing is required, they are confident that General Dynamics' redesign solutions will address these issues. The contractor plans to retrofit all vehicles with the new redesigned parts by the time of delivery and officials stated they do not expect the redesign to affect the program schedule.

Leading Product Development Practices

Program officials stated that they used an iterative design approach for development in addition to the program being designed to be rapidly fielded by integrating existing, mature subsystems. We recently found that leading companies use an iterative design approach to successfully develop a system that delivers the most critical capabilities needed in the near term, while incorporating user feedback, and deferring capabilities that are less urgent or not mature. As a result, these companies can ensure they deliver essential product capabilities to users with speed.

According to program officials, throughout the development and test process, the program was structured to continue to utilize user feedback to provide technical support and system integration expertise. End users, such as vehicle operators, assess vehicle capabilities and determine whether changes are needed to better operate the system. Program officials stated that this feedback resulted in several operational and maintainability improvements. For example, the vehicle side skirts were updated based on soldier feedback to allow easier and faster accessibility to perform track maintenance.

End users also began evaluating and providing feedback on software capabilities in April 2021. In addition, the Army's approach is intended to allow for future development by including additional electrical power to account for potential future capabilities.

Software and Cybersecurity

Software is primarily based on the Abrams tank software, modified to meet the M10 Booker requirements. A majority of software development was completed under the MTA effort that ended in June 2022. The program plans to deliver two additional versions of modifications by the fourth quarter of fiscal year 2025.

Since our last assessment, the program conducted additional major subsystem and component cybersecurity assessments. According to program officials, testing identified cybersecurity vulnerabilities, which they stated the contractor is required to address and correct. The program plans to conduct a system-level cybersecurity assessment in the third quarter of fiscal year 2024.

Other Program Issues

Program officials stated that the eight retrofitted prototype vehicles will be delivered approximately 4 months later than the program reported last year due to material delays. Program officials stated that the delays were associated with a handful of key components. If the program faces additional delays in retrofitting the prototypes, the vehicles will not be ready to support operational testing currently planned for the fourth quarter of fiscal year 2024. However, program officials stated that operational testing will begin as planned with the initial low-rate production vehicles that will be delivered starting in the second quarter of fiscal year 2024.

Program Office Comments

We provided a draft of this assessment to the Army for review and comment. The Army provided technical comments, which we incorporated as appropriate.

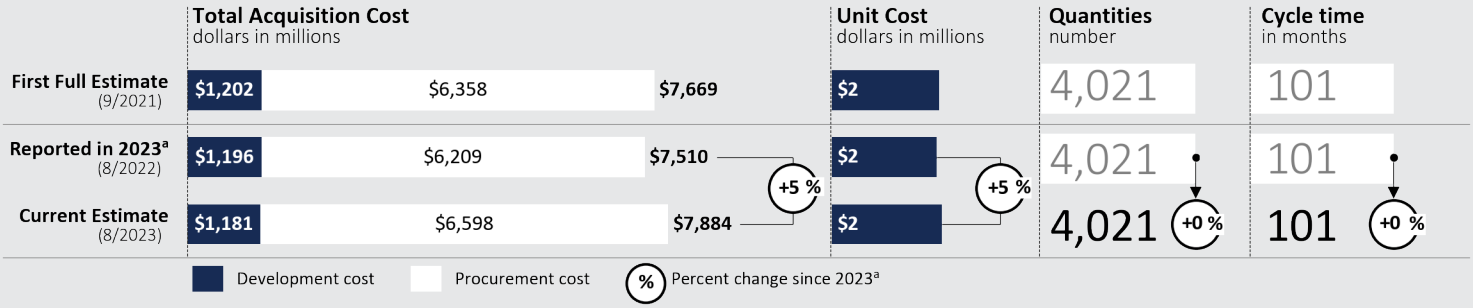
The Army stated that the M10 Booker program is currently executing within cost, schedule, and performance. It noted that the program is preparing to receive production vehicles to support operational testing, which it expects will begin in the fourth quarter of fiscal year 2024. It added that the eight prototype vehicles being retrofitted to the production representative configuration will support performance testing and development activities.

Source: Lockheed Martin. | GAO-24-106831

Precision Strike Missile Increment 1 (PrSM Inc 1)

The Army's PrSM is a ballistic missile designed to attack area and point targets at distances ranging from 70 kilometers to more than 400 kilometers. Each PrSM missile container will hold two missiles, double the current missile container's capacity. The Army designed PrSM as one of a family of munitions for compatibility with existing rocket launcher systems and to comply with (1) statutory requirements for insensitive munitions, which are less dangerous than previous weapons when subjected to accidental stimuli, and (2) DOD's policy on cluster munitions to minimize unintended harm from unexploded ordinance.

Program Performance fiscal year 2024 dollars in millions



Total quantities comprise 35 development quantities and 3,986 procurement quantities. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Agile and Waterfall

Frequency of end user evaluation (months)

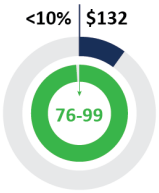
Other frequency (see notes)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that end user feedback on software occurs during limited user tests.

Program Essentials

Prime contractor: Lockheed Martin

Contract type: FFP

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	○	●
Demonstrate all critical technologies in a realistic environment	○	○
Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	●	●
Test a system-level integrated prototype	●	●
Manufacturing processes are mature	**Production Start**	
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

We did not assess PrSM's manufacturing maturity because the program has yet to reach production.

PrSM Inc 1 Program

Technology Maturity and Design Stability

According to the Army, PrSM has demonstrated its critical technologies in a relevant environment. The Army previously reported that PrSM had 10 critical technologies; however, this year it stated that three technologies previously identified as critical are no longer designated as such. According to the Army, the dropped technologies either have been used successfully in similar applications and are mature and stable, or it will use an alternate design that meets all system requirements until a more advanced version of the technology is available. For these reasons, we reduced the number of critical technologies applicable to the program to seven. We updated our Attainment of Product Knowledge table to reflect the program's change in critical technologies.

The Army noted that the demonstration of critical technologies in a relevant environment met the DOD requirement for a program's development start. However, our prior work on acquisition best practices shows that (1) demonstration of technologies in a realistic environment is the level of maturity that constitutes a low risk for development start, and (2) until all critical technologies are mature—that is, tested in a realistic environment—programs risk costly and time-intensive redesign work if problems are found later in testing.

Program officials reported that all subassembly qualification testing, which verifies that major subassemblies of the PrSM system meet performance requirements and specifications, was complete as of December 2023. The Army stated that it expects the completion of two remaining test reports in the second quarter of fiscal year 2024, which, as we noted last year, is 2 years later than initially planned.

The program expected to conduct a design completion review by December 2023. However, it delayed the review until all design completion review entrance criteria have been met. The review is now scheduled for the third quarter of fiscal year 2024.

Production Readiness

Although PrSM has yet to demonstrate production readiness, the program started production and accepted four increment 1 early operational capability missiles in 2023 (of a total of 80 planned missiles). The program's cost estimate increased by approximately 5 percent since our last assessment, due in part to Army senior leadership's decision to increase production throughput to maintain planned schedule.

Program officials reported that increment 1 missiles are built by the vendor on a pilot production line and will not include the cybersecurity redesign needed to meet survivability requirements. Program officials reported that hardware and software changes needed to fully implement all critical technologies and cybersecurity requirements in future missiles are expected to be incorporated by the end of fiscal year 2028. Program officials do not expect to retrofit early operational capability missiles with future capabilities.

Software and Cybersecurity

The program is shifting from an Agile and waterfall software development approach to only Agile. However, program officials reported that they are experiencing challenges in hiring personnel with expertise in Agile development and testing.

As reported in our last assessment, cybersecurity requirements were finalized after initial system design. PrSM used draft cybersecurity requirements as the basis for the performance specifications provided to the contractor. In fiscal year 2023, the program completed a trade study to determine cost and schedule impacts of implementing the finalized cybersecurity requirements. Officials estimate that this redesign will cost approximately $200 million and take approximately 5 years to complete. Program officials are analyzing hardware and software changes and associated effects on life-cycle costs prior to taking next steps.

Program Office Comments

We provided a draft of this assessment to the Army for review and comment. The Army provided technical comments, which we incorporated where appropriate.

The Army stated that the PrSM program is executing within cost, schedule, and performance. According to the Army, to restore parity against existing threats, its leaders authorized production of an early operational capability version of the missile concurrent with system development activities. The Army stated that, in September 2023, the program awarded its third production contract to Lockheed Martin to produce additional missiles.

The Army noted that all PrSM major sub-assemblies are qualified as of December 2023 and anticipates that the planned design completion review will confirm design maturity. According to the Army, system-level qualification flight testing began in the first quarter of fiscal year 2024 and will continue through the second quarter of fiscal year 2025. The Army noted that production of early operational capability missiles is concurrent with that flight testing and with operational testing.

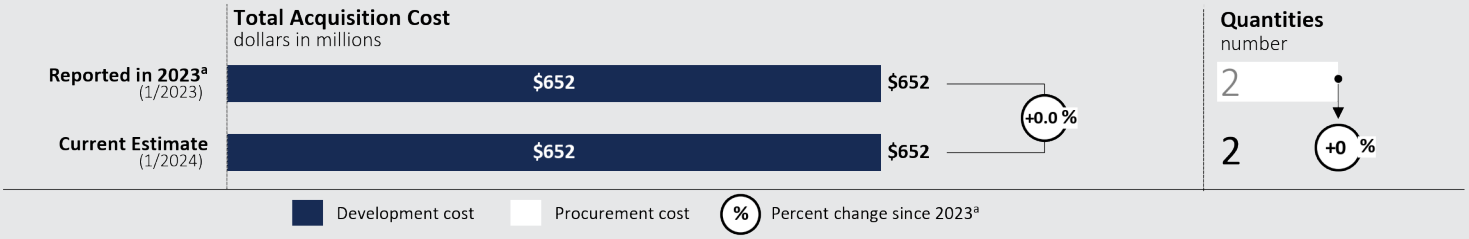
Common Name: FLRAA

Source: Bell Textron, Inc. | GAO-24-106831

Future Long Range Assault Aircraft (FLRAA)

FLRAA is part of the Future Vertical Lift portfolio of systems, a top modernization priority for the Army. It is intended to be a medium-sized assault and utility aircraft and deliver speed, range, agility, endurance, and sustainability improvements as compared to current Black Hawk helicopters. The Army also expects the program to provide combatant commanders with tactical capabilities at operational and strategic distances. The Army initiated FLRAA using the MTA rapid prototyping pathway in October 2020 to develop two virtual prototypes.

Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2024 dollars in millions



[a]GAO-23-106059.

Program Background and Transition Plan

In March 2020, the Army selected two contractors for project awards to develop FLRAA conceptual prototype designs. In December 2022, the Army awarded a development contract to Bell Textron, Inc. to support completion of virtual prototype development, as well as system development and low-rate initial production. The MTA effort will culminate in a virtual prototype of the FLRAA to reduce technical risk prior to prototype aircraft production. The Army plans to transition FLRAA to the major capability acquisition pathway with entry at development start during the third quarter of fiscal year 2024. The Army plans to deliver its first aircraft in 2030.

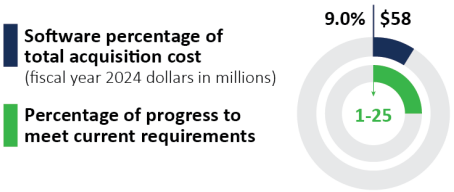
Software Development as of January 2024

Approach: Agile, Incremental, and DevSecOps

Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)



Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case	Status at Initiation	Current Status
Approved requirements document	●	●
Approved middle tier of acquisition strategy	●	●
Formal technology risk assessment	○	○
Cost estimate based on independent assessment	●	●
Formal schedule risk assessment	○	○

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

Program Essentials

Prime Contractor: Bell Textron, Inc.

Contract type: CPIF/FPI (development)

FLRAA Program

Updates to Program Performance and Business Case

FLRAA has yet to complete all five elements of its business case, but the program plans to complete the two remaining assessments. Program officials stated that they started conducting a formal schedule risk assessment in the first quarter of fiscal year 2024 in association with the establishment of an integrated master schedule, which the program plans to complete during fiscal year 2024. The program expects the Army to complete a formal technology risk assessment by the spring of 2024.

Program officials also reported plans to update the completed elements of FLRAA's business case. The program had an approved acquisition strategy at program initiation and expects to update it prior to entering system development on the major capability acquisition pathway in the third quarter of fiscal year 2024. The program also plans to obtain two new independent cost estimates for reconciliation by a cost estimation review board prior to the transition to system development. The Army validated the FLRAA capability development document in July 2023, and DOD plans to validate the document in the second quarter of fiscal year 2024. The program has had an abbreviated capability development document—which is used to establish characteristics and help the Army understand a potential capability—since program initiation.

FLRAA officials reported that preliminary design work during the MTA effort will continue to mature FLRAA's two critical technologies. While officials stated that they plan to demonstrate the maturity of these critical technologies to a level required by development start, their maturity will not conform to the level recommended by leading practices. These practices call for demonstration in an operational environment.

Leading Product Development Practices

The program reported that it is using an iterative approach for development, including identifying an initial set of capabilities to be fielded in a minimum viable product based on user feedback. The program is also soliciting and incorporating user feedback through regular soldier touchpoints that it uses to iterate on the prototype design, and it intends to use a modular open system approach to enable rapid insertion of software in response to evolving needs.

Program officials reported using digital twins—virtual representations of physical products that incorporate dynamic data—for design modeling and simulation, validation, and production and delivery activities. Program officials stated that the digital twin they are developing will evolve from a twin that represents the system in development to eventually support production and sustainment, consistent with leading practices. The program will use data from digital modeling, sensors, and simulations for the digital twin.

However, the program stated that it has encountered two main challenges in developing the digital twin—ensuring the use of open, adaptable, and secure digital engineering tools; and providing secure access to the data/models to stakeholders that need it. The program is addressing these challenges through close collaboration with stakeholders.

While the program is planning for digital prototypes, it is not planning to have physical prototypes prior to system development. Once in system development, the program plans to build, integrate, and test a physical prototype in an operational environment prior to entering production.

Software and Cybersecurity

FLRAA plans to use a mixture of software development approaches—including Agile, DevSecOps, and incremental—to deliver off-the-shelf and custom software. The program office noted that it completed cybersecurity and architectural vulnerability assessments in fiscal year 2023 and plans to conduct additional future assessments. FLRAA officials expect to have an approved cybersecurity strategy during the third quarter of fiscal year 2024.

Other Program Issues

Program officials stated that the development contract award process, along with a bid protest of that award, delayed the preliminary design review by approximately 9 months, to the second quarter of fiscal year 2024. The program plans to conduct a critical design review in the third quarter of fiscal year 2024.

Program Office Comments

We provided a draft of this assessment to the Army for review and comment. The Army provided technical comments, which we incorporated where appropriate.

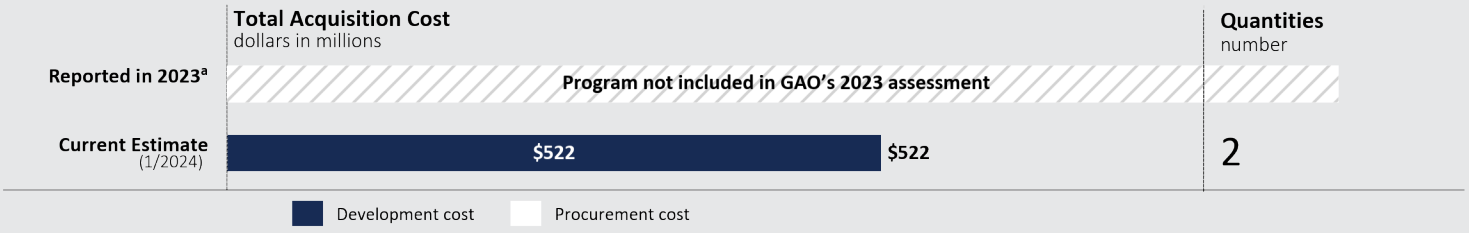
The Army stated that FLRAA began execution with Bell Textron, Inc. in April 2023. The Army noted that the program completed a requirements review using model-based systems engineering in August 2023 to ensure clear, understandable, and testable requirements. It added that this requirements baseline supported preliminary design activities during this time period. The Army stated that in November 2023, FLRAA conducted its first soldier touchpoint at the Bell Flight Research Center, which it stated allowed soldier feedback to shape the final cabin and cockpit design. According to the Army, FLRAA plans to conduct recurring soldier touchpoints every 6 months. The Army also noted that it remains focused on program execution in order to deliver this next-generation aircraft to soldiers.

High Accuracy Detection and Exploitation System (HADES)

Source: PEO-Avn, FWPO(SEMA) HADES. | GAO-24-106831

The HADES program intends to integrate a commercial-variant business jet with long-range, multi-intelligence sensors to provide enhanced battlefield surveillance for mission command and long-range weapon systems. HADES is expected to provide a decisive advantage in intelligence and targeting, while increasing lethality through early indications and warnings, providing commanders with enhanced reaction time to inform flexible response options. As part of the Multi-Domain Sensing System concept, HADES's capabilities are planned to help the Army and Joint Forces achieve wartime objectives against peer adversaries. We assessed the first of several expected HADES MTA efforts.

Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2024 dollars in millions



[a]GAO-23-106059.

Program Background and Transition Plan

The Army initiated HADES as an MTA rapid prototyping effort in December 2023. The Assistant Secretary of the Army for Acquisition, Logistics and Technology approved the MTA to develop the first two HADES prototype aircraft, including development of the external shape of the aircraft, ensuring adequate power distribution and integrating both legacy and newly developed sensors.

Software Development as of January 2024

Approach: Information not available

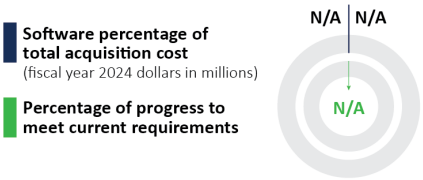
Frequency of end user evaluation (months)

Information not available

Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)



The program reported that no software development is expected under the MTA effort.

Program Essentials

Prime Contractor: TBD

Contract type: TBD

Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case	Status at Initiation	Current Status
Approved requirements document	●	●
Approved middle tier of acquisition strategy	●	●
Formal technology risk assessment	○	○
Cost estimate based on independent assessment	●	●
Formal schedule risk assessment	○	○

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

HADES Program

Key Elements of Program Business Case

Program officials reported that they did not address two business case elements before initiation—assessments of technology and schedule risk—but plan to do so in the coming year. Completing these elements before initiation could have helped identify whether the program was well positioned to deliver the planned capability within desired time frames.

The program plans to use four fully mature critical technologies for sensors and other military equipment in the first prototype aircraft. Program officials stated that this technology is derived from other Army programs. The HADES program is leveraging a fifth critical technology called a digital backbone to implement a fully integrated modular open systems architecture to allow sensors to transmit data across the system on future HADES prototypes. However, this technology is not a program requirement for the current MTA effort. The Army expects that future efforts, which have yet to be approved for program initiation, will rely on critical technologies developed through other programs.

Program officials plan to develop two prototype aircraft under the current MTA effort. One aircraft is planned for completion early in fiscal year 2026 and another in early fiscal year 2027.

Leading Product Development Practices

HADES program officials plan to use an iterative development approach that delivers a minimum viable product suitable to be fielded in an operational environment. For the first prototype, the program plans to integrate previously developed sensors onto the aircraft. For the second prototype, the program plans to install newly developed sensors, including a new radar and sensors for advanced signals intelligence. Program officials expect to integrate sensors currently in technology development into other future prototype aircraft in later years.

As part of its iterative development approach, the HADES program plans to incorporate user feedback into its decisions regarding the minimum set of capabilities to be delivered. The program also expects to incorporate feedback during validation testing. The Army plans for a 6-month operational demonstration following completion of each prototype, involving execution of collection missions that maximize soldier touchpoints. Our prior work showed that leading companies use ongoing engagement with customers to prioritize features and identify product improvements.

Software and Cybersecurity

Program officials stated that there are no plans to develop software under the HADES MTA program, and that any software would be developed by other programs and provided to HADES with equipment to integrate.

The HADES MTA requirements documents address cybersecurity and program officials expect to have a cybersecurity strategy approved by the second quarter of fiscal year 2025, prior to the production of the first prototype aircraft. The program is working to determine what types of cybersecurity assessments will be performed.

Other Program Issues

Program officials stated that they plan to use the MTA program to define the program's requirements, concluding with operational demonstrations beginning in 2026 and a resulting report in 2027 to support a rapid fielding decision to be made in 2028. Program officials expect that operational testing will occur in 2028 and 2029 using production aircraft.

Program officials released the HADES integration request for proposal in September 2023. This request solicited contractor proposals for integration of payloads, implementation of a modular open systems approach, testing, and other activities.

The program plans for the contract to be an indefinite delivery/indefinite quantity contract with a 5-year base ordering period followed by seven, 1-year option ordering periods. Program officials estimate that they will award the contract in the fourth quarter of fiscal year 2024.

Program officials identified the lack of a digital environment that the program can use for system design and development as a challenge. This issue slows program timelines by preventing the program from doing model-based systems engineering. The Army is in the early stages of preparing to roll out a commercial solution that may in part address this challenge, although the program reported that it must also train staff on the use of this solution and purchase licenses. Our prior work found these kinds of tools enable programs to quickly determine the most optimal design that meets users' specifications, among other things.

Program Office Comments

We provided a draft of this assessment to the Army for review and comment. It provided technical comments, which we incorporated where appropriate. The Army stated that it awarded a contract to Bombardier for a Global 6500 aircraft for the first HADES prototype and that the HADES integration contract is currently under source selection. It noted that the program is leveraging lessons learned from the Future Attack Reconnaissance Aircraft and Future Long Range Assault Aircraft to develop a digital environment in support of HADES.

Program officials added that they are implementing a risk management tool to support HADES impacts, risks, and opportunities analysis and management. They expect to complete a formal HADES risk analysis following contract award.

MTA | Lead Component: Army

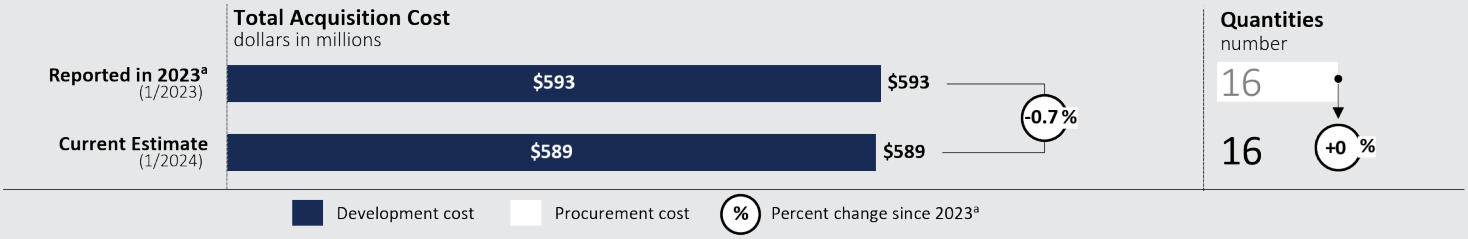
Common Name: IFPC Inc 2

Source: Dynetics. | GAO-24-106831

Indirect Fire Protection Capability Increment 2 (IFPC Inc 2)

The Army's IFPC Inc 2 is intended to enhance and extend the range of the first IFPC increment, which provided a short-range capability to counter threats from rockets, artillery, and mortars. IFPC Inc 2 consists of four subsystems—an existing sensor, an existing mission command system, a new air defense launcher, and an all-up-round magazine with an existing launcher.

Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2024 dollars in millions



[a]GAO-23-106059.

Program Background and Transition Plan

IFPC Inc 2 was designated as an MTA rapid prototyping effort in August 2021 in accordance with the Army's strategy for the program. The Army reported this strategy to Congress in February 2020. The Army awarded a prototype project other transaction agreement in September 2021 to Dynetics, Inc. to develop 16 prototypes of the air defense launcher. The Army plans to conduct an operational assessment in early fiscal year 2025 prior to transitioning to the major capability acquisition pathway at production start, after the conclusion of the rapid prototyping effort in the second quarter of fiscal year 2025.

Software Development as of January 2024

Approach: Agile

Frequency of end user evaluation (months)

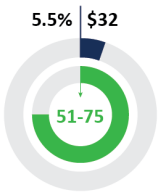
Other frequency (see notes)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that end user evaluation and feedback will occur during verification, validation, and training for the software. The program provided updated costs this year and stated that software costs they reported last year included costs beyond the current MTA effort. The program reported a revised percentage of progress that it stated was a more accurate value.

Program Essentials

Prime Contractor: Dynetics, Inc.

Contract type: FFP (using other transaction authority)

Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case	Status at Initiation	Current Status
Approved requirements document	●	●
Approved middle tier of acquisition strategy	●	●
Formal technology risk assessment	○	○
Cost estimate based on independent assessment	●	●
Formal schedule risk assessment	○	○

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

IFPC Inc 2 Program

Updates to Program Performance and Business Case

Although several key elements of IFPC's business case were approved prior to initiation, the program has yet to complete a formal schedule or technology risk assessment, as we previously reported. The program planned to complete a technology risk assessment in the third quarter of fiscal year 2023. However, the program office delayed that assessment until early fiscal year 2025, just prior to IFPC's operational assessment. Program officials stated that the delay was to allow IFPC to participate in an Army air and missile defense integrated test event to demonstrate successful integration of IFPC into the air and missile defense architecture. Program officials also delayed the schedule risk assessment that was scheduled for the third quarter of fiscal year 2023. They have yet to determine an updated time frame for that assessment. Program officials stated that the Army will use the assessment to determine the schedule for fielding the air defense launchers, sensors, fire control systems, and interceptors that form the IFPC batteries.

IFPC continues to have an aggressive timeline for fielding capability. The program's developmental test, operational assessment, and planned MTA completion dates have all been delayed, primarily to allow the program to fully align its schedule with the Army's Integrated Air and Missile Defense fire control system. We previously reported that IFPC planned to conduct its developmental test and operational assessment with whichever version of the fire control system was available at that time, even if it was not the version ultimately deployed. IFPC's planned MTA completion and entry into production is now more than a year later than the program initially planned. However, the program remains within the 5-year objective established by DOD policy for MTA completion.

Program officials stated that ongoing technical issues with one subsystem have been resolved by the contractor. However, the program will be unable to fully verify this until developmental testing in the third quarter of fiscal year 2024.

Leading Product Development Practices

IFPC is implementing some aspects of leading practices for product development; however, the extent to which they are implemented varies. Specifically, IFPC reported that program requirements identify a specific materiel solution, which is counter to our leading practices. We previously found that through the design modeling and simulation cycle, leading companies work together with users to define requirements, which, in turn, inform the selected solution. In doing so, leading companies ensure that the design meets most essential user needs.

However, the program is taking steps to obtain user feedback as IFPC undergoes development, consistent with our leading practices. For example, as we reported last year, soldiers from the 188th Air Defense Brigade participated in design reviews and changes were made based on that participation. We previously found that leading companies seek and obtain continuous user feedback through iterative cycles of design modeling and simulation, validation, and production and delivery. IFPC officials stated that this feedback can be used to inform the requirements of the IFPC system and could provide an opportunity for requirements to change to better reflect user needs, among other items.

Software and Cybersecurity

The program plans to have an approved cybersecurity strategy in early fiscal year 2025, prior to completing its operational assessment. The program reported using an Agile development approach to develop its launcher software and other software capabilities. Officials identified software development as a high risk in part due to hardware design changes and challenges integrating the software with hardware.

Other Program Issues

Program officials stated that supply chain management issues for Dynetics, Inc. related to the COVID-19 pandemic also affected the program schedule. They stated, however, that the contractor resolved these supply chain issues, and production of the launch vehicle is proceeding according to the updated schedule.

Program Office Comments

We provided a draft of this assessment to the Army for review and comment. The Army provided technical comments, which we incorporated as appropriate.

The Army stated that the program is managing IFPC Inc 2 within its cost, schedule, and performance targets, and is on path to deliver a prototype battery of systems. It added that ongoing qualification and developmental testing, and the planned operational assessment, will inform the program's transition to the major capability acquisition pathway in fiscal year 2025.

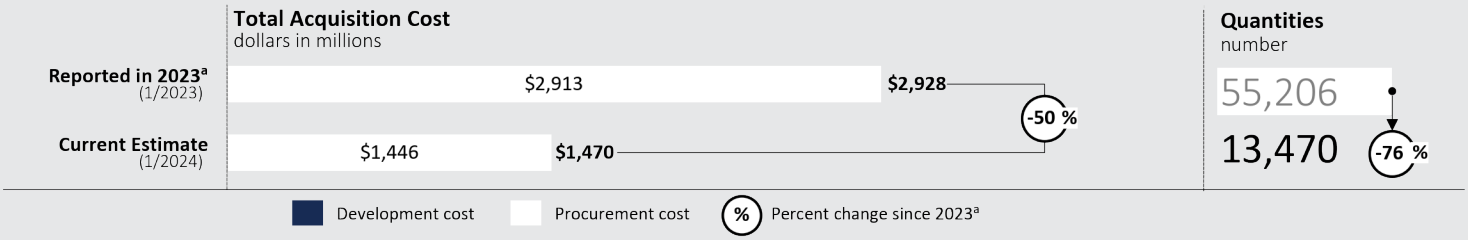
Integrated Visual Augmentation System (IVAS)

Source: PEO Soldier. | GAO-24-106831

The Army's IVAS program seeks to improve warfighter close combat capabilities by providing a single platform that allows the warfighter to fight, rehearse, and train using augmented-reality headgear. The system includes a heads-up display, sensors, on-body computer, and other elements intended to improve warfighter sensing, decision-making, target acquisition, and target engagement via a 24/7 situational awareness tool. IVAS has rapid prototyping and rapid fielding efforts ongoing. This assessment focuses on the rapid fielding effort.

- **9/18** MTA Rapid Prototyping initiation/Funds obligated
- **12/20** MTA Rapid Fielding initiation
- **3/21** Rapid Fielding contract award
- **9/21** Replan system review
- **5/22** Operational demonstration
- **9/23** First unit issued
- **1/24** GAO review
- **10-12/25** Expected MTA Rapid Fielding completion

Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2024 dollars in millions



Cost and quantity reflect only the IVAS rapid fielding effort. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance.
[a]GAO-23-106059.

Program Background and Transition Plan

The Army initiated IVAS as an MTA rapid prototyping effort in 2018. After developing and testing a prototype, the Army approved a follow-on rapid fielding effort in 2020. In 2021, the Under Secretary of Defense for Acquisition and Sustainment conditionally approved the rapid fielding effort pending correction of known technical deficiencies. As a result, the program conducted a replan in the same year to address the issues. At the conclusion of the rapid fielding effort in 2025, the program plans to transition to another acquisition pathway.

Software Development as of January 2024

Approach: Agile, DevOps, and DevSecOps

Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements

N/A | N/A

SEE NOTES

The program reported that the firm-fixed-price agreement does not separate out software costs. The program also stated that the minimum viable product is complete, but annual software updates are expected throughout the life cycle of the program.

Program Essentials

Prime Contractor: Microsoft

Contract type: FFP (production) (using other transaction authority)

Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case	Status at Initiation	Current Status
Approved requirements document	●	●
Approved middle tier of acquisition strategy	●	●
Formal technology risk assessment	○	●
Cost estimate based on independent assessment	○	○
Formal schedule risk assessment	○	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

IVAS Program

Updates to Program Performance and Business Case

The program fielded the first IVAS systems—version 1.0—to units at the Army's Maneuver Center of Excellence in September 2023, which was a change from its previous plan to fully equip the first operational unit by the end of the fourth quarter of fiscal year 2023. The program plans to begin production of version 1.1, which incorporates an improved low-light sensor to improve image quality, during the third quarter of fiscal year 2024. The program stated that it revised its fielding plans based on the expected availability of version 1.2, which is intended to complete improvements identified during a 2022 operational demonstration.

As we previously reported, the Army received 5,000 sets of version 1.0 and began fielding them to training units to collect feedback for future versions under the Army's Campaign of Learning. The Army also ordered 5,000 sets of version 1.1 to field to operational units. Based on initial user feedback, version 1.2 is expected to provide increased reliability and an improved physical design. In December 2022, the Army designated version 1.2 as the full-rate production model. As previously reported, IVAS has been challenged with low reliability and soldier acceptance.

The program underwent a replan in 2022 that delayed an independent cost estimate from the Office of the Deputy Assistant Secretary of the Army - Cost and Economics. The program now expects the cost estimate to be completed during the third quarter of fiscal year 2024—a year later than we reported last year.

Leading Product Development Practices

The program stated that it used an iterative development approach during the rapid prototyping effort, but is not currently using iterative development because IVAS is now a rapid fielding program with a finalized production design. We found that leading companies leverage production designs that allow for iteration to occur based on user feedback to ensure capabilities remain relevant before and after delivery.

Some of the program's acquisition activities to date have been iterative. For example, the program refined its design based on the results of recurring soldier touchpoints. The program stated that soldier feedback indicated a need to improve version 1.0 peripheral vision and head-borne center of gravity physical design. Version 1.2 prototypes incorporated this feedback. However, the program's plans to field the system without defining minimum user acceptance levels to determine whether IVAS meets user needs were contrary to leading practices, which use iterative development to ensure the minimum viable product meets user needs prior to production.

IVAS also reported leveraging 3D printing to demonstrate design changes and assess multiple design options before scaling for production. The program noted that this approach allowed for a hands-on assessment without finalizing a design. However, it added that 3D printed parts are less durable, so there are some operational use cases that cannot be assessed with 3D models.

Software and Cybersecurity

We previously reported that the program received a cybersecurity certification for version 1.0 in October 2022. However, officials stated that IVAS is not able to receive an Army-approved cybersecurity strategy (CSS) while on the MTA pathway. Officials stated that the program will obtain a CSS prior to its transition to a new acquisition pathway, scheduled for the first quarter of fiscal year 2026, and plans to obtain a CSS for future versions of IVAS.

Other Program Issues

The program reported a decrease in its overall rapid fielding quantity since our last assessment. It noted that it did not receive procurement funding in fiscal year 2023. Although the program does not currently have funding planned in fiscal year 2026 and beyond, the program office anticipates being funded for procurement in those years. As a result, according to officials, the Army decided to reduce its procurement quantities and focus on updating its design. The program also reported increases in unit cost compared to our last assessment. Our past work suggests that if the number of quantities to be produced decreases, then unit costs can be expected to increase because certain fixed costs must be spread over fewer items. Program officials also noted that unit costs were affected by inflation.

Program Office Comments

We provided a draft of this assessment to the Army for review and comment. The Army provided technical comments, which we incorporated as appropriate.

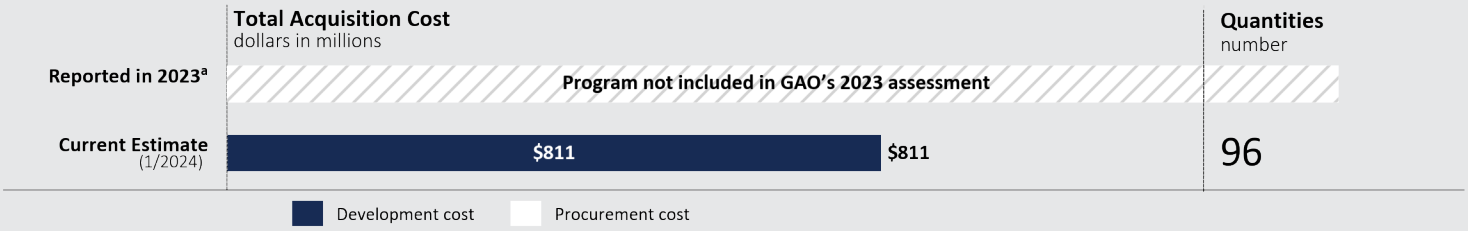
The Army stated that it adjusted the IVAS program plan to field a limited number of IVAS 1.0 and 1.1 systems to support its Campaign of Learning while accelerating development, production, and fielding of IVAS 1.2. The Army also stated that it anticipates that version 1.2 will achieve its desired capabilities, including improved software reliability, improved low light sensor performance, and improved physical design. According to the Army, the program office tested and conducted user assessments for the first two prototype builds of IVAS 1.2 and received positive soldier feedback and test results. Three additional prototype builds and test events are planned, according to the Army, including an operational test in the third quarter of fiscal year 2025 that will inform a production decision in the following quarter. The Army stated that the program plans to begin fielding version 1.2 in the first quarter of fiscal year 2026.

Source: U.S. Army. | GAO-24-106831

Maneuver Short Range Air Defense Increment 3 (M-SHORAD Inc 3)

M-SHORAD Inc 3 is a new MTA rapid prototyping effort intended to modernize the Army's air and missile defenses by replacing the M-SHORAD Increment 1 Stinger missile with a next generation short range interceptor (NGSRI). The Army plans for the NGSRI to have improved targeting capabilities by increasing its range and lethality against threats. A separate Army effort will develop a new 30-millimeter ammunition for M-SHORAD Inc 3. We assessed the current effort to upgrade the new short range interceptor—NGSRI.

Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2024 dollars in millions



[a]GAO-23-106059.

Program Background and Transition Plan

The Army plans to launch the NGSRI from an M-SHORAD Inc 1 combat vehicle to defeat rotary-wing, fixed-wing, and unmanned aerial systems while retaining soldier portability and compatibility with existing launcher assemblies. In September 2023, two vendors were selected to design, develop, and test a prototype NGSRI during the rapid prototyping effort. The Army plans to select one vendor to proceed with the effort after completing an operational assessment in fiscal year 2027. The M-SHORAD Inc 3 MTA effort intends to transition to the major capability acquisition pathway at its low-rate production decision in fiscal year 2028. The Army expects two platoons to each receive approximately 48 NGSRI rounds at that time.

Software Development as of January 2024

Approach: Information not available

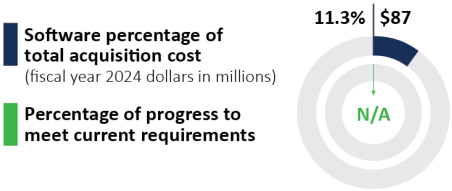
Frequency of end user evaluation (months)

Information not available

Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)



The program reported that software development has not started.

Program Essentials

Contractors: Raytheon; Lockheed Martin

Contract type: CPFF (using other transaction authority)

Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case	Status at Initiation	Current Status
Approved requirements document	●	●
Approved middle tier of acquisition strategy	●	●
Formal technology risk assessment	○	○
Cost estimate based on independent assessment	●	●
Formal schedule risk assessment	○	○

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

M-SHORAD Inc 3 Program

Key Elements of Program Business Case

Prior to initiation, the Army completed an independent assessment of the program cost estimate and determined that significant effort by both the program office and the Army are required to make the program affordable. The program began negotiations with suppliers to address anticipated shortfalls in fiscal years 2024 and 2025 funding, and will seek to have the program fully funded in future year budgets. The program plans to execute a schedule risk assessment in the second quarter of fiscal year 2024 and a formal assessment of technology risk in the second quarter of fiscal year 2025. Our prior work has shown that this type of information helps decision-makers make well-informed decisions on whether an MTA effort is likely to meet its objectives within the 5-year time frame described in DOD policy.

The program has yet to mature its critical technologies. Program officials reported four categories of critical technologies in developing the NGSRI. Both contractors anticipate that all critical technologies will be mature by the end of the MTA effort in 2028. However, if one or both contractors do not mature their critical technologies in time, the program may be unable to meet its timeline.

Leading Product Development Practices

M-SHORAD Inc 3 intends to use certain approaches in line with key product development practices that our prior work found leading companies employ. For example, program officials plan to solicit feedback on the design from operational combat units. We previously found that ongoing customer engagement is an important aspect of iterative development to prioritize features and identify product improvements. The program also intends to track the vendors' technical and design progress quarterly and assess that information at each of three design reviews planned during the MTA rapid prototyping effort.

The program reported having high-level requirements that allow for iterative planning of capability. However, it does not plan to refine capabilities to a minimum set that provides value to the warfighter or to off-ramp those that could delay delivery. Instead, if the supplier's technologies are not sufficiently mature to meet the MTA timeline, officials said they may continue development on the major capability acquisition pathway. Our prior work found that leading companies prioritize delivering an initial set of capabilities that provide value to the user rather than taking years to provide more capability. Leading companies also only embark on product development once they assess and establish confidence that the product's underlying technologies are sufficiently mature to meet user needs and support the product development schedule.

Software and Cybersecurity

M-SHORAD Inc 3 intends to conduct one cyber tabletop test per vendor in 2026. Program officials stated that the need for additional cybersecurity developmental test events, such as a cooperative vulnerability identification and an adversarial cybersecurity developmental test, had not yet been determined and that officials are awaiting completion of the NGSRI design. Officials stated that they would decide after they review the final NGSRI design and the decision will be based on how, or if, the system subcomponents communicate with external networks.

Officials added that the NGSRI does not currently communicate externally to any networks, but that they have cybersecurity requirements and intend to remain compliant with DOD instructions and policies. They are also considering the potential cost implications for executing developmental cybersecurity testing on two vendors when only one will be chosen. We previously found that not conducting this testing risks acquiring a system with vulnerabilities that may not be discovered until operational testing, when program officials will have less time to address them prior to making a production decision.

Other Program Issues

Program officials noted that the aggressive schedule presents some risk. For example, contractors need to buy hardware early to meet the Army's schedule and outside factors, such as supply chain issues, may affect their timelines.

Program Office Comments

We provided a draft of this assessment to the Army for review and comment. The Army provided technical comments, which we incorporated as appropriate.

The Army stated that the M-SHORAD Inc. 3 NGSRI program is on track to meet cost, schedule, and performance goals. It stated that it awarded other transaction agreements to Raytheon and Lockheed Martin in September 2023 to start the development effort and that current funding is sufficient to support program costs in fiscal year 2024.

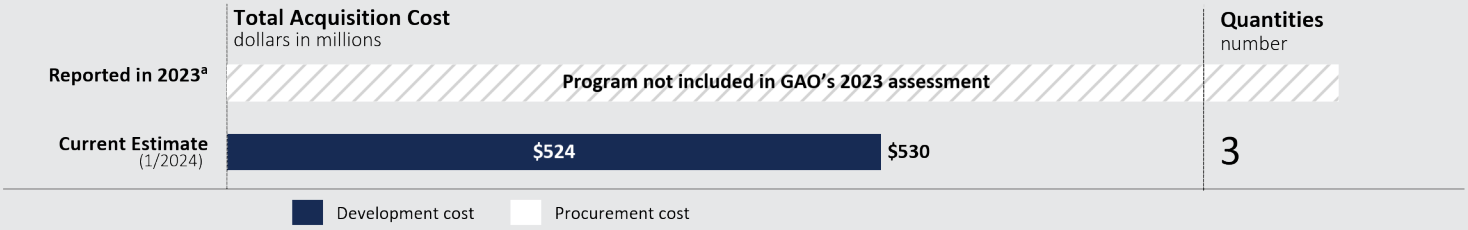
For fiscal year 2024, the Army stated that it expects there will be startup meetings, two design maturity reviews, integrated baseline reviews, a soldier touchpoint, and subsystem technology demonstrations. The Army added that it plans for the program to complete initial prototyping by the end of fiscal year 2025, followed by developmental testing, an operational assessment, and down-selection between fiscal years 2026 and 2028. According to the Army, following the MTA effort, the program anticipates transitioning to the major capability acquisition pathway at production start in fiscal year 2028.

Mid-Range Capability (MRC)

The Army is developing an offensive, ground-based MRC weapon system to bridge a capability gap between systems designed for short- and long-range fires. MRC is leveraging existing Navy Standard Missile (SM)-6 and Tomahawk cruise missile technology and modifying the Navy's ship-based vertical launching system (VLS) for containerized use with existing Army vehicles. The Army intends to deliver three MRC batteries under the current MTA rapid prototyping effort no later than fiscal year 2026.

Source: Lockheed Martin with edits from U.S. Army RCCTO. | GAO-24-106831

Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2024 dollars in millions



The graphic bars depict only research and development and procurement costs. However, total acquisition cost also includes costs for acquisition operation and maintenance.
[a]GAO-23-106059.

Program Background and Transition Plan

The Army's Rapid Capabilities and Critical Technologies Office (RCCTO) began MRC prototype development in November 2020. RCCTO conducted the first MRC flight test in July 2023 and delivered the first battery—consisting of a battery operations center, four launchers, a support vehicle, and reloads—in September 2023. RCCTO also delivered eight Tomahawk and eight SM-6 missiles for operational use. MRC initiated as an MTA rapid prototyping effort in November 2023 to develop and deliver batteries 2 through 4. Program Executive Office Missiles and Space is leading the current MTA effort, which expects to build on battery 1 capabilities, to include enhanced communications, survivability, and incorporation of future Tomahawk and SM-6 variants. A fifth battery is expected during a follow-on MTA rapid fielding effort.

Software Development as of January 2024

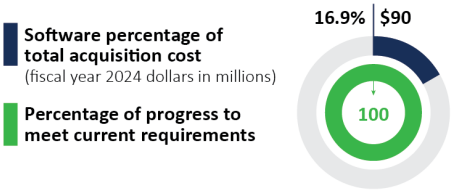
Approach: Agile, Waterfall, DevOps, and DevSecOps

Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)



According to the program, different software applications on MRC are being developed with different software approaches, so the frequency of testing and feedback could not be generalized.

Program Essentials

Prime Contractor: Lockheed Martin

Contract type: CPFF (using other transaction authority)

Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case	Status at Initiation	Current Status
Approved requirements document	●	●
Approved middle tier of acquisition strategy	●	●
Formal technology risk assessment	○	○
Cost estimate based on independent assessment	●	●
Formal schedule risk assessment	○	○

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

MRC Program

Key Elements of Program Business Case

MRC had an approved acquisition strategy and requirements document at program initiation. The Deputy Assistant Secretary of the Army for Cost and Economics also completed a cost estimate in August 2023. However, the program has not completed other key activities to establish a sound business case. Namely, the program said it had not obtained formal assessments of technology risk or schedule risk and has no plans to do so. According to the program, it does not plan to undergo a technology risk assessment because it is leveraging existing capability that is already mature, and there is no schedule risk because the program already fielded an operational prototype as part of the RCCTO effort.

The MRC program said it has no critical technologies and the MTA effort intends to integrate existing technology from Army and Navy systems that have already been demonstrated. Specifically, the program noted that the Navy's VLS, Tomahawk, and SM-6 are all fielded systems with extensive track records of operational success.

Leading Product Development Practices

The program office reported that MRC is using an iterative approach for development. The MTA effort is expected to leverage and build upon the battery 1 prototype through technology insertion points for batteries 2 through 4. According to the program, these insertion points will add improvements that are driven, in part, by soldier feedback. The program said it will conduct joint flight tests as necessary—up to two per year—to prove out new technology insertions that require firing a missile from MRC. According to program documentation, these tests are intended to validate safety and performance, as well as incorporate the insertion point improvements. We previously found that leading companies use iterative design and testing to identify a minimum viable product—a product, such as the first MRC battery, with the minimum capabilities needed for users to recognize value that can be followed by successive updates.

The MRC weapon system is also utilizing modularity. We previously found that leading companies employ modular design and manufacturing to combine and reuse common elements. This enables these companies to develop customized solutions and more easily produce systems at scale. According to the program office, the system is using a shared architecture for Navy-developed canisters that enable the firing of multiple missile types. However, the program had to make adjustments to accommodate MRC's unique ground transport requirements. The program noted that MRC requires transport of the canisters with munitions loaded. This requirement necessitated a change to cabling locations, missile orientation within the canister, and software to adjust for the orientation changes.

Software and Cybersecurity

The MRC program office reported using multiple software development approaches because different entities are responsible for different software applications used within the MRC weapon system. For example, the contractor is leading efforts to modify existing Navy software related to the Aegis Weapon System and VLS. The government is developing software for the Tomahawk Weapon System under the direction of the Navy, and a communications system under an Army program office.

The program stated that initial plans assumed that the Army would utilize Navy software and hardware as-is. However, the program later realized that software development was necessary due to architecture changes, hardware changes, and technical differences between the Army and Navy concepts of employment. According to the program office, this resulted in increased software development and validation costs.

Cybersecurity assessments were conducted at the subsystem level in July 2022, but no additional testing is scheduled as of October 2023, according to the program. Our prior work has shown that early and regular discovery of mission-impacting system vulnerabilities makes them easier to fix and reduces risk to schedule.

Other Program Issues

According to program documentation, continued MRC development is reliant on the funding and execution of the Navy programs of record for the Tomahawk, SM-6, and Aegis Weapon System. Further, if the Tomahawk or SM-6 programs fail to maintain their schedules, it could affect future planned upgrades for MRC.

In addition, according to the program office, the delivery schedule restricts the ability to implement and validate models and simulations for all critical design elements. User collaboration during the design of these models is limited, which introduces design limitations for some elements, such as system cooling.

Program Office Comments

We provided a draft of this assessment to the Army for review and comment. The Army provided technical comments, which we incorporated as appropriate.

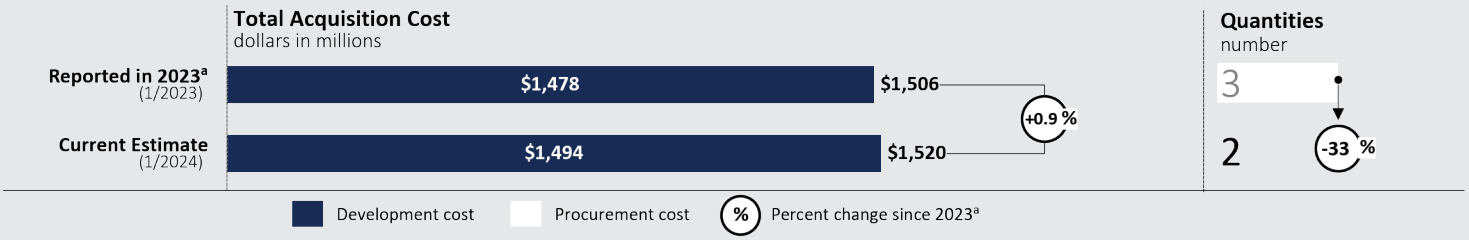
According to the Army, MRC remains on track to meet the Army's schedule. It added that the program will continue its close coordination and partnership with the associated Navy program offices to ensure the continued development and increased capability of the system.

XM30 Mechanized Infantry Combat Vehicle (XM30)

The Army's XM30, formerly known as the Optionally Manned Fighting Vehicle, is the planned solution to maneuver warfighters on the battlefield to advantageous positions for close combat. XM30 is expected to allow for crewed or remote operation. It is intended to replace the existing Bradley Infantry Fighting Vehicle, which no longer has the capacity to integrate new technologies. The program is developing additive software separately on the software acquisition pathway.

Source: U.S. Army. | GAO-24-106831

Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2024 dollars in millions



Although quantities now reflect two virtual prototypes instead of three, program officials stated that there was not a corresponding decrease to the cost estimate because the rapid prototyping effort does not include actual prototypes and a decrease in virtual prototypes would not reduce costs. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance.
[a]GAO-23-106059.

Program Background and Transition Plan

The Army initiated XM30 in 2018 but revised its acquisition plan in 2020, after experiencing difficulties with the desired capabilities and time frames. Under a five-phase plan, the Army completed market research and requirements refinement (phase 1) in July 2021, and concept design (phase 2) in June 2023. After preparing to award up to three contracts, the Army awarded two in June 2023 to begin a combined detailed design phase (phase 3) and prototype build and test phase (phase 4). The Army plans to transition to the major capability acquisition pathway with entry at development start, where it expects to subsequently select one contractor for a low-rate production contract (phase 5).

Software Development as of January 2024

Approach: Agile, Incremental, and DevSecOps

Frequency of end user evaluation (months)

Information not available

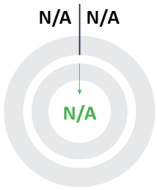
Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that software development is planned to start in the fourth quarter of fiscal year 2024.

Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case	Status at Initiation	Current Status
Approved requirements document	○	●
Approved middle tier of acquisition strategy	○	●
Formal technology risk assessment	○	○
Cost estimate based on independent assessment	○	●
Formal schedule risk assessment	○	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

Program Essentials

Prime Contractor: General Dynamics Land Systems; American Rheinmetall Vehicles

Contract type: FFP

XM30 Program

Updates to Program Performance and Business Case

Since our prior assessment, XM30 completed its concept design and transitioned into detailed design and prototyping. In June 2023, the Army awarded the contracts for competitive detailed design and prototyping to General Dynamics Land Systems and American Rheinmetall Vehicles. Both contractors participated in the concept design phase.

These contracts were awarded approximately 3 months later than originally planned, which represents the only delay to the revised acquisition plan's schedule, according to program officials. Officials stated that it took longer to release the request for proposals due to a lack of experience with digital engineering while directing contractors to use specific software design approaches. Officials also stated that the Army lacked precedent for scoping a digital open architecture project, which delayed the Source Selection and Evaluation Board process. For example, the program office reported tasking potential vendors to find and correct errors in digital architecture but found that it needed to normalize the data collected so that it could fairly compare the results. Officials stated that the entire program schedule has been delayed approximately 3 months due to the delay in awarding contracts. The vendors each plan to deliver a digital prototype at the critical design review that will inform the decision in the second quarter of fiscal year 2025 to transition to the major capability acquisition pathway and enter at development start.

While program officials stated that both vendors conducted technology readiness level assessments for the technologies in their designs, the Army has yet to identify XM30's critical technologies, as we reported last year. The Army plans to complete the first technology assessment in the first quarter of fiscal year 2025, prior to the critical design review but one quarter before XM30 is expected to transition to the major capability acquisition pathway. Identifying critical technologies at this point poses risks that they may not reach maturity before XM30 transitions to the major capability acquisition pathway. Using immature technologies further increases the risk of requiring redesigns.

Leading Product Development Practices

XM30 reported it is using an iterative approach for development, and cited practices that we found leading companies employ to successfully develop and deliver products to users with speed. For example, soldiers used virtual reality to study XM30 designs and provide feedback on human engineering factors such as soldier accommodation and crew station design. Officials stated that there are three more scheduled events to collect soldier feedback, including a review using augmented and virtual reality to gather feedback on maintenance tasks.

In addition, XM30 will use multiple forms of digital twins during its combined phases 3 and 4, according to program officials. Officials stated that the program will execute its digital design in phase 3 with two types of architecture: a not-to-scale representation of everything in the platform, and a three-dimensional computer-aided design model. During phase 4, officials stated that the vendors will be directed to build both a computer-aided design model and physics-based model to test components such as heat transfer and fluid dynamics. The phase will end with a limited user test, which officials stated will provide feedback on operational effectiveness, and phase 5 development, during which officials expect to further revise the digital twins.

Software and Cybersecurity

XM30 is developing its software in two parallel efforts. First, vendors will develop the basic vehicle software, which officials stated will be done in a government-provided software engineering environment with formal deliveries every 6 weeks. For example, the program reported that phase 3 and phase 4 vendors are required to create an artificial intelligence-enabled target recognition system for interaction with a human operator. Officials stated that this environment will allow for daily testing and collaboration, if desired. Second, a government-led effort will use the software acquisition pathway to develop additive software. The government-led effort will seek to move forward with artificial intelligence to increase automation and move the human interaction later in the process. Program officials stated that there is a workforce requirement of 11 software engineers for this effort that the program expect to fill with contract support.

Program Office Comments

We provided a draft of this assessment to the Army for review and comment. The Army provided technical comments, which we incorporated as appropriate.

The Army stated that the XM30 program is executing within cost, schedule, and performance parameters. It added that the requirements developed using modeling and simulation and informed by digital concepts from five vendors during phase 2 are being executed by two vendors during phases 3 and 4, while planning and preparation for phase 5 is underway.

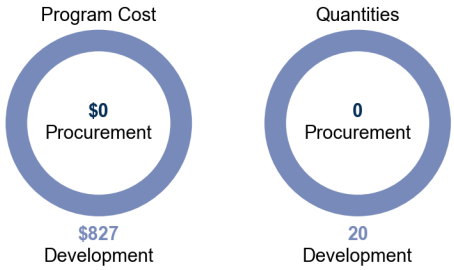
Extended Range Cannon Artillery (ERCA)

Source: U.S. Army. | GAO-24-106831

ERCA is part of the long-range precision fires portfolio, a top modernization priority of the Army. The Army initiated the ERCA program as a rapid prototyping effort on the MTA pathway in September 2018. The program plans to develop an upgrade to the M109 self-propelled howitzer that is intended to improve lethality, range, and reliability. The program also plans to add armament, electrical systems, and other upgrades to the existing vehicle. In future upgrades, the program plans to deliver further improvements, such as increasing the number of rounds fired per minute.

Estimated Cost and Quantities

(fiscal year 2024 dollars in millions)



Cost and quantity represent the MTA effort from fiscal years 2018-2023.

Software Development as of January 2024

Approach: Agile

Frequency of end user evaluation (months)

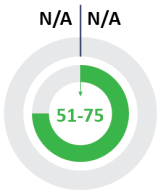
Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that the frequency of testing and feedback is unknown because they are dependent on the delivery of hardware. According to the program, software costs are not tracked. The program reported that the decrease in the percentage of progress as compared to last year is related to adjustments to the scope of the program to align with goals for fielding.

Program Essentials

Prime contractor: Army's Development Command, Armaments Center, supported by BAE Systems

Contract type: CPFF (development) (using other transaction authority)

Current Status

In September 2023, Army officials reported that the ERCA program was unable to transition to the major capability acquisition pathway at production start as planned within the 5-year MTA time frame. In December 2022, the program paused the developmental testing it expected would assess fixes to previously encountered technical challenges. Officials said the Army is conducting root cause analyses for five identified critical issues. As of September 2023, officials reported that root cause analyses for two of these critical issues were complete. Technical challenges have been identified for the remaining three critical issues and Army officials stated that they are developing mitigation strategies. Army officials stated that they were unsure when the program would be able to resolve these issues and resume testing.

The James M. Inhofe National Defense Authorization Act for Fiscal Year 2023 required the Army to brief Congress on ERCA's acquisition strategy, and a cost and value comparison between different approaches before moving to post-prototype production. However, as of January 2024, the Army had yet to determine the path forward for ERCA. Officials stated that the Army is conducting a portfolio-level study of its tactical fires systems that includes long-range precision fires. They noted that the findings from the study and completion of root cause analyses related to the five critical issues will influence ERCA's acquisition strategy, cost, and schedule.

While the program reported that it was using an iterative approach for development, Army officials reported challenges in implementing modeling and simulation activities into system design. They stated that attempts to validate the design too early without rigorous design analysis led to failures and delays. They noted that these challenges stemmed from the difficulty of properly capturing a first-of-its-kind system within the time frames of the MTA pathway.

Program Office Comments

We provided a draft of this assessment to the Army for review and comment. The Army provided technical comments, which we incorporated as appropriate. The Army stated that the ERCA rapid prototyping effort concluded and that the program is exploring a range of options to deliver operational capabilities identified through a portfolio study. Activities planned for fiscal year 2024 include industry engagements, continued market research, and ongoing analysis of mature and available systems, according to the Army.

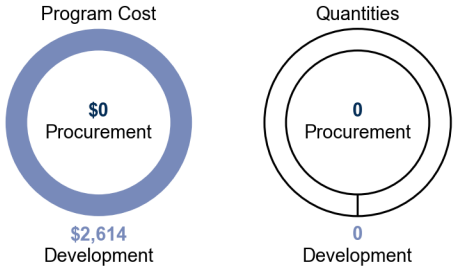
Source: U.S. Army. | GAO-24-106831

Future Attack Reconnaissance Aircraft (FARA)

FARA is part of the Future Vertical Lift portfolio of systems, a top modernization priority for the Army. The Army envisioned that it would provide enhanced capabilities for reconnaissance, attack, and aerial security. The Army expected FARA to provide these capabilities with increased performance, lethality, range, and sustainability over the current fleet, which is currently using the AH-64 Apache as an interim solution for armed reconnaissance. The Army has been pursuing the major capability acquisition pathway and a two-phase competitive prototyping strategy to acquire FARA. The Army now plans to end FARA development.

Estimated Cost and Quantities

(fiscal year 2024 dollars in millions)



Costs represent fiscal years 2019-2024.

Software Development as of January 2024

Approach: Agile, Incremental, and DevSecOps

Frequency of end user evaluation (months)

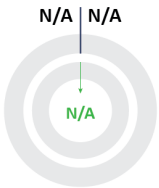
Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)

Software percentage of total acquisition cost
(fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported developing software for prototyping but has yet to begin full scale software development.

Program Essentials

Prime contractors: Bell Helicopter Textron, Inc; Sikorsky Aircraft Corporation

Contract type: FFP (prototype design and build) (using other transaction authority)

Current Status

In February 2024, the Army announced a rebalancing of its aviation portfolio. As part of this rebalancing, the Army plans to end the development of FARA at the conclusion of fiscal year 2024 prototyping activities and continue its investments in other aviation systems, including the Future Long Range Assault Aircraft and the CH-47F Block II helicopter. We discuss these aircraft in separate assessments.

Prior to this decision, the Army was developing and testing FARA prototype aircraft, the second phase of its competitive prototyping strategy. According to the program, the two vendors were about 97 percent complete with their prototypes as of September 2023. The remaining work relied on the delivery of a critical technology from a separate Army development program—the Improved Turbine Engine Program (ITEP). Army officials reported that first engine deliveries took place in October 2023, a total delay of 21 months. The Army also attributed delays to the FARA analysis of alternatives to these ITEP delays. The analysis of alternatives was initially scheduled for completion during fiscal year 2022, but was delayed until the second quarter of fiscal year 2024, according to Army officials. We discuss ITEP in a separate assessment.

The program reported using several leading practices for product development, such as using design modeling to iterate on prototype designs for flight testing and final contractor selection. Program officials stated that they developed early digital twins—virtual representations of physical products—for testing and had planned to develop a system-level digital twin as the design progressed. Officials noted that FARA conducted verification demonstrations to gain confidence in the program's modular open system approach and that the Army can apply this approach to its other aviation platforms.

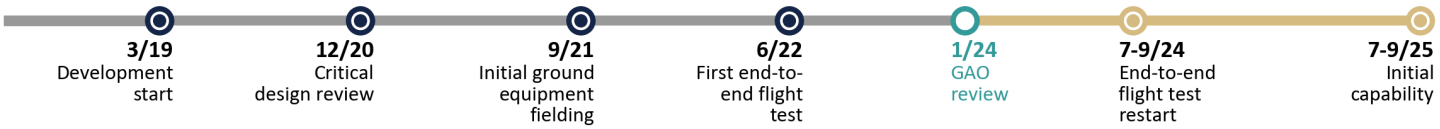
Program Office Comments

We provided a draft of this assessment to the Army for review and comment. The Army provided technical comments, which we incorporated where appropriate. It stated that given the evolution of aerial technologies, it is rebalancing its aviation portfolio to prioritize current, unmanned, joint, and space-based assets to enable it to meet the objectives envisioned for FARA. The Army further noted that this decision reflects the need to quickly adapt to changing requirements and evolving technology to deliver overmatch capabilities to its soldiers.

Long Range Hypersonic Weapon System (LRHW)

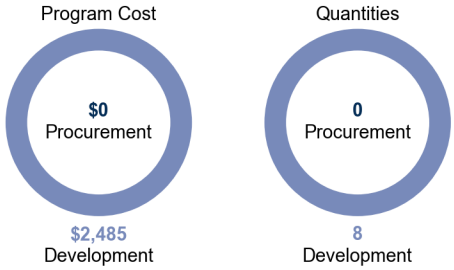
The Army's LRHW system is a ground-launched hypersonic missile battery designed to engage an adversary's long-range weapons and high-value, time-critical targets. The current research and development effort is managed by the Army's Rapid Capabilities and Critical Technologies Office. This effort's goal is to field the first LRHW battery, consisting of four launchers, related equipment, and an initial load of eight missiles. The missile is common with the Navy's Conventional Prompt Strike program, which is developing a ship-fired version. The Army initiated a separate MTA rapid fielding effort in August 2023 to field two more LRHW batteries.

Source: U.S. Army. | GAO-24-106831



Estimated Cost and Quantities

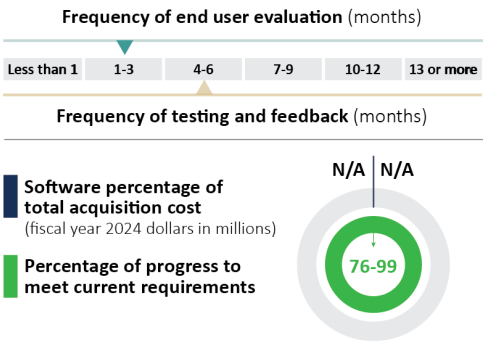
(fiscal year 2024 dollars in millions)



Cost and quantity information is from fiscal years 2019-2023. Reported funding only includes fielding the first battery, not follow-on efforts. This funding also includes four test rounds, which are not included in the quantities above.

Software Development as of January 2024

Approach: Agile and DevSecOps



The program reported that software costs are not currently tracked but are planned to be in the future.

Program Essentials

Prime contractor: Lockheed Martin; Dynetics, Inc.; Dynetics Technical Solutions

Contract type: CPIF/CPFF/FFP (includes use of other transaction authority)

Current Status

The Army missed its goal of fielding its first LRHW battery—including missiles—by fiscal year 2023 due to integration challenges. Based on current test and missile production plans, the Army will not field its first complete LRHW battery until fiscal year 2025. Before the Army can field an operational system, it must conduct a successful end-to-end missile flight test using the Army's launch system. The two most recent flight tests in 2023 were not completed due to launcher and launch sequence issues identified at the test range. The Army is conducting an independent technical review of the launcher and plans to test the launch sequence separately from the missile before it resumes flight testing. In that scenario, LRHW officials stated that the next end-to-end flight test with the launcher would not occur until the fourth quarter of fiscal year 2024. The Navy plans to return to flight testing earlier in fiscal year 2024.

The LRHW integration issues discovered during testing also affect missile production. The Army cannot complete the missiles for the first battery until a successful test demonstrates that the current design works. LRHW officials stated that once a successful flight test is achieved, the first production missile will be delivered within approximately 6 weeks and the first battery of eight missiles will be delivered within approximately 11 months. If the Army discovers issues with missile performance in flight testing, missile deliveries and the fielding of the first operational LRHW system could be further delayed. According to Army officials, the schedule for the MTA rapid fielding effort for two more batteries is also contingent on what the Army identifies as the root cause of the integration issues.

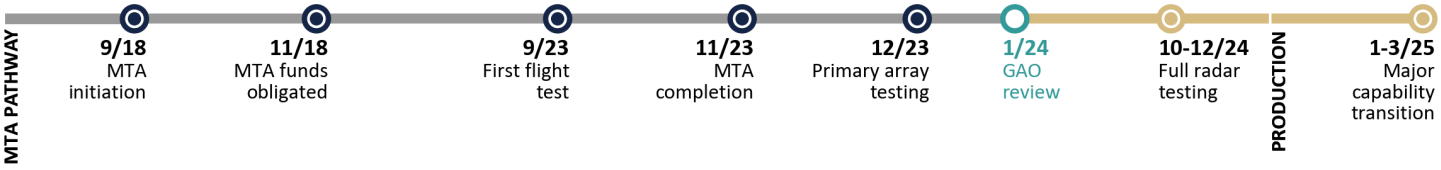
Program Office Comments

We provided a draft of this assessment to the Army for review and comment. The Army provided technical comments, which we incorporated where appropriate. According to the Army, the LRHW program is committed to delivering this critical capability in coordination with the Navy. It stated that following the integration challenges discovered in flight test, the military departments and industry partners established an independent review of the entire system and embarked on a rigorous risk reduction test campaign. The Army added that the program is on track to implement required corrective actions and successfully demonstrate system performance by the fourth quarter of fiscal year 2024.

Lower Tier Air and Missile Defense Sensor (LTAMDS)

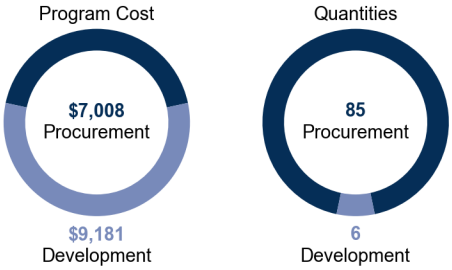
Source: Copyright 2020 Raytheon Company. | GAO-24-106831

The Army's LTAMDS is expected to be a multifunction radar that will replace the current Patriot radar. As part of the Army's Integrated Air and Missile Defense Battle Command System architecture, LTAMDS intends to address critical capability gaps, modernize technology, and increase reliability and maintainability. The Army plans to continue developmental testing and execute an operational assessment in the first quarter of fiscal year 2024, and enter the major capability acquisition pathway at production start in the second quarter of fiscal year 2025.



Estimated Cost and Quantities

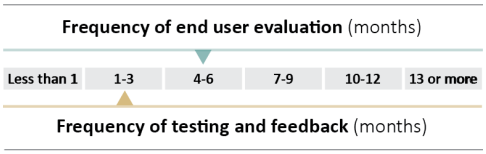
(fiscal year 2024 dollars in millions)

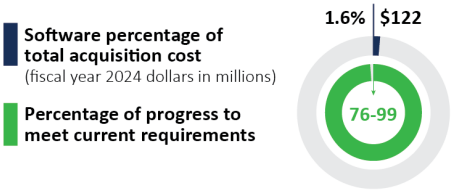


Cost includes recurring development estimates for technology advancement, capability improvements, and obsolescence through fiscal year 2065.

Software Development as of January 2024

Approach: Agile





Program Essentials

Prime contractor: Raytheon

Contract type: FFP (build and test prototypes) (using other transaction authority)

Current Status

The LTAMDS MTA effort ended in November 2023, but the Army extended the date to enter production on the major capability acquisition pathway to the second quarter of fiscal year 2025—over a year later than we previously reported. The delay stemmed from challenges to interoperability, software, and radar performance during contractor verification testing and prevented LTAMDS from transitioning within 5 years. Program officials reported that additional contractor testing in June and July 2023 showed hardware stability and software improvements, enabling the program to enter developmental testing.

LTAMDS completed an operational assessment in December 2023. It successfully detected, tracked, and classified a target ballistic missile, but was unsuccessful in engaging the target. In the first quarter of fiscal year 2024, LTAMDS verified updated radar software and completed two missile flight tests that the Army stated were successful. Prior to entering production, the program will conduct two phases of developmental testing—first with the primary array, and then with the two secondary arrays for full integration of the radar. During this period, the program office plans to finalize documentation for its transition into production.

LTAMDS reported that soldiers participate in training events to provide feedback that the program incorporates into the development process to improve usability. Our previous work found that incorporating user feedback allows leading companies to identify problems early and inform decision-making.

Program Office Comments

We provided a draft of this assessment to the Army for review and comment. The Army provided technical comments, which we incorporated where appropriate. According to the Army, LTAMDS was authorized to complete pre-milestone activities prior to a planned production decision in the second quarter of fiscal year 2025. The Army stated that flight tests successfully validated solutions to technical challenges in the primary, forward-facing array of the radar, and the test program in 2024 will expand to the 360-degree capabilities. It added that Air and Missile Defense, including LTAMDS, is in the top six Army modernization priorities.

NAVY

Program Assessments

▲ CVN 78 Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)

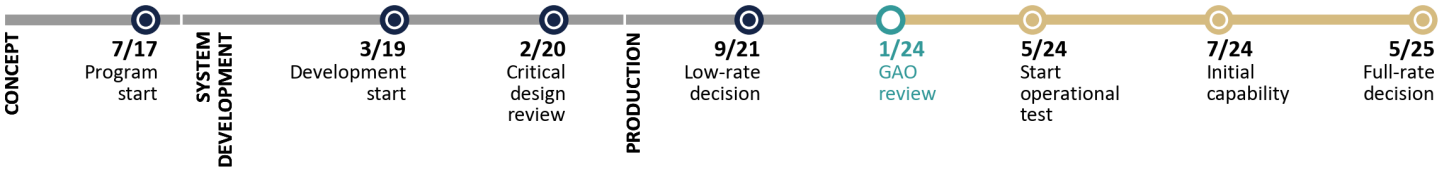
Assessment type	Program name
MDAPs	Advanced Anti-Radiation Guided Missile - Extended Range (AARGM-ER)
	Air and Missile Defense Radar (AMDR)
	CVN 78 Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)
	DDG 1000 Zumwalt Class Destroyer (DDG 1000)
	F/A-18E/F Infrared Search and Track (IRST)
	FFG 62 Constellation Class Frigate (FFG 62)
	MQ-25 Unmanned Aircraft System (MQ-25 Stingray)
	MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)
	Next Generation Jammer Mid-Band (NGJ MB)
	Ship to Shore Connector Amphibious Craft (SSC)
	SSBN 826 Columbia Class Ballistic Missile Submarine (SSBN 826)
	T-AO 205 John Lewis Class Fleet Replenishment Oiler (T-AO 205)
MDAP Increments	DDG 51 Arleigh Burke Class Destroyer, Flight III (DDG 51 Flight III)
	LPD 17 San Antonio Class Amphibious Transport Dock, Flight II (LPD 17 Flight II)
	SSN 774 Virginia Class Submarine Block V (VCS Block V)
MTA Programs	Conventional Prompt Strike (CPS)
	Hypersonic Air-Launched Offensive Anti-Surface Warfare Weapon System (HALO)
Future Major Weapon Acquisitions	DDG(X) Guided Missile Destroyer (DDG(X))
	E-6B Recapitalization (E-XX)
	Large Unmanned Surface Vehicle (LUSV)
	Medium Landing Ship (LSM)
	MK 54 MOD 2 Advanced Lightweight Torpedo (ALWT)
	Orca Extra Large Unmanned Undersea Vehicle (XLUUV)
	Submarine Tender Recapitalization Program (AS(X))

Source (previous page image): U.S. Navy. | GAO-24-106831

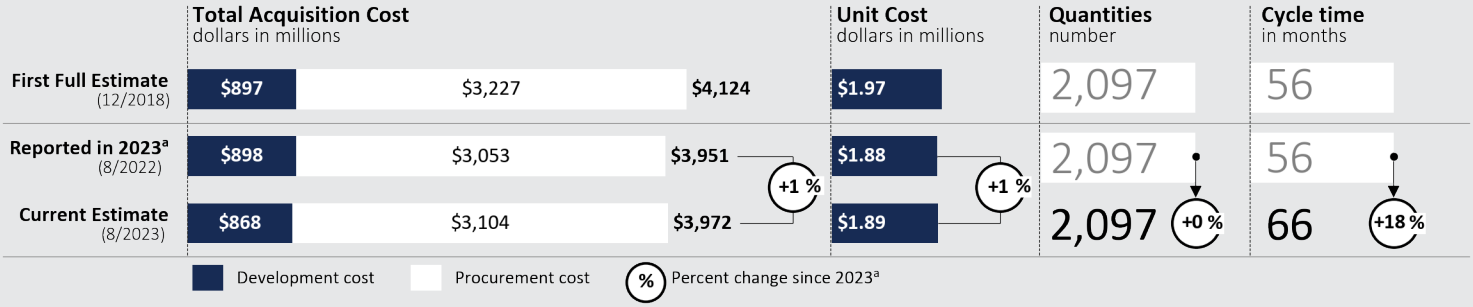
Advanced Anti-Radiation Guided Missile—Extended Range (AARGM-ER)

Source: Northrop Grumman Innovation System (NGIS). | GAO-24-106831

The Navy's AARGM-ER program is an upgrade to the AGM-88E AARGM. The AARGM-ER is an air-launched missile that is intended to provide increased range, higher speed, and more survivability to counter enemy air defense threats. It will incorporate upgrades to the AARGM missile's guidance and control sections, as well as a new rocket motor, warhead, and control actuation system, which includes fins that help steer the missile. AARGM-ER will be integrated on the F/A-18E/F and EA-18G aircraft and configured to be carried on the F-35 aircraft.



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise 17 development quantities and 2,080 procurement quantities.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Spiral

Frequency of end user evaluation (months)

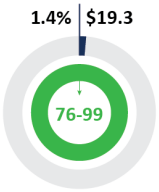
Information not available

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that end users are not involved in evaluating and providing feedback on the software because the software is for weapon performance, not for the user interface. According to the program, the software requires fewer changes in code as it reaches maturity, which enabled more frequent testing and feedback as compared to last year.

Program Essentials

Prime contractor: Alliant Techsystems Operations, LLC

Contract type: CPIF (development); FFP (procurement)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	○	●
Demonstrate all critical technologies in a realistic environment	○	●
Complete a system-level preliminary design review	●	●
Product design is stable	Design Review	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	○	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

AARGM-ER Program

Technology Maturity, Design Stability, and Production Readiness

According to the AARGM-ER program, it currently has mature critical technologies, a stable design, and mature manufacturing processes, but it continues to experience challenges. The Navy approved the AARGM-ER program to start production in August 2021, at which point it had met some, but not all, leading practices for production readiness. Specifically, the program had not tested a system-level integrated prototype or a production-representative prototype in an operational environment. The program has since conducted these prototype flight tests as part of its developmental test program in 2023. We have found that starting production before demonstrating a system will work as intended increases the risk of discovering deficiencies that require costly, time-intensive rework. In the case of the AARMG-ER program, it continues to make software updates to address the findings from developmental tests.

Although AARGM-ER's manufacturing processes are mature, the program reported experiencing delivery delays of 5 to 8 months on its first production contract. According to Defense Contract Management Agency officials, multiple parts delays and quality issues are delaying missile production. For example, the program has experienced challenges related to the AARGM and AARGM-ER's digital radio frequency processor, which is part of the guidance system. Program officials attributed the processor delays to quality issues and supplier learning curves, among other factors, which the prime contractor has tried to address through better training. Further, the AARGM-ER contractor is also manufacturing the final three production lots of AARGM missiles, the predecessor to AARGM-ER, among other efforts. According to program officials, juggling the needs of all its military customers is a management challenge for the contractor as it tries to keep AARGM-ER production on track to provide an initial operational capability in July 2024.

Software and Cybersecurity

Software development and the software changes required to address the findings from AARGM-ER testing are among the main drivers of schedule delays for the program. Since our last assessment, the program delayed the start of operational testing and the fielding of an initial operational capability by 9 and 7 months, respectively. The program completed the final planned software build for the missile in June 2023, but is continuing to refine it based on the results of developmental testing. According to the Office of the Director, Operational Test and Evaluation (DOT&E), the program's developmental test findings required software updates that proved more complex than anticipated. The updates required additional time to correct and implement, which has delayed both software deliveries and test events. Additionally, both industry and government have struggled to hire and retain skilled developers, resulting in a staffing shortfall for AARGM-ER and delays to software releases. Cybersecurity testing for the program began in 2023.

Other Program Issues

The AARGM-ER program compressed its planned operational test schedule to mitigate the effects of other schedule delays on its initial operational capability date. Since our last assessment, the program reduced the initial operational test period from 10 months to 3 months. Program officials stated they could realize efficiencies by increasing the pace of testing. However, increasing the pace of testing can pose risks, too, such as not allowing enough time to implement fixes for any issues discovered.

Test range availability and limitations have also been a challenge for AARGM-ER and resulted in test plan changes and scheduling delays. According to a DOT&E official, AARGM-ER's extended range and advanced capabilities, as well as the requirement to test it against advanced targets and threats, exceed the capabilities of most test ranges. The program has made progress addressing these challenges. For example, for the last developmental test in 2023, the Air Force's Nevada Test and Training Range and the Navy's China Lake Range cooperated to enable an AARGM-ER flight from one range at a target set in the other range, through coordination with the Federal Aviation Administration.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

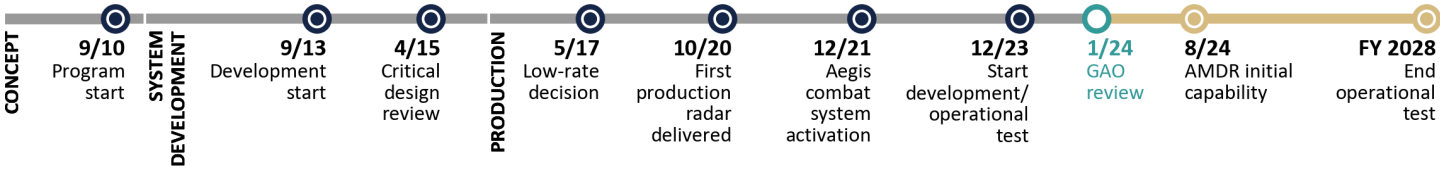
The program office also provided perspectives on the status of the program. Specifically, it stated that the program completed developmental testing in 2023. It noted that, upon the completion of qualification testing and with concurrence from a safety review board, the program would enter operational testing in 2024. It added that during this accelerated test period, Navy and DOD testers would be able to assess the operational performance and suitability of AARGM-ER for initial operational capability.

Finally, the program office stated that to meet warfighter needs, it awarded the first two production contracts concurrently with developmental testing. The program stated that it expects delivery of the first missiles in 2024. It noted that it awarded a third production contract in late 2023 to maintain the production line in light of the extended lead times it was facing for parts. The program office stated that it is currently planning for the fourth production contract.

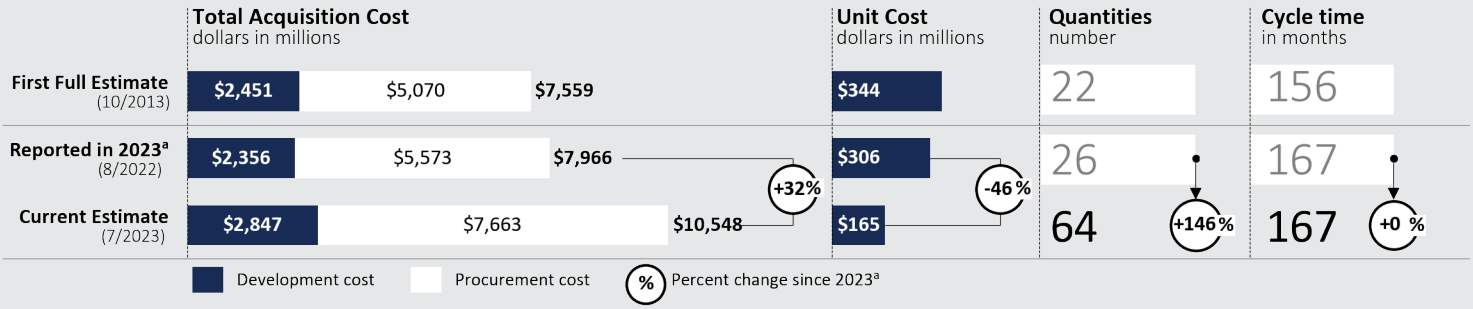
Source: Huntington Ingalls Industries. | GAO-24-106831

Air and Missile Defense Radar (AMDR)

The Navy's AMDR is a next-generation radar program supporting surface warfare and integrated air and missile defense. The Navy expects AMDR's family of radars—beginning with the AN/SPY-6(V)1—to provide increased sensitivity for long-range detection to improve ballistic missile defense against advanced threats. The Navy is also developing a radar suite controller to interface with an updated Aegis combat system (ACS) to provide integrated air and missile defense for DDG 51 Flight III destroyers. In January 2023, the Navy added two Enterprise Air Surveillance Radar (EASR) variants of the AN/SPY-6 radar to the program. These variants will provide next generation radars for other ship classes.



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise zero development quantities and 64 procurement quantities. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance. The addition of two EASR radar variants as subprograms in January 2023 added 37 additional units to the program baseline. EASR radars are planned to cost less than the AN/SPY-6(V)1 radar, driving down the program's unit cost.
[a]GAO-23-106059.

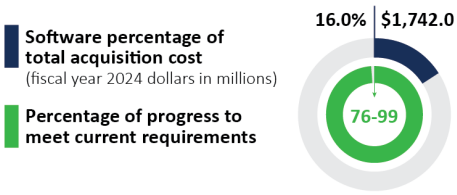
Software Development as of January 2024

Approach: Agile and Incremental

Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)



Program Essentials

Prime contractor: Raytheon

Contract type: FFP (procurement); CPFF (engineering)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	●	●
Demonstrate all critical technologies in a realistic environment	○	●
Complete a system-level preliminary design review	○	●
Product design is stable	Design Review	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	●	●
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	○	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

We did not assess AMDR's demonstration of critical processes on a pilot production line because the program office stated that this program uses no critical manufacturing processes.

AMDR Program

Technology Maturity, Design Stability, and Production Readiness

Program officials reported that the contractor has produced seven of nine AMDR AN/SPY-6(V)1 radars and expect delivery of the remaining two by August 2024. Three of the delivered radars are now installed on DDG 51 Flight III ships. According to AMDR officials, the program also installed two of the smaller EASR radar variants on other ship classes. According to program officials, AMDR radar production is outpacing ship production of DDG 51 Flight III ships, which may result in storage of completed radars prior to their final installation. We assess the DDG 51 Flight III ship program separately in this report and reported that DDG 51 Flight III ship production is delayed by 6 to 25 months.

The program continues to identify and address issues discovered during environmental qualification testing. For example, program officials stated that the program resolved an issue we previously reported on with the Transmit/Receive Integrated Microwave Modules that would have affected both AMDR and EASR radars. They added that they made additional engineering changes to the inverter modules, a critical part of the power supply system, to address issues discovered during shock testing. These engineering changes are being incorporated into the radars, with plans to retrofit 13 inverter module systems already delivered, according to the program.

In June 2023, during acceptance trials for the DDG 125, Navy inspectors identified major integration deficiencies between the AN/SPY-6(V)1 radar and ACS. According to program officials, these deficiencies caused errors in tracking performance and processing during the test. As a result of these deficiencies, DDG 125 has yet to demonstrate that it is capable of completing the air warfare mission. Officials stated that they have taken steps to address the deficiencies; however, some software that needs to successfully interface with the ACS may not be certified until August 2024.

The next opportunity to test the AN/SPY-6(V)1 at sea with the ACS and DDG 125 is combined developmental and operational testing, which the Navy began in December 2023. The Navy expects to continue operational testing through 2028. Discovery of additional deficiencies during testing could result in costly and time-intensive revisions, particularly if rework is required for installed radars. Program officials acknowledged this risk and noted it is somewhat mitigated by other opportunities to identify and correct defects during transits and other underway periods.

Software and Cybersecurity

Program officials continue to track a risk from cyber threats related to countermeasures seeking to defeat the radar and plan to address this risk as part of combined radar and combat system operational testing with DDG 125. Further, program officials plan to continually update software, beginning with a release in spring 2024, to add countermeasures as the system encounters new threats, such as jamming. The program also expects to conduct a cooperative vulnerability and penetration assessment and an adversarial assessment in 2025.

Other Program Issues

Program officials reported that the low-rate initial production contract was at its price ceiling due to global inflation increasing material and component pricing. The Navy reported converting the low-rate initial production contract from fixed-price-incentive to firm-fixed-price in August 2023. Program officials stated that, while this resulted in the government paying a higher price, they believe that the Navy negotiated better pricing on the hardware production and sustainment contract as a result.

The Navy plans to begin backfitting a SPY-6 radar variant on mid-life DDG 51 destroyers starting in fiscal year 2026, according to program officials. These officials noted that a limited supplier base for components could affect pricing, but that there is sufficient industrial base capacity to support additional radar quantities. They explained that recent sustainment contracts include the backfitting plan and represent a demand signal to the supplier base. The Navy plans to use funding for the surface combatant industrial base to accelerate purchases of equipment and larger quantities, as well as encourage competition for critical components to reduce the cost and schedule risk caused by the limited supplier base.

Program Office Comments

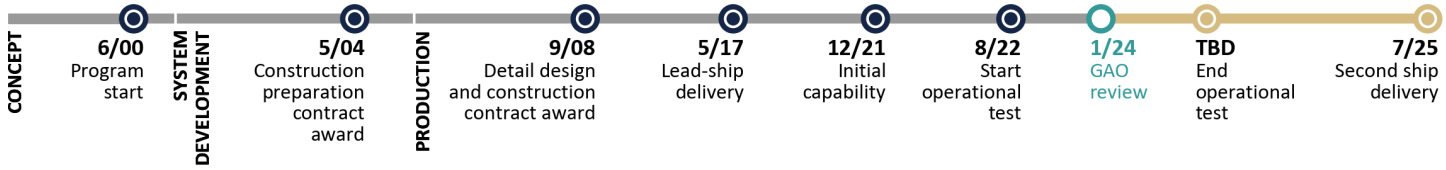
We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office stated that it remains on track to support combat systems for all variants including radars for DDG Flight III, DDG Flight IIA backfit, and other ship types. According to the program, DDG 125 was delivered and conducted a successful live-fire Anti-Air Warfare intercept upon sail-away in September 2023. It also noted that discovery and correction of defects continues as underway time permits opportunities to collect data. It added that resolution of defects identified in acceptance trials remains on-plan to be corrected in May 2024 and that all SPY-6 variants remain on schedule to support shipbuilding schedules, with variants SPY-6(V)2 and (V)3 installed in other ship classes and undergoing trials.

In May 2024, after our cutoff date for new information, the program office reported that planned initial capability was delayed until fiscal year 2027.

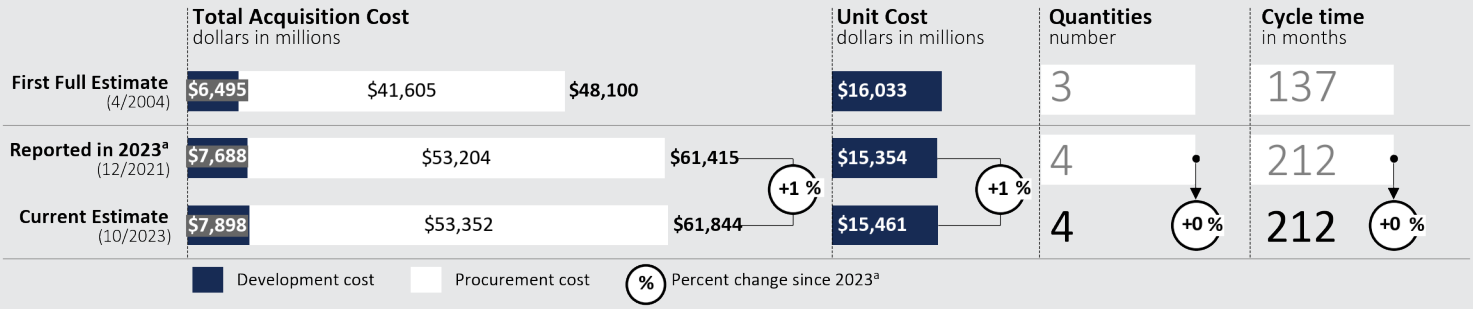
CVN 78 *Gerald R. Ford* Class Nuclear Aircraft Carrier (CVN 78)

Source: U.S. Navy. | GAO-24-106831

The Navy developed the CVN 78 (or *Ford* class) nuclear-powered aircraft carrier to introduce new propulsion, aircraft launch and recovery, and survivability capabilities to the carrier fleet. The *Ford* class is the successor to the *Nimitz* class aircraft carriers. Its new technologies are intended to create operational efficiencies and increase the rate of sustained flight operations, compared with legacy carriers. The Navy also expects the new technologies to enable *Ford* class carriers to operate with smaller crews than *Nimitz* class ships.



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise zero development quantities and four procurement quantities. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Information not available

Frequency of end user evaluation (months)

Information not available

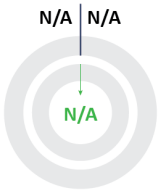
Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program office reported that it does not separately track software because other Navy programs provide software.

Program Essentials

Prime contractor: Huntington Ingalls Industries; Newport News Shipbuilding

Contract type: FPI (detail design and construction)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Construction Preparation Contract Award	Current Status
Demonstrate all critical technologies in a relevant environment	○	●
Demonstrate all critical technologies in a realistic environment	○	●
Complete a system-level preliminary design review	○	●
Product design is stable	Fabrication Start	
Complete 100 percent of basic and functional design using computer-aided modeling	○	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

We assessed the CVN 78 resources and requirements knowledge metrics at the time of the construction preparation contract award, rather than the detail design contract award, because that is the point at which the program began CVN 78 development.

CVN 78 Program

Technology Maturity, Design Stability, and Testing

Twenty-four years after the program started, CVN 78's 12 critical technologies are mature and the design is stable, though the program replaced the *Ford* class's original Dual Band Radar with the new Enterprise Air Surveillance Radar (EASR) on CVN 79 and later ships. Program officials stated that they plan to begin EASR testing on CVN 79 in 2024. The program also anticipates that the transition to a digital design tool will enhance construction efficiency.

The Navy began operational testing on CVN 78 in August 2022, but extended the test period by 16 months to March 2025, and the Office of the Director, Operational Test and Evaluation (DOT&E) reported an additional delay into fiscal year 2027. According to program officials, two factors caused this test extension. First, the program needs additional time to plan and prepare for one of the ship's final test events that will also demonstrate CVN 78's ability to launch and recover aircraft more quickly than *Nimitz* class ships. Second, the Navy moved CVN 78's first operational deployment from 2024 to 2023 in support of operations in the Middle East, which also delayed test events. DOT&E identified a third factor: the time to incorporate data on aircraft launch and recovery testing, run associated models, and analyze results.

Cybersecurity

According to program officials, the CVN 78 program completed a second cybersecurity vulnerability assessment in February 2023, and they plan for a third to be completed in February 2024. Program officials also said the third assessment will use data from prior assessments to conduct an adversarial assessment on live ship systems.

Other Program Issues

Since our last assessment, the Navy increased the CVN 79 cost limitation baseline by $236 million to support full ship delivery efforts. According to Navy documentation, this amount does not reflect new costs for the program because the Navy previously planned and budgeted this amount for post-delivery activities. As of December 2023, CVN 79 is 90 percent complete, according to program officials. This change moves work originally planned to occur after delivery—such as modifications to support the F-35—to the construction phase. Program officials told us they based this decision on lessons learned from CVN 78, which had more post-delivery work than expected, resulting in schedule delays and cost growth. The Navy anticipates that this will decrease the time required to resolve discrepancies discovered during the ship's trials.

The shipbuilder is now scheduled to deliver CVN 79 in July 2025 instead of September 2024. Program officials stated this change did not result in new program costs. However, it did move planned post-delivery costs into CVN 79's construction cost limitation baseline, resulting in an increase to $12.9 billion—more than $1.5 billion over the same baseline since 2021. As we reported last year, CVN 79 costs increased $1.3 billion largely due to contract overruns.

Construction delays are emerging for CVN 80 because of ongoing industrial base challenges. Program officials project that the ship will not meet its planned March 2028 delivery and are conducting a schedule assessment with the shipbuilder. CVN 80 is 36 percent complete and facing supply chain delays, as well as challenges with shipyard and vendor workforces. Program officials explained that the shipbuilder is struggling with a smaller, inexperienced workforce that is less efficient at completing work, especially after many skilled, senior workers retired during the COVID-19 pandemic. The Navy reported that the contractor is taking steps to mitigate these issues by using contracting incentives to improve shipyard facilities to better attract and support workers and expanding the dry dock to enable simultaneous construction of two carriers. While these mitigations can help the *Ford* class more broadly, they are unlikely to improve CVN 80 construction performance because they are not yet in place.

Program officials do not expect industrial base issues to affect CVN 81, based on planned shipyard improvements. CVN 81 keel laying is planned for 2026 and delivery in 2032. Further, officials are considering a two-ship contract for planned CVNs 82 and 83, like the Navy reported awarding for CVNs 80 and 81. They are examining potential acquisition strategies to inform the fiscal year 2025 budget submission.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. It provided technical comments, which we incorporated where appropriate.

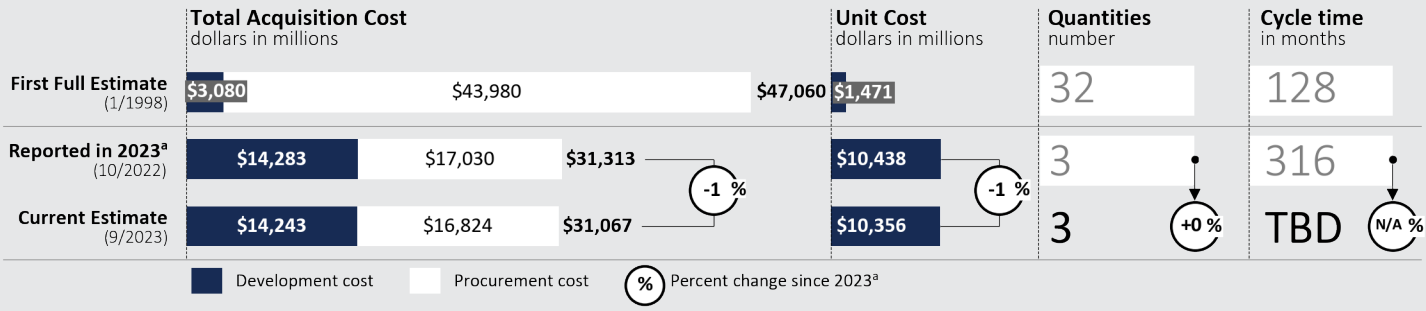
The Navy noted that CVN 78's first operational deployment was accelerated from 2024 to 2023, and that the ship returned from the eastern Mediterranean in January 2024 after an extended deployment that included working with 17 nations, sailing 83,476 nautical miles, conducting 10,396 sorties, and logging 17,826 flight hours. Program officials did not provide additional details on DOT&E's reported delay of the end of operational testing except to note that they are evaluating the schedule of remaining test events. The program stated that CVN 79's delivery strategy is expected to lead to a more capable ship at delivery and prepare it as the first Ford class carrier to operate in the Indo-Pacific region while decreasing post-delivery time at the shipyard. It added that the Navy and the shipbuilder are upgrading shipyard facilities and assessing shipbuilder and vendor resources to improve efficiency and schedule performance. The program stated that it expects initiatives such as a digital shipbuilding model and shipyard improvement incentives to improve planning and construction efficiency.

DDG 1000 *Zumwalt* Class Destroyer (DDG 1000)

Source: BAE Systems San Diego. | GAO-24-106831

The DDG 1000 was conceived as primarily a land-attack ship, but the Navy is in the process of changing its primary mission to offensive surface strike. The *Zumwalt* class ships feature a stealth design, an integrated power system, and a total ship computing environment. Among other capabilities added to fulfill the strike mission, the Navy now plans to add Conventional Prompt Strike (CPS) hypersonic missile capability, with availability on the lead ship planned for 2025. We evaluate the CPS program in a separate assessment in this report.

Program Performance fiscal year 2024 dollars in millions



The program office stated that it provided an incorrect date for the initial operational capability—April 2023 instead of April 2024—in last year's assessment. The cycle time above for our 2023 report reflects the corrected date. Total quantities comprise zero development quantities and three procurement quantities.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Agile and DevOps

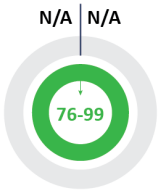
Frequency of evaluation and feedback (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that software cost elements are not tracked. The program reported that the decrease in the frequency of testing and feedback was to better align with ship schedules and reduce operational impacts.

Program Essentials

Prime contractors: General Dynamics Bath Iron Works; Huntington Ingalls Industries; Raytheon

Contract type: FPI/FFP/CPFF (ship construction); CPFF/CPAF (mission systems equipment)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Detail Design Contract Award	Current Status
Demonstrate all critical technologies in a relevant environment	○	○
Demonstrate all critical technologies in a realistic environment	○	○
Complete a system-level preliminary design review	●	●
Product design is stable	Fabrication Start	
Complete 100 percent of basic and functional design using computer-aided modeling	...	...

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

We could not assess DDG 1000 design stability because the program office stated that it did not collect information on the status of basic and functional design completion.

DDG 1000 Program

Technology Maturity, Design Stability, and Production Readiness

The DDG 1000 program has yet to mature a total of four critical technologies despite completing construction for all three ships in the class. According to the program, the Navy intends to demonstrate full maturity for three of these technologies—which involve the ships' signature, computing, and radar capabilities—during operational testing.

However, the program experienced recent testing delays. For example, the program office noted that DDG 1001 did not complete its final contract trial in September 2023 as planned to support the ship's delivery to the Navy. The program also did not complete initial operational test and evaluation in January 2024 as planned. The program office reported that the dates for completing that testing and achieving initial operational capability are under review by the program. The program office added that it continues testing to support initial operational capability at some point in 2024—capability that is already delayed more than 7 years from the approved acquisition program baseline date.

The program's fourth immature critical technology—an intelligence system—is part of surface strike capabilities that were added to the program's requirements. As we reported in last year's assessment, installation of this intelligence system and one other surface strike critical technology was delayed at the direction of the Chief of Naval Operations. The program office stated that installation of these two technologies continues to be deferred because the Navy prioritized integrating the CPS hypersonic weapons system on the ships. Two other mature critical technologies for surface strike were previously added to provide enhanced missile capabilities. For these technologies, the program is preparing DDG 1001 to conduct testing and demonstration events in fiscal year 2024.

Other Program Issues

Since our last assessment, DDG 1000 conducted a multinational fleet training exercise focused on fostering joint interoperability and improved combat readiness. The Navy also awarded a contract modification in August 2023, increasing the contract value by approximately $157 million to support a modernization period for DDG 1000. The primary purpose of the ship's modernization period—planned through mid-2025—is to install the CPS hypersonic weapon system. Adding CPS involves removing the advanced gun system from *Zumwalt* class ships and a major structural change to enable installation and integration of a large missile vertical launch system. According to the program office, DDG 1000 will be the first ship to deliver CPS capability, with a live demonstration scheduled for 2025.

DDG 1000 program officials noted that CPS installation in the *Zumwalt* class destroyers is a top priority for the Chief of Naval Operations. Since last year's assessment, the Navy developed an integrated acquisition strategy for the DDG 1000 program reflecting the prioritization of CPS installation. Specifically, the new strategy reorders the CPS installation schedule, with DDG 1000 receiving the system first, followed by installation beginning in early 2025 for DDG 1002 and in summer 2026 for DDG 1001.

Program officials stated that the decision to install the CPS weapon system on DDG 1001 last creates efficiencies for the Navy. They noted that the previous installation plan would have negatively affected sailors by creating a schedule where DDG 1001 embarked for a limited period at sea after ship delivery before returning to the shipyard for the installation. The revised schedule also delays final delivery of DDG 1002 by 26 months to the end of 2026. This delay allows the ship—already at the shipyard in Mississippi for its combat systems installation and activation—to remain at the yard to complete CPS installation. Finally, DDG 1000 program officials stated that the new CPS installation strategy allows the Navy to maintain operational availability of at least one *Zumwalt* class ship throughout the program's overall installation period.

Despite these efforts to achieve efficiencies, CPS continues to present risks to DDG 1000's installation schedule. Program officials stated that remaining technical risks and the need to demonstrate CPS capability through successful testing make upholding the DDG 1000 installation schedule the biggest challenge. They noted that they are managing the risk through regular communication with the CPS program.

In addition to installing CPS, the Navy plans to address several design deficiencies during the DDG 1000 modernization period. For example, Navy officials stated that the ship experienced significant biofouling during its first deployment. Biofouling—which occurs when sea life is ingested through the seawater cooling system and continues to thrive inside the ship—contributes to clogged filters, valves, and pipes. According to Navy officials, the program is also addressing an issue with the ship ingesting its own engine exhaust.

Program Office Comments

We provided a draft of this assessment for program office review and comment. The program office provided technical comments, which we incorporated where appropriate. According to the program, it has made significant progress in testing and modernization on DDG 1000 and DDG 1001 while completing combat system activation on DDG 1002. The program office also stated that since 2020, DDG 1000 and DDG 1001 supported significant testing and certain fleet exercises and operations. The program office added that the Navy accelerated modernization efforts to support fielding a long-range precision hypersonic capability on *Zumwalt* class destroyers and is on track to field the capability in 2025.

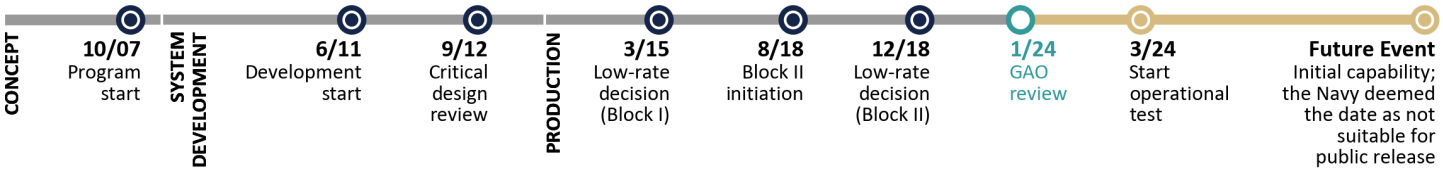
MDAP | Lead Component: Navy

Common Name: IRST

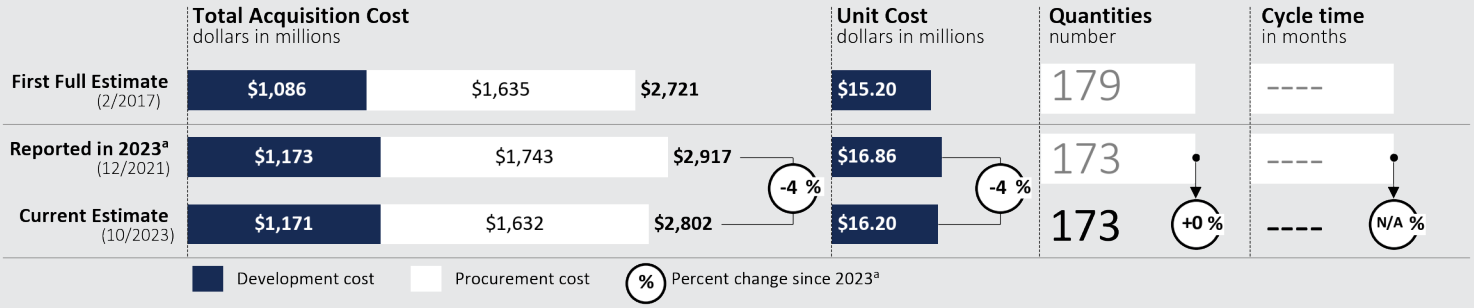
Source: U. S. Navy. | GAO-24-106831

F/A-18E/F Infrared Search and Track (IRST)

The Navy is integrating new and existing infrared search and track sensors onto the F/A-18E/F fuel tank. The sensors are intended to enable F/A-18s to detect and track objects from a distance and in environments where radar is ineffective. The Navy is acquiring IRST with an evolutionary acquisition approach, including two system configurations (referred to as blocks). Block I integrated an existing IRST system onto the F/A-18 external fuel tank pod. Block II, which we assessed, develops an improved sensor, upgraded processor, and additional software.



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise three development quantities and 170 procurement quantities. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance. The Navy determined that the program's expected initial operational capability date is not suitable for public release. As such, the program's cycle times have been removed from the graphic.

[a]GAO-23-106059.

Software Development as of January 2024

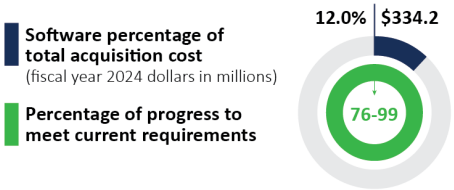
Approach: Agile

Frequency of end user evaluation (months)

Other frequency (see notes)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)



The program reported that aircrews evaluate and provide feedback on software during flight tests. According to the program, the improved frequency of testing and feedback and the percentage of software completed can be attributed to the maturation of its Agile software development process, increased workforce, and test asset availability.

Program Essentials

Prime contractor: Boeing (through Lot 4 procurement); Boeing, Lockheed Martin, and Meggitt

Contract type: FPI (procurement)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	●	●
Demonstrate all critical technologies in a realistic environment	○	●
Complete a system-level preliminary design review	●	●
Product design is stable	Design Review	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	○	●
Test a production-representative prototype in its intended environment	○	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

IRST Block II did not have a separate development start date from Block I; therefore, we assessed Block II's critical technology based on its technology readiness level at the time Block I development started.

IRST Program

Technology Maturity, Design Stability, and Production Readiness

In early 2023, the IRST program demonstrated critical processes on a pilot production line with delivery of the first Block II production representative articles—called infrared optimized configuration (IROC) pods. Officials stated that IRST accepted delivery of all IROC pods as of December 2023.

Program officials stated that they made progress over the past year in addressing production quality issues related to microelectronics that had delayed pod deliveries. The effects of prior production issues are still evident, as IRST has yet to deliver the first Block II low-rate initial production (LRIP) lot, which was expected by June 2023. Officials expect those pods to be delivered by June 2024.

IRST also faces new production challenges that have caused cascading delays up the production chain, which could result in deployment delays. Program officials explained that multiple subcontractors delayed delivery of key components needed for integration into the pods. For example, IRST officials stated that the program experienced a 5-month delay in a subcontractor's delivery of an IRST subassembly. This component is driving the schedule for delivery of the infrared receiver. To mitigate risks, the program plans to clearly define subcontractor manufacturing processes and improve efficiency.

Although the program revised its baseline schedule in 2022, the current schedule shows that IRST will miss its target date for initial operational capability established in the revised baseline. We previously reported that IRST's approach increased the risk of schedule delays because it included overlapping development and production to achieve an accelerated initial operational capability.

Software and Cybersecurity

Program officials reported significant progress in software development in the last year. IRST completed all of its planned firmware releases and multiple Agile software bug fixes, including the V3 Build 2.1 family, which is meant for operational testing and fleet fielding. The program plans to deliver the final software iteration in February 2024. IRST officials stated that the program's software progress improved since last year due to improved contractor staffing, delivery of the first IROC pods enabling maturation, and a modified Agile approach utilizing more frequent monthly releases to address issues found in testing.

Program officials added that the largest area of concern is addressing software stability in the full range of operational flight conditions during testing.

The program completed cybersecurity testing in November 2023 and is awaiting the cyber report that will support initial operational capability and full-rate product decisions.

Other Program Issues

Since last year's report, the program accelerated its planned start of operational testing by 1 month, to March 2024, although this time frame is still behind its baseline schedule target of August 2023. Program officials stated that they expect to be able to start operational testing earlier due to process improvements and accelerated software development. The program plans to complete operational testing by fall 2024.

Officials reported that they implemented an improved contracting strategy that reduced the procurement unit prices after LRIP lot 4. They stated that IRST now contracts directly with three prime contractors—instead of one—to procure IRST components, and Navy squadrons integrate these components into IRST pods. According to officials, this strategy allowed the program to achieve economies of scale by combining orders from outside the program and avoiding prime contractor pass-through fees. As a result, IRST reduced procurement unit costs from $7 million in LRIP lot 4 to $4.96 million in LRIP lot 7.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated as appropriate.

The program office reported that although IRST will not meet the acquisition program baseline objective dates due to the outlined delays in technology maturity, software development, and integration issues, IRST is on track to meet baseline threshold dates for the start of operational testing, the full-rate production decision, and initial capability.

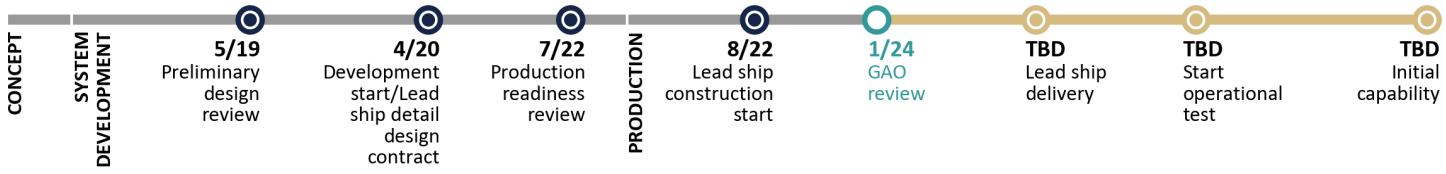
However, the program office noted that it faces volatile scheduling challenges related to air test range space, test squadron assets, and required targets. It added that these challenges present risk to completing operational tests within time frames that support finalized reporting and recommendations to field on baseline schedule threshold dates.

Given these challenges, the program office stated that it facilitated an "early look" prior to operational testing in January 2024 and continues to solidify test events earlier in the year on available ranges and assets to accelerate issue discovery and operational testing. The program reported that initial assessments of program data gathered last year, as well as feedback from the January 2024 flights, indicate that IRST is a mature system that will provide the Navy with vital capability advantages.

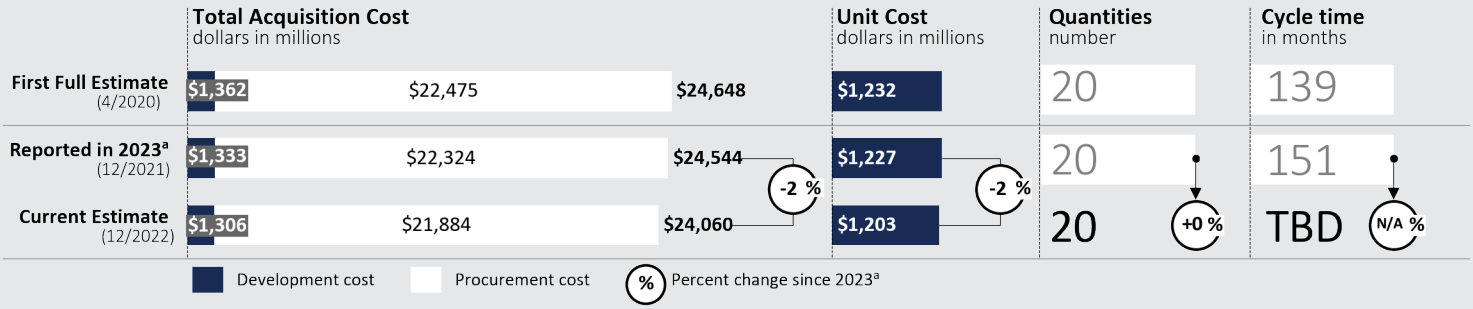
FFG 62 *Constellation* Class Frigate (FFG 62)

Source: Fincantieri Marinette Marine (FMM). | GAO-24-106831

The Navy's FFG 62 guided missile frigate program plans to develop and deliver a small surface combatant based on a modified (parent) design of an Italian Navy frigate. The Navy expects the frigates to operate independently and as part of groups to support Navy and joint maritime operations by providing anti-submarine, surface, electromagnetic, and air warfare capabilities. As of December 2023, the Navy has exercised three contract options (FFG 63, FFG 64, and FFG 65) in addition to the lead ship (FFG 62).



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise zero development quantities and 20 procurement quantities. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance. The program's reported acquisition costs do not reflect unbudgeted cost growth that the program has identified in future budget requests. The cycle time will not be confirmed until the program completes an ongoing schedule assessment and identifies an updated initial capability date.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Agile, DevOps, and DevSecOps

Frequency of end user evaluation (months)

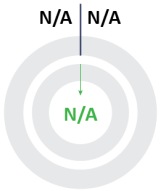
Information not available

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



According to the program, software costs are not broken out in the cost expenditures and estimates provided by the contractor.

Program Essentials

Prime contractor: Fincantieri Marinette Marine

Contract type: FPI (detail design and construction)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Detail Design Contract Award	Current Status
Demonstrate all critical technologies in a relevant environment	NA	NA
Demonstrate all critical technologies in a realistic environment	NA	NA
Complete a system-level preliminary design review	●	●
Product design is stable	Fabrication Start	
Complete 100 percent of basic and functional design using computer-aided modeling	○	○

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

We did not assess critical technologies for the FFG 62 because the Navy's technology readiness assessment and independent technical risk assessment for the program found that the ship does not have any.

FFG 62 Program

Technology Maturity, Design Stability, and Production Readiness

The Navy identified no critical technologies for the frigate program. Frigate capabilities rely predominantly on successful incorporation of mission systems already developed and deployed in the Navy's fleet. For example, the frigate design includes the Enterprise Air Surveillance Radar and Aegis combat system—both currently fielded on other ship classes. Nonetheless, integrating these systems into the frigate design has necessitated changes to the scaling of hardware and development of new software code. The Navy is mitigating resulting integration risk by leveraging data from ongoing tests aboard *Gerald R. Ford* class aircraft carriers and *Arleigh Burke* class destroyers, coupled with land-based tests that began in 2023.

While the program is predominately leveraging existing mission systems to mitigate risk, two planned newly developed systems pose high technical and integration risks. The frigate will field new propulsion and machinery control systems never used by the Navy. In response to statute, the Navy is building a Land Based Engineering Site (LBES) to test these systems to mitigate development and integration risks. LBES was not expected to be fully operational prior to the previously forecasted December 2026 delivery date, according to Navy officials.

Completing functional design and 3D modeling continues to take longer than the Navy anticipated and remains incomplete over a year after beginning lead ship construction. As of October 2023, the functional design was 92 percent complete and 3D modeling was 84 percent complete. Program officials stated that they set a goal to complete 80 percent of the functional design by construction start. However, the program's approach is inconsistent with shipbuilding leading practices, which call for completion of these design activities prior to construction start.

Ongoing delays have resulted from challenges adapting a foreign ship design to meet Navy survivability requirements, outstanding vendor-furnished information needed to inform the design, and workforce issues. The Navy increased on-site coordination efforts with its shipbuilder and industry stakeholders to remedy and approve deficient design products, but progress remains limited. As a result, the shipbuilder constructed early modules using an incomplete design and, more recently, slowed construction activities to await design stability.

As a result of the delays, the shipbuilder will not meet either its April 2026 contract delivery date or its more-recently estimated December 2026 delivery date for the lead frigate, according to the program. In December 2023, the Navy reported that the lead ship will be delayed at least 1 year, but an estimated delivery date for the lead and follow-on ships will not be confirmed until the Navy completes an ongoing schedule assessment. In January 2024, the Secretary of the Navy directed a separate assessment of the shipbuilding portfolio due, in part, to concerns with the frigate program.

Software and Cybersecurity

The program is using a modern software development approach, including Agile, DevOps, and DevSecOps to develop, deliver, and test various subsystem software, such as Aegis and the machinery control system.

Initial developmental testing of Aegis software started in August 2023 at land-based test sites, with follow-on tests scheduled to occur every 1 to 3 months. Testing provides system operators with the opportunity to test radar and Aegis equipment on simulators. Machinery control system software development is planned over three software releases, comprised of six builds. The contractor has released four of these builds to date with two more planned to follow, scheduled through January 2025.

The program completed its second cyber tabletop exercise in April 2023. It also plans to conduct a vulnerability identification assessment and adversarial cybersecurity development test and evaluation in April 2024 and April 2025, respectively. Additional cybersecurity tests are planned prior to initial operational capability in 2029.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

The Navy stated that it chartered an independent review team to perform a holistic assessment of the shipbuilder's production schedules, identify key issues, and recommend actions. Additionally, the Navy reported that it increased design and production efforts by bringing in both Navy and contracted engineering design support personnel at the shipbuilder's site to bolster and accelerate design stability completion and ramp-up of production.

In April 2024, after our cutoff date for new information, the Navy announced that the delivery of the lead ship was expected to be delayed approximately 3 years past the April 2026 contract delivery date.

MDAP | Lead Component: Navy

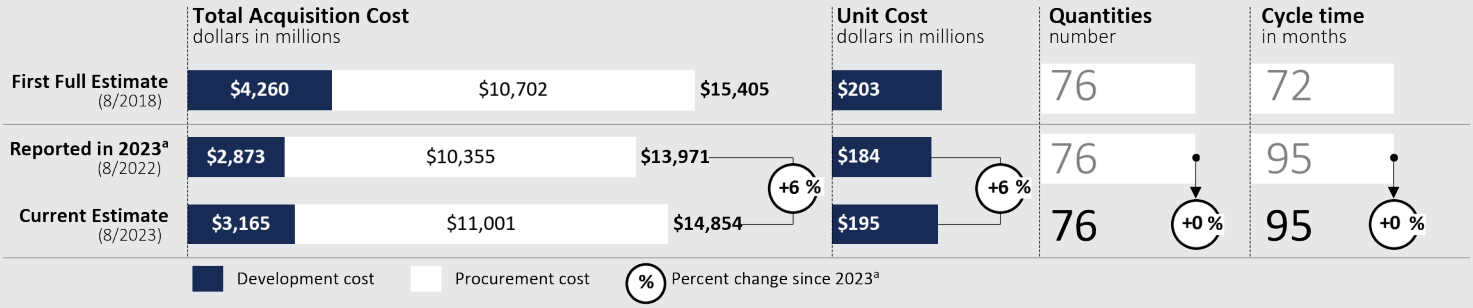
Common Name: MQ-25 Stingray

Source: U. S. Navy. | GAO-24-106831

MQ-25 Unmanned Aircraft System (MQ-25 Stingray)

The Navy's MQ-25 Stingray is a catapult-launched, uncrewed aircraft system designed to operate from aircraft carriers. The Navy plans for the MQ-25 to provide a refueling capability for the carrier air wing. The MQ-25 is expected to provide the intelligence, surveillance, and reconnaissance capabilities needed to identify and report on surface targets. The system is comprised of an aircraft segment, a control station segment, and a carrier modification segment. We evaluated the aircraft segment and related control station segment.

Program Performance fiscal year 2024 dollars in millions



Total quantities comprise nine development quantities and 67 procurement quantities. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Agile, Waterfall, and Incremental

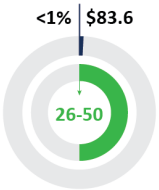
Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



Program Essentials

Prime contractor: Boeing

Contract type: FPI (development)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	●	●
Demonstrate all critical technologies in a realistic environment	○	●
Complete a system-level preliminary design review	○	●
Product design is stable	Design Review	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	●	●
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

While the Navy identified no critical technologies for MQ-25, the program relies on two critical technologies being developed under another program. Our scores for technology maturity reflect these two technologies. We did not assess MQ-25 manufacturing process maturity because the system has yet to reach production.

MQ-25 Stingray Program

Technology Maturity and Design Stability

MQ-25 Stingray's two critical technologies are fully mature, and the program reported that its design is stable, consistent with our last assessment. Program officials stated that the subcontractor conducted additional assessments of the engine inlet's shape design—which we previously reported the program was concerned could lead to engine damage—and does not expect any related design changes.

However, future design changes are still possible, and additional time will be needed before the program can fully assess the extent of any needed changes. The program has yet to receive test aircraft to start developmental testing. Delivery is currently planned to start in the first quarter of fiscal year 2025. Furthermore, the program has identified significant obsolescence issues for at least seven technologies, and additional related testing is planned. Any design changes needed to address deficiencies identified in testing, or obsolete technologies requiring retrofits, could cause delays and cost increases.

Production Readiness

Since our last assessment, the Navy has requested approval to rebaseline the production schedule to delay the low-rate production decision from September 2023 to July 2025. This request was based on postponed deliveries of developmental aircraft, which program officials told us is due to quality issues such as fastener hole alignment issues, in addition to previously reported issues. The same factors have also led to a 6 percent acquisition cost growth.

The program stated the new schedule will allow Boeing sufficient time to establish a pilot production line, among other things. The program office also stated that Boeing has made some improvements to the production lines in the last year, which the program anticipates will prevent any further delays. According to the program, initial operational capability is still achievable in 2026 as planned because the test assets will be used to support the first deployment.

The Navy placed an order with Boeing in October 2022 to include completion of a production readiness review, and to obtain manufacturing readiness level data. We previously reported that according to program officials, Boeing was not required under the development contract to provide manufacturing readiness level data. In prior years, we reported that obtaining this data could mitigate risks associated with not demonstrating critical manufacturing processes prior to the start of production. Program officials stated that Boeing's deliverables are expected before the start of production.

Software and Cybersecurity

To date, Boeing has provided the first software release to support developmental tests. The program noted that software integration will be an iterative effort through 2025 and potentially longer to fix any deficiencies found during ground and flight tests.

Program officials stated that they do not plan to complete cyber testing before production start due to limited test asset availability. By waiting until after the start of production, the program runs the risk of increased costs or delays to fix vulnerabilities. To mitigate this risk, program officials stated that they are coordinating with the testing community to initiate testing as early as possible once test aircraft are delivered. Officials also stated that they are investigating limited testing with models in a lab environment. However, before developmental testing with the models can begin, they need to finalize the necessary architecture, interfaces, and test harness construction.

Other Program Issues

Delivery of the seven initial test aircraft remains critical to start production and achieve initial operational capability. Boeing will not start delivering the initial test aircraft until the first quarter of fiscal year 2025, about a year later than we reported last year. Further, three of the seven initial developmental test aircraft are not planned to be delivered until after the Navy awards the first low-rate initial production contract, increasing the risk of concurrency between developmental testing and the start of production, and potentially leading to cost increases and further delays if changes are needed based on testing.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

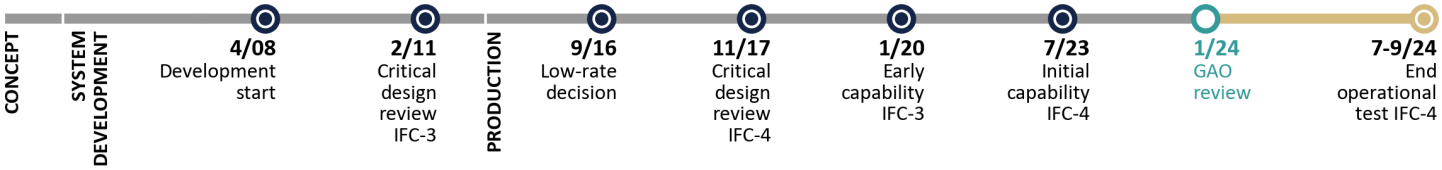
The program attributed cost increases to obsolescence issues, impacts to testing and production due to the 2-year program extension, and contractor performance risks, among other issues. It noted existing challenges to implementing manufacturing processes but stated that it projected quality improvements and efficiencies between the first and second aircraft in production. Specifically, it stated that performance metrics captured improvements to build quality and speed, including a 57 percent reduction in rework.

The program also projected heightened productivity in fiscal year 2024 as two test aircraft near completion and six developmental aircraft are under construction. According to the program, the aircraft under construction include the first production representative build.

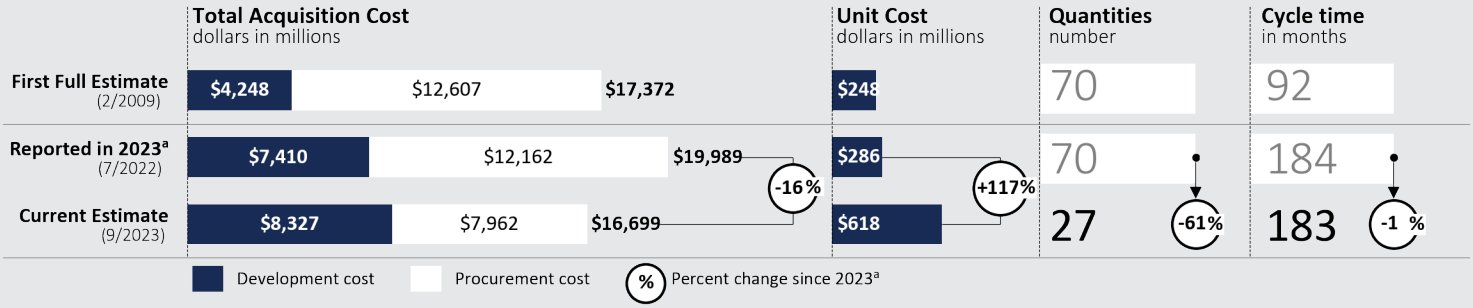
Source: U.S. Navy. | GAO-24-106831

MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)

The Navy plans for MQ-4C to replace the EP-3E Aries aircraft and provide intelligence, surveillance, and reconnaissance, as well as data collection and dissemination. Each system includes an air vehicle, communications suites, and mission payload, among other components. In 2021, the Navy restructured the program into two increments. The first increment consists of two aircraft configurations—Integrated Functional Capabilities (IFC)-3 and IFC-4, which adds signals intelligence. The Navy is retrofitting the IFC-3 aircraft to the IFC-4 configuration. It plans to further upgrade IFC-4 capabilities in a second increment. We assessed the first increment.



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise five IFC-4 development quantities and 22 IFC-4 procurement quantities. The graphic bars depict research and development and procurement costs for both the first and second increments. Total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Agile and Incremental

Frequency of end user evaluation (months)

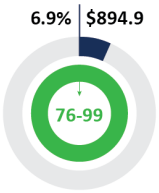
Other frequency (see notes)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that advisory groups that include end users meet annually to provide guidance and address issues on software.

Program Essentials

Prime contractor: Northrop Grumman

Contract type: Cost-sharing (development); FPI (procurement)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	●	NA
Demonstrate all critical technologies in a realistic environment	○	NA
Complete a system-level preliminary design review	○	●
Product design is stable	Design Review	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	○	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

We did not assess MQ-4C critical technologies because the program stated it no longer has any such technologies. We assessed the design stability and manufacturing maturity of the IFC-4 increment 1 aircraft.

MQ-4C Triton Program

Technology Maturity, Design Stability, and Production Readiness

The MQ-4C Triton has no critical technologies, and the program office reported that the system design is stable and producible.

In December 2022, the Navy reported to Congress increases to the program's acquisition unit cost and average procurement unit cost that exceeded statutory critical unit cost growth thresholds. Planned MQ-4C quantities dropped significantly since our last assessment, from 70 to 27, due to the Joint Requirements Oversight Council's reevaluation of needed assets. The unit cost for each Triton consequently increased by about 79 percent, from $286 million in our last report, to about $513 million this year (excluding increment 2 costs). Adding in increment 2 costs, the unit cost for each Triton now stands at about $618 million—approximately 117 percent more than we reported last year.

Whether the program can maintain its planned production schedule in the future is uncertain because testing to date may not have revealed all engineering changes needed for the IFC-4 aircraft. Production plans call for delivery of five aircraft in fiscal year 2023 and up to four in fiscal years 2024 through 2029. The contractor delivered the five aircraft planned for fiscal year 2023; however, the Defense Contract Management Agency reported that the program deferred a test flight on one aircraft to post-government delivery because the Navy removed the multi-function sensor assembly from the test aircraft for use in the fleet. This postponement provided the contractor with relief from having to incorporate changes that the testing might have uncovered. Given the role of this sensor assembly—to detect, track, and identify targets as well as provide high-resolution imagery—discovery and correction of deficiencies in its functionality could be necessary to ensure MQ-4C performance.

The Navy declared initial operational capability for MQ-4C in July 2023 with two IFC-4 aircraft deployed. However, according to an official from DOD's Director, Operational Test and Evaluation, the system's operational effectiveness for some of its primary missions is unknown due to insufficient testing. For example, critical capabilities related to signals intelligence are not fully tested. The program office projects it will complete this testing in the fourth quarter of fiscal year 2024—by which point the Navy plans to have a total of seven IFC-4 aircraft deployed. Until this performance information is available, it will be difficult for the Navy to determine whether IFC-4 can fulfill mission needs.

Testing, production of IFC-4 aircraft, and retrofit of IFC-3 aircraft to the IFC-4 configuration remain concurrent, as we previously reported. Such concurrency carries the difficulties inherent in managing multiple production efforts, as well as the possibility of time-consuming and expensive rework if issues are found that must be corrected on aircraft that are already produced and deployed. The latter could mean changes to the seven deployed and four additional delivered aircraft by the time the program completes operational testing in the fourth quarter of fiscal 2024.

Software and Cybersecurity

The program currently plans for seven major software releases, with five completed. It expects to deliver the next software release to the fleet in the second quarter of fiscal year 2024. It stated that 4 to 6 months is typically necessary between software deliveries due to the flight clearance process, test flights, and defect/feedback analysis.

The program is executing cybersecurity efforts based on its 2015 cybersecurity strategy, which no longer reflects the program's current schedule or content. According to the program, it plans to update the strategy in fiscal year 2024. The strategy serves as an integral part of the MQ-4C overall acquisition approach by providing programmatic and technical linkage, including schedule, necessary to execute cybersecurity requirements. The lack of an updated document makes this linkage less visible.

Other Program Issues

According to the program office, it awarded a contract for MQ-4C increment 2 development in October 2023. Increment 2 is intended to enhance IFC-4 effectiveness and survivability via more than a dozen added and upgraded subsystems. The Navy expects to spend about $2.9 billion in fiscal year 2024 dollars to develop and procure this increment.

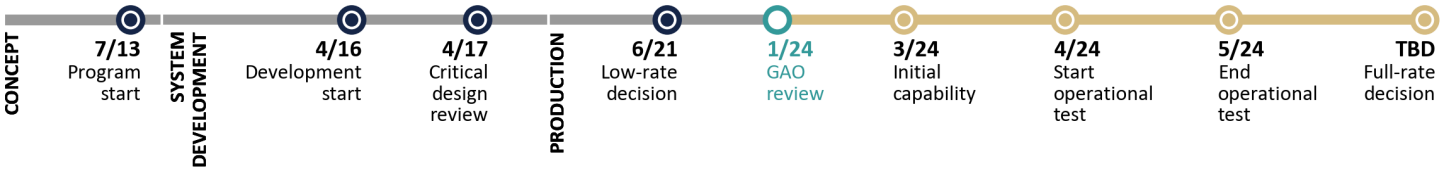
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program stated that the MQ-4C plays a pivotal role in the replacement of the legacy EP-3E Aries aircraft within the maritime patrol and reconnaissance community, but that the Triton was not intended or designed to be a one-for-one replacement of the retiring EP-3E. According to the program office, MQ-4C provides a persistent, real-time intelligence, surveillance, reconnaissance, and targeting capability, including geospatial and signals intelligence capabilities. The program office noted that MQ-4C enables distributed maritime operations by delivering actionable information to fleet commanders within a signals intelligence framework.

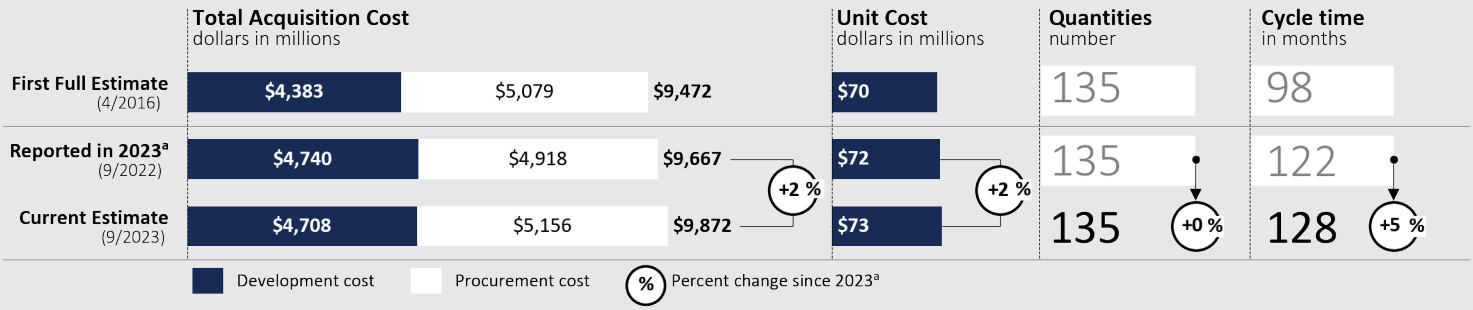
Source: U.S. Navy. | GAO-24-106831

Next Generation Jammer Mid-Band (NGJ MB)

The Navy's NGJ MB is an external jamming pod system the Navy plans to integrate on EA-18G Growler aircraft. NGJ MB is expected to augment, then replace, the ALQ-99 jamming system in the mid-band frequency range. The Navy plans for it to provide enhanced airborne electronic attack capabilities to disrupt adversaries' electromagnetic spectrum use for radar detection, among other purposes. The Navy also has a low-band frequency program and will roll out a high-band program later. We assessed the mid-band program.



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise six development quantities and 129 procurement quantities. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Agile

Frequency of end user evaluation (months)

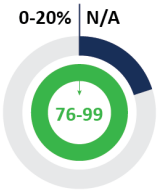
Other frequency (see notes)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that end users provided feedback on software after maintenance and aircrew training. According to the program, software costs were not available because software was not broken out in amounts paid to the contractor.

Program Essentials

Prime contractor: Raytheon; Boeing

Contract type: CPIF (development); FPI (low-rate initial production)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	●	●
Demonstrate all critical technologies in a realistic environment	○	●
Complete a system-level preliminary design review	●	●
Product design is stable	Design Review	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	○	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

NGJ MB Program

Technology Maturity, Design Stability, and Production Readiness

Since last year, the program has delayed its planned fielding of capability by 6 months, to March 2024, because of testing challenges stemming from previously identified design issues. In an April 2023 memo of the program's operational test readiness review results, the Director, Operational Test and Evaluation (DOT&E) raised concerns that the current pod configuration was not operationally representative because of changes to software and a limited range of operational flight conditions used for testing—also known as the flight envelope. We previously reported that the program had redesigned parts of the pod, delaying the program's ability to demonstrate system performance in the full flight envelope and complete tests.

DOT&E will not approve the program to begin initial operational testing and evaluation (IOT&E) until the program completes an update to the operational test readiness review, scheduled for April 2024. The update will evaluate the new software configuration, flight envelope, and any other significant changes to ensure the system is operationally representative before starting IOT&E.

Although the program did not obtain approval for IOT&E, DOT&E did allow the program to conduct integrated testing. Program officials stated that they conducted incremental testing of the flight envelope to help prevent further delays. For example, in October 2023, the Navy's test squadrons flew air-to-air missions with various flight conditions to cover additional range of the flight envelope, according to officials. The program plans to begin and complete IOT&E in April and May 2024, respectively, by using data collected during testing. The program has delayed the planned start and end of IOT&E by 1 year and 9 months, respectively, since our last assessment. Program officials stated that achieving an initial operational capability in March 2024 is not dependent on completing IOT&E because they can use a stable build that has been in deployment since September 2023 to declare initial operational capability. According to officials, DOT&E agreed with this approach.

As a result of the testing challenges, the program initially delayed its full-rate production decision by 6 months to May 2024. The program subsequently delayed this decision to beyond May 2024, because it is waiting for the DOT&E report to be completed to inform the full-rate production decision timing. To avoid a gap in production, the Navy increased the low-rate production quantity from 19 to 32 pods.

Software and Cybersecurity

The NGJ MB program office continues to identify software development as a risk, but program officials stated they made progress in addressing this risk by modifying their contract. Officials said that the contractor hired 25 full-time equivalent software engineers to address software deficiencies as needed. Program officials stated that the engineers can now release software builds to address issues in a matter of days or weeks, rather than months. Previously, the contractor would release a specific number of software builds, which the program said affected its ability to quickly implement software changes.

In April 2023, DOT&E raised concerns about the program's planned software changes. Specifically, program officials stated that DOT&E is concerned because as the program continues to release new updates to its software, with each successive software build, the program could fix one software issue but inadvertently cause another. In response to that concern, program officials told us that they are focused on quickly releasing software builds to correct deficiencies and are not introducing new capabilities. They noted this approach is consistent with Agile development principles.

The program office reported completing full and major subsystem cybersecurity assessments in August 2023. However, the program postponed other cybersecurity tests, such as an adversarial assessment, from April 2023 to March 2024 to obtain additional flight data from operational testing. According to program officials, using the additional data will allow for more comprehensive cybersecurity assessments.

Other Program Issues

The program continues to identify the pod's ability to meet reliability requirements as a main cost risk, consistent with our past reporting. If the pods are unable to meet reliability requirements, the Navy may spend more to operate and support them than planned. According to program officials, operator resets to address software challenges have increased the mission failure rates. Officials added that sometimes the resets are not necessary and contribute to the increased failure rates. The program is evaluating operator training to address these reliability challenges.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

The program office stated that it will continue to address NGJ MB's reliability issues during development, fielding, and sustainment. It added that an agreement was reached with DOT&E on what the final version of the software for NGJ MB will contain and the test plan is being updated accordingly. The program office said it does not expect to repeat data collection for testing that it previously completed.

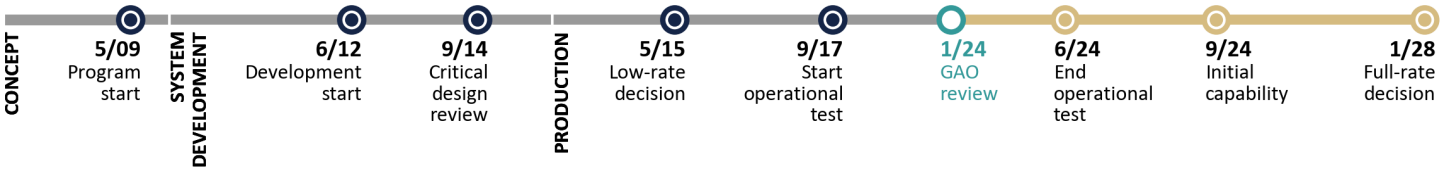
MDAP | Lead Component: Navy

Common Name: SSC

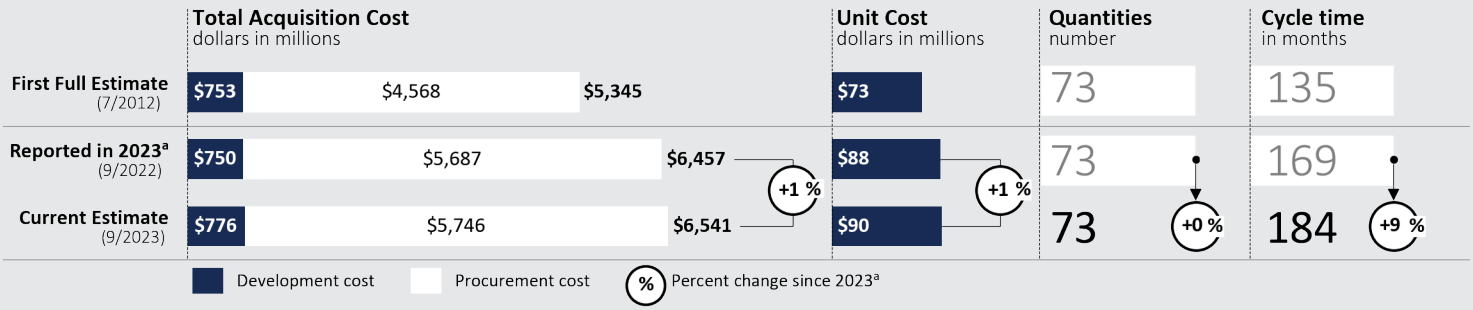
Source: U.S. Navy. | GAO-24-106831

Ship to Shore Connector Amphibious Craft (SSC)

The Navy's SSC is an air-cushioned landing craft intended to transport personnel, weapon systems, equipment, and cargo from amphibious vessels to shore. It is the replacement for the legacy Landing Craft, Air Cushion (LCAC, a designation that SSCs will share once in service), which is approaching the end of its service life. The SSC is designed to deploy in and from Navy amphibious ships that have well decks, such as the LPD 17 class, and will support operations.



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise one development quantity and 72 procurement quantities. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Modified Waterfall

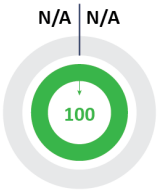
Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



Program officials stated that they do not track software in their cost reporting system. Software development is complete and is currently in the maintenance phase, according to the program.

Program Essentials

Prime contractor: Textron, Inc.

Contract type: FPI (detail design and construction)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	●	●
Demonstrate all critical technologies in a realistic environment	●	●
Complete a system-level preliminary design review	●	●
Product design is stable	Design Review	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	…	●
Test a production-representative prototype in its intended environment	○	●

● Knowledge attained ○ Knowledge not attained … Information not available NA - Not applicable

Program officials stated that SSC critical manufacturing processes were demonstrated on a pilot production line prior to delivery of the testing and training craft in April 2020, but they did not know the actual date.

SSC Program

Technology Maturity, Design Stability, and Production Readiness

Since our assessment last year, the program accepted LCACs 105-108, for a total of nine craft—eight fleet assets and one test and training craft. The program continues to plan and conduct testing events to support planned initial operational test and evaluation (IOT&E) and initial operational capability (IOC). The contractor also successfully increased the number of craft it has delivered in a year, delivering four craft over the last 12 months. This is the first time in the program's history that it delivered craft at this rate.

However, since our last assessment, the program delayed IOC by over 1 year—until September 2024—due, in part, to IOT&E slipping to June 2024 because of ongoing delays to developmental testing. Program officials said that they previously defined IOC as having six craft delivered to the fleet. However, because the program has yet to complete IOT&E, it has yet to declare IOC even with nine craft delivered. The schedule slip is consistent with IOC delays we have reported on for several years. Specifically, we have reported that the program delayed its IOC date in each of our annual assessments since the initial date in August 2020.

According to program officials, the program continues to install solutions to the program's top two technical issues—cracking propeller blades and premature gearbox wear—on all new craft during construction, and acceptance trials do not indicate any further issues related to these components. The program continues to monitor these issues through additional testing on the propeller blades and gearbox but has found no further issues.

LCAC 107 and 108 reflect the lowest number of deficiencies that the program has found in acceptance trials to date. LCAC 107 was only the second craft to have no deficiencies that prevented the Navy from immediately accepting the craft. However, the program reported that LCAC 108 did have one severe deficiency. Specifically, weld repairs on the bottom of the hull failed during testing, allowing water to enter the hull, and additional weld defects were found after the acceptance trials. According to the program office, the weld defects were subsequently corrected, and the Navy accepted LCAC 108 in November 2023.

Other Program Issues

The program recently adjusted its procurement timeline to include fewer craft during fiscal years 2025 through 2028, despite the contractor demonstrating this year that it could deliver four craft in one year. Several of the recently delivered craft took over 5 years from construction start to completion. These craft have experienced major production quality issues, which prevented the Navy from accepting them on time.

As a result of these procurement schedule changes, the program now expects to procure two craft per year during fiscal years 2025 through 2028, compared with five per year as originally planned. The program sees this lower level of craft procurement as a cost risk. It reported that to maintain the contractor's production line and increase cost savings in procuring future LCACs, it would need to increase the number of craft procured annually, but that it cannot do so at the current level of planned funding.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

According to the program office, the SSC program has 24 craft under contract with nine delivered. The program office also reported that it resolved early technical issues and that the contractor is on track to deliver four craft in fiscal year 2024. It further noted that the program continues to make progress on quality and schedule.

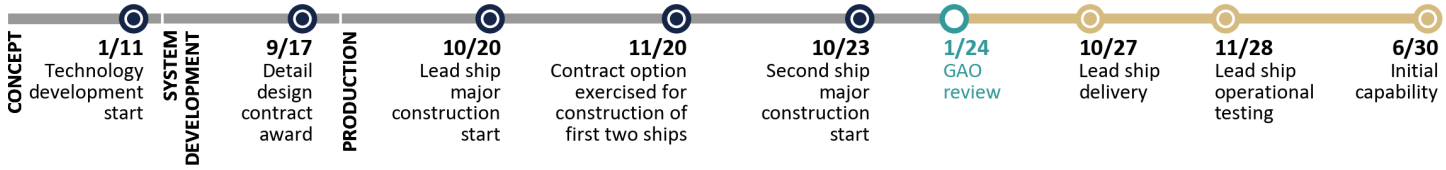
According to the program office, with the delivery of LCAC 108, all SSC under the original contract have been delivered. It added that the delivery schedule for fiscal year 2024 projects that the program will maintain the four craft per year delivery schedule. It attributed the ability to maintain this production rate to production line improvements.

Finally, the program office confirmed that it achieved partial IOC with the delivery of six craft to the fleet in July 2023. It further noted it is focused on issue resolution and improving reliability to support IOT&E. The program expects to achieve full IOC after the completion of IOT&E.

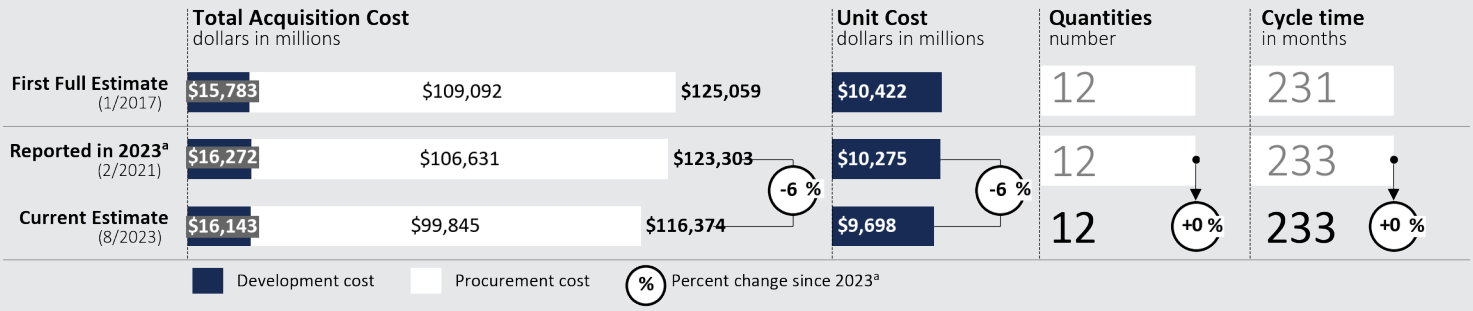
SSBN 826 *Columbia* Class Ballistic Missile Submarine (SSBN 826)

Source: General Dynamics Electric Boat. | GAO-24-106831

The Navy's *Columbia* class submarine (SSBN 826) will replace the *Ohio* class ballistic missile submarines, which the Navy plans to start retiring in 2027. SSBN 826 will serve as the sea-based, strategic nuclear deterrent that is expected to remain in service through 2084. General Dynamics Electric Boat is the lead contractor, with Huntington Ingalls Industries Newport News Shipbuilding serving as its major subcontractor.



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise zero development quantities and 12 procurement quantities. The figure depicts only research and development and procurement costs. However, total acquisition costs may also include costs for military construction as well as acquisition operation and maintenance. According to the program, the decrease in total acquisition cost reflects a change in assumptions about the effect of inflation on future-year costs. The program previously reported an accelerated construction schedule with planned delivery in April 2027.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Incremental

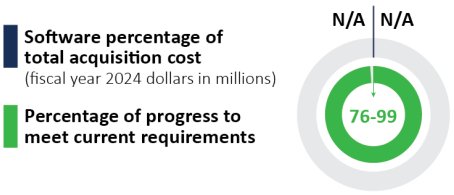
Frequency of end user evaluation (months)

Other frequency (see notes)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)



The program reported that software was developed by another Navy program or is reused with minor modifications. End user feedback is obtained through another Navy program when issues are identified. The program revised its reported frequency of testing and feedback to reflect that there will be only one software delivery.

Program Essentials

Prime contractor: General Dynamics Electric Boat

Contract type: CPIF (development and construction)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Detail Design Contract Award	Current Status
Demonstrate all critical technologies in a relevant environment	○	●
Demonstrate all critical technologies in a realistic environment	○	○
Complete a system-level preliminary design review	●	●
Product design is stable	Fabrication Start	
Complete 100 percent of basic and functional design using computer-aided modeling	●	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

SSBN 826 Program

Technology Maturity, Design Stability, and Testing

The SSBN 826 program is unlikely to meet the lead submarine's delivery date. In October 2023, the program reported that lead submarine construction progress did not support the submarine's planned October 2027 delivery date. Our prior work has shown that at this point in construction, there is limited opportunity for getting back on track.

The program continues to face problems issuing timely and quality work instructions—design products that detail how to build the submarine—which is slowing construction. Program officials stated that (1) low proficiency among shipbuilder planning staff, and (2) the need for more detailed instructions for less-experienced tradespeople at the shipyards contributed to work instruction issues.

Program officials told us that without timely work instructions, the shipbuilders cannot fully staff lead submarine construction. We previously found that poor-quality instructions can cause time-intensive and costly rework. The shipbuilders and program implemented additional reviews to speed work instruction issuance and identify quality problems early. According to the program, although issuance has improved, as of October 2023, the shipbuilders still face delays caused by the need to fix poor-quality work instructions.

The shipbuilders recently replanned work in all major areas of the lead submarine and for final assembly and test—the most difficult phase of construction when the shipbuilder joins large sections of the hull together. According to program officials, the replans were needed to re-sequence some of the program's delinquent work and to maintain hull section delivery dates. However, a shipbuilder representative stated that the plan to deliver some hull sections in close succession could slow their follow-on integration and testing work. If final assembly and test take longer than planned, the program risks falling further behind schedule and delaying the lead submarine's operational availability, planned for 2030.

Three of SSBN 826's critical technologies remain below our definition of maturity. However, as we reported last year, the program considers all nine of SSBN 826's critical technologies mature. We consider technology mature after successful testing of a prototype near or at the planned operational system configuration in a realistic environment. Testing for two of the technologies has been delayed due to the availability of test assets, but the program expects both to reach maturity in fiscal year 2025. One will remain immature through post-delivery sea trials, scheduled to start in 2027. Changes to these technologies at this stage of construction could result in costly and time-consuming rework, revised performance requirements, or both.

Other Program Issues

Electric Boat's cost estimate at completion for the lead submarine's construction may be unrealistic and does not appropriately account for risk. As of May 2023, based on cost and schedule trends at the time, our estimated additional costs for the program were two to three times Electric Boat's best-case estimate. Navy officials told us that the shipbuilder's estimate does not reflect major risks toward the end of construction.

In addition, the program stated that the lower reported acquisition costs this year resulted from updated inflation calculations rather than a lower cost estimate. The Navy planned to revise the cost estimate by the end of 2023 to better reflect the effects of inflation and program performance. As a result, the Navy may need to request more funding than currently planned to complete construction.

In September 2023, DOD authorized the start of full construction for the second submarine, SSBN 827. According to an October 2022 Navy review, the Navy is concerned about the achievability of SSBN 827's 80-month construction schedule. The review states that without further improvements to work instructions and staffing, the schedule will remain challenging.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

According to the program office, the program remains positioned to provide the capability needed to meet national strategic deterrence requirements. The program stated that, to reduce risk, it ensured stable requirements, executed manufacturing readiness and supplier base efforts, and continued cost reduction efforts. The program noted that it exceeded the design maturity of previous submarine classes at the start of construction and worked through initial design tool development and implementation issues.

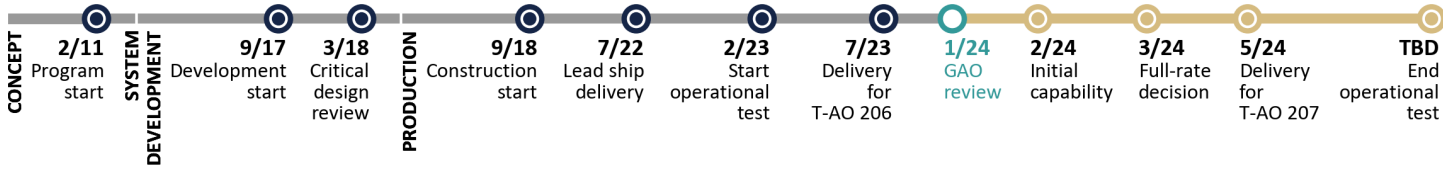
The program acknowledges that the construction schedule is aggressive, and submarine industrial base performance has been challenging. According to the program, the Navy is addressing these challenges with aggressive actions focused on the shipbuilder and industrial base and continues to focus on schedule execution. It added that it complies with all Navy, DOD, and statutory requirements associated with managing critical technologies and engineering integration.

In April 2024, after our cutoff date for new information, the Navy announced that the delivery of the lead *Columbia* class submarine was expected to be delayed 12 to 16 months past the contracted delivery date based on current construction performance.

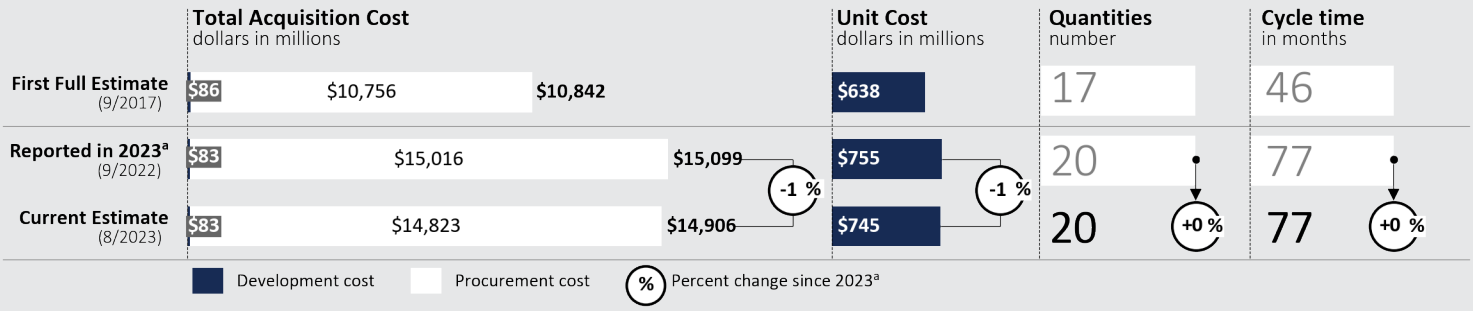
Source: General Dynamics NASSCO. | GAO-24-106831

T-AO 205 *John Lewis* Class Fleet Replenishment Oiler (T-AO 205)

T-AO 205 will replace the Navy's 15 existing *Henry J. Kaiser* class fleet oilers (T-AO 187), which are nearing the end of their service lives. The primary mission of the oilers is to transport bulk petroleum products; dry stores; and packaged cargo, fleet freight, mail, and personnel to other vessels at sea.



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise zero development quantities and 20 procurement quantities. The program reported that the decrease in total acquisition cost since last year was due to revised DOD indices used to convert program cost information. The reduction does not reflect a cost savings.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Information not available

Frequency of end user evaluation (months)

Information not available

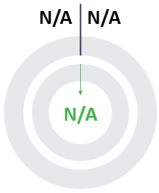
Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that it is using off-the-shelf software systems and does not collect information on software delivery time frames or cost.

Program Essentials

Prime contractor: General Dynamics National Steel and Shipbuilding Company (NASSCO)

Contract type: FPI (detail design and construction)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Detail Design Contract Award	Current Status
Demonstrate all critical technologies in a relevant environment	●	●
Demonstrate all critical technologies in a realistic environment	●	●
Complete a system-level preliminary design review	○	●
Product design is stable	Fabrication Start	
Complete 100 percent of basic and functional design using computer-aided modeling	●	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

T-AO 205 Program

Technology Maturity, Design Stability, and Production Readiness

Since our last assessment, T-AO experienced construction and testing delays to its schedule that was rebaselined in October 2022. According to the program, T-AO 205 to T-AO 207 delivery delays required the Navy to extend the service life of two of the legacy vessels that T-AO was intended to replace. However, in March 2024, the program noted that production milestones have begun to stabilize and the program is tracking to delivery dates rebaselined in October 2022 for T-AO 208 and the following ships.

The Navy accepted delivery of the lead ship in July 2022 according to the rebaselined schedule. However, the second ship was not delivered until July 2023—about 2 months beyond its rebaselined schedule. The program office attributed the delays to slower-than-projected testing progress due to other shipyard work, lack of materiel readiness that delayed ship trials and, for the second ship, ripple effects from the lead ship delivery delay.

Similarly, the program expects the shipbuilder to deliver the next ship in the class, T-AO 207—currently under construction—at least 5 months later than planned in the rebaselined schedule. Per the program, the shipbuilder attributed this delay to continued labor issues and a failure of robotic steel cutting and welding equipment.

The program also completed some testing but encountered delays to its overall test plan. For example, some survivability events were delayed by at least 1 year due to ship availability for testing. The program has test events planned in fiscal year 2024, including finalizing the initial operational test and evaluation report and the final survivability assessment.

Cybersecurity

In June 2023, the program completed two cybersecurity assessments—an adversarial assessment and a cooperative vulnerability and penetration assessment.

Other Program Issues

We previously reported that delivery of the main reduction gear for the fourth ship—T-AO 208—was delayed for 12 months. Program officials stated that they implemented a mitigation plan, and that the gear—a critical propulsion component comprised of gears that harness the power generated by the engines to move the shaft and propeller—has since been delivered. The delay had a ripple effect on future hulls, which was accounted for in the October 2022 revised schedule. Program officials stated that they have not seen delays beyond the revised schedule.

The program office estimates that the first six vessels will exceed their original contract ceiling price, including T-AO 207, which is scheduled for delivery in May 2024. As a result, the Navy requested an additional $42 million in its fiscal year 2024 budget request to complete construction of T-AO 208 through T-AO 212. The program also continues to implement cost reduction measures. For example, it plans to transition to a commercial diesel generator for future ships, in line with our leading practice for ship design to incorporate proven design elements when possible. This action is expected to reduce costs on T-AO 211 through T-AO 213 by an additional $2 million to $4 million per hull. However, based on the program manager's projections, material costs are likely to continue increasing into 2026.

Program officials are considering options for contracting for the ninth ship. The current shipbuilder submitted preliminary pricing, which demonstrated potential significant savings. However, the program has not ruled out competing the contract for the next ship, and is evaluating the benefits of continuing production with the experienced shipbuilder compared to holding a competition. The program plans to award a contract in March 2024.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. It stated that the T-AO class is on its way to the fleet with T-AO 206 delivery in July 2023 and no change over the last 22 months in delivery dates for T-AO 208 to T-AO 213.

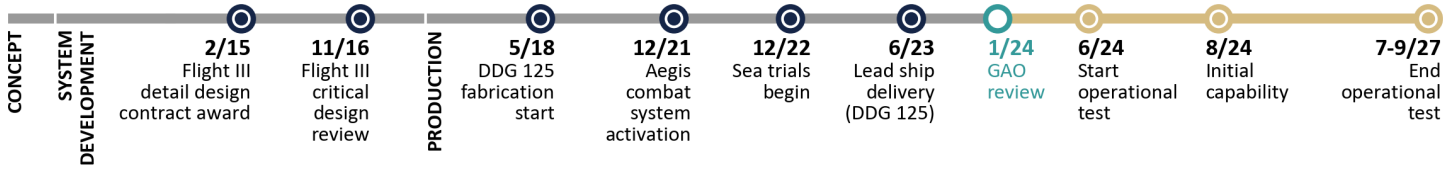
The program office also stated that the Navy continues to work with the shipbuilder to identify problems earlier in the production cycle to avoid delays during test and trials. It stated that the lead ship, T-AO 205, successfully demonstrated its capability to conduct underway replenishment of ships at sea, is currently finishing post-delivery efforts to address remaining ship deficiencies, and is estimated to finish initial operational test and evaluation by July 2024.

According to the program, it continues to use shipbuilding best practices along with leveraging commercial vessel design practices to minimize risks, reduce ship costs, and drive affordability into the design. The program also stated that, beyond the cost reductions that have been identified to date, the Navy and the shipbuilder continue to seek out opportunities to reduce costs while balancing life-cycle costs and fleet requirements. According to the program, cost performance is stabilizing with the leveling of inflation, serial production, and learning.

DDG 51 *Arleigh Burke* Class Destroyer, Flight III (DDG 51)

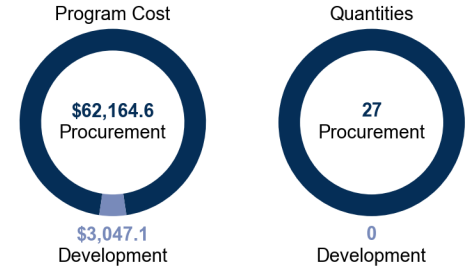
Source: U. S. Navy. | GAO-24-106831

The Navy's DDG 51 Flight III destroyer is planned to be a multimission ship designed to operate against air, surface, and underwater threats. Compared with existing Flight IIA ships of the same class, the Navy expects Flight III ships to provide the fleet with enhanced ballistic missile and air defense capability. Flight III's changes include replacing the current SPY-1D(V) radar with the Air and Missile Defense Radar program's AN/SPY-6(V)1 radar and upgrading the destroyer's Aegis combat system. As with prior ships in the class, Flight III ships are being built by two different shipyards—in Bath, Maine, and Pascagoula, Mississippi.



Estimated Cost and Quantities

(fiscal year 2024 dollars in millions)



Cost reflects 27 Flight III ships bought or planned from fiscal years 2017-2028.

Software Development as of January 2024

Approach: Agile, Incremental, and DevSecOps

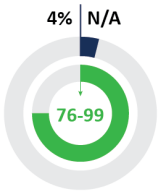
Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



Program Essentials

Prime contractors: General Dynamics-Bath Iron Works; Huntington Ingalls Industries

Contract type: FPI (construction)

Current Status

Since last year's assessment, the Navy completed the acceptance trial for the lead Flight III ship—DDG 125—and took delivery of the ship in June 2023 as planned. The program experienced cost growth for the first two Flight III ships, with the program office stating that it requested an additional $290 million for fiscal years 2023 and 2024 to cover the government's portion of cost overruns for certain contracts. The program office stated that issues at both shipyards with hiring, retention, and workforce experience—and the associated construction inefficiencies—contributed to the cost growth.

Shipyard performance is also significantly hindering the schedule for follow-on ships. The program office estimates delivery delays ranging from 6 to 25 months for the 13 follow-on ships purchased during fiscal years 2017-2022. The Navy awarded new contracts to both shipbuilders in August 2023 that support procurement of nine more DDG 51 Flight III ships, with options for additional ships in fiscal years 2023 through 2027. Further delivery delays could have significant consequences for the Navy's efforts to counter current and future air and surface threats.

The program office stated that it plans to complete Flight III initial operational test and evaluation by fiscal year 2028. The plan's first test period focuses on ballistic missile defense, surface warfare, and initial integrated air and missile defense events. The program office expects the results from this test period to inform an initial operational capability determination for Flight III planned for August 2024. The program office also noted risk to achieving initial operational capability as scheduled because of all the test events planned to be accomplished in what the program considers a compressed timeline.

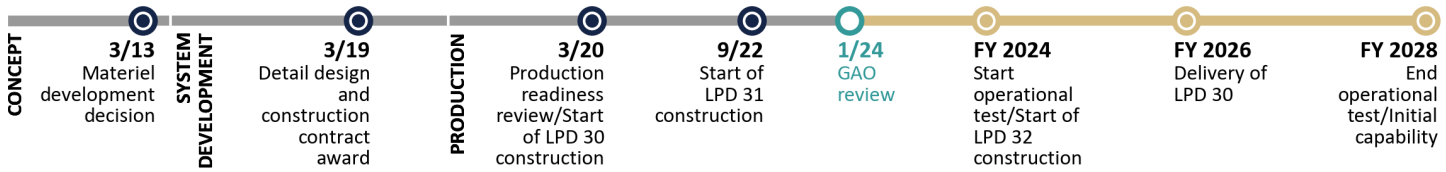
Program Office Comments

We provided a draft of this assessment for program office review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office stated that the DDG 51 program is one of the Navy's longest-running production lines and has delivered 73 ships to the fleet. The program office also stated that, of the 26 *Arleigh Burke* class ships under contract, 12 ships are in various stages of production and the rest are in pre-construction activities. The program office added that, in addition to progressing toward delivery of the final few Flight IIA ships, the program is making significant progress in testing the first Flight III ship.

Source: Huntington Ingalls, Ingalls Shipbuilding. | GAO-24-106831

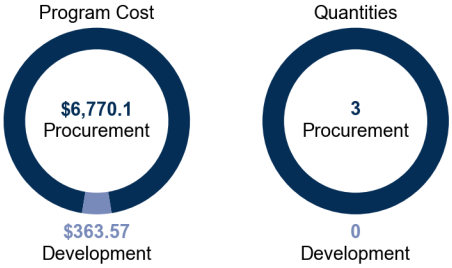
LPD 17 *San Antonio* Class Amphibious Transport Dock, Flight II (LPD 17 Flight II)

The Navy's LPD 17 Flight II will replace retiring dock landing ships. The Navy intends to use LPD 17 Flight II ships to transport Marines and equipment to support a wide variety of combatant and noncombatant missions, ranging from expeditionary operations ashore to humanitarian assistance. The Flight II ships will use the LPD 17 Flight I hull but the Navy made changes intended to reduce the costs of acquiring and maintaining the Flight I vessel. As of its fiscal year 2024 budget submission, the Navy plans to acquire three Flight II ships, beginning with LPD 30.



Estimated Cost and Quantities

(fiscal year 2024 dollars in millions)



Cost and quantity represent fiscal years 2010-2028.

Software Development as of January 2024

Approach: Information not available

Frequency of end user evaluation (months)

Information not available

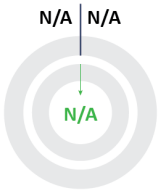
Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)

Software percentage of total acquisition cost
(fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that it does not track these metrics because software is not a significant work element.

Program Essentials

Prime contractor: Huntington Ingalls Incorporated

Contract type: FPI (detail design and construction)

Current Status

The Office of the Secretary of Defense paused the program in the spring of 2023 to study the costs and capabilities of the platform. As of January 2024, the Navy-led study has been completed. The Navy is evaluating program quantities and if the acquisition strategy for using what the Navy refers to as a block buy would generate cost savings for LPD Flight II purchases.

The Navy now expects delivery of LPD 30 in fiscal year 2026, a delay of approximately 6 months since our last assessment. The Navy attributed LPD 30 delays to COVID-19-related labor shortfalls in the 2020 to 2022 time frame. Navy program officials stated that the shipyard is holding hiring events and accelerating training efforts to grow its workforce in response to this challenge.

The program continues to track risks associated with the integration of a new surface radar system as construction of LPD 30 and 31 continues. The new radar was developed to standardize the Navy's surface search radars in response to the Navy's ship collisions. The radar has been installed on several in-service ships but has yet to go through independent testing. Navy officials anticipate that the program's master plan for operational testing—to include testing the integration of the new radar system—will be approved prior to LPD 30 delivery and testing, which begins in 2026. While fleet officials reported some issues with the new radar, radar program officials are confident that they can fix the issues and the radar will meet requirements.

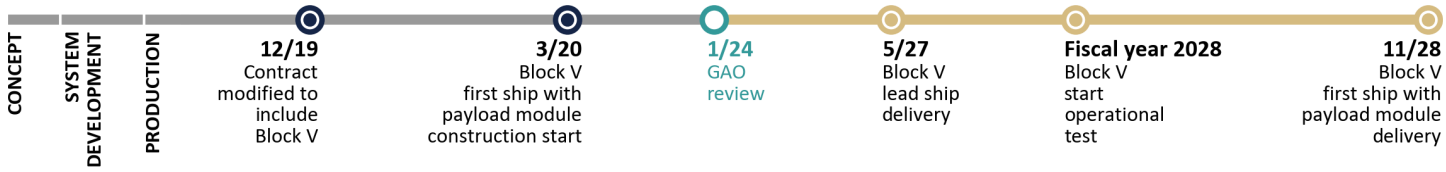
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. It provided technical comments, which we incorporated where appropriate. According to the program office, the Navy continues to successfully manage and deliver LPD 17 class ships. The program reported that it received funding for LPD 30, 31, and 32, and has budgeted for LPD 33, 34, and 35. The program also stated that in 2023, it: (1) conducted final contract trials for LPD 28; (2) took LPD 29 to sea with a new radar; (3) continued construction of LPD 30 and 31; and (4) placed LPD 32 under contract for construction.

Source: U.S. Navy photo courtesy of Huntington Ingalls Industries. | GAO-24-106831

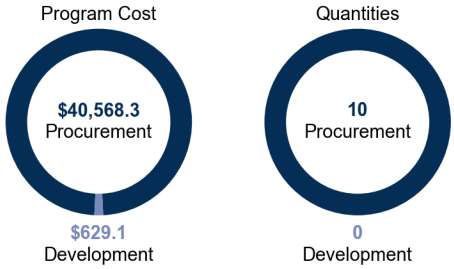
SSN 774 *Virginia* Class Submarine (VCS) Block V

The Navy's VCS is a class of nuclear-powered, attack submarines capable of performing multiple missions. Block V is the most recent version to enter production and includes enhanced undersea acoustic improvements for its 10 submarines. The Navy also plans for the last nine submarines to increase capacity for Tomahawk cruise missiles by inserting the Virginia Payload Module (VPM), a new midbody section that makes the submarines 30 percent larger. Block V starts with SSN 802, which includes acoustic improvements but not the VPM.



Estimated Cost and Quantities

(fiscal year 2024 dollars in millions)



According to the Navy's fiscal year 2024 budget request, the Navy has 10 Block V submarines currently under contract. The Navy also requested funding to acquire two more Block V submarines, one with extensive modifications for subsea and seabed warfare.

Software Development as of January 2024

Approach: Waterfall

Frequency of end user evaluation (months)

Information not available

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements

N/A | N/A

See notes

The program reported that all software has been developed and tested, and costs are not tracked separately. According to the program, software is modified as necessary to accommodate additional payload and revised ship characteristics.

Program Essentials

Prime contractor: General Dynamics Electric Boat

Contract type: FPI (procurement)

Current Status

VCS program officials reported that the VCS delivery rate stabilized at 1.2 submarines per year, and they plan to produce at a rate of two submarines per year by 2028. However, the Navy will be challenged to improve production enough to meet the Australia-United Kingdom-United States initiative for Australia to acquire conventionally-armed nuclear-powered submarines, while also meeting the Navy's planned submarine fleet numbers.

To mitigate the effects of the workforce shortages and slower-than-expected work completion rates we reported last year, program officials reported that they continue to outsource additional work, re-sequence tasks, and attempt to grow the workforce, among other actions. The Navy also rebaselined Block V's construction schedule in 2023 to align with demonstrated performance, though its delivery dates remain unchanged from last year.

In June 2023, the Navy found that the shipbuilder was not meeting efficiency and schedule criteria the program set to assess shipbuilder readiness for full construction for SSN 808. As a result, the Navy delayed that event. However, program officials stated that they have been able to continue construction largely as planned. They stated that these assessments help establish priorities with the shipbuilder, and working without formal construction authorization does not limit the Navy's ability to discuss shipbuilder performance.

The shipbuilder is completing work at a higher cost than expected due to the workforce shortages and slow progress noted above. Consequently, the Navy estimated in its fiscal year 2024 budget request that it will need $530 million more to complete the first two Block V submarines over the next five years.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. According to the program office, the Navy is working closely with the shipbuilders and the industrial base to stabilize its production rate and improve the construction process. The program stated that it has a goal of 1.5 submarine deliveries per year by the end of 2024, and that continued investment in the industrial base is critical to achieve its goal of reaching a delivery rate of two per year by the end of 2028.

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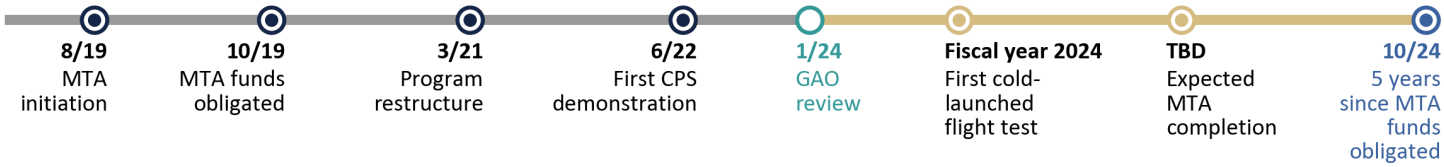
MTA | Lead Component: Navy

Common Name: CPS

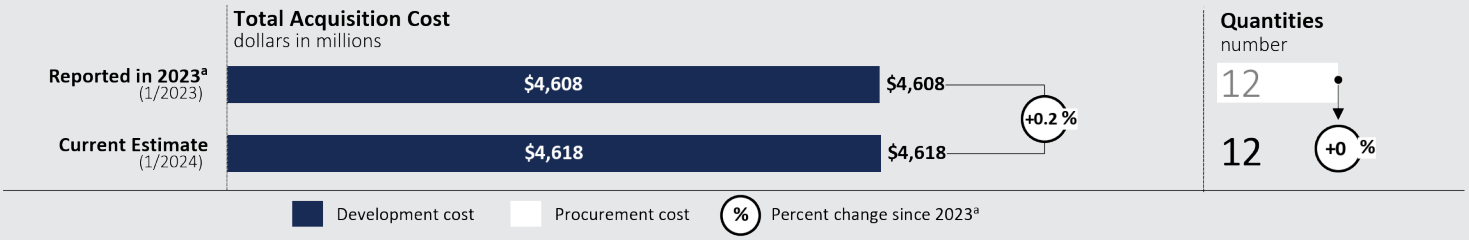
Conventional Prompt Strike (CPS)

Source: U.S. Navy. | GAO-24-106831

The Navy's CPS program aims to develop an intermediate-range, hypersonic missile in phases. We assessed phase one, an MTA rapid prototyping effort. That effort plans to conduct a cold-gas launch—in which the booster ignites after the missile ejects—by 2024. The second phase, a planned MTA rapid fielding effort, aims to field the missile on a surface ship by 2025. The third phase, a planned major defense acquisition program, aims to field the missile on *Virginia* class submarines by 2030. CPS partners with the Army's Long Range Hypersonic Weapon program, which we assessed separately.



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2024 dollars in millions



The CPS program is acquiring 12 test assets to support the rapid prototyping phase. Four are complete missiles to support flights tests. Eight are other types of test vehicles or missile simulators.
[a]GAO-23-106059.

Program Background and Transition Plan

The Navy initiated the CPS MTA rapid prototyping effort in 2019, although CPS technology development efforts began in 2009. CPS plans to complete its rapid prototyping effort in 2024 within the 5-year MTA time frame established in DOD policy, but it has yet to conduct a successful flight test of a complete missile. The first such flight test in 2022 was partially successful. Three subsequent flight tests in 2023 were aborted before launch. The Navy plans to initiate a rapid fielding effort for the second phase of CPS once it completes a successful end-to-end flight test.

Software Development as of January 2024

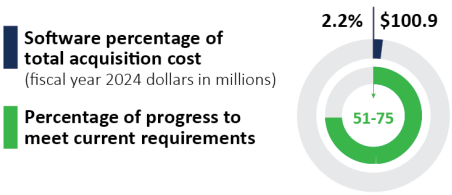
Approach: Agile, Waterfall, Incremental, and DevSecOps

Frequency of end user evaluation (months)

Other frequency (see notes)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)



The program reported that end user feedback occurs once or twice per year through operational exercises. According to the program, the change in software cost compared to last year is due to updated estimates.

Program Essentials

Prime Contractor: Lockheed Martin

Contract type: CPIF

Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case	Status at Initiation	Current Status
Approved requirements document	○	●
Approved middle tier of acquisition strategy	●	●
Formal technology risk assessment	○	○
Cost estimate based on independent assessment	○	●
Formal schedule risk assessment	○	○

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

CPS Program

Updates to Program Performance and Business Case

Since our last assessment, the Navy approved new acquisition and test strategies for CPS and its rapid prototyping phase, but the program subsequently experienced testing problems and delays. In 2023, the Army and Navy attempted three flight tests of the CPS missile using an Army launch system. All three were aborted before launch. The two most recent flight tests were not completed due to launcher and launch sequence issues identified at the test range. The CPS program plans to restart flight testing in 2024 with a test off a launch pad instead of using the Army's launch system. The program will conduct this test after an independent technical review of the missile's design is completed. Subsequent flight tests using a CPS launcher are tentatively scheduled after the Navy first conducts a series of launcher-related tests to reduce risk.

According to program officials, testing issues are one of the primary schedule risks for the rapid prototyping effort and have already caused delays. The program has yet to conduct a successful end-to-end flight test of a complete missile. Due to the flight test issues, the first cold-launch end-to-end flight test of a complete missile using a Navy launcher has been delayed. The final flight test of the rapid prototyping effort, which includes a cold-launch end-to-end test of the version of the missile that the Navy intends to field on *Zumwalt* class destroyers, was also delayed. The CPS program reported that it would need additional funding in fiscal year 2024 to address testing issues and complete the rapid prototyping effort without incurring further delays. The lack of a successful end-to-end test also delayed the production of Army missiles and Navy test assets, which cannot be completed until the program verifies that the missile design works.

Software and Cybersecurity

The CPS program continued to report that software development is a risk. It stated that completing the originally planned software effort has proven more difficult than expected and deliveries have lagged. Testing delays and software changes to support retests contributed to the slower deliveries. The program also cited difficulty hiring and retaining acquisition professionals with the software experience needed to oversee contractor efforts. The program has used a variety of tools, including surge support from other Navy organizations, to increase its software development staff.

Leading Product Development Practices

The CPS program reported that it is using an iterative approach for development, including certain practices that we found leading companies employ to successfully develop and deliver products to users with speed. For example, CPS established a process to strategically prioritize capabilities through technology insertions every 2 years that are informed by factors such as technology maturity, affordability, and evolving user needs. The CPS program uses this process to inform requirements for the current rapid prototyping effort and subsequent phases. We previously found that leading companies collect feedback on delivered products—such as how well they are performing or whether other functions are needed—to identify improvements for subsequent iterations and increase the product's value for users.

Program officials also stated that CPS has used a 3D model for the entire weapon, which they have found to be useful in development. We found that leading companies use digital twins—virtual representations of a physical system—to test the performance of different designs and prioritize the most essential capabilities. Program officials stated that they experienced challenges bringing the various subsystem models together to create a digital representation of the weapon system, and not having data from a successful end-to-end flight test to help anchor their models.

Other Program Issues

Several issues could affect the planned fielding dates in subsequent phases of the CPS program. First, the Navy did not initiate the MTA rapid fielding effort for the *Zumwalt* class destroyers when planned and will not do so until the program completes a successful end-to-end flight test. Next, the Navy needs to complete the remaining flight tests on schedule for the rapid prototyping effort or risk having to delay production of the missiles needed for *Zumwalt* fielding. Finally, program officials stated that other schedule risks include the timely completion of launch system integration on the *Zumwalt* and the underwater launch test facility for *Virginia* class submarines.

Program Office Comments

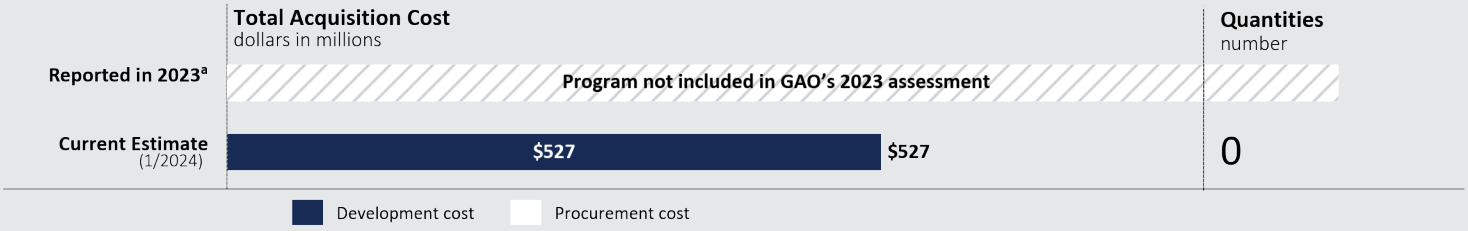
We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. According to the CPS program office, the Navy's CPS and Army's Long Range Hypersonic Weapon programs have pursued an aggressive schedule to develop the Army and Navy's first common hypersonic weapon. It noted that the programs experienced flight testing challenges in 2023, but in each case, they rapidly reacted to identify root causes, complete corrective actions, and return to testing. Further, the programs initiated a series of design reviews and additional tests to restore technical confidence, achieve critical knowledge points, and reduce risk. The CPS program office also stated that it will continue efforts to improve affordability of the weapon system through initiatives to reduce material costs, as well as leverage additional prototype test bed opportunities. Finally, the program continues to coordinate with the *Zumwalt* class and *Virginia* class programs to support design, development, and testing in preparation for sea-based fielding of the CPS weapon system.

Hypersonic Air-Launched Offensive Anti-Surface Warfare Weapon System (HALO)

The Navy's HALO, a new MTA rapid prototyping effort, is developing an anti-ship missile. The Navy expects HALO to address long-term capability needs for longer-range missiles with increased survivability to target heavily defended ships from near-peer competitors. HALO is also known as Offensive Anti-Surface Warfare (OASuW) Increment II. Its predecessor, OASuW Increment I, partially addressed capability needs identified by the Navy in 2008.

Source: U.S. Navy. | GAO-24-106831

Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2024 dollars in millions



[a]GAO-23-106059.

Program Background and Transition Plan

The Navy initiated HALO as an MTA rapid prototyping effort in March 2023. The Navy changed the HALO acquisition strategy in August 2023. The program now plans to conduct preliminary design reviews with two vendors in 2024. It will then conduct a full and open competition, select a single vendor, and transition to the major capability acquisition pathway at development start in fiscal year 2025—which is 2 years earlier than planned. The program no longer plans to build prototype missiles as a part of the MTA rapid prototyping effort. Program officials stated that they initially lacked the funding to begin HALO as a major capability acquisition program and used the MTA rapid prototyping pathway to get it underway sooner.

Software Development as of January 2024

Approach: Information not available

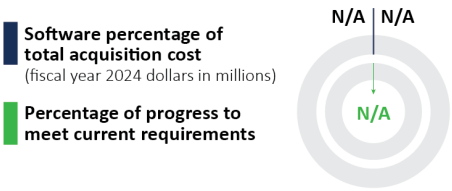
Frequency of end user evaluation (months)

Information not available

Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)



The program reported that software development has not started and that it is too early to identify and track software costs.

Program Essentials

Prime Contractor: Lockheed Martin; Raytheon

Contract type: FFP

Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case	Status at Initiation	Current Status
Approved requirements document	○	●
Approved middle tier of acquisition strategy	●	●
Formal technology risk assessment	○	○
Cost estimate based on independent assessment	○	○
Formal schedule risk assessment	○	○

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

HALO Program

Key Elements of Program Business Case

The HALO program did not have four of the five key elements of its business case approved at initiation in March 2023. The Navy approved the acquisition strategy in November 2022. However, the Navy did not approve the top-level requirements for the HALO MTA effort until August 2023, after initiation. The program also did not conduct formal technology and schedule risk assessments, or have a cost assessment based on independent assessment prior to initiation. Our prior work has shown that this type of information is important to help decision-makers make well-informed decisions about MTA program initiation.

The Navy updated the HALO acquisition strategy in August 2023. The MTA effort was expected to proceed in two phases. The first would include two vendors and conclude with an assessment of design maturity. The second phase would follow with a single vendor and include at least two flight demonstrations of the HALO prototype by the end of fiscal year 2026. The program now plans to transition to the major capability acquisition pathway at development start in early fiscal year 2025—2 years earlier than planned and before any prototypes are built and demonstrated. The program plans to have a cost assessment based on independent assessment and formal assessment of technology risk before entering the major capability acquisition pathway and beginning system development. It has no plans to conduct a formal assessment of schedule risk until after it begins system development.

Leading Product Development Practices

The HALO program reported that it was not using an iterative approach for development. We previously found that leading companies use iterative processes to design, validate, and deliver products with speed. Even though the HALO program stated it was not using an iterative development approach, the program is using certain modern design tools. HALO plans to use these tools by establishing a single, integrated, secure computing environment. Vendors will upload digital models of the components that will go into the design, which can then be assembled and tested as a digital prototype. We found that leading companies use virtual representations of physical products—known as digital twins—to enable rapid iterative design cycles that incorporate user feedback and changes at earlier stages, where they are easier to implement.

Software and Cybersecurity

According to the HALO program, it is not developing software as part of the rapid prototyping effort. The program plans to have an approved cybersecurity strategy before transitioning to the major capability acquisition pathway.

Other Program Issues

The HALO program manager stated that manufacturing and testing are a risk, much like for other hypersonic weapon programs. The risks will still be relevant for the HALO effort after its planned transition to the major capability acquisition pathway. From a manufacturing perspective, there is limited industrial capacity to serve multiple hypersonic programs. To address this concern, the HALO program said it worked with the Office of the Secretary of Defense to fund studies of both HALO vendors and their subcontractors to identify potential choke points in the manufacturing process. From a testing perspective, a program official noted, the demand for ground and flight test facilities among hypersonic programs is a challenge. The program manager said HALO plans to leverage models and simulations and data from other programs to help address this challenge.

Program Office Comments

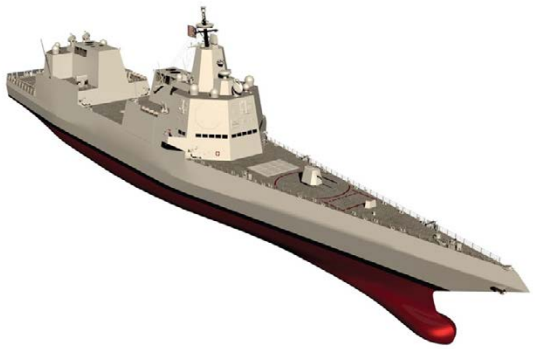
We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

According to the HALO program office, the program was initiated as an MTA rapid prototyping program in accordance with an approved acquisition strategy. It stated that this strategy included a cost estimate and a prototyping plan that defined the requirements to be demonstrated at the completion of the MTA. Additionally, the program office stated that it is proceeding with a competition for the system development contract in the second quarter of fiscal year 2024.

The program office further stated that the acquisition strategy for the major capability acquisition program was approved, and the requirements document was submitted to the Joint Requirements Oversight Council for validation. The program office also stated that it plans for a formal technology risk assessment and a cost estimate based on an independent assessment in fiscal year 2024, as well as a formal schedule risk assessment as part of the competition for the system development contract.

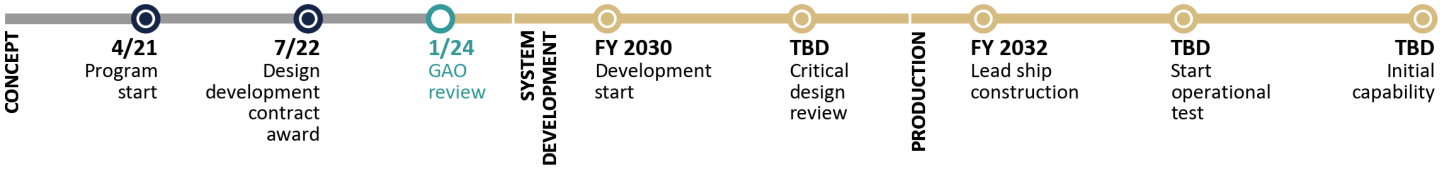
Finally, according to the program office, the HALO program will implement an open, agile, and digital approach to development. This approach, it stated, will enable an iterative design strategy that will mature into a digital twin of the system.

DDG(X) Guided Missile Destroyer



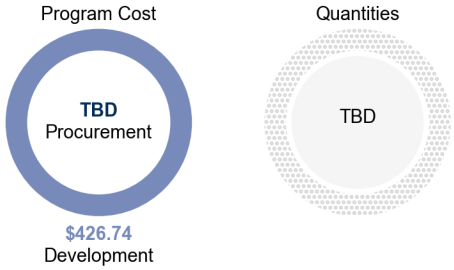
Source: U.S. Navy. | GAO-24-106831

The Navy's DDG(X) program is developing a new integrated air and missile defense large surface combatant to follow the DDG 51 class destroyers, which the Navy plans to be more fuel-efficient and to accommodate future capability growth. The Navy expects DDG(X) to incorporate existing weapons, such as the Aegis combat system and the SPY-6 radar, onto a new hull with a new integrated power system. The Navy intends for the design of the DDG(X) to provide sufficient size and power margins to enable greater flexibility to incorporate new systems as they become available. We evaluate DDG 51 in a separate assessment in this report.



Estimated Cost and Quantities

(fiscal year 2024 dollars in millions)



DDG(X) costs represent development efforts for fiscal years 2022-2024 and include multiple funding lines.

Software Development as of January 2024

Approach: Information not available

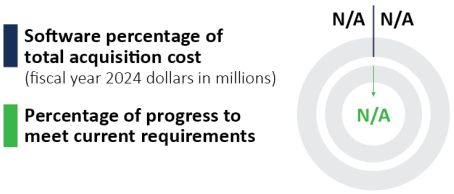
Frequency of end user evaluation (months)

Information not available

Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)



Program officials stated that it is too early in the program to know the need for, or the extent of, software development.

Program Essentials

Prime contractors: General Dynamics Bath Iron Works; Huntington Ingalls Industries

Contract type: CPAF (design)

Current Status

DDG(X) remains in its concept design phase and expects an additional 2-year delay to development start, now planned for 2030. Program officials attributed the delays to the Navy's efforts to revise the draft operational requirements to address changes in the threat environment. The delays affect the timing of when the lead DDG(X) ship will be available to counter emerging threats. Program officials expect Navy leadership to approve the changes by March 2024, after which preliminary design is expected to begin. The Navy plans to continue building DDG 51 destroyers while starting DDG(X) construction in an effort to facilitate a smoother transition. But, unless the DDG 51 program addresses ongoing delays, building both classes could strain the shipbuilders' capacity. The program does not plan to develop a digital twin of the ship, but it is considering doing so for ship components and systems. A digital twin would enable real-time data to inform design changes and system validation.

According to the program, the Navy is working with the shipbuilders to inform requirements and identify cost saving opportunities. Our work on leading practices highlights the importance of stakeholder involvement in developing and refining requirements. Given the program's efforts to revise requirements, the cost of the ships is in flux pending requirements approval. Prior estimates for the lead ship reached about $4 billion. The Navy has yet to determine quantities for the DDG(X), as it is considering options for its future fleet.

The program plans to develop and test a full-scale physical prototype of the integrated power system—one of two critical technologies—by 2030 to help inform the ship's design. Since last year, the Navy began testing power generation equipment at the land-based test site to reduce the integrated power system's design risk. As a result, the Navy expects to gain knowledge about the system's performance prior to developing the ship's design.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. It provided technical comments, which we incorporated where appropriate. According to the program, DDG(X) will combine DDG 51 Flight III combat systems with a new hull form and power systems to accommodate future capabilities. The program stated that it will conduct land-based testing prior to detailed design to reduce risk. It also stated that the Navy established a collaborative Navy-industry team.

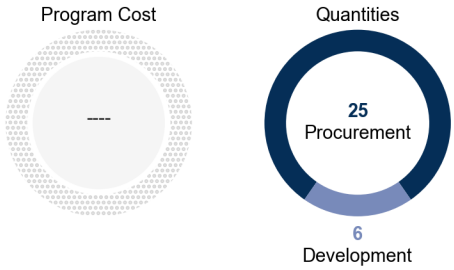
Source: U.S. Navy. | GAO-24-106831

E-6B Recapitalization (E-XX)

The Navy's E-XX program is intended to perform the Take Charge and Move Out (TACAMO) mission, which provides a survivable, airborne nuclear command, control, and communications link between the U.S. National Command Authority and U.S. strategic forces. E-XX is planned to augment and eventually replace the TACAMO capabilities currently performed by aging E-6B aircraft. The Navy plans to integrate the E-XX mission systems, which include communications through multiple radio frequency bands, onto C-130J-30 aircraft. E-XX plans to initiate as a major capability acquisition entering at development start.

Estimated Cost and Quantities

(fiscal year 2024 dollars in millions)



The Navy did not approve cost information for public release.

Software Development as of January 2024

Approach: Agile and DevSecOps

Frequency of end user evaluation (months)

Information not available

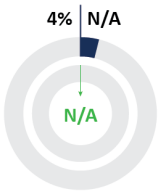
Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program office reported that software development has not started. The Navy did not approve software cost information for public release.

Program Essentials

Prime contractor: TBD

Contract type: TBD

Current Status

The E-XX program plans to award a development contract in November 2024. The solicitation calls for offerors to submit how they will integrate mission systems into a C-130J-30 aircraft. The solicitation calls for three engineering development model aircraft and has options for up to three system demonstration test aircraft and one initial production lot.

Despite stated goals in its acquisition strategy that align with leading practices for iterative development, such as rapidly executing the program to accelerate fielding as E-6B aircraft approach end of operations, the Navy plans to use a traditional, linear approach to develop E-XX and design the system to operate for decades using legacy technologies. This approach hampers innovation and poorly positions the program to upgrade capabilities to match evolving user needs. For example, one planned technology for E-XX was developed in the 1980s and relies on unsupportable hardware and software. The Navy is modernizing the technology for E-6B—an effort that E-XX program officials anticipate will also enable the technology to meet E-XX requirements. This view represents an update to language the Navy included in the November 2021 E-XX acquisition strategy, which stated that the modernization effort would not fully meet E-XX's requirements. Even so, our prior work found that the needs of users evolve as technology advances, which causes leading companies to rely on iterative development to ensure capabilities remain relevant before and after deliveries. Applying such an approach to E-XX could enable rapid delivery of the most critical capabilities soonest in a first iteration while the program simultaneously pursues newer technologies for subsequent iterations.

The Navy's goal of rapidly fielding the aircraft is compromised by establishing detailed performance requirements 18 months before embarking on E-XX system design. This approach constrains the use of design iterations and risks the Navy paying up front for capabilities it may later find it cannot fully deliver.

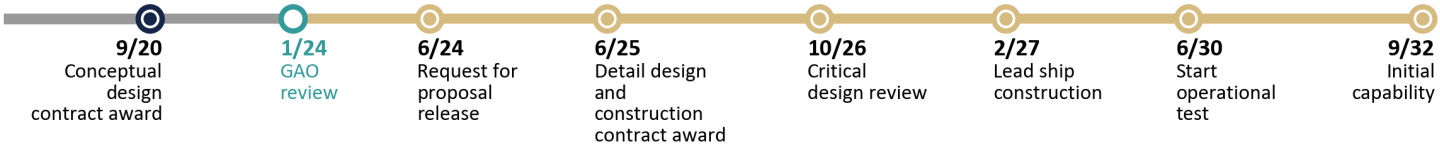
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. It provided technical comments, which we incorporated where appropriate. The program office stated that detailed E-XX requirements were approved in March 2023 and will be continuously reviewed. It also stated that modernization of the planned technology has progressed and the current design is projected to fully meet performance and sustainment requirements.

Large Unmanned Surface Vessel (LUSV)

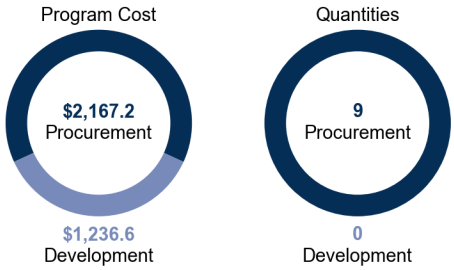
The Navy's LUSV is a planned, long-endurance, uncrewed ship intended to conduct warfare operations with varying levels of autonomy and in conjunction with crewed ships. The Navy also expects the LUSVs to be low-cost, reconfigurable ships with capacity for carrying various modular payloads. LUSV is a research and development effort that builds on earlier prototyping efforts funded by the Office of Naval Research and the Office of the Secretary of Defense (OSD) Strategic Capabilities Office. LUSV started concept development in September 2020.

Source: U.S. Navy. | GAO-24-106831



Estimated Cost and Quantities

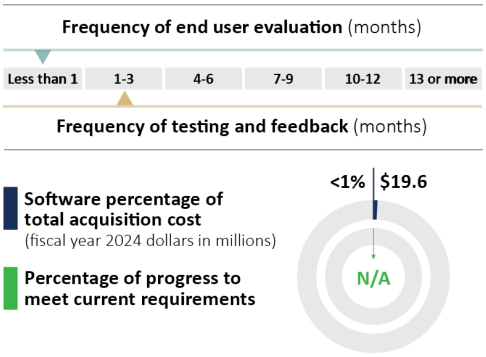
(fiscal year 2024 dollars in millions)



Cost and quantity represent fiscal years 2020-2028.

Software Development as of January 2024

Approach: Agile and DevSecOps



The program reported that software development is in progress but the percentage of completed software is unknown.

Program Essentials

Prime contractor: TBD

Contract type: FFP (conceptual design contracts)

Current Status

LUSV continues to work toward a milestone review in 2025, when it plans to transition to the major capability acquisition pathway. The Navy plans to begin construction of the first of nine production LUSVs in 2027. The program acquired prototypes, but fleet officials stated that they are still developing plans to assess prototype capabilities and technical maturity, as we previously recommended. In the interim, the Navy's fleet is experimenting with these prototypes to understand their capabilities, familiarize sailors with operating them, and identify critical technologies that require maturation. For example, some of the prototype vessels are participating in a developmental deployment and testing operational concepts with Pacific Fleet forces.

A primary differentiating factor between LUSV and crewed ships is autonomy software. Officials reported that the Navy plans to use vendor-created software with an option to install government software if needed. They previously noted that intellectual property rights and integration of autonomy on the vessels were key considerations. Specifically, Navy program office and fleet officials have experienced issues and identified inefficiencies with data collection and operations because of vendor-protected intellectual property and interfaces. We have ongoing work assessing the Navy's efforts to develop uncrewed systems, including the LUSV.

Navy officials stated that the draft LUSV requirements call for several sailors on board in some instances, such as entering or exiting port, due to limitations of current autonomy technology. While officials stated that they are using an iterative development approach, they do not plan to deliver initial capability to the fleet until 2032, at which time autonomy should be more advanced. We previously found that leading companies use iterative design and testing to identify a minimally viable product that can deliver essential capabilities to users with speed.

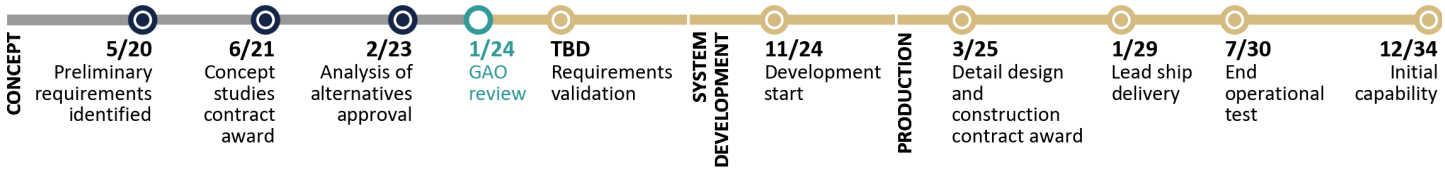
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. In April 2024, officials stated that there is a new schedule to allow for more technology development prior to contract award. The program also reported changes to quantity and cost.

Medium Landing Ship (LSM)

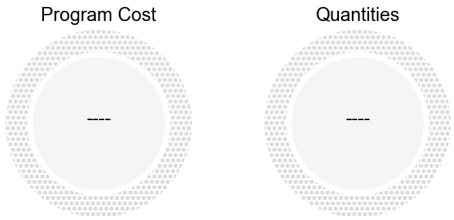
Source: U. S. Navy. | GAO-24-106831

The Navy's LSM program, formerly the Light Amphibious Warship, is developing a medium-sized landing ship that is intended to transport 50 to 75 Marines and their associated supplies and fuel from shore to shore in contested operational environments. The Navy expects LSM to support the operations of the Marine Corps' new Marine Littoral Regiments (MLR) and to provide distributed maneuverability, mobility, and logistics in support of near-shore expeditionary operations. The Navy initially plans to procure 18 LSMs, although further Navy and Marine Corps refinement of the program's concept of operations may increase required quantities to 35 ships. Nine LSMs will be required for each MLR.



Estimated Cost and Quantities

(fiscal year 2024 dollars in millions)



The Navy did not approve cost information for public release.

Software Development as of January 2024

Approach: Information not available

Frequency of end user evaluation (months)

Information not available

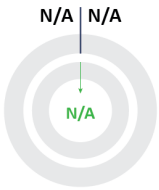
Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)

Software percentage of total acquisition cost
(fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that it is not developing software but is using software that has been fielded on other platforms.

Program Essentials

Prime contractor: TBD

Contract type: TBD

Current Status

The LSM program plans to award a detail design and construction contract in 2025, 2 years later than initially planned. MLRs became operational in 2023, so the ships are late to need. The Navy is developing a bridging strategy to use other ships for the MLRs until LSM achieves initial operational capability. The Navy has yet to determine the total cost of this bridging strategy but expects to spend approximately $304 million through 2029. LSM is at risk of additional delays—due to issues such as requirements instability—which could increase bridging costs. Navy and Marine Corps leadership reached initial agreement on LSM's key attributes in February 2023. The Navy approved these requirements in February 2024, but DOD leadership had yet to validate LSM's requirements as of March 2024. We previously found that leading companies focus on the minimum acceptable requirements and balance requirements with schedule to deliver useful capability more quickly.

The Navy is trying to leverage commercial ship designs for LSM, but existing commercial designs require significant modifications to meet LSM's requirements. For example, none of the commercial designs the Navy assessed provide needed cargo fuel capacity or meet beachability requirements—the ability to drive the ship on shore. Vulnerability and recoverability improvements are also needed to increase LSM's survivability. These modifications have significant bearing on LSM's costs, with per hull cost estimates varying by more than $115 million, depending on the modifications included.

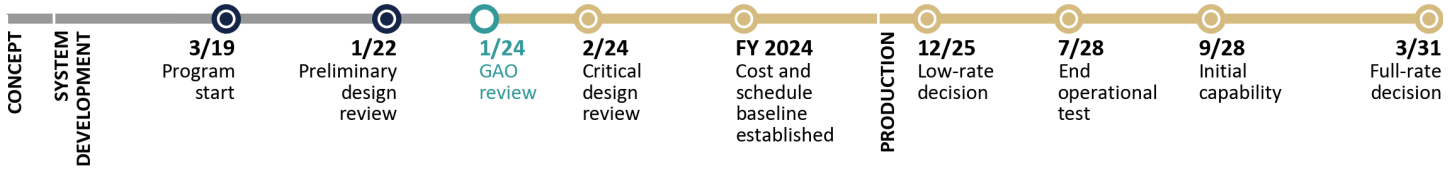
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. It provided technical comments, which we incorporated as appropriate. It stated that the Navy and Marine Corps have collaboratively finalized the best mix of industry-informed requirements to efficiently and affordably procure LSM. The program noted that it achieved Navy endorsement of requirements in October 2023 and system specification approval in November 2023, and released a detailed design and construction request for proposal in January 2024. It stated that it is on track for a fiscal year 2025 award to support fiscal year 2029 lead ship delivery, and is exploring alternate approaches to more rapidly procure LSMs.

MK 54 MOD 2 Advanced Lightweight Torpedo (ALWT)

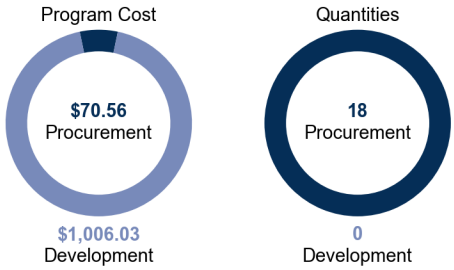
The Navy's MK 54 MOD 2 program is developing an advanced lightweight torpedo for use by U.S. surface ships, fixed-wing aircraft, and helicopters in anti-submarine warfare. The Navy plans to upgrade the MK-54 MOD 1 torpedo's guidance and control, propulsion system, and warhead to achieve higher speeds and maneuverability, greater depths, and increased lethality. The program continues to complete early system development activities and plans to formally get approval for development start as a major defense acquisition program on a yet-to-be determined date in fiscal year 2024.

Source: Alion Science and Technology. | GAO-24-106831



Estimated Cost and Quantities

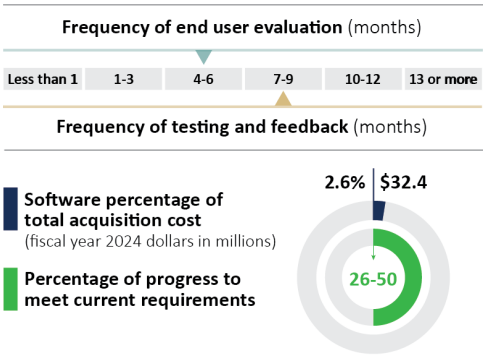
(fiscal year 2024 dollars in millions)



Cost and quantity represent fiscal years 2019-2028.

Software Development as of January 2024

Approach: Agile and Iterative (other than Agile)



Program officials reported that the decrease in the frequency of testing and feedback this year was due to delays in the delivery of hardware for in-water testing.

Program Essentials

Prime contractor: Progeny Systems Corporation; Northrup Grumman Corporation; Aerojet Rocketdyne; Raytheon Technologies

Contract type: CPFF (using other transaction authority)

Current Status

The Navy tailored the major capability acquisition pathway to accelerate delivery of the MK 54 MOD 2 torpedo. However, since our last assessment, most major program milestones have been delayed by 8 to 9 months. Last year we reported that the program's acquisition strategy had significant risks, in part due to a compressed schedule.

According to the program office, subsystem development has taken longer than expected because the contractors' delivery of the hardware needed for testing has been delayed. The program now expects to begin in-water tests, which are critical to discovering issues on torpedo programs, in late fiscal year 2024. Program officials also reported that contractors' estimated costs to complete system development and testing were significantly higher than expected. This delayed the anticipated award of the other transaction agreement for this work to fiscal year 2024. The program moved the decision review to formally enter system development from 2023 to a to-be-determined date in 2024 because DOD has yet to complete its independent cost estimate.

The program stated it is using an iterative approach for development and cited practices that we found leading companies employ to successfully develop and deliver products to users with speed. For example, according to program officials, the Navy deferred the high altitude and vertical launch capabilities for the MK 54 MOD 2 to deliver a minimally viable product faster. The program is also building on the Navy's history of using a modular open systems approach and an architecture that supports software updates for its torpedo programs. We previously found that these practices helped leading companies add to or enhance capabilities and keep systems relevant longer.

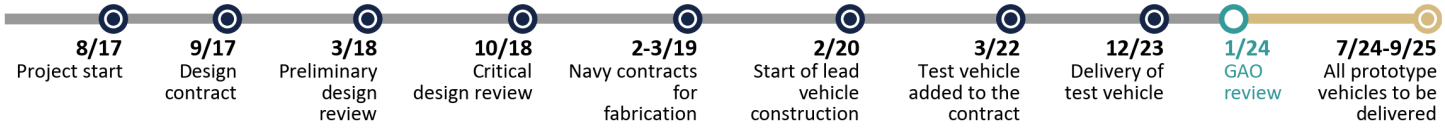
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. According to the program office, the MK 54 MOD 2 ALWT addresses a critical gap in the U.S. Navy's Anti-Submarine Warfare weapon inventory to prosecute challenging adversary submarines. The program added that to meet the operational need for the MK 54 MOD 2, it continues to optimize the development schedule and approach to field lethality upgrades as quickly as possible within funding constraints.

Source: Boeing. | GAO-24-106831

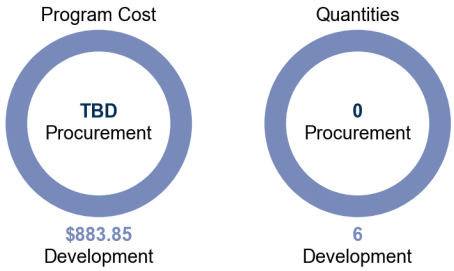
Orca Extra Large Unmanned Undersea Vehicle (XLUUV)

The XLUUV is the Navy's largest uncrewed undersea vehicle, and meets an emerging operational need for laying undersea mines. With future development after prototyping, the Navy intends to use the XLUUV to carry and deploy various payload types. The Navy began developing the XLUUV in fiscal year 2017 and its strategic plans state that the XLUUV will likely serve a key role in the future fleet by removing sailors from performing dangerous missions. The XLUUV is currently a research and development effort.



Estimated Cost and Quantities

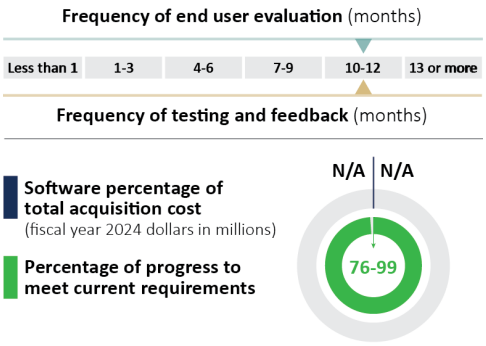
(fiscal year 2024 dollars in millions)



In addition to the first prototype, the Navy expects to receive the remaining five XLUUV prototypes in fiscal years 2024 and 2025. XLUUV officials also reported about $326 million in estimated procurement costs, which reflects potential costs if the Navy proceeds with the purchase of additional XLUUVs. The Navy plans to make the decision about future production once it assesses the prototypes' operational capability.

Software Development as of January 2024

Approach: Agile and Incremental



XLUUV reported that software costs are not known as software is developed through the contractor's own research and development. According to XLUUV officials, the frequency of testing and feedback decreased because software deliveries are on hold until the test vehicle is ready for testing.

Program Essentials

Prime contractor: Boeing

Contract type: FPIF

Current Status

The XLUUV effort has experienced cost growth and is at least $242 million, or 64 percent, over its original 2016 cost estimate. However, XLUUV reported that additional cost risk to the government is limited because the contractor reached the ceiling price for the fabrication work.

The Navy expects to receive five prototype vehicles in fiscal years 2024 through 2025—3 years later than initially planned due to fabrication delays and ongoing challenges related to battery development. To mitigate the delays, the Navy bought a prototype XLUUV to improve software and battery design while it awaits delivery of the five prototype XLUUVs. The project received this asset in December 2023 and plans for it to have enduring value as a technology testbed and training vehicle.

According to XLUUV officials, XLUUV construction was under contract before the Navy's current autonomy architecture standards were implemented. Therefore, the XLUUVs will be delivered with proprietary autonomy software. As such, the Navy reports it will have to pay the contractor for future software modifications it determines necessary after delivery. The Navy may also repurpose XLUUV for other missions and payloads beyond offensive mining. XLUUV officials stated that the effort did not use iterative practices for prototype design and validation. However, officials support adopting an iterative approach, especially with mission payloads and autonomy, for the intended XLUUV program of record. Adopting leading practices for product development could improve the Navy's readiness for future XLUUV production and help deliver essential capabilities to users with speed.

Program Office Comments

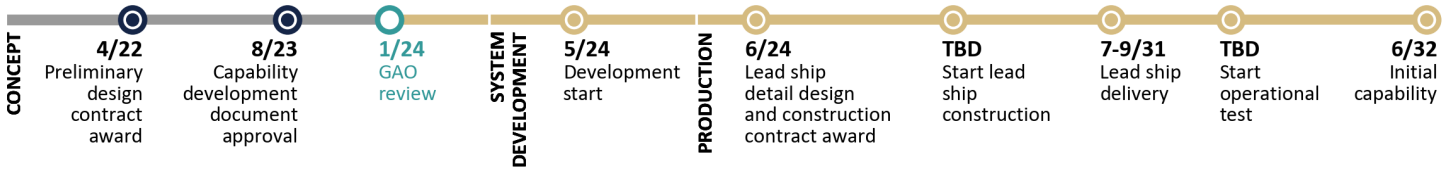
We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

The program office stated that, in parallel with the Navy accepting delivery of these first-of-kind platforms, the program of record will begin the formal acquisition and approval review process in fiscal years 2024 and 2025. The program is prioritizing limited resources toward the testing and delivery of each prototype, while also working to establish staffing, processes, and expertise to sustain delivered prototype XLUUVs while simultaneously standing up the XLUUV program of record.

Submarine Tender Recapitalization Program (AS(X))

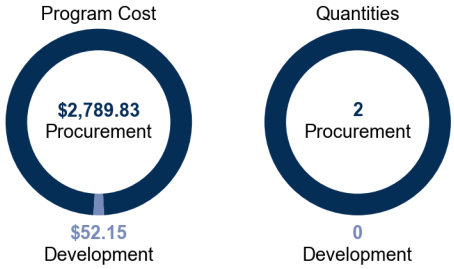
The Navy's AS(X), a major system acquisition that affects two MDAPs, will replace the Navy's existing AS 39 class submarine tenders, which are beyond the end of their expected service life. The ship is being designed to conduct forward-based tending, resupply, and repair operations for deployed *Virginia* class, *Columbia* class, and future generation submarines, and will be capable of supporting the *Los Angeles* class and *Ohio* class submarines until their retirement. The Navy plans to purchase two ships to replace the two aging AS 39 class ships.

Source: CACI. | GAO-24-106831



Estimated Cost and Quantities

(fiscal year 2024 dollars in millions)



Cost and quantity represent fiscal years 2022-2026.

Software Development as of January 2024

Approach: Information not available

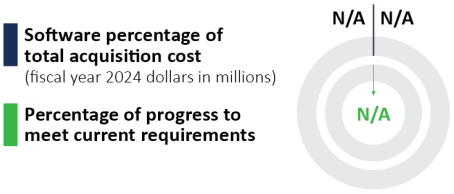
Frequency of end user evaluation (months)

Information not available

Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)



The program expects software development to begin after contract award.

Program Essentials

Prime contractor: TBD

Contract type: FPIF (anticipated)

Current Status

The Navy's AS(X) program worked with three contractors to develop ship specifications. In July 2023, it issued a solicitation for detail design and construction of up to two ships and plans to award a contract in June 2024. Program officials said that the AS(X) will be larger and have more capability than existing tenders to support new classes of submarines and the use of uncrewed undersea vehicles.

According to program officials, any delays to the program schedule present risk to the fleet due to decreased mission availability as the existing ships become increasingly difficult and costly to keep operational with age. The program plans to employ commercial standards and meet performance requirements using proven, rather than new, technologies. While these practices can increase design maturity to speed delivery, the program estimates it will provide the lead ship to the fleet in 2032, about 8 years after contract award. Officials said this reflects industry feedback on the time needed to design and construct the ship.

Program officials stated that they set requirements through an iterative process involving Navy, fleet, and industry representatives. They stated that they can make changes within the set requirements through testing and production. They also stated that the Military Sealift Command and Naval Sea Systems Command incorporated operator feedback into the detail design and construction contract solicitation and will continue to do so throughout design and construction, consistent with leading practices. While the program will employ a system-level test plan, it does not plan to conduct integrated, systems-level testing in a digital or physical environment prior to production, though this could provide additional knowledge into how key systems will perform and reduce ship design and construction risk. The program office stated that Military Sealift command does not intend to develop a digital twin capability. It noted that AS(X) is considered a low-risk structural design and such capability is typically reserved for novel or high-risk designs. However, as we have previously reported, companies use digital twins to understand optimal factory design and manufacturing processes.

Program Office Comments

We provided a draft of this assessment for program office review and comment. The program office provided technical comments, which we incorporated where appropriate.

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SPACE FORCE

Program Assessments

▲ GPS-III Follow-on (GPS-IIIF)

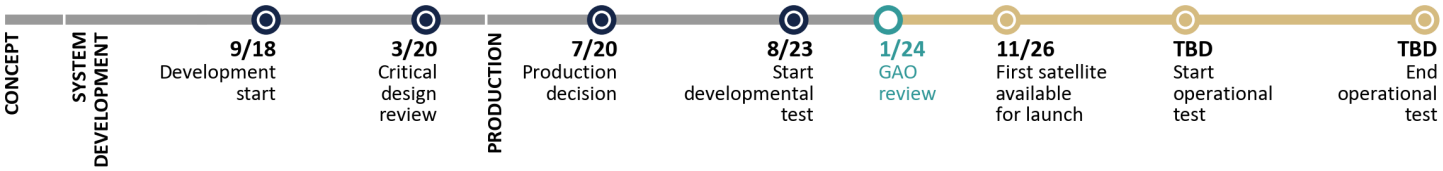
Assessment type	Program name
MDAPs	GPS III Follow-on (GPS IIIF)
	Military GPS User Equipment Increment 1 (MGUE Inc 1)
	Next Generation Overhead Persistent Infrared Geosynchronous Earth Orbit Satellites (Next Gen OPIR GEO)
	Next Generation Overhead Persistent Infrared Space Polar (Next Gen OPIR Polar)
	Next Generation Operational Control System (OCX)
	Weather System Follow-On (WSF)
MDAP Increments	National Security Space Launch (NSSL)
MTA Programs	Deep Space Advanced Radar Capability (DARC)
	Evolved Strategic SATCOM (ESS)
	Future Operationally Resilient Ground Evolution (FORGE)
	Military GPS User Equipment Increment 2 (MGUE Increment 2)
	Protected Tactical SATCOM (PTS)
	Tranche 1 Tracking Layer (T1 TRK)
	Tranche 1/Tranche 2 Transport Layer (T1TL/T2TL)
Future Major Weapon Acquisitions	Missile Track Custody (MTC), Resilient Missile Warning, Missile Tracking, and Missile Defense, Epoch 1

Source (previous page image): Lockheed Martin Corporation. | GAO-24-106831

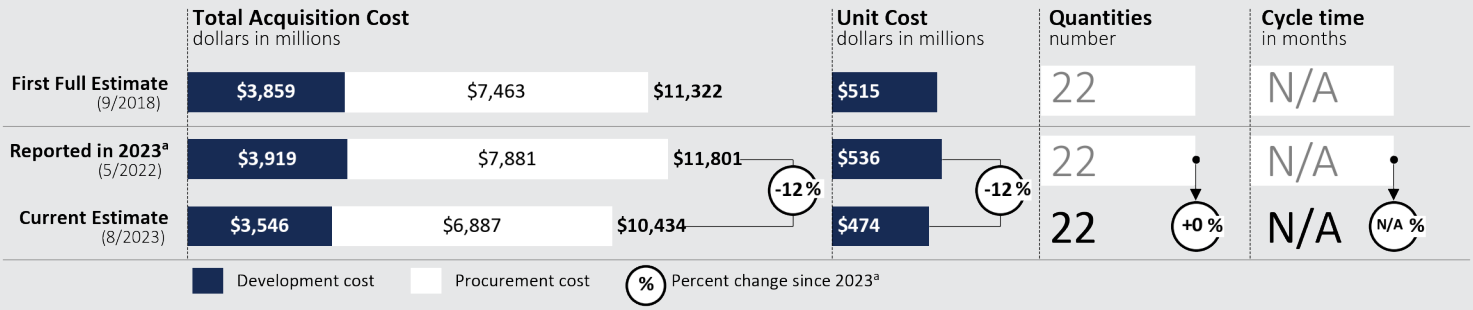
Source: Lockheed Martin Corporation. | GAO-24-106831

GPS III Follow-On (GPS IIIF)

The Space Force's GPS IIIF program is intended to build upon the efforts of the GPS III program to develop and field next-generation satellites to modernize and replenish the GPS satellite constellation. In addition to the capabilities built into the original GPS III design, GPS IIIF is expected to provide new capabilities. These capabilities include a steerable, high-power military code (M-code) signal—known as Regional Military Protection—to provide warfighters with greater jamming resistance in contested environments.



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise two development quantities and 20 procurement quantities. We could not calculate cycle time because the initial capability depends on the availability of complementary systems.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Waterfall and Incremental

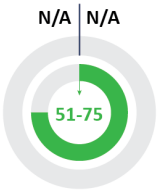
Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program expects to begin tracking software costs in the first quarter of fiscal year 2024. According to the program, the estimated percentage of progress that it provided to us last year was incorrect. The program provided an updated estimate based on a software build completed in May 2023.

Program Essentials

Prime contractor: Lockheed Martin

Contract type: FPI (development); FPAF (procurement)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	●	●
Demonstrate all critical technologies in a realistic environment	NA	NA
Complete a system-level preliminary design review	○	○
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	●	●
Test a system-level integrated prototype	○	○
Manufacturing processes are mature	**Production Start**	
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

We did not assess either the demonstration of GPS IIIF critical technologies in a realistic environment or testing of a production representative prototype in its intended environment due to the difficulty of conducting tests in a realistic or intended environment—space. Also, the Air Force waived the requirement for conducting a preliminary design review prior to development start.

GPS IIIF Program

Technology Maturity, Design Stability, and Production Readiness

The program made progress with its linearized traveling wave tube amplifier (LTWTA) development efforts in 2023, but, according to program officials, schedule concerns persist due to contractor personnel shortages. The program selected the LTWTA to meet the power requirements of the satellite's Regional Military Protection capability. The program reported that the contractor produced all planned developmental LTWTAs. However, according to the program, the contractor is tracking timely delivery of the LTWTAs for the first four GPS IIIF satellites as an area of concern. To mitigate challenges with LTWTA manufacturing, the program reported that the contractor subcontracted LTWTA work for the third GPS IIIF satellite onward.

In 2023, the program experienced delays to the projected satellite deliveries due to continued challenges with the satellite's mission data unit (MDU)—the brain of the satellite's navigation mission. The program reported that MDU efforts have been beset by parts shortages, as well as investigations and rework pertaining to technical challenges with the MDU's timekeeping system and digital waveform generator. As a result, between October 2022 and December 2023, delivery of two of six developmental MDUs for use in satellite simulators were delayed by an average of 8 months, with one still awaiting a projected January 2025 delivery. Over the same period, the flight qualification MDU and the MDUs for the first two GPS satellites experienced delays averaging 13 months to their projected deliveries. As result of these delays, the program delayed the projected deliveries of the GPS IIIF satellites under contract by an average of 15 months.

In August 2023, the program successfully powered and began early testing of an assembled non-flight, system-level testbed, which includes all key GPS IIIF subsystems and components. However, due to component delivery delays, the projected completion of this testing shifted from November 2023 to April 2024. The program expects the construction and demonstrations of this testbed to inform the first GPS IIIF satellite's integration and testing, which is projected to begin in November 2024—a shift from the previously forecast May 2024 start.

Since last year, the program also delayed the planned start of system performance testing on the first GPS IIIF satellite by 9 months, from April 2024 to January 2025, due to component delivery delays. However, the program is reporting an earlier planned start to developmental testing—August 2023 this year as compared to March 2024 last year. The developmental test start date that the program provided this year coincides with the initial powering and start of early testing on the GPS IIIF non-flight testbed. Previously, the developmental test start date provided by the program coincided with the initial powering and start of system performance testing on the first GPS IIIF satellite.

Software and Cybersecurity

The program completed software acceptance reviews of three major software segments. The program had previously forecast a February 2023 acceptance review for one of the segments, but the review was delayed to December 2023 due to a software error that was subsequently corrected.

In August 2023, the program reported exercising a contract action for an additional MDU software version. Program officials stated that this update will deliver some functionalities that are required for the GPS IIIF satellites' Regional Military Protection capability. According to program officials, these functionalities were not included in the original MDU software because certain technical requirements related to the operational segment were unknown at that time.

Other Program Issues

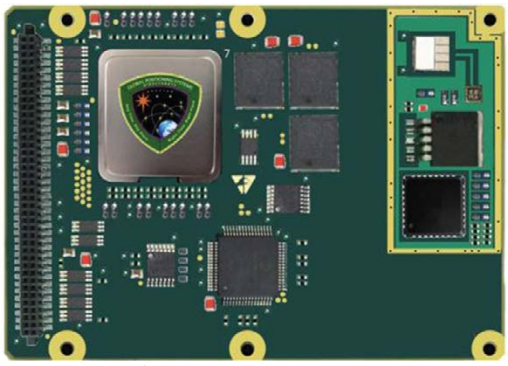
The program's total reported acquisition costs decreased by 12 percent since our last assessment. According to the program office, costs decreased approximately 8 percent due to revised DOD indices used to convert program cost information for DOD reporting purposes. The remainder of the decrease was attributed to a variety of factors, including realized economies of scale due to shifting two space vehicles from fiscal year 2024, economic price adjustments, and revised Space Force priorities.

Launch and operation of GPS IIIF satellites depends on the delivery of Next Generation Operational Control System (OCX) Block 3F. The OCX Block 3F program acknowledged schedule risk resulting from late incorporation of technical documentation and training activities into the program schedule, anticipated delayed receipt of GPS IIIF software by the OCX Block 3F contractor, and delays to the OCX Block 1/2 program, which we assess separately in this report. These challenges could have corresponding effects on the GPS IIIF program.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

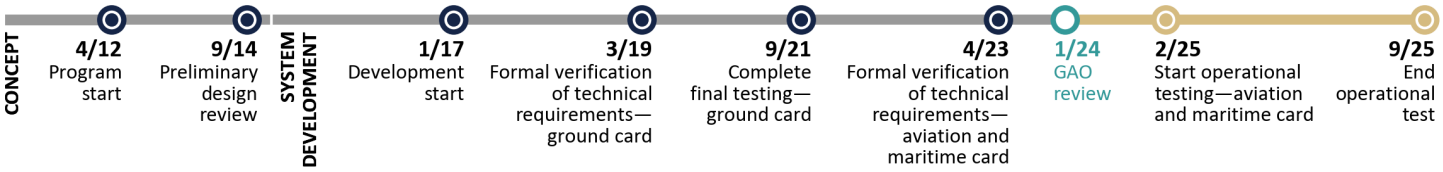
According to the program office, it is encountering technical delays but is working closely with the contractor to address these issues. The program office stated that appropriate and stable funding would enable the program to mitigate current and future challenges.



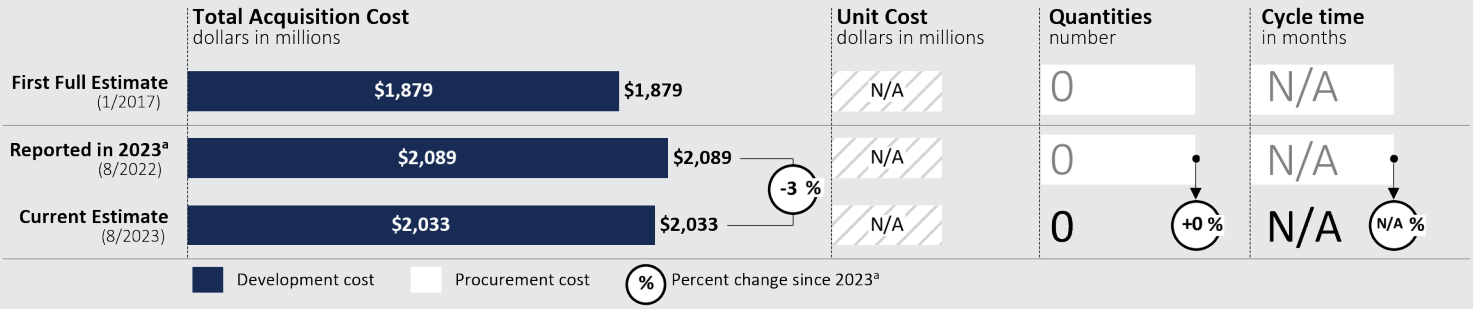
Source: U.S. Air Force. | GAO-24-106831

Military GPS User Equipment (MGUE) Increment 1

The Space Force's MGUE Increment 1 program develops GPS cards capable of receiving a modernized GPS signal known as military code (M-code). The receiver cards are expected to provide the military departments with more robust threat-resistant positioning, navigation, and timing capabilities. The program is developing one card for ground applications and one card for aviation and maritime applications. The MGUE program is integrating and testing cards on three service-selected lead systems. These cards will then be available to the military services for procurement.



Program Performance fiscal year 2024 dollars in millions



We did not assess unit cost because the program does not intend to procure cards beyond test articles, which are not reported as development or procurement quantities. We did not assess cycle time because the program will end with operational testing.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: Agile, DevOps, and Incremental

Frequency of end user evaluation (months)

Information not available

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

N/A N/A

Percentage of progress to meet current requirements

76-99

The program reported that end users have not evaluated and provided feedback on the software. It reported that the services acquiring the product have this responsibility instead. The program does not track software costs.

Program Essentials

Prime contractor: L3Harris; Raytheon Technologies; BAE Systems

Contract type: CPIF/CPFF/FFP (development)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	●	●
Demonstrate all critical technologies in a realistic environment	○	○
Complete a system-level preliminary design review	●	●
Product design is stable	Design Review	
Release at least 90 percent of design drawings	NA	NA
Test a system-level integrated prototype	NA	NA
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

We did not assess MGUE design stability or manufacturing maturity metrics because the program is only developing production-representative test items that the military departments may decide to procure.

MGUE Increment 1 Program

Technology Maturity and Design Stability

As of July 2023, the program office considers its fifth and final critical technology—anti-spoofing software designed to prevent tracking false GPS signals—to be mature. This is approximately a year earlier than the program expected as of our last report. According to the program office, the government reviewed the results of contractor software testing from 2022 and concluded that prior performance issues were resolved. However, although the technology went through verification testing, it has not been demonstrated in an operational environment. We do not consider technologies to be mature until after successful testing in this environment.

The MGUE Increment 1 program office considers ground card development efforts complete. The Space Force finished development of that card in 2022. In January 2023, the program office conducted additional testing to confirm that the ground card tracks and navigates using at least one M-code signal and behaves correctly when an expired M-code key is present. As we previously reported, the program conducted a field user evaluation of the ground card in September 2021 on a Joint Light Tactical Vehicle with the Marine Corps. During this testing, the ground card never connected to an M-code signal and did not alert operators of this issue. The program office reported that the card performed as required for all executed test cases in the recent testing. However, developmental test officials from the Office of the Secretary of Defense noted that the test was not conducted in a contested environment, and, therefore, is not considered a test in an operationally representative environment.

In April 2023, the aviation/maritime card achieved its technical requirements verification milestone, which certifies that the card can meet its requirements. However, the program discovered an issue with the card's current software that could affect GPS accuracy in aircraft while using the M-code signal. An Air Force official stated that there are plans to start testing the current software on the lead platform instead of waiting for an update to correct the deficiency because the benefit of fielding now outweighs benefits that might be gained with a software update. The official added that the Air Force is considering the operational implications of this decision and how to address them.

The MGUE Increment 1 program plans to complete combined developmental and operational testing on the Air Force's B-2 Spirit bomber in September 2025. Program documentation indicates that card-level certification is now forecast to be complete in the second quarter of fiscal year 2024, prior to the start of B-2 combined development and operational testing, rather than after it. According to the program office, this approach ensures that card level certification occurs before the start of operational testing. It also may help the program avoid a schedule breach as certification for the B-2 had a threshold date of January 2025 in the program's acquisition program baseline.

Program officials stated that they anticipate that card-level certification for the maritime platform will be completed in the fourth quarter of fiscal year 2024. Follow-on operational testing on the Navy's *Arleigh Burke* class destroyers is planned to be completed in August 2025 and is now forecasted to take place over the course of 3 months, rather than 6 months as previously reported by the program.

Production Readiness

In May 2023, Raytheon completed the aviation/maritime manufacturing readiness assessment, signifying the card's readiness for entry into low-rate initial production. The program will not request a low-rate or full-rate production decision because the military departments and their respective programs are expected to make such procurement decisions when integrating the cards into their platforms.

Software and Cybersecurity

The Space Systems Command reported that the average length of time between software deliveries for testing and feedback is 4 to 6 months. Last year, the program stated that it was 13 or more months. According to the command, the increased frequency of testing and feedback on the software was driven by the consolidation of testing under the software developer as opposed to a reliance on government testing. It also stated that more frequent testing was a recommendation from an independent program assessment and improved defect resolution. Additionally, according to the program, the number and complexity of the test issues gradually decreased as the software developer worked through the backlog of test problem reports, allowing quicker turnaround times between software builds.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

According to the program office, the program successfully completed a critical milestone, technology requirements verification, in April 2023. The program stated that it is on track to complete the remaining two acquisition program baseline milestones—for the Navy's *Arleigh Burke* class destroyer and the B-2—on schedule.

Next Generation Overhead Persistent Infrared Geosynchronous Earth Orbit Satellites (Next Gen OPIR GEO)

The Space Force's Next Gen OPIR GEO is a missile warning follow-on to the Space Based Infrared System (SBIRS) that will consist of at least two geosynchronous Earth orbit satellites. The program began as an MTA rapid prototyping effort in 2018 and was initiated because of capability limitations in SBIRS against evolving threats. The program transitioned to the major capability acquisition pathway in 2023. Two additional, ongoing efforts are expected to deliver two polar coverage satellites and modernize the ground segment.

Source: U.S. Space Force. | GAO-24-106831

Program Performance fiscal year 2024 dollars in millions

	Total Acquisition Cost (dollars in millions)	Unit Cost (dollars in millions)	Quantities (number)	Cycle time (in months)
First Full Estimate (1/2024)	Program has not developed formal cost or schedule estimates			
Reported in 2023[a]	Not a Major Defense Acquisition Program in GAO's 2023 assessment			
Current Estimate (1/2024)	Program has not developed formal cost or schedule estimates			

[a]GAO-23-106059.

Software Development as of January 2024

Approach: Agile, Incremental, DevOps, and DevSecOps

Frequency of end user evaluation (months)

Other frequency (see notes)

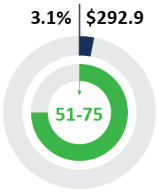
Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that end users assess software qualification test results but did not provide a frequency for these assessments.

Program Essentials

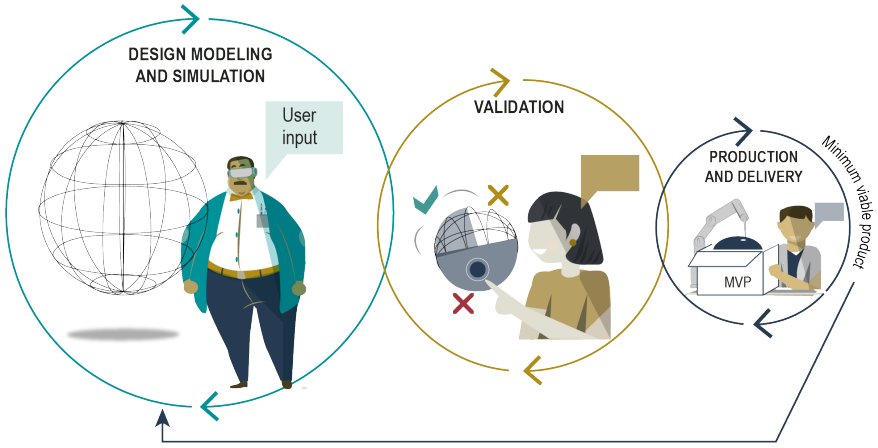
Prime contractor: Lockheed Martin

Contract type: CPIF

Attainment of Product Knowledge as of January 2024

Plan for leading product development practices

We have ongoing work to refine our leading product development practices associated with iterative development. We plan to use this space in the future to assess program implementation of leading practices, including those programs transitioning from the middle tier of acquisition to the major capability acquisition pathway. These leading practices criteria include plans to use tools and approaches that refine requirements into a minimum viable product (MVP) with users through iterative cycles of development, as depicted in the figure below. The MVP is the initial set of warfighting capabilities suitable to be fielded in an operational environment that provides value to the warfighter in a rapid timeline.



Source: GAO analysis of leading company information; GAO (illustration). | GAO-24-106831

Next Gen OPIR GEO Program

Program Performance

In July 2023, the Assistant Secretary of the Air Force, Space Acquisition and Integration office, approved the transition of Next Gen OPIR GEO from an MTA rapid prototyping effort to a major capability acquisition program. The program entered system development following successful thermal vacuum testing of the payload engineering unit and system critical design review in 2022. The program completed an integrated baseline review in May 2023, although it has yet to finalize an acquisition program baseline since transitioning to the major capability acquisition pathway. Program officials anticipate approval of the baseline by March 2024. The program office reported that all 18 of its critical technologies were mature at transition.

Successful completion of these and other milestones during the Next Gen OPIR GEO MTA effort suggested to the Space Force that the program was on track to deliver the first GEO satellite on time, in December 2025. Given this, and the continued positive performance of the SBIRS constellation, the Space Force removed the third GEO satellite from its plans. According to program officials, the removal of the third GEO satellite represents a risk-based, threat-informed decision that facilitates the Space Force's pivot to a Resilient Missile Warning/Missile Tracking architecture, known as the Proliferated Warfighting Space Architecture. The program updated its acquisition strategy in July 2023, which reflects this decision. The program reported retaining the option to still buy the third satellite, with a decision expected no later than October 2024.

The Proliferated Warfighting Space Architecture also includes the Tranche 1 and 2 Transport Layers, and the Tranche 1 Tracking Layer, both of which we assessed separately in this report.

However, the program continues to face schedule challenges, driven largely by the mission payload. According to the program office, flight hardware production and integration challenges already delayed payload delivery by roughly 11 months, until July 2024. As a result, payload and space vehicle integration delays will likely result in launch delays and program cost increases. Our work in this area indicates that a launch delay of at least a year is likely for the first GEO satellite.

Leading Product Development Practices

The program reported that it is using an iterative approach for development and cited certain product development practices used by leading companies. For example, the program stated that it conducts integrated system-level prototype testing with users and stakeholders. Our work on leading practices found that conducting fully integrated testing prior to production allows users to verify performance and can uncover problems that were not apparent when subsystems were tested earlier.

Additionally, the program indicated that it utilizes a digital twin, which allows for updating requirements to reflect changes in user needs. Leading companies use digital models along with user feedback to further develop and refine a product's business case. Digital twins—which are virtual representations of physical systems and are more dynamic than 3D models—help development teams iterate on the system's design.

Software and Cybersecurity

According to the program office, the contractor underestimated the complexity and scope of new development software required for both the space vehicle and payload. Additional work was necessary to ensure performance and cybersecurity requirements were met. This additional work resulted in cost increases, but program officials stated that they cannot quantify the amount. According to the program, the previous cost estimate did not reflect significant software development or a significant portion of the program. Finally, the program stated that the contractor has had difficulty hiring and retaining qualified software development engineers, due in part to a competitive hiring environment.

The program updated its cybersecurity strategy in September 2022 to remove the polar coverage satellites and to reflect only the Next Gen OPIR GEO mission.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program provided technical comments, which we incorporated where appropriate.

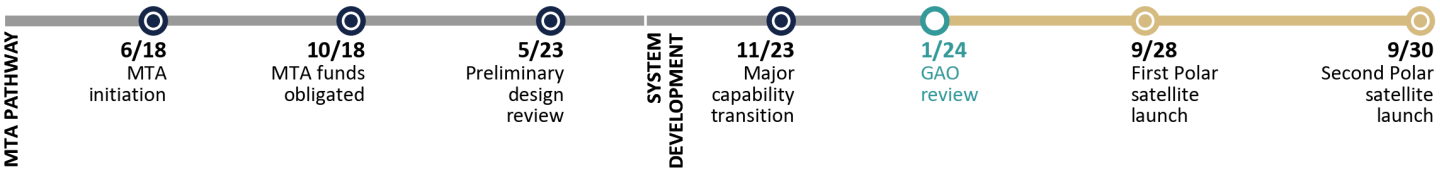
The program stated that it is committed to delivering two resilient GEO missile warning satellites that will contribute to battlespace awareness, technical intelligence, and missile defense mission areas. The program stated that, through a rigorous risk management process, it identifies and mitigates risks, while addressing and solving defects during production and integration. According to the program, it continues to be resolute in overcoming challenges to remain on-track for the first space vehicle delivery in 2025.

The program office noted that, over the past year, it successfully transitioned to the major capability acquisition pathway in July 2023 with cost, schedule, and performance targets approved by the milestone decision authority and an acquisition program baseline that is in coordination for final approval. The program stated that it anticipates OPIR mission payload delivery and space vehicle environmental testing in 2024 in preparation for launch in 2025.

Source: LAAFB Art Department. | GAO-24-106831

Next Generation Overhead Persistent Infrared Space Polar (Next Gen OPIR Polar)

The Space Force's Next Gen OPIR Polar is a missile warning program intended to detect intercontinental- and submarine-launched missiles, and tactical ballistic missile launches. Two polar-orbiting satellites will consist of new payloads on a highly resilient space vehicle. Initiated as part of an MTA rapid prototyping effort in 2018, the program transitioned to the major capability acquisition pathway in 2023. Two related efforts are assessed separately in this report: Next Generation Overhead Persistent Infrared Geosynchronous Earth Orbit Satellites (Next Gen OPIR GEO), and Future Operationally Resilient Ground Evolution (FORGE).



Program Performance fiscal year 2024 dollars in millions

	Total Acquisition Cost (dollars in millions)	Unit Cost (dollars in millions)	Quantities (number)	Cycle time (in months)
First Full Estimate (1/2024)	Program has not developed formal cost or schedule estimates			
Reported in 2023[a]	Program not included in GAO's 2023 assessment			
Current Estimate (1/2024)	Program has not developed formal cost or schedule estimates			

[a]GAO-23-106059.

Software Development as of January 2024

Approach: Agile, Incremental, DevOps, and DevSecOps

Frequency of end user evaluation (months)

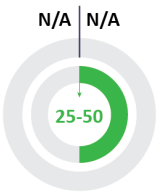
Information not available

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



According to the program, a current cost estimate is not available. The program reported that end users will evaluate and provide feedback on the software in the future.

Program Essentials

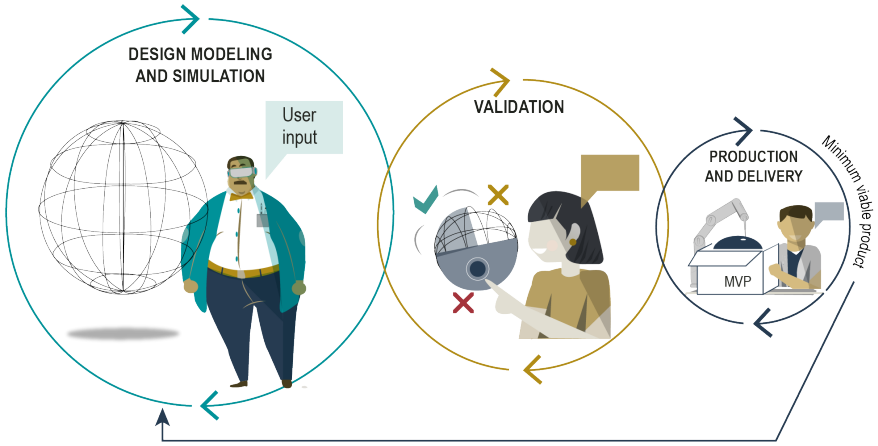
Prime contractor: Northrop Grumman

Contract type: CPIF

Attainment of Product Knowledge as of January 2024

Plan for leading product development practices

We have ongoing work to refine our leading product development practices associated with iterative development. We plan to use this space in the future to assess program implementation of leading practices, including those programs transitioning from the middle tier of acquisition to the major capability acquisition pathway. These leading practices criteria include plans to use tools and approaches that refine requirements into a minimum viable product (MVP) with users through iterative cycles of development, as depicted in the figure below. The MVP is the initial set of warfighting capabilities suitable to be fielded in an operational environment that provides value to the warfighter in a rapid timeline.



Source: GAO analysis of leading company information; GAO (illustration). | GAO-24-106831

Next Gen OPIR Polar Program

Program Performance

In November 2023, the Assistant Secretary of the Air Force, Space Acquisition and Integration office, approved the transition of the Next Gen OPIR Polar program from an MTA effort to the major capability acquisition pathway. The program entered system development following successful testing of the main mission payload. Additionally, completion of a system preliminary design review in May 2023, and a ground preliminary design review and system preliminary integration review in August 2023, indicated to the Space Force that the program was ready to transition.

The Next Gen OPIR Polar main mission payload is intended to leverage an existing payload from the Next Gen OPIR GEO program, which is expected to deliver two geosynchronous Earth orbit satellites for the space segment. The main mission payload will need to be modified to some extent to accommodate the polar versus geosynchronous orbit, but the program considers these changes low risk because they are not expected to involve development or maturation of new technologies.

The May 2023 system preliminary design review focused on the space segment and indicated that the Polar space vehicle was sufficiently mature to proceed. The review identified no high-risk areas. The system preliminary integration review held in August 2023 included key technical areas such as requirements traceability, mission-unique hardware, and mission-unique software for mission and command and control. The program does not intend to test a system-level integrated prototype because the heritage program has been tested at the system-level and flown successfully.

Leading Product Development Practices

The Next Gen OPIR Polar program reported that it was not using an iterative development approach. We previously found that leading companies use iterative processes to design, validate, and deliver products with speed. The program stated that for a satellite system, an MVP is not suitable to be fielded to an operational environment. However, we found that leading companies use modern tools such as digital twins—virtual representations of physical objects—to simulate potential operating scenarios. This builds confidence that the products they designed will work once produced. The program stated that additional modeling and digital twins would add unnecessary cost to the program, as the program's foundation is built on successfully flown heritage technology and engineering design units.

Software and Cybersecurity

The program reported that it is using a software development approach that includes the use of integrated product teams and continuous integration and delivery. According to program officials, their approach was similar to waterfall—a linear, sequential approach to development—prior to the preliminary design review in 2023. They stated that the program pivoted to an Agile approach specifically for its software coding effort afterwards. The program plans to involve end users to evaluate and provide feedback on the software in late 2024.

Cybersecurity is addressed in one or more of the program's key performance parameters. The program expects to have a signed cybersecurity strategy by the end of the second quarter of fiscal year 2024. The program has undergone two cyber exercises since 2021—including a major subsystem assessment—and neither identified repeated vulnerabilities. The program expects to conduct at least two more tests through 2025, followed by a full system assessment in 2027.

Other Program Issues

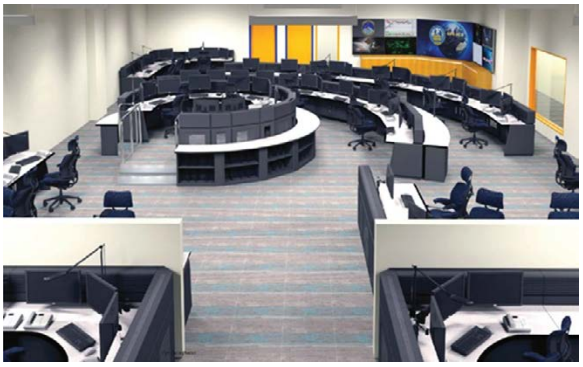
Next Gen OPIR Polar is dependent on satellite command and control functions from a related MTA ground system called FORGE, which we assess separately in this report. The Next Gen OPIR Polar program is tracking several risks associated with FORGE, including, primarily, FORGE readiness for Next Gen OPIR Polar system-level testing in fiscal year 2026. Numerous development, integration, and testing steps are needed before the FORGE command and control functions will achieve readiness for system-level testing. If FORGE command and control functions are still immature by the end of fiscal year 2026, the first polar satellite launch is likely to be delayed and program costs are likely to increase.

In addition to issues related to FORGE, the program is tracking risks associated with the integration of the main mission payload onto the space vehicle. Although the space vehicle is a proven design, modifications will be made to the vehicle to accommodate the new payload. These modifications present unique integration issues that could add to program costs and schedule if design issues are discovered.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program provided technical comments, which we incorporated where appropriate. The program office stated that it is committed to delivering two resilient Polar missile warning satellites that contribute to battlespace awareness, technical intelligence, and missile defense mission areas. It further stated that it is identifying and mitigating risks, while addressing and solving defects during design, production, and integration. It added that it continues to be resolute in overcoming challenges to remain on-track for the first space vehicle delivery in 2028. The program stated that it anticipates successful completion of its critical design review campaign in August 2024, at which point it plans to enter the assembly, integration and test phase.

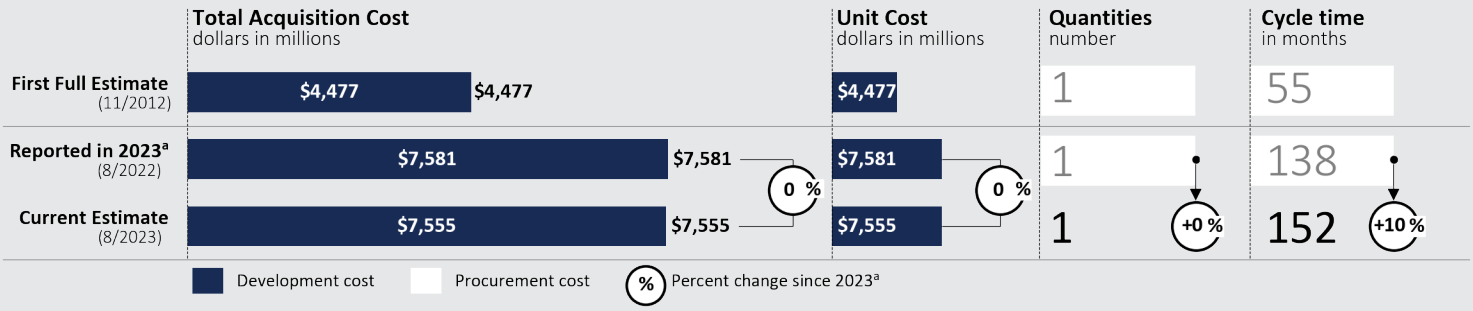
Next Generation Operational Control System (OCX)



Source: U.S. Air Force. | GAO-24-106831

The Space Force's OCX program is developing a new software-centric system to replace the existing GPS ground control system. The Space Force intends for OCX to ensure reliable, secure delivery of position, navigation, and timing information. The Space Force is developing OCX in a series of blocks. The first, called Block 0, is for launch and limited testing of GPS III satellites and was delivered in 2017. The second, called Blocks 1 and 2, includes satellite control, among other functions. OCX Block 3F is a separate follow-on program for the GPS IIIF satellites. We assessed Blocks 1 and 2.

Program Performance fiscal year 2024 dollars in millions



Total quantities comprise one development quantity and zero procurement quantities.
[a]GAO-23-106059.

Software Development as of January 2024

Approach: DevSecOps and Waterfall

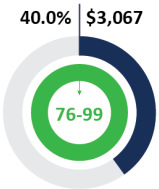
Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



Program Essentials

Prime contractor: Raytheon

Contract type: CPIF/CPAF (development)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	●	●
Demonstrate all critical technologies in a realistic environment	○	●
Complete a system-level preliminary design review	●	●
Product design is stable	Design Review	
Release at least 90 percent of design drawings	NA	NA
Test a system-level integrated prototype	NA	NA
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

We did not assess OCX design stability or manufacturing maturity because OCX is primarily a software program and therefore does not track the metrics we use to assess this knowledge.

OCX Program

Technology Maturity and Design Stability

The OCX program continues to report its five critical technologies as mature, consistent with our last assessment. As OCX is primarily a software development effort, the program does not track the metrics we use to measure design stability, such as the number of releasable design drawings.

The program is continuing to experience development delays due, in part, to ongoing challenges in meeting performance requirements during testing. For example, though the program completed an initial qualification test run in December 2023, the retests to demonstrate that it is meeting performance requirements are planned through April 2024—13 months later than the program office estimate we reported last year.

The program's next major milestone is to complete site acceptance testing. According to program documentation, this testing is planned to occur prior to the delivery of OCX Blocks 1 and 2, which the program estimates will take place in September 2024—about 9 months later than we reported last year. During site acceptance testing, the program will validate system functionality at a deployed site. According to program officials, they are completing steps to support this testing. For example, the Space Force approved the program's authority to operate for testing OCX Blocks 1 and 2 in June 2023, and OCX successfully established connections with 13 of 14 external systems, such as those of the United States Naval Observatory and a mission planning system.

Another step before delivery is for the contractors to complete the technical orders for operator training support—an effort the program identified as a potential schedule risk. Delivery of these materials from the contractor has been delayed, in part because the contractor is waiting for information from qualification testing. According to the program, it completed the first round of operator training in February 2024.

Software and Cybersecurity

Resolving the remaining deficiencies continues to be a risk to the program. According to program officials, as of October 2023, OCX had 379 critical deficiencies affecting 234 contractual requirements. These deficiencies ranged from issues related to uploading navigation data to the satellites, to not receiving alerts when there are anomalies.

According to the Defense Contracting Management Agency, these critical software deficiencies are part of a much larger list of thousands of deficiencies of various levels of importance submitted by the contractor over the last couple years. The program created a working group to prioritize and address them. However, in September 2023, the Defense Contracting Management Agency still expected over 1,900 major deficiencies to be open when OCX Blocks 1 and 2 are delivered.

The program noted that hiring and maintaining qualified software staff continues to be a challenge for the contractor. According to DOD testing officials, the contractor adopted "swarm teams" to focus on OCX software deficiencies identified during qualification testing. However, this effort diverted staff from the OCX Block 3F program, exacerbating schedule risk for efforts necessary to launch and control the GPS IIIF satellites.

The program plans to conduct a series of cybersecurity tests, including penetration testing and adversarial assessment, by November 2024.

Other Program Issues

In October 2022, the program declared a breach in its schedule baseline for initial operating capability. The delay initiated a review by the Joint Requirements Oversight Council, which in August 2023 validated a new objective date. The new date of July 2024 reflected a 27-month delay from the baseline set in 2018, when the schedule was reset due to previous delays. However, the program has since reported an additional 12-month delay for the initial operating capability, now estimated to occur in July 2025. These delays also increase the schedule risk of Block 3F, which is reliant on OCX Blocks 1 and 2 as a stable baseline.

To provide continued support for the program after delivery to operations, as well as address some remaining deficiencies, the program plans to award a modification to the development contract by June 2024. This is 3 months before the estimated delivery of Blocks 1 and 2 in September 2024.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

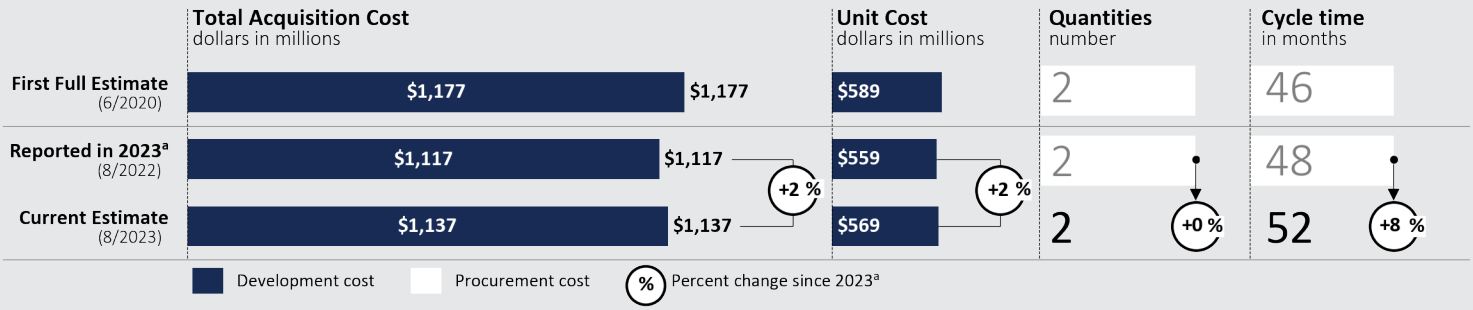
The program office stated that as the OCX program continues, it is focused on ensuring quality as the contractor completes qualification retests. It noted that the program has accordingly concentrated its resources toward addressing the most difficult deficiencies in the navigation subsystem. The program stated that it plans to complete site acceptance test dry runs to address deficiencies early and assess full system performance. Lastly, the program added that it expects to ship an alternate master control station to Vandenberg Space Force Base for final OCX deployment by the end of March 2024.

Source: © 2020 by Ball Aerospace & Technologies Corp. All rights reserved. | GAO-24-106831

Weather System Follow-On (WSF)

The Space Force's two polar-orbiting WSF satellites are intended to contribute to a family of space-based environmental monitoring systems by providing three of 11 mission critical capabilities in support of military operations. WSF aims to conduct remote sensing of weather conditions, such as wind speed and direction at the ocean's surface, and to provide real-time data for use in weapon system planning and weather forecasting models. The family of space-based environmental monitoring systems replaces the Defense Meteorological Satellite Program.

Program Performance fiscal year 2024 dollars in millions



Total quantities comprise two development quantities and zero procurement quantities.
[a]GAO-23-106059.

Software Development as of January 2024

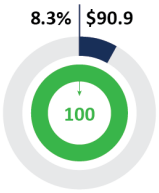
Approach: Agile, Waterfall, and Incremental

Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)



Percentage of progress to meet current requirements

The program reported that software development was completed in April 2021. According to the program, software costs were revised this year to include two additional software development efforts.

Program Essentials

Prime contractor: Ball Aerospace and Technologies Corporation

Contract type: FFP (development)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	●	●
Demonstrate all critical technologies in a realistic environment	NA	NA
Complete a system-level preliminary design review	●	●
Product design is stable	Design Review	
Release at least 90 percent of design drawings	NA	NA
Test a system-level integrated prototype	NA	NA
Manufacturing processes are mature	Production Start	
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

We did not assess whether WSF demonstrated critical technologies in a realistic environment because satellite technologies demonstrated in a relevant environment are assessed as fully mature. We also did not assess design stability because the program told us the metrics were not applicable, and we did not assess manufacturing metrics because the program does not have a production milestone.

WSF Program

Technology Maturity and Design Stability

WSF's critical technologies are mature, and the program considers the design complete for both the first and second satellite. Since our last assessment, the program completed all environmental testing for the first satellite.

Over the past year, the program continued to address a risk to WSF's launch segment. According to the program, WSF was originally intended to fly as a standalone satellite launched on SpaceX's Falcon 9R. However, per the program, Space Systems Command directed SpaceX to add Blaze—a mount for other satellites—to the launch vehicle to make use of excess capacity. Early launch integration analysis predicted that Blaze amplified the vibration transmitted to the WSF satellite, significantly exceeding the current load design limits of some WSF subsystems.

Follow-on analysis in June 2023 found that design loads were significantly exceeded even when WSF is a standalone satellite on the Falcon 9R. The program reported that Space Systems Command then directed SpaceX to conduct its trajectory and verification analyses with WSF as a solo mission. The analysis was delivered to Ball Aerospace in November 2023, according to the program office. Ball Aerospace worked directly with suppliers to understand the load margins of critical components and determine whether there is room to reduce loads, program officials told us.

Ball Aerospace completed its assessment of the verification loads cycle in January 2024 and determined that the satellite no longer exceeded design loads, according to the program office. The program completed the last mission test in January 2024 after addressing the design load issue, a delay of 6 months since our last assessment.

The WSF satellite was shipped to Vandenberg Space Force Base in January 2024 to meet the planned March 2024 launch, according to the program office. If the launch date slips past March 2024, the program will have to compress post-launch testing—such as additional calibration and validation testing—and the resolution of any resulting issues before its planned September 2024 initial operational capability. Alternatively, the program may need to delay initial operational capability, which would result in a schedule breach. The program already delayed initial operational capability by 4 months since our last assessment due to this design launch issue.

In October 2023, the program completed a critical design review for the second satellite, which uses the first satellite design with minimal changes to ground software. According to program officials, they are implementing lessons learned for the manufacturing process and component-level improvements from the first satellite and plan to finalize the launch vehicle for the second satellite at least 2 years before launch, currently planned for July 2027.

Cybersecurity

Since our last assessment, the program completed all planned developmental cybersecurity testing for the first satellite. Previous cybersecurity tests found issues with WSF's mission data processing software, but these issues were identified as common and not obstacles to proceeding, program officials told us. The program has two cybersecurity tests remaining for the first satellite. The program will conduct both tests after launch, according to the program office.

Other Program Issues

Per the program, Space Operations Command determined that the Naval Research Laboratory Blossom Point Tracking Facility—the ground-based satellite operations center for WSF—requires a backup command and control capability for WSF. The Blossom Point Tracking Facility was not originally designed to have a physical backup facility for continuity of operations, according to the program office. The program identified a concept for a cloud-based command and control capability, but the Space Force has yet to make a final decision on acquiring the capability. WSF is planning to proceed without backup capability at launch, program officials told us. However, according to the program office, the program is developing a plan with Space Operations Command for initial operational capability that includes a lien for the backup command and control capability.

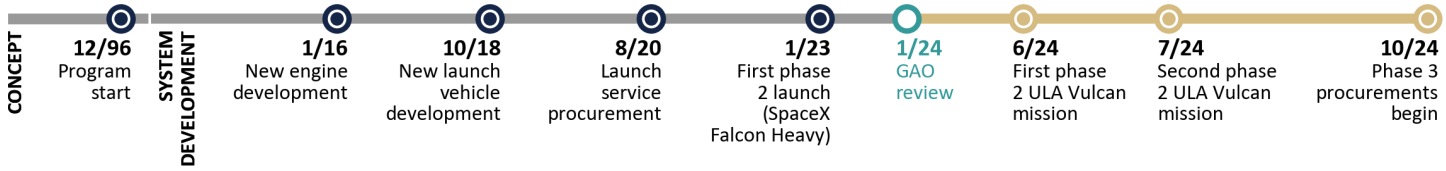
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

National Security Space Launch (NSSL)

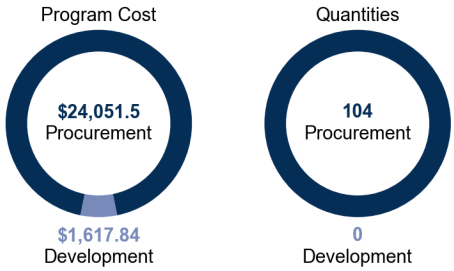
The Space Force's NSSL program provides space lift support for national security and other government missions. NSSL procures launch services from United Launch Alliance (ULA) and Space Exploration Technologies Corporation (SpaceX). These procurements are intended to ensure the U.S. has the capabilities necessary to insert national security payloads into space. We focused our review on NSSL's investment in new launch systems from U.S. providers.

Source: United Launch Alliance and SpaceX. | GAO-24-106831



Estimated Cost and Quantities

(fiscal year 2024 dollars in millions)



The program provided updated cost figures that represent funding associated with the Phase 2 and 3 contracts instead of total program costs previously reported. Cost and quantity represent fiscal years 2020-2030.

Software Development as of January 2024

Approach: Information not available

Frequency of end user evaluation (months)

Information not available

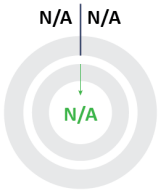
Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)

Software percentage of total acquisition cost
(fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that it only procures the launch service and does not take any ownership of hardware or software.

Program Essentials

Prime contractors: United Launch Alliance; Space Exploration Technologies Corporation

Contract type: Other Transaction (engines and launch vehicle prototypes); FFP (launch services)

Current Status

NSSL procured 48 national security missions to launch through fiscal year 2028 as part of Phase 2. The number of launches increased from the original plan for an estimated 34 missions due to added Space Development Agency missions and other emergent missions. NSSL launched the first Phase 2 mission in January 2023 using SpaceX's Falcon Heavy rocket. The distribution of Phase 2 launches is approximately 60 percent ULA and 40 percent SpaceX.

ULA continues to encounter delays in developing its new Vulcan launch system to meet Phase 2 needs. The Vulcan's upper stage Centaur V structural qualification test article experienced a significant anomaly in March 2023. Officials said that ULA identified corrective actions and is implementing them. This anomaly delayed the first Vulcan certification test flight to January 2024, more than 2 years after originally planned. The second certification test flight is scheduled for April 2024. ULA and NSSL program certification requires two successful test flights. The first Phase 2 Vulcan mission is scheduled for summer 2024. If Vulcan experiences a serious failure, officials said that the Phase 2 contract allows contingencies to reassign missions to SpaceX.

The milestone decision authority approved the program's acquisition strategy for Phase 3 launch services in September 2023, according to program officials. The program made changes based on responses to two requests for proposals, with responses to a final request received in December 2023. According to program documentation, Phase 3 expects to use a "dual lane" approach with two contract types to allow for new providers and to reduce risk to DOD missions. In Lane 1, unlimited providers would compete for approximately 30 less-demanding launches to encourage competition and new launch providers. In Lane 2, approximately 49 launches would be awarded to three providers able to meet the most demanding requirements, according to program officials.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program provided technical comments, which we incorporated where appropriate. The program office stated that NSSL continues to provide resilient and responsive launch services that secure the nation's access to space. It noted that competition and Falcon reuse has reduced launch costs and increased tempo. It further stated that transition to a domestic engine for the Vulcan launch will provide the nation with additional launch systems to meet the demands placed on the program.

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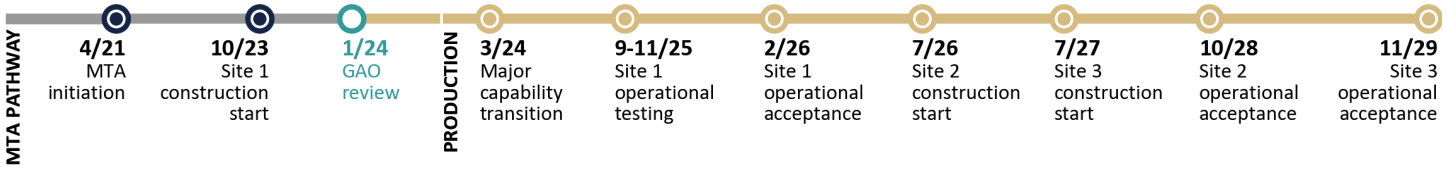
Common Name: DARC

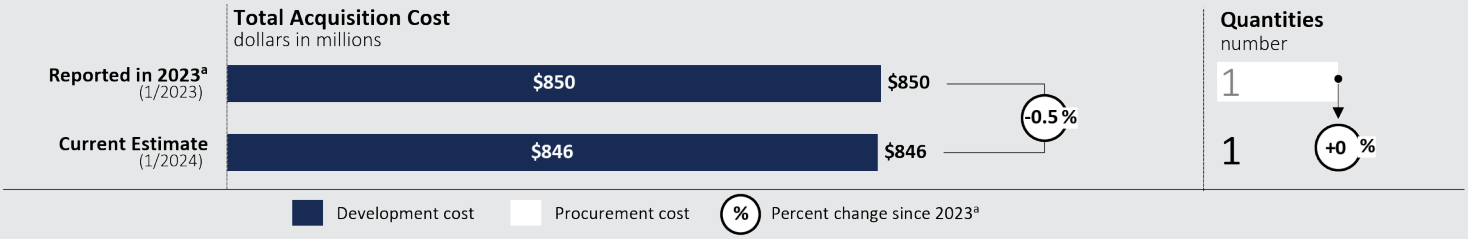
Deep Space Advanced Radar Capability (DARC)

Source: L3 Harris Datron. | GAO-24-106831

The Space Force's DARC program seeks to develop three ground-based radar sites that will track objects in the geosynchronous satellite belt. DARC plans to leverage defense science and technology efforts to mature radar concepts and technologies that can demonstrate increased sensitivity, capacity, search rates, and scalability to detect and track objects in deep space orbit. DARC's first site is being developed through an MTA rapid prototyping effort.



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2024 dollars in millions



Cost and quantity reflect only the DARC rapid prototyping effort for site 1 and do not include construction delay costs.
[a]GAO-23-106059.

Program Background and Transition Plan

The Air Force initiated the DARC MTA effort in 2021 to develop an initial site (site 1) and a command and control center. The Johns Hopkins University Applied Physics Laboratory completed a technology demonstration the same year, which the Space Force reported successfully tested the radar's technology. Previously, sites 2 and 3 were to be developed as MTA rapid fielding efforts. The DARC program office now plans to restructure the three sites into one program and transition to the major capability acquisition pathway at production start in March 2024.

Software Development as of January 2024

Approach: Agile and DevSecOps

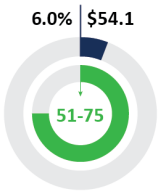
Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that the user interface and the user experience is evaluated every 2 weeks.

Program Essentials

Prime Contractor: Northrop Grumman Systems Corporation

Contract type: CPIF (using other transaction authority)

Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case	Status at Initiation	Current Status
Approved requirements document	●	●
Approved middle tier of acquisition strategy	●	●
Formal technology risk assessment	○	○
Cost estimate based on independent assessment	○	●
Formal schedule risk assessment	○	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

DARC Program

Updates to Program Performance and Business Case

In September 2023, DOD signed a memorandum of understanding with Australia and the United Kingdom to establish one site in each of the three participating countries. The agreement states that each international partner should contribute approximately $1 billion in financial costs and non-financial contributions toward full project costs. The memorandum was signed 6 months later than the Space Force expected in our last assessment, which delayed construction start for site 1 until October 2023. According to the program, this delay resulted in a $25.5 million cost increase, which was needed to maintain the construction workforce. Since our last assessment, the Space Force delayed site 1 operational acceptance by an additional 5 months, from September 2025 to February 2026.

In August 2023, the Assistant Secretary of the Air Force for Space Acquisition and Integration directed the DARC program office to restructure its three planned sites into one program. The DARC program office plans to complete this restructuring and enter production in March 2024. According to DARC program officials, the restructuring is expected to increase staffing efficiencies and reduce timelines for Office of the Secretary of Defense reviews of program data.

For sites 2 and 3, program officials stated that they plan to award contracts in April 2024 and June 2025 and start construction in July 2026 and July 2027, respectively. The Space Force now anticipates operationally accepting site 2 in October 2028—a 3-month delay since our last assessment—followed by site 3 acceptance in November 2029.

According to the DARC program office, it plans to demonstrate full maturity of DARC's four critical technologies in February 2026 as a part of testing for operational acceptance of site 1. The program reported that three critical technologies are approaching maturity. However, the fourth—radar software—is immature. The program reported that this technology is at a technology readiness level that is relatively primitive in efficiency and robustness compared with the eventual system. The program office stated that the Space Force has completed, but not yet fully approved, a formal technology risk assessment. According to the program office, it expects final approval of the assessment by the March 2024 transition date.

Leading Product Development Practices

The program reported using an iterative approach for development, and cited practices that we found leading companies employ to successfully develop and deliver products to users with speed. As described in our last assessment, the program coordinated with end users for feedback through regular briefings and working groups, and plans to off-ramp requirements, as needed, to meet its planned schedule. However, the program office did not substantiate that any off-ramped requirements would correspondingly decrease program costs—or whether the government would simply pay the same amount for less capability under any such scenario.

The program also reported using a digital thread to collect data from design simulations and systems-integrated testing, and is supporting modularity through use of an open system architecture for its software. We previously found that leading companies use knowledge in the digital thread to inform decision-making throughout the product life cycle and use modularity—designing systems so components can be added, removed, or replaced—to update and improve products after delivery.

Software and Cybersecurity

The program office reported that software development poses medium risk to program execution—a decrease from the high risk we reported in our last assessment. According to the program office, it has mitigated many of the software development risks since last year when DARC software development was at its inception with many unknown variables. The program also reported that it scheduled two software demonstrations for fiscal year 2024 and secured government purpose data rights to DARC software.

The program plans to conduct key developmental cybersecurity assessments in October 2024, followed by key operational cybersecurity assessments in September 2025 and January 2026.

Other Program Issues

The program reported that system interoperability with a space situational awareness data repository and a missile defense system program has been identified as a high risk. These other programs are responsible for primary software integration with DARC. The program is working with the other program offices to ensure the communications infrastructure will interface properly with DARC.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

The program office stated that the September 2023 signing of an $8 billion, 22-year trilateral memorandum of understanding with Australia and the United Kingdom allows the United States to partner with allies on a key space domain awareness asset. It also stated that it has high confidence that site 1 development to date positions the government to award the site 2 contract and start design and development work to achieve site 2 operational acceptance as quickly as possible.

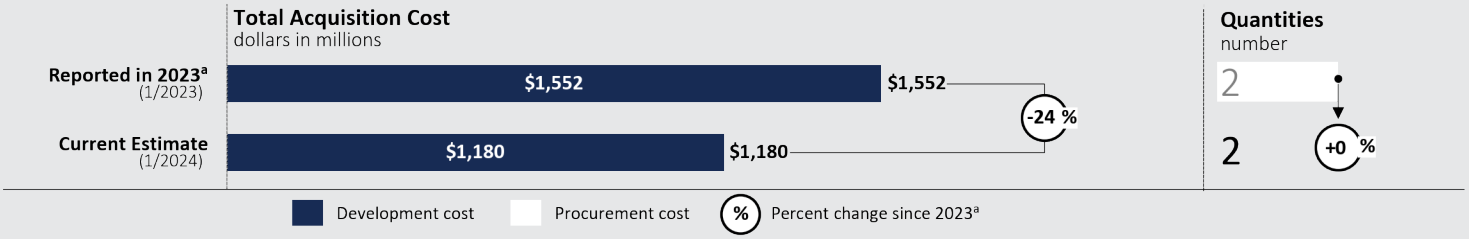
Evolved Strategic SATCOM (ESS)

The Space Force's ESS program is using the MTA pathway to prototype space-based capabilities, which are expected to provide worldwide DOD users with strategic and secure communications to support DOD's nuclear command, control, and communications mission.

Source: U.S. Space Force. | GAO-24-106831

- **8/19** MTA initiation
- **9/20** MTA funds obligated
- **9-11/20** Contract award
- **10/21** Program review
- **1/24** GAO review
- **9/25** 5 years since MTA funds obligated

Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2024 dollars in millions



According to the program office, the cost decrease this year is due to a 9-month schedule acceleration to transition the program to the major capability acquisition pathway. Transition is anticipated to occur with the award of the space segment production contract in December 2024.
[a]GAO-23-106059.

Program Background

The Air Force initiated ESS as an MTA rapid prototyping effort in August 2019. In 2020, the program awarded contracts to three contractors, each to develop a virtual advanced satellite communications payload prototype and other capabilities. By the end of the 5-year MTA effort, the program expects to test and demonstrate preliminary design payload capabilities for each contractor's virtual payload design. ESS expects to transition to the major capability acquisition pathway before payload development.

Software Development as of January 2024

Approach: Agile and DevSecOps

Frequency of end user evaluation (months)

Information not available

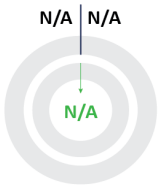
Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program determined that the frequency of end user evaluation, frequency of testing and feedback, and the percentage of progress to meet current requirements were not suitable for public release. The program reported that software costs are unknown at this time.

Program Essentials

Prime Contractor: The program determined that this information was not suitable for public release.

Contract type: FFP (development)

Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case	Status at Initiation	Current Status
Approved requirements document	○	●
Approved middle tier of acquisition strategy	●	●
Formal technology risk assessment	○	●
Cost estimate based on independent assessment	○	●
Formal schedule risk assessment	○	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

ESS Program

Updates to Program Performance and Business Case

In June 2023, the Air Force approved the ESS program's transition to the major capability acquisition pathway before development start while continuing rapid prototyping. The Air Force also authorized the program to proceed with the ESS space segment production contract. This combined decision is an option for certain acquisition programs, such as space programs, that will not produce prototypes solely for testing because of the high cost of each satellite.

The program plans to transition to the major capability acquisition pathway with the award of the space segment production contract.

In January 2024, a U.S. Space Force official stated that contractors successfully completed the preliminary design review in December 2023. The program intends to continue development efforts following the review for the remainder of the MTA effort and work toward a critical design review following the award of the production contract.

Software and Cybersecurity

Program officials stated that most cybersecurity assessments will be deferred to the follow-on contract. However, our prior work has shown that early and regular discovery of mission-impacting system vulnerabilities makes them easier to fix and reduces schedule risks.

Other Program Issues

The program continues to track the progress of its four immature critical technologies. Program officials stated that one critical technology is approaching maturity, while the remaining three have different maturation levels. Our past work found that, until all critical technologies are mature, programs risk costly and time-intensive redesign work if problems are found later in testing. Officials noted that the contractors will continue to mature the critical technologies after the preliminary design review in December 2023.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program deemed substantial amounts of information in the draft assessment to be sensitive, which must be protected from public disclosure. Therefore, this assessment omits the sensitive information and is limited.

The program office stated that the MTA effort laid the foundation for the planned transition to a major capability acquisition by significantly reducing risk, maturing technology, and demonstrating critical technologies, such as testing space system components in relevant environments. The program office also stated that it incorporated extensive cybersecurity requirements to address current and future threats with additional planned cybersecurity assessments.

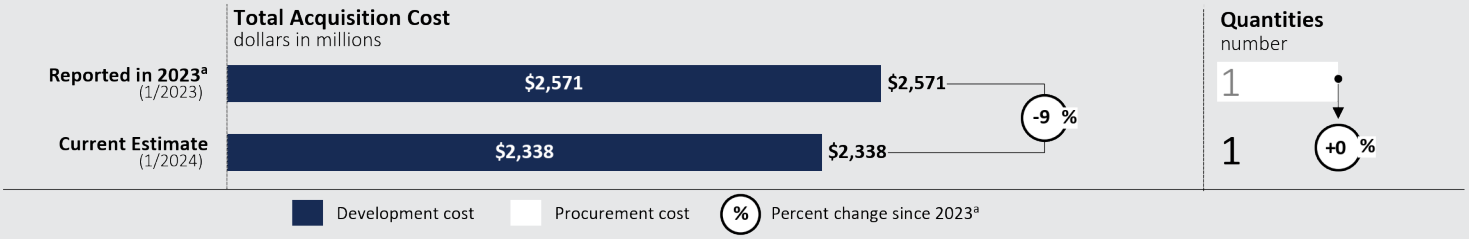
According to the program office, the space segment includes the delivery of digital models of the ESS system throughout the prototyping and development phases, enabling future digital twin development and integration.

Future Operationally Resilient Ground Evolution (FORGE)

Source: U.S. Space Force. | GAO-24-106831

The Space Force's FORGE is using the MTA rapid prototyping pathway to develop a follow-on capability to the Space Based Infrared System (SBIRS) ground processing system. FORGE is designed to process data from SBIRS and Next Generation Overhead Persistent Infrared (Next Gen OPIR) missile warning satellites and is developing capabilities in three areas: satellite command and control, mission data processing, and communication relay stations. The program is also developing an interim command and control solution called Next Gen Interim Operations (NIO). The Next Gen OPIR efforts are assessed separately in this report.

Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2024 dollars in millions



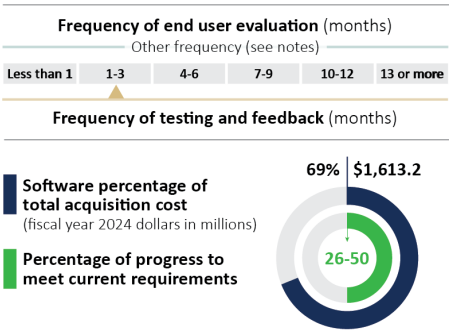
[a]GAO-23-106059.

Program Background and Transition Plan

The Air Force initiated FORGE as a rapid prototyping effort in December 2019. FORGE is intended to support legacy satellites and provide enhanced ground processing capabilities for Next Gen OPIR satellites. The program's interim solution, NIO, is intended to modify the current SBIRS ground processing system to provide satellite command and control capabilities for the earliest planned Next Gen OPIR satellites, the first of which is scheduled to launch in 2025. The program office expects to transition remaining development efforts to the software acquisition pathway at the end of the MTA effort.

Software Development as of January 2024

Approach: Agile and DevSecOps



The program reported that the timing of end user engagement varies depending on stakeholder needs. According to the program, revised software costs reflect increased program maturity and an improved understanding of contracts.

Program Essentials

Prime Contractor: Raytheon; SciTec; Lockheed Martin; Northrop Grumman

Contract type: Cost reimbursement with various fee structures (using other transaction authority)

Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case	Status at Initiation	Current Status
Approved requirements document	●	●
Approved middle tier of acquisition strategy	○	●
Formal technology risk assessment	○	●
Cost estimate based on independent assessment	●	●
Formal schedule risk assessment	●	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

FORGE Program

Updates to Program Performance and Business Case

In September 2023, the Air Force approved an updated FORGE acquisition strategy that outlines plans for delivering satellite command and control capabilities. As we previously reported, the program planned to use command and control capabilities from the Air Force's Enterprise Ground Services (EGS)—a separate acquisition effort—but determined in 2022 that EGS would not fully support FORGE. Program officials stated that they awarded contracts to four vendors in September 2023 as part of a prototyping competition for a new command and control system. The program plans to select one of these vendors in late 2024 to continue development. The prototype must be complete before the planned launch of the first Next Gen OPIR Polar satellite in late 2028. After the prototype is complete, the program plans to award a follow-on development contract for additional work to support command and control capabilities for SBIRS and the Next Gen OPIR Geosynchronous Earth Orbit (GEO) systems.

The FORGE program continues to execute an interim command and control capability, NIO, to support the Next Gen OPIR GEO satellites—the first of which is expected to launch in 2025. As we previously reported, NIO began as a risk reduction effort but, in August 2022, the Air Force Acquisition Executive for Space designated it the baseline ground system for launch and initial operations of the earliest Next Gen OPIR space vehicles. With the new acquisition strategy, NIO will be the only system available to command and control the space vehicles for several years. According to the program office, when the FORGE command and control capability is mature, it will replace NIO's support of Next Gen OPIR GEO space vehicles. The office also noted that Next Gen OPIR Polar vehicles will only be supported by FORGE command and control. An independent schedule risk assessment from April 2023 noted the potential for delays but did not identify NIO as a primary driver for delays to the 2025 launch.

A FORGE program official indicated that the first operational acceptance test demonstration is planned for February 2024, when the FORGE framework will begin hosting the software application used to convey SBIRS data to users for battlespace awareness and technical intelligence. Program officials stated that this is an important step to operationally demonstrate the FORGE framework. Program officials noted that this milestone was delayed from an initial estimate of June 2023 due to challenges preparing the baseline software for migration to FORGE and other integration issues.

Leading Product Development Practices

The program reported that it is implementing an iterative approach for development, including refining a minimum set of capabilities to be included in a minimum viable product base and using modularity throughout requirements and design. The program office stated that early versions of FORGE have been delivered to its Tools, Applications and Processing Laboratory, which is a collaborative research environment that enables application testing on current and legacy satellite systems. The agency developed this testing environment to collaborate in the development of advanced capabilities and incorporate user feedback. We previously found that leading companies collect feedback on delivered products to identify improvements for subsequent iterations and increase the product's value for users.

Software and Cybersecurity

Program officials reported that contractors have been providing major software deliveries three times per year utilizing Agile and DevSecOps principles. The program plans for future software development to follow a similar delivery cadence. The program reported that user group engagement meetings are held quarterly, allowing for end user evaluation and feedback during the development of FORGE. To assess cybersecurity, a system survivability and operational resilience test is planned for September 2024, according to program officials.

Other Program Issues

The Air Force fiscal year 2024 budget request includes the initial funding for a survivable and endurable iteration of FORGE, called Endurable FORGE, for missile warning reporting across all phases of military operations. Program officials stated that initial work on Endurable FORGE is on hold pending the results of a Space Warfighting Analysis Center study expected in the first quarter of fiscal year 2025.

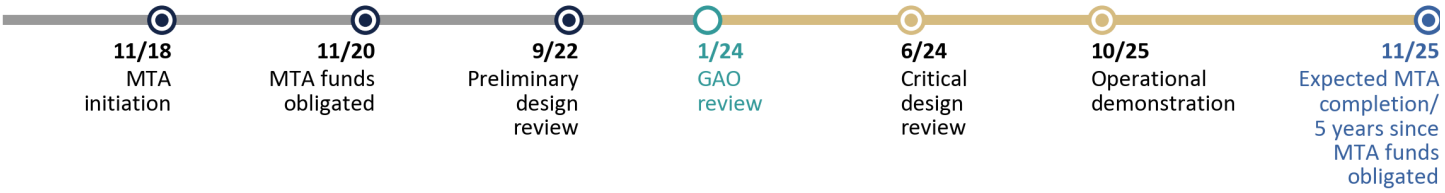
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

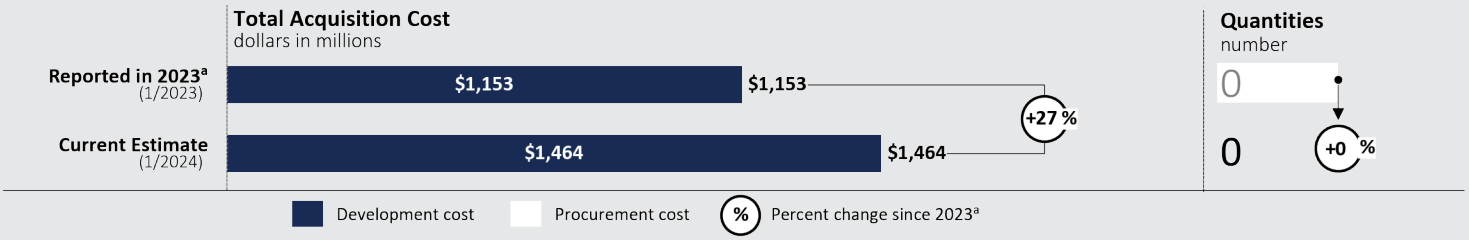
Military GPS User Equipment (MGUE) Increment 2

The Space Force's MGUE programs are developing GPS receivers compatible with the military code (M-code) signal. MGUE Increment 2 is an MTA rapid prototyping effort intended to mature a miniature serial interface (MSI) card for use in receiving GPS signals with handheld devices and munitions. Another MTA effort is developing the handheld device for use across the military departments. We assessed the current effort to mature the MSI receiver cards.

Source: U.S. Air Force. | GAO-24-106831



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2024 dollars in millions



The program reported a quantity of zero because it is maturing an MSI card that will be used for capabilities developed during another MTA effort.
[a]GAO-23-106059.

Program Background and Transition Plan

The Air Force first obligated funds for MGUE Increment 2 in November 2020, awarding contracts to three vendors to develop the next-generation, application-specific integrated circuit (ASIC) and MSI. The next-generation ASIC is a key component of the MSI on which the vendors will encode M-code receiver functions. As of January 2024, program officials stated that one of the three vendors completed its critical design reviews for the ASIC and MSI concepts. The program plans to transition production-ready receiver card capability for the military departments to procure through separate efforts in the first quarter of fiscal year 2026.

Software Development as of January 2024

Approach: Agile, Waterfall, Incremental, DevOps, DevSecOps, and Spiral

Frequency of end user evaluation (months)

Information not available

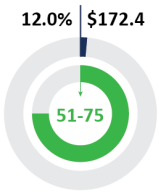
Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that, because the software does not have a direct user interface, end users do not evaluate and provide feedback. According to the program, delivery of software for testing has yet to occur.

Program Essentials

Prime Contractors: BAE; Interstate Electronics

Contract type: CPIF/CPAF; CPFF; FFP

Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case	Status at Initiation	Current Status
Approved requirements document	●	●
Approved middle tier of acquisition strategy	●	●
Formal technology risk assessment	○	○
Cost estimate based on independent assessment	○	●
Formal schedule risk assessment	○	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

MGUE Increment 2 Program

Updates to Program Performance and Business Case

MGUE Increment 2 requirements and contract deliverables continue to evolve, contributing to cost and schedule uncertainty. Program officials stated that each of the three vendors continue to have challenges related to cost, schedule, or technical performance, consistent with our assessments over the last 2 years, in which we identified vendor challenges meeting power and thermal requirements.

To address some of these challenges, program officials stated that the Joint Requirements Oversight Council approved a reduction in requirements in August 2023. Program officials stated that two vendors' contract requirements would be similarly reduced. Program officials reported having discussions with the vendors about concessions the vendors can offer due to the decreased requirements. For the third vendor, program officials stated that the vendor's performance had not met program needs. The program office reported that this vendor completed its period of performance in November 2023 following a bilaterally negotiated contract modification.

The program office continues to track schedule as a risk. Most recently, the program experienced a delay in completing its overall critical design review, which was planned for late fiscal year 2023. As of January 2024, program officials stated that one vendor completed critical design reviews for the ASIC and MSI and they expect the other vendor to complete the reviews in June 2024. Critical design review is a key point at which the decision authority determines whether the program can meet its requirements within the planned 5-year schedule and whether changes are needed. Program officials are reassessing schedule estimates in coordination with Air Force leadership.

The program has experienced variation in its estimated costs year-to-year. Last year we reported a 14 percent reduction in cost, and this year there is a 27 percent cost increase. Program officials stated that the variation is due to budget constraints at the time of the fiscal year 2023 estimate, as well as poor performance and development challenges.

As we previously reported, the program had cost and schedule parameters defined at the start of the MTA effort. Even though cost grew since last year, program officials stated that they expect to stay within their cost parameter (i.e., no more than 10 percent above the military cost position, which is $1.499 billion). However, as previously mentioned, the program exceeded its schedule parameter (i.e., critical design review for all vendors by the end of fiscal year 2023).

Leading Product Development Practices

The program reported that it is not using an iterative development approach. Iterative development involves continuous cycles to refine requirements with users and develop a minimum viable product that can be followed by successive updates to that product. For example, rather than fixing detailed requirements before the start of design, we found that leading companies use technical data from fast, iterative design simulations to confirm that the team captured the right requirements and is on track to meet them. Program vendors have struggled to meet performance requirements initially established and after numerous delays, requirements for two vendors will be adjusted. By not implementing an iterative design approach, the program could continue to chase unachievable requirements at the expense of delivering meaningful capabilities to the warfighter more quickly.

Software and Cybersecurity

Program officials stated that vendors continue to experience challenges in hiring software development staff. Officials noted that the program's vendors are competing with other vendors for individuals with the necessary skills.

The program previously reported that it expects to complete a cybersecurity assessment during developmental testing and to test cybersecurity objectives during the operational demonstration. The program plans to conduct its assessment in March 2025.

Other Program Issues

The Defense Contract Management Agency, which provides contract management support, predicted that the program will continue to encounter cost and schedule challenges. As of November 2023, the agency estimated that the program will not complete its rapid prototyping effort within the 5-year MTA time frame established by DOD policy. It attributed the potential for further delays, in part, to vendor staffing levels, ongoing delays in ASIC development, and program office delays in providing information to support vendor testing.

Program Office Comments

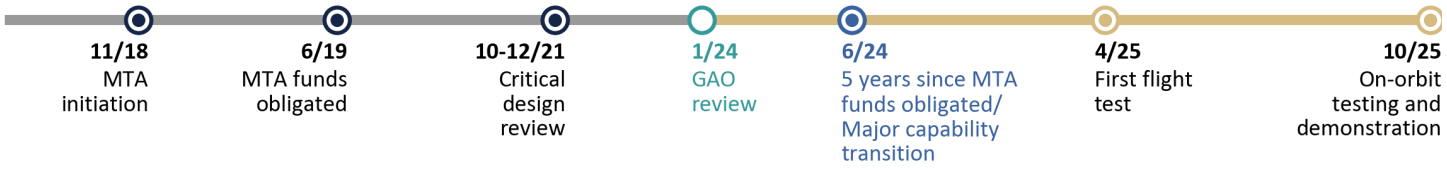
We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

According to the program office, it has made progress in 2023 toward delivering capability. It stated that it successfully completed the ASIC and MSI critical design reviews with one of its two contractors, ASIC critical design review with the other contractor, and is addressing various obstacles and uncertainties to mitigate schedule delays. The program stated that, despite reporting the poor performance and removal of one contractor, it still has two viable vendors.

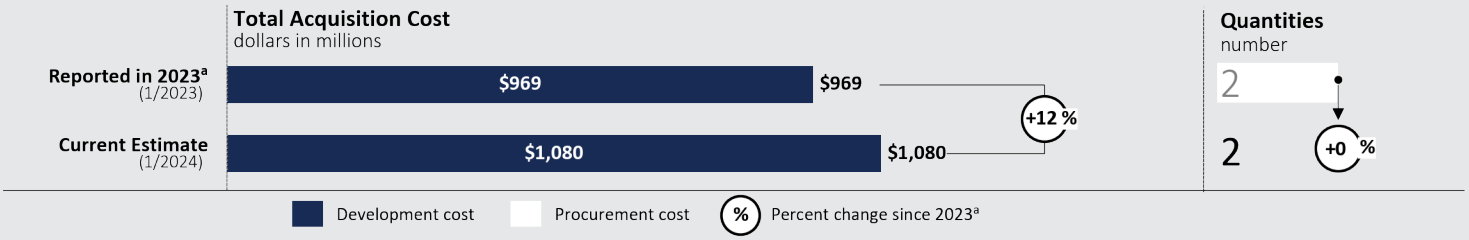
Protected Tactical SATCOM (PTS)

The Space Force's PTS, an MTA rapid prototyping effort, is a space-based system that will transmit a protected, antijamming waveform to users in contested environments. The PTS MTA effort is intended to prototype modular, scalable, hostable payloads. PTS is part of the Space Force's broader Protected Anti-Jam Tactical SATCOM (satellite communications) mission area.

Source: U.S. Air Force. | GAO-24-106831



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2024 dollars in millions



According to the program office, the cost increase this year is due to a program reporting error in last year's assessment. Specifically, the program stated that it updated the allocation of costs between the end of the MTA and the program's transition to the major capability acquisition pathway in fiscal year 2024.
[a]GAO-23-106059.

Program Background and Transition Plan

The Air Force initiated PTS using the MTA pathway in 2018. The program awarded three other transaction agreements in 2020 for different vendors to design payload prototypes. Following preliminary design reviews, the program reported selecting two contractors in 2021 to continue building payload prototypes. According to program officials, the program plans to transition to the major capability acquisition pathway with entry in technology development no later than June 2024.

Software Development as of January 2024

Approach: Agile and DevSecOps

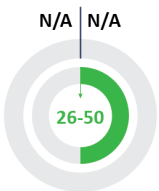
Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program reported that updated software cost and percentage of total acquisition cost data were not available for this year, as the contractor has yet to submit the related annual report.

Program Essentials

Prime Contractor: Boeing; Northrop Grumman

Contract type: FFP (development)

Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case	Status at Initiation	Current Status
Approved requirements document	○	●
Approved middle tier of acquisition strategy	○	●
Formal technology risk assessment	●	●
Cost estimate based on independent assessment	○	●
Formal schedule risk assessment	○	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

PTS Program

Updates to Program Performance and Business Case

Since our last assessment, PTS reported that its five critical technologies are mature. Officials stated that the two payload prototype contractors completed five more hardware and software demonstrations each, bringing the total to over 50.

Delays continue for security verification testing of the program's cryptographic unit, a critical technology. The program has yet to set a new date to complete testing, which will be at least 11 months later than we reported last year.

PTS completed its first schedule risk assessment in April 2023. The program office stated that the assessment did not result in changes to the schedule but is informing areas for risk mitigation. For example, program officials stated that they communicated delays in delivering production representative cryptographic units to the payload contractors and requested potential impacts. Despite these delays, PTS officials said the payload contractors continued development using government-provided engineering design models of the cryptographic unit. They also reported plans to complete the unit's certification in March 2024. Rapid prototyping is intended to develop fieldable prototypes that can be demonstrated in an operational environment and provide for residual operational capability within 5 years of program start. The PTS program, however, does not intend to demonstrate a prototype until after transitioning to the major capability acquisition pathway.

Leading Product Development Practices

The program office said it does not consider its development approach for the MTA effort to be iterative because prototype requirements are well-defined. However, aspects of the program incorporate some leading practices. For example, the program said user feedback collected during on-orbit testing of the prototypes—intended to provide fielded on-orbit operational capability—will be incorporated into the follow-on PTS-Resilient satellites that the program plans to develop on the major capability acquisition pathway. Still, the program reported that requirements for the follow-on satellite will already be set prior to prototype demonstrations. Implementing an iterative development structure could result in better program outcomes and efficiencies. Rather than fixing requirements before the start of design, leading companies use digital twins—virtual representations of a physical system—to test the performance of different designs and prioritize the most essential capabilities.

PTS officials said they provided static digital models to the prototype payload contractors to visualize the design and serve as the authoritative source for key interfaces, such as the ground mission planning element. The program office said it identified issues earlier in development because of digital modeling and realized the importance of maintaining version control. The program also identified challenges with providing the digital models, such as finding and fixing errors in the models and training stakeholders to use them.

Software and Cybersecurity

PTS continued to report difficulty in hiring and retaining sufficient software development program staff. Program officials stated that they rely on contractors to provide the expertise necessary to complete software development tasks.

In early 2023, PTS completed four cybersecurity tabletop exercises, which did not identify any repeated vulnerabilities, according to the program. Program officials added that cyber stakeholders are involved throughout the development process to review the system and provide feedback.

Other Program Issues

In the fall of 2023, the service acquisition executive approved PTS's major capability acquisition strategy and allowed the program to prepare for and conduct a competitive source selection between the two prototype vendors. The program reported that it plans to transition to the major capability acquisition pathway with entry in technology development no later than June 2024. The program plans to leverage knowledge gained from the rapid prototype effort to meet the full PTS requirements. The program plans to achieve initial operational capability in 2030.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program provided technical comments, which we incorporated where appropriate.

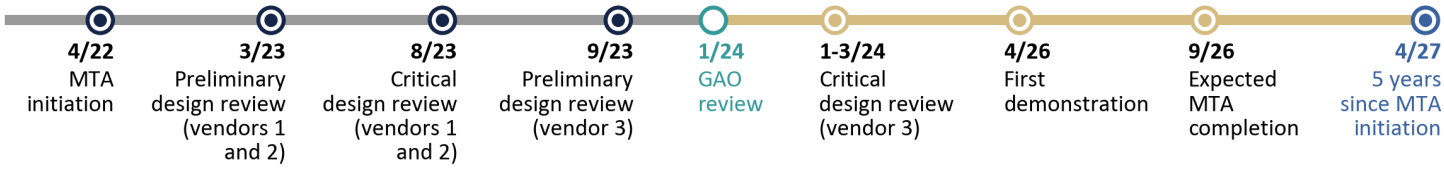
The program office stated that it made progress in the build and test phases of the program. It noted that the payload contractors completed 10 demonstrations, which it stated showcased payload capability, matured critical technology, and mitigated risks. The program office also stated that it completed and delivered equipment to the payload contractors for integration and test use. Further, it added that four cybersecurity exercises the program completed this year will be critical to achieving an interim authority to test and authority to operate the payloads.

According to the program office, the contractor made updates necessary to restart security verification testing of the cryptographic unit, which it stated will occur after the National Security Agency completes review of updated program documentation. The program office added that it is mitigating the cryptographic unit delays and still plans for payload delivery in fiscal year 2024. According to the program, PTS will ultimately provide a robust, antijam capability to warfighters in close proximity to adversaries.

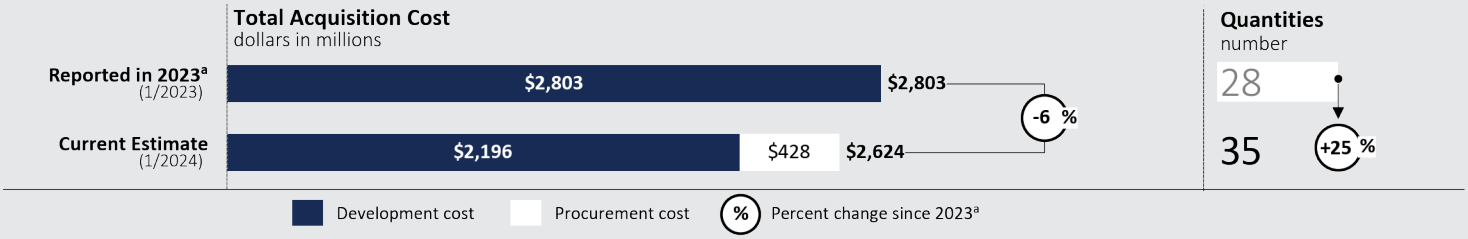
Source: Qinteq on contract to Space Development Agency. | GAO-24-106831

Tranche 1 Tracking Layer (T1 TRK)

T1 TRK is an MTA rapid prototyping effort by the Space Force's Space Development Agency (SDA). The Tracking Layer is one of several layers in SDA's planned Proliferated Warfighter Space Architecture, to include data communications and missile warning satellites. T1 TRK is the first tranche of low-Earth orbit space vehicles (SV) equipped with infrared sensors to provide initial missile warning and missile tracking capabilities. T1 TRK will interoperate with SDA's data communications T1 and T2 Transport Layer (T1TL and T2TL), which we assessed separately.



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2024 dollars in millions



[a]GAO-23-106059.

Program Background and Transition Plan

SDA initiated the T1 TRK rapid prototyping effort in April 2022. It is informed by the Tranche 0 (T0) Tracking Layer proof-of-concept, and intends to demonstrate the feasibility of the architecture and advanced missile detection and tracking to provide an initial operational warfighting capability. SDA established other transaction agreements in July 2022 with two vendors for 28 SVs and established an agreement in February 2023 with a third vendor for seven SVs. Before transitioning T1 TRK to operations, SDA plans to demonstrate T1 TRK with tests against representative targets in the third quarter of fiscal year 2025.

Software Development as of January 2024

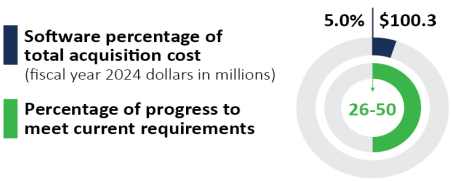
Approach: Agile, DevOps, and DevSecOps

Frequency of end user evaluation (months)

Information not available

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)



The program reported that end users will begin evaluating and providing feedback on software in March 2026. According to the program, estimated software costs have been adjusted this year after receipt of updated contractor reports.

Program Essentials

Prime Contractor: L3Harris; Northrop Grumman; Raytheon

Contract type: FFP

Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case	Status at Initiation	Current Status
Approved requirements document	●	●
Approved middle tier of acquisition strategy	●	●
Formal technology risk assessment	●	●
Cost estimate based on independent assessment	●	●
Formal schedule risk assessment	●	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

T1 TRK Program

Updates to Program Performance and Business Case

T1 TRK's total acquisition costs decreased by 6 percent since our last assessment, despite the selection of a third vendor to acquire seven additional SVs. According to the program office, last year's cost reflected the estimated funding requirement used to inform the program's initiation decision, while the current cost is based on actual contract values, as well as the procurement line for its launches and more refined program requirements now that T1 TRK is underway.

SDA completed a preliminary design review and critical design review in March 2023 and August 2023, respectively, with the first two vendors. The third vendor completed a preliminary design review in September 2023 and is planning to conduct a critical design review in the second quarter of fiscal year 2024. The SDA Risk Oversight and Management Board is evaluating risk on a continuous basis, such as the subcontractor's capacity to support multiple vendors working on Tranche 1 efforts, and electronic components shortages in the supply chain.

SDA launched the first four SVs for the T1 TRK predecessor, T0, in April and September 2023. The program delayed these launches from September 2022 because of supply chain issues and technical problems it found during testing, according to program officials. SDA officials previously described T1 as an incremental evolution of T0; however, officials now stated that T1 TRK is informed by T0, but is not considered an incremental evolution. SDA is planning to complete T0 with the launch of four additional SVs in the second quarter of fiscal year 2024, and will support SDA's first interoperability test among different vendors in space. Given that T1 TRK has already begun development, this delay will limit the extent to which the program could obtain early knowledge from T0 to reduce design risk for T1 TRK.

Leading Product Development Practices

SDA indicated that it is implementing an iterative approach aligned with key product development practices used by leading companies. For example, SDA stated that it leads a monthly warfighter council working group on program requirements and performance to obtain feedback and identify user needs as it develops and refines SDA's minimum viable product. For T1 TRK, it is expected to provide low-Earth orbit missile warning and missile tracking coverage capability. The program office stated that SDA is still determining what wargaming and exercises will be conducted, but anticipates that these efforts will assist in refining the product agreed to by the warfighter. In addition, SDA stated that it will incorporate user feedback throughout the development cycles to validate that the design continues to meet user needs and inform the next iteration of development.

Software and Cybersecurity

SDA is managing software development for T1 TRK and T1TL together as part of an enterprise effort. Program officials reported that they began software development in September 2022 and expect to complete a minimum viable product for software in May 2024. Program officials identified software development as a medium risk, driven in part by the effort proving to be more difficult than expected. Specifically, the program stated that the vendors' vehicle and constellation management software was not as mature as SDA expected.

SDA's cybersecurity strategy encompasses the full Proliferated Warfighter Space Architecture. SDA plans to require vendors to conduct their own cyber testing and evaluation and to support planned SDA-led efforts. The program plans to conduct cooperative vulnerability assessments in June 2024.

Other Program Issues

SDA reported that it uses a modular open systems approach across the Proliferated Warfighter Space Architecture that leverages commercial capabilities. SDA developed an optical communication terminal (OCT) standard for vendors. It anticipates that this approach will enable competition for future tranches, interoperability among multiple vendors, and a stable market for sustainment. However, it has a challenge of ensuring interoperability among multiple vendors because, per testing officials, the SDA OCT standard is different from commercial OCT standards, and vendors can have different interpretations of it. Program officials stated that T1 TRK data initially may have to be processed on the ground and relayed back into the Transport layer, adding delays in transfer. However, they want to reduce these delays by working toward processing tracking data on orbit in future tranches.

Program Office Comments

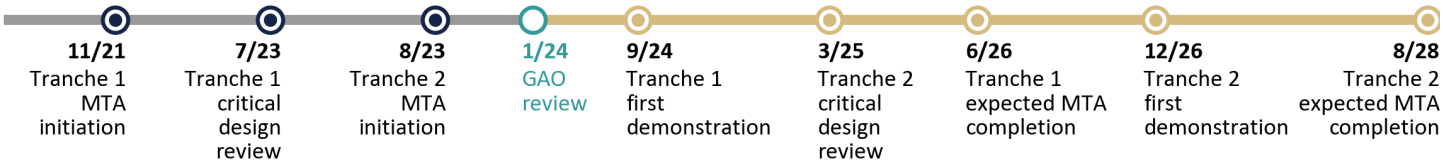
We provided a draft of this assessment to the program office for review and comment. It provided technical comments, which we incorporated where appropriate.

The program office stated that T0 delivered four tracking SVs on orbit in 2023, 27 months from authority-to-proceed to first light, for approximately $30 million. The program office stated that T1 TRK will demonstrate global detection and tracking of traditional and advanced infrared targets by merging innovative solutions with proven technologies in a low-Earth orbit constellation of mass-producible SVs. It added that these SVs will be equipped with infrared sensors, predicated on resilient sensing and communications capabilities. According to the program office, T1 TRK will expand upon T0 capabilities with targeted technology enhancements, expanded coverage, increased autonomy, and greater production efficiencies. T1 TRK, with T1TL, is the first step toward global persistent, assured, and resilient future missile warning and missile tracking architecture, according to the program office.

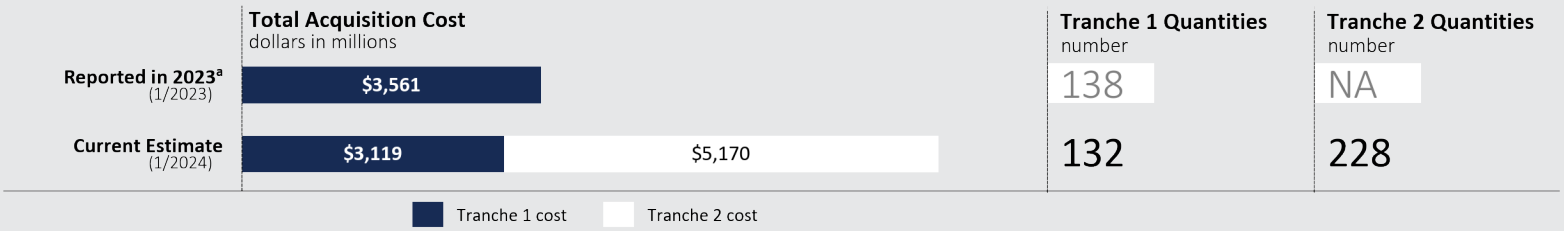
Source: Qinteq on contract to Space Development Agency. | GAO-24-106831

Tranche 1 and 2 Transport Layers (T1TL and T2TL)

T1TL and T2TL are MTA rapid prototyping efforts by the Space Force's Space Development Agency (SDA). The Transport Layer is one of several layers in SDA's planned Proliferated Warfighter Space Architecture (PWSA). PWSA is launching space vehicles into low-Earth orbit in tranches, starting with demonstration satellites launched in Tranche 0 (T0) in 2023. According to SDA, T1TL is intended to provide initial warfighting capability, and T2TL is the next increment that will deliver enhanced warfighting capability. We also evaluated the PWSA's Tranche 1 Tracking Layer (T1 TRK) in a separate assessment.



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2024 dollars in millions



[a]GAO-23-106059.

Program Background and Transition Plan

SDA initiated the T1TL rapid prototyping effort in November 2021 and initiated the T2TL effort in August 2023. T1TL and T2TL aim to demonstrate global data communications. SDA established other transaction agreements for T1TL in February 2022 and awarded agreements for T2TL in August and October 2023 and January 2024. T1TL has three vendors and T2TL has four vendors. SDA intends to transition the first rapid prototyping effort to operations and sustainment for its planned 5-year life cycle if it successfully completes a planned operational demonstration in August 2025.

Software Development as of January 2024

	Tranche 1	Tranche 2
Approach	Agile, DevOps, and DevSecOps	Agile, DevOps, and DevSecOps
Frequency of end user feedback	Information not available	Information not available
Frequency of testing and feedback (months)	1-3	Information not available
Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)	5%, $110.6	5%, $308
Percentage of progress to meet current requirements	51-75%	Information not available

For Tranche 1, the program reported that end users will begin evaluating and providing feedback on software in August 2025. According to the program, estimated software costs for Tranche 1 have been adjusted this year after receipt of updated contractor reports. For Tranche 2, the program reported that software development has yet to start.

Attainment of Business Case Knowledge as of January 2024

Key Elements of a Business Case – Tranche 1	Status at Initiation	Current Status
Approved requirements document	●	●
Approved middle tier of acquisition strategy	●	●
Formal technology risk assessment	●	●
Cost estimate based on independent assessment	●	●
Formal schedule risk assessment	●	●
Key Elements of a Business Case – Tranche 2	**Status at Initiation**	**Current Status**
Approved requirements document	●	●
Approved middle tier of acquisition strategy	●	●
Formal technology risk assessment	●	●
Cost estimate based on independent assessment	●	●
Formal schedule risk assessment	●	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

Program Essentials

Prime Contractor: York Space Systems; Lockheed Martin; Northrop Grumman Systems; Rocket Lab
Contract type: FFP

T1TL and T2TL Programs

Updates to Program Performance and Business Case

The T1TL program completed a system-level critical design review in July 2023 and identified three critical technologies—space vehicles, antenna ground entry points, and planning and control software. For our prior assessment, the program reported that it did not have any critical technologies. For the new T2TL effort, the program identified the same three critical technologies as T1TL, and added a fourth, mission radio. Program officials stated that they target technologies used in the commercial market that are mature or approaching maturity. However, for one technology that the PWSA relies on—optical communication terminals—SDA reported introducing a new government standard used to build the technology. Further, this government standard has changed and officials say it will evolve with each tranche.

Leading Product Development Practices

SDA plans to use certain key product development principles used by leading companies. For example, the program considers T1TL and T2TL as part of an iterative approach to the PWSA program, and the program reports that it plans to update programmatic requirements to address evolution in user needs. SDA officials stated that they formed a warfighter working group that meets monthly and a warfighter council that meets semi-annually, and established a warfighter integration portal to capture user needs and provide feedback to develop and refine SDA's minimum viable products and capabilities. We previously found that ongoing engagement with users is an important aspect of iterative development that leading companies use to prioritize features and identify improvements to the product.

SDA officials stated that T0—a set of 23 demonstration satellites launched in April and August 2023—is a proof-of-concept demonstration. We reported last year that SDA described T1 as an incremental evolution of T0. SDA officials stated this year that T1TL and T2TL are informed by T0, but the demonstration is not considered an incremental evolution. These launches were delayed from the original plans to launch in September 2022. Program plans describe PWSA as being developed using an iterative approach and officials stated that lessons learned from T0 would be integrated into T1TL and T2TL. However, program officials report that testing for T0 has been delayed and there has been no schedule change for T1TL, which is planned for launch in 2024, or T2TL, which is planned for launch in 2026. Our prior work found that leading companies collect user feedback to inform the next iteration of the product or the design of a new product. However, by moving forward with two additional iterations before testing the initial tranche, the program is missing an opportunity to validate that T0 is demonstrating planned capability prior to building on the design in T1TL and T2TL.

Software and Cybersecurity

Software development for T1TL and T2TL is part of an enterprise effort, including the T1 TRK. Program officials reported that they began software development in September 2022 for T1TL and expect to complete a minimum viable product for software by April 2024. Program officials also reported that they are assessing use of the software acquisition pathway. SDA identified software development as a medium risk for both T1 and T2, driven in part by the effort proving to be more difficult than expected, as well as changes needed to meet cybersecurity needs that led to additional software. Specifically, officials said that the constellation management software was not as mature as expected.

SDA's cybersecurity strategy encompasses the full PWSA, which includes T1TL, T2TL, and T1 TRK. For T1TL, SDA has conducted multiple cyber tabletop exercises, which are low-technology, low-cost, intellectually intensive exercises to introduce and explore the effects of cyber offensive operations on the capability of a system to execute a mission. SDA has yet to conduct any cybersecurity testing for T2TL, but the program reported that it plans to conduct testing.

Other Program Issues

According to program officials, hiring and retaining the necessary workforce—including acquisition professionals, software engineers, and user experience specialists—is a challenge on both T1TL and T2TL. Officials stated that they are competing with other DOD entities and commercial companies.

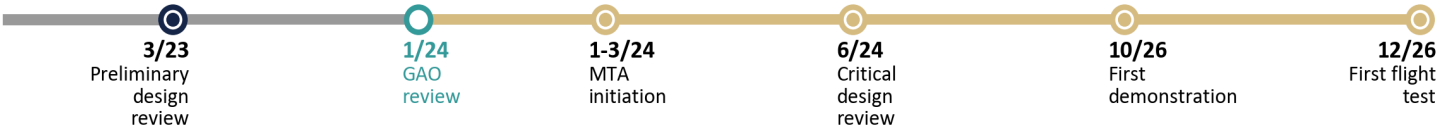
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. According to the program office, the T0 proof of concept delivered 23 satellites in under 36 months from order to orbit and demonstrated Link 16 military networking capability from space. The program office also stated that T1TL consists of approximately 126 space vehicles—with first launch expected in September 2024—to provide assured, resilient, low-latency data and connectivity worldwide to a full range of warfighter applications. It noted that it expects T2TL to consist of approximately 216 space vehicles, with tactical satellite communication capabilities, expanded targeting capacity, and resilience with minimal change to T1TL technical specifications. The program office stated that PWSA employs an open architecture leveraging commercial capabilities. According to the program office, this multi-vendor interoperability employs a standards-based approach with framework and protocol definitions for optical communications and networking, and includes ground-based constellation, network, and mission management.

Source: U.S. Space Force. | GAO-24-106831

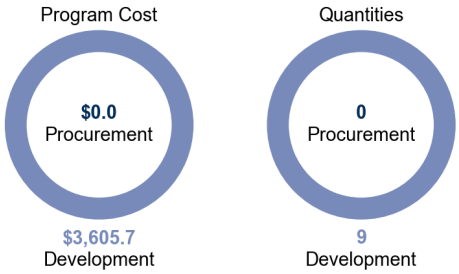
Resilient Missile Warning (MW)/Missile Tracking (MT) Medium Earth Orbit (MEO) - Epoch 1

Resilient MW/MT MEO is a new effort by the Space Force's Space Systems Command (SSC) that intends to provide missile warning, tracking, and defense data to legacy and future missile warning and tracking space systems. Epoch 1 is the first of at least three, and potentially more, satellite Epochs focused on delivering the latest Overhead Persistent Infrared sensing technology into medium-Earth orbit. The Epochs will work with Space Based Infrared Systems and the Space Development Agency's Tracking and Transport Layer satellites, the latter of which we assessed separately.



Estimated Cost and Quantities

(fiscal year 2024 dollars in millions)



Cost and quantity represent fiscal years 2021-2030.

Software Development as of January 2024

Approach: Agile, Waterfall, Incremental, and DevSecOps

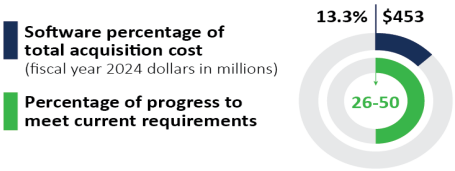
Frequency of end user evaluation (months)

Information not available

Less than 1	1-3	4-6	7-9	10-12	13 or more

Information not available

Frequency of testing and feedback (months)



The program reported that there are plans to involve end users in evaluating and providing feedback on software in the future. The program stated that it will know more about the frequency of testing and feedback once the software verification and validation process begins.

Program Essentials

Prime contractor: Raytheon; Millennium Space Systems; L3Harris; Parsons

Contract type: FFP; CPIF; CPFF

Current Status

DOD is expected to approve an Epoch 1 rapid prototyping effort by the end of the second quarter of fiscal year 2024. The program plans to develop up to nine satellites, up to nine ground antennas, and an operations center.

Program officials identified two critical technologies for Epoch 1—large format focal plane arrays, which are sensors that can capture images with high resolution and sensitivity, and medium-Earth orbit optical crosslinks, which will enable space-to-space laser communications between satellites. Officials expect both technologies to reach maturity by September 2026.

The program reported it is using an iterative approach for development and cited certain product development practices used by leading companies. For example, officials said the program regularly engages the user community to define and implement requirements, such as data types and tasking procedures, and uses modeling and simulation and continued interaction with warfighter groups to present capabilities to stakeholders. Each successive Epoch will expand on the capability development document requirements approved in February 2024—moving from an initial warfighting capability expected by Epoch 2, toward the full capability expected sometime after Epoch 3. SSC plans to use a model-based systems engineering tool, Cameo, for digital design of its payloads and platforms. However, officials said the program has been challenged in leveraging Cameo for efficiencies due to difficulties with shared access to the Cameo infrastructure and communicating with other stakeholders. We previously found that leading companies use design modeling and simulation to refine requirements to be addressed in the minimum viable product to deliver essential capabilities with speed.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. It provided technical comments, which we incorporated where appropriate. The program office stated that the nine ground antennas are being grouped into sets of three, at three separate sites. According to the program, the antennas will be able to communicate with any vendor satellite and deliver data back to the missile warning and tracking operations center at very low latency speeds. In addition, the program noted that an operations and integration contractor will enable hosting of command and control of orbital planes in collaboration with the Joint Overhead Persistent Infrared Center.

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JOINT DOD

Program Assessments

▲ F-35 Lightning II (F-35)

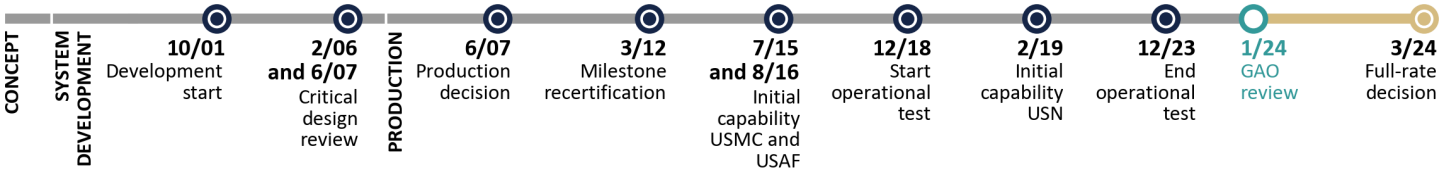
Assessment type	Program name
MDAP	F-35 Lightning II (F-35)

Source (previous page image): U.S. Navy photo courtesy Lockheed Martin/Dane Wiedmann. | GAO-24-106831

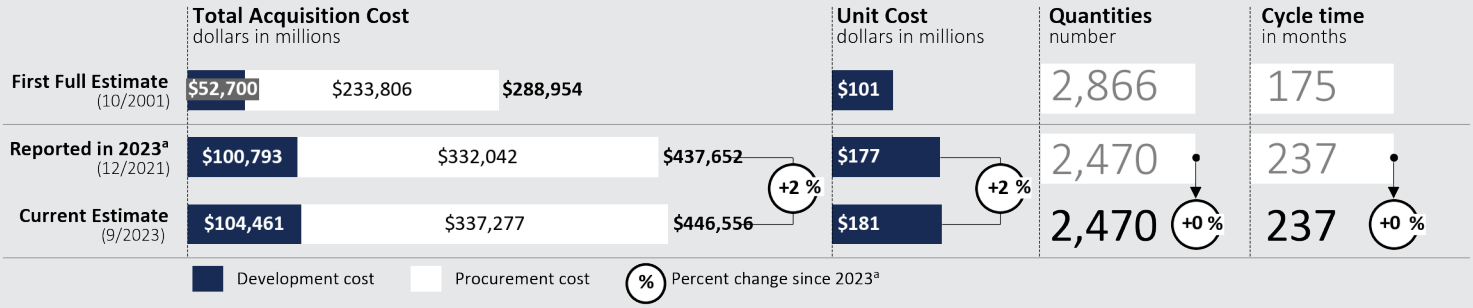
Source: Department of Defense. | GAO-24-106831

F-35 Lightning II (F-35)

DOD is developing three fighter aircraft variants integrating stealth technologies, advanced sensors, and computer networking for the U.S. Air Force (USAF), Marine Corps (USMC), and Navy (USN); international partners; and foreign military sales customers. The Air Force's F-35A variant will replace the F-16 and A-10's air-to-ground attack capabilities. The Marine Corps' F-35B variant will replace its F/A-18A/C/D and AV-8B aircraft. The Navy's F-35C will complement its F/A-18E/F aircraft. DOD is 6 years into a development effort to modernize the F-35 aircraft's capabilities, known as Block 4.



Program Performance fiscal year 2024 dollars in millions



Total quantities comprise 14 development quantities and 2,456 procurement quantities. The graphic bars depict only research and development and procurement costs. However, total acquisition costs may also include costs for military construction, as well as acquisition operation and maintenance.

[a]GAO-23-106059. We updated the cost information for 2023 this year to reflect what the program reported in its December 2021 Selected Acquisition Report. In our 2023 report, we used data from the program's May 2022 update to its acquisition program baseline, but the program office subsequently stated that baseline was less accurate than the December 2021 Selected Acquisition Report because it did not include updated procurement costs.

Software Development as of January 2024

Approach: Agile

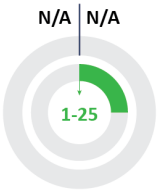
Frequency of end user evaluation (months)

Less than 1	1-3	4-6	7-9	10-12	13 or more

Frequency of testing and feedback (months)

Software percentage of total acquisition cost (fiscal year 2024 dollars in millions)

Percentage of progress to meet current requirements



The program stated that software costs are not tracked in a way that would allow for reporting on total cost at the program level. The program reported the percentage complete for development of software for the Block 4 modernization effort.

Program Essentials

Prime contractor: Lockheed Martin (Lot 15-17 production contract; Block 4 Phase 2.3 contract); Pratt & Whitney (engine contract)

Contract type: CPIF/CPAF (Block 4 Phase 2.3 contract) (procurement, development); majority FPIF (Lot 15-17 production contract, engine contract) (procurement)

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current Status
Demonstrate all critical technologies in a relevant environment	○	●
Demonstrate all critical technologies in a realistic environment	○	●
Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
Demonstrate critical processes on a pilot production line	○	●
Test a production-representative prototype in its intended environment	○	●

● Knowledge attained ○ Knowledge not attained ... Information not available NA - Not applicable

F-35 Program

Technology Maturity, Design Stability, and Production Readiness

According to program officials, the program successfully conducted 64 simulated flight tests in September 2023 to complete initial operational testing and evaluation. The program plans to use the test results to inform the full-rate production decision planned for March 2024.

Even with near-term plans for full-rate production, the program continues to experience ongoing and new production challenges. According to program officials, the aircraft contractor continues to face parts and workforce shortfalls, among other things, resulting in late aircraft deliveries. For example, leading edge flaps—a critical component of the aircraft's wing—are one of the main parts shortages that are causing delays. According to program officials, it will be early 2025 before the production line can reliably support on-time F-35 assembly. According to program officials, to mitigate delays, the contractor is building around the missing parts.

Software and Cybersecurity

The program continues to experience significant delays due to software challenges related to Technology Refresh 3 (TR3), the $1.64-billion suite of upgraded hardware and software technologies critical to enabling many future Block 4 capabilities. TR3 hardware—primarily, processors and display units—is being installed onto new F-35s, but TR3 software is delayed until April 2024. DOD officials are not accepting new F-35 deliveries from the contractor until both TR3 hardware and software are installed.

According to program officials, Block 4 modernization recently underwent a technical baseline review. DOD officials worked with the military departments to reprioritize Block 4 capabilities for development based on several factors, including the departments' feedback and technology maturity. However, some Block 4 capabilities are delayed until aircraft are TR3-capable, as they rely on TR3 hardware and software to function. Block 4's reliance on TR3 means the two schedules are highly interwoven.

The program made Block 4 software development improvements over the past year, including increasing automated testing to ensure that new or updated software does not affect existing software. The program also continued to improve its Block 4 software development oversight tool.

The program and contractor continue to make progress on integrating cybersecurity into the software development process, including investing in cyber range testing facilities and developing an updated cyber strategy.

Other Program Issues

Since our last assessment, costs increased by approximately $8.9 billion (2 percent). In part, the cost growth resulted from increasing modernization costs and rising procurement costs driven by delaying aircraft deliveries.

As capabilities on the aircraft have increased, the aircraft's power and cooling needs have also increased, which is reducing the life of the aircraft's engine. The engine assists with power and cooling by generating air pressure for the plane's power and thermal management system (PTMS), which cools subsystems such as the radar. As more capabilities have been added to the plane, the amount of air pressure needed for the PTMS to sustain them has risen. To meet the demand for more air pressure, the engine is working harder than designed, causing it to degrade faster than anticipated. This degradation increased life-cycle costs for the aircraft.

In response, the program is modernizing the F-35's engine. In fiscal year 2022, Congress provided funding for an engine enhancement, now known as the Engine Core Upgrade. A preliminary design review is planned for 2024. The upgrade would modernize the current engine's power module and gearbox but leave most other components untouched. According to program officials, this upgrade would increase the amount of pressurized air the engine can provide to the PTMS without overworking the engine. The program office stated that it is currently conducting market research to inform an acquisition strategy for future phases following the preliminary design effort.

The program is also planning to upgrade the PTMS to provide greater cooling and electrical power. This upgrade would significantly increase the maximum power the system can generate, allowing it to support a greater number of capabilities. The program has yet to select a path for upgrading the PTMS but has determined that it must upgrade the system by 2029 to enable capabilities planned through 2035. Until the F-35 has both a modernized engine and PTMS upgrades, the F-35's current engine will struggle to meet the needs of newly added capabilities.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

Appendix II: Objectives, Scope, and Methodology

This report responds to title 10, section 3072 of the United States Code.[70] Specifically, this report assesses (1) the characteristics of the Department of Defense's (DOD) portfolio of its costliest weapon programs and how selected programs have performed over time; (2) the extent to which selected programs followed leading product development practices; (3) the extent to which programs implemented modern software development approaches and recommended cybersecurity practices; and (4) challenges reported by DOD with the software workforce in acquisition program offices and the extent to which DOD has implemented related changes.

This report also presents assessments of 70 major defense acquisition programs (MDAP), future major weapon acquisitions, and middle tier of acquisition (MTA) programs (see appendix I for assessments).

Program Selection

To identify DOD's most expensive weapon programs, we took the following steps.

- **MDAPs.** We retrieved DOD's list of MDAPs from the Defense Acquisition Visibility Environment (DAVE) system as of April 2023 to identify the scope of DOD's MDAP portfolio for our review.

  To identify MDAPs for individual assessments, using the Defense Acquisition Executive Summary (DAES) data obtained from DAVE, we narrowed our list to those that were either between the start of development and the early stages of production or well into production

[70]Title 10, section 3072 of the U.S. Code was previously codified at title 10, section 2229b of the U.S. Code until it was transferred on January 1, 2022. This statute was enacted by section 833 of the John S. McCain National Defense Authorization Act for Fiscal Year 2019. See Pub. L. No. 115-232, § 833 (2018). This statute was later amended by section 813 of the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 and section 812 of the James M. Inhofe National Defense Authorization Act for Fiscal Year 2023. See Pub. L. No. 116-283, § 813 (2021) and Pub. L. No. 117-263, § 812 (2022). This statute includes a provision for us to submit to the congressional defense committees an annual assessment of selected DOD acquisition programs and initiatives by March 30 of each year from 2020 through 2026. Our assessment of the performance of DOD's IT programs is included in a separate report, which we also prepared in response to title 10, section 3072 of the United States Code. That report will issue later this year.

but introducing new increments of capability or significant changes expected to exceed the cost threshold for designation as an MDAP.[71]

- **Future major weapon acquisitions.** We retrieved the list of programs from DOD's DAVE system that were identified by DOD as pre-MDAPs—programs planning to develop their systems on the major capability acquisition (MCA) pathway—as of April 2023. We also reviewed budget documentation to identify other programs that had yet to be formally initiated on an Adaptive Acquisition Framework (AAF) pathway with costs expected to exceed thresholds for designation as a MDAP.[72] In addition, we included two programs—the Army's Extended Range Cannon Artillery and Lower Tier Air and Missile Defense Sensor—that have completed their MTA efforts but have yet to complete their planned transitions to the MCA pathway.
- **MTA programs.** We obtained a list of programs using the MTA rapid prototyping or rapid fielding path from DAVE that were reported by the military departments, as of April 2023, as having a cost for the current MTA effort above the equivalent threshold cost for designation as an MDAP or were included in our scope last year.[73] In some instances, current MTA efforts represent one of multiple planned efforts that are planned as part of a program's overall acquisition strategy. Our assessment focused on the current MTA effort.

[71]MDAPs generally include programs that are not a highly sensitive classified program and that are either (1) designated by the Secretary of Defense as a MDAP; or that are (2) estimated to require an eventual total expenditure for research, development, test, and evaluation, including all planned increments or spirals, of more than $525 million in fiscal year 2020 constant dollars or, for procurement, including all planned increments, of more than $3.065 billion in fiscal year 2020 constant dollars. See 10 U.S.C. § 4201(a); Department of Defense, *Major Capability Acquisition*, DOD Instruction 5000.85 (Aug. 6, 2020) (incorporating change 1, Nov. 4, 2021) (reflecting statutory MDAP cost thresholds in fiscal year 2020 constant dollars).

[72]While we generally selected future major weapon acquisitions where costs are expected to exceed the MDAP threshold, in one instance we selected one program—the Submarine Tender Recapitalization Program (AS(X))—where the Navy subsequently indicated costs are not expected to exceed this threshold. However, this program's development affects two other ACAT I programs in our review.

[73]We selected 20 MTA efforts for review, of which 14 met the acquisition category (ACAT) I threshold. We included two programs (Future Long Range Assault Aircraft [FLRAA], and Integrated Visual Augmentation System [IVAS] Rapid Fielding) whose costs did not meet the ACAT I criteria because they were included in our prior report. We also included two MTA programs designated as pre-decisional—High Accuracy Detection and Exploitation System (HADES) and Mid-Range Capability (MRC)—and one additional MTA program—Maneuver Short Range Air Defense Increment 3 (M-SHORAD)—that initiated prior to our January 2024 cut-off threshold.

We excluded the Missile Defense Agency's Missile Defense System and its elements from all analyses due to the lack of an integrated long-term baseline. We also excluded from our analyses classified programs and selected programs for which significant amounts of programmatic information was considered sensitive.

Standardization of Terminology and Cost Comparisons

To make DOD's acquisition terminology consistent across programs we reviewed, we standardized the terminology for key program events.

- For most MDAPs and future major weapon acquisitions in our assessment, "development start" refers to the initiation of an acquisition program as well as the start of either engineering and manufacturing development or system development. This date generally coincides with DOD's milestone B for non-shipbuilding programs on the MCA pathway.

  A few MDAPs or future major weapon acquisitions in our assessment have a separate program start date, which begins a pre-system development phase for program definition and risk-reduction activities. This program start date generally coincides with DOD's milestone A on the major capability acquisition pathway, which denotes the start of technology maturation and risk reduction.

  The production decision generally refers to the decision to enter the production and deployment phase, typically with low-rate initial production. This decision generally coincides with milestone C for non-shipbuilding programs on the major capability acquisition pathway. The initial capability refers to the initial operational capability, which some programs refer to as their first unit equipped or required asset availability.

- For shipbuilding programs, the schedule of key program events in relation to acquisition milestones varies for each program. Our work on shipbuilding leading practices has identified the detailed design contract award and the start of lead ship fabrication as the points in the acquisition process roughly equivalent to development start and design review for other programs.[74]
- For programs using the MTA pathway, the program start date for programs designated on or after December 30, 2019, is generally the date that the program was designated, which is the date that an

[74]GAO, *Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding*, GAO-09-322 (Washington, D.C.: May 13, 2009).

acquisition decision memorandum was signed initiating an MTA rapid prototyping or rapid fielding program. MTA programs designated before December 30, 2019, and certain programs designated after this date, generally maintain their MTA program start date as the date funds were first obligated.[75] For the purposes of this report, we refer to the initiation date as the date that a program was designated.

- According to DOD policy, programs using the MTA pathway also develop transition plans as a part of their acquisition strategies. Transition refers to the point at which the program begins another effort using the MTA pathway or another acquisition pathway. For each MTA program using the rapid prototyping path, DOD policy directs DOD components to develop a process for transitioning successful prototypes and programs to new or existing acquisition programs for production, fielding, and operations and sustainment.[76] For each MTA program using the rapid fielding path, DOD components are required to develop a process for transitioning successful programs to operations and sustainment.

Additionally, for all programs we reviewed, we converted all cost information to fiscal year 2024 dollars using conversion factors from DOD Comptroller's National Defense Budget Estimates for Fiscal Year 2024.[77]

Data Sources and Reliability

To obtain information about current costs and changes in costs of the MDAPs and MTA programs we reviewed, we took steps to collect and assess the reliability of this year's data.

- For MDAPs, we generally obtained and analyzed cost data from each program's September 2023 DAES. In cases where DAES data were not available or we found these data to be incomplete, we instead analyzed data from an acquisition program baseline issued in 2023 or a December 2022 Selected Acquisition Report. For two programs—the Air Force's F-15EX and MH-139A Grey Wolf programs—we used cost data presented in the December 2023 DAES. We compared these cost data to each program's September 2022 DAES, acquisition

[75]Four MTA programs in our selection (Conventional Prompt Strike, F-22 Rapid Prototyping, XM30 Mechanized Infantry Combat Vehicle, and Protected Tactical SATCOM) were designated before December 30, 2019. These programs plan to complete their MTA efforts in fiscal year 2024 or 2025.

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

[77]Department of Defense, Office of the Under Secretary of Defense (Comptroller), *National Defense Budget Estimates for Fiscal Year 2024* (May 2023), 76-77.

program baseline issued in 2022, or December 2021 Selected Acquisition Report to determine changes in cost over the past year. We also relied on these sources for our assessment of cost changes within the portfolio of MDAPs for which we produced two-page assessments.

- For future major weapon acquisitions, MDAPs introducing new increments, and MTA programs, we obtained cost and funding information from the program offices. We received responses from August 2023 through October 2023. For MTA programs, we also obtained and analyzed scope and quantity data from each MTA effort's program identification documents submitted to the Office of the Secretary of Defense (OSD) during fiscal year 2023.

We also distributed a questionnaire to the 70 selected program offices that manage the programs we assessed in individual or combined assessments:

- 34 MDAPs in development or early production,
- 4 MDAPs that are well into production but introducing new increments of capability or significant changes, which we refer to as MDAP increments,
- 12 future weapon acquisitions, and
- 20 MTA programs.

We used the questionnaire to obtain information on programs' schedule and use of leading acquisition practices, and selected software and cybersecurity practices, among other things.

To help ensure the reliability of the data collected through our questionnaire and data provided by the program offices, we took several steps to reduce measurement and non-response error. These steps included:

- conducting pretests of new questions (those that were not included in our previous assessments) prior to distribution to ensure our questions were clear, unbiased, and consistently interpreted.
- collecting and analyzing supplemental program information, such as budget submissions, acquisition decision memorandums, acquisition strategies, transition plans (from the MTA pathway to other pathways, new MTA rapid fielding efforts, or to operations and sustainment), program cost and schedule estimates, service cost positions or independent cost estimates, risk assessments, and documents

relating to technology maturity, software development, and cybersecurity. We also interviewed or received written responses from program officials to supplement and clarify this information.

To assess the reliability of the DAES data and the DAVE system that houses the data, we sent questions to DOD related to DAVE, the DAES data in DAVE, and the custodians of the data in January 2024. Specifically, we asked how DOD monitors and updates DAVE, how the data is updated over time, and quality assurance steps taken to ensure data accuracy, among other topics.

To assess the reliability of MTA cost data, we compared the data received from each of the MTA programs to cross-check data from the program identification documents submitted to OSD for the fiscal year 2023 President's Budget and solicit any updates to the numbers, with explanation.

Based on these efforts, we determined that the December 2022 Selected Acquisition Report data, the September 2023 DAES data retrieved from DAVE, and MTA program cost data provided by programs were sufficiently reliable for the purposes of reporting cost and schedule information.

Assessment of MDAP Cost and Schedule Performance and Knowledge-Based Practices

MDAP Cost and Schedule Performance

Our analysis of the portfolio we reviewed for this year's report includes comparisons of total cost and schedule changes and the number of programs as compared with the portfolio we reviewed in last year's report and from baseline estimates (first full estimates) from the programs' initial Selected Acquisition Report submissions. To analyze cost changes, we generally compared the individual and combined procurement; research, development, test, and evaluation (RDT&E); military construction; and operations and maintenance, and total acquisition costs from the September 2023 DAES with those individual and combined costs reported in September 2022 DAES. In cases where DAES data were unavailable or incomplete, we used acquisition program baselines or Selected Acquisition Reports. We also calculated the total cost changes

from programs that were included in the both the 2022 and 2023 portfolios that were both attributable and not attributable to quantity changes (increases or decreases in total quantity of units a program plans to order).

We analyzed the factors affecting costs across the 31 MDAPs for which we produced two-page assessments in both this report and our most recent report.[78] The data used in this analysis were drawn from DAES reporting. Of those 31 programs, we examined the 14 programs reporting cost increases and 16 programs reporting cost reductions and analyzed the factors programs reported drove their cost changes.[79] We identified these factors from program documentation, meetings with program officials, and program questionnaire responses. We also analyzed the extent to which changes in planned total unit order quantities effected total costs for these programs.

To analyze factors affecting MDAP schedule performance, we also focused on MDAPs for which we produced two-page assessments in this and our most recent report.[80] We identified 25 MDAPs assessed in both years that had yet to declare initial operational capability as of their September 2023 DAES reports. We compared the average cycle time of these programs, defined as the number of months between program start and the achievement of initial operational capability or an equivalent fielding date, with the average cycle time reported in our most recent report.[81] For programs with a cycle time change, we compared the extent of the new cycle time change with the program's original cycle time and identified the driving factors from the assessments. The data for this analysis were drawn primarily from DAES reporting and program offices' questionnaire responses.

Assessment of MTA Program Cost and Schedule and Critical Technologies

[78]GAO-23-106059.

[79]One program, the Army's CH-47F Block II Modernized Cargo Helicopter, reported no cost change from the previous year.

[80]GAO-23-106059.

[81]GAO-23-106059.

Cost and Schedule

To determine the planned costs for current MTA efforts, we generally reviewed the individual and combined procurement, RDT&E, military construction, operations and maintenance, and total acquisition costs from data provided by the program offices. We also used data provided by the program offices to analyze current quantity estimates. In cases where program offices did not provide quantity data, we used program identification documents that the military departments submitted to the OSD for the fiscal year 2025 President's Budget request. To determine 1-year MTA cost changes, we compared costs reported for our prior assessment in June 2023 against costs reported for this assessment.[82]

We reviewed schedule data from program identification documents and program questionnaires, including program start and planned end dates. To assess the extent to which planned operational demonstrations have shifted earlier or later since MTA program start, we compared (1) the planned operational demonstration date reported in the program's first data submission to OSD following program start, and (2) the planned demonstration date reported in the program identification documents submitted for the 2025 Budget Estimate Submission, which were reported by the programs in August 2023 or September 2023. To ensure this information was reliable, we took steps such as comparing the dates included with the program identification documents submitted for the 2025 Budget Estimate Submission with dates provided by individual MTA programs in program questionnaires and subsequently confirming those dates with individual MTA programs.

Critical Technologies

To collect data on the maturity of MTA programs' critical technologies, in our questionnaire we asked MTA programs to identify their critical technology elements, the current technology readiness level (TRL) for each critical technology, and projections for the technologies' TRLs at completion of the current MTA effort. We assessed the extent to which programs that reported having immature technologies last year increased their TRLs over the past year. We identified the critical technologies and associated TRLs reported to us for our prior report, and determined whether the MTA programs reported a different TRL for these technologies for this report. We also analyzed the current TRL and projected TRL at MTA completion for each critical technology for each MTA effort to understand the amount of expected maturation work that

[82]GAO-23-106059.

remains before the end of the current effort. Appendix VI provides further details on TRLs.

Leading Practices for Product Development

To assess the extent to which current MTA programs, MTA programs which recently transitioned to the MCA pathway (MTA to MCA programs), and future major weapon acquisitions utilized approaches generally aligned with leading practices for product development, our program questionnaires included questions related to activities associated with an iterative approach identified in our prior work.[83] In addition to asking whether the MTA programs, MTA to MCA programs, and future major weapon acquisitions use an iterative approach for development, we also asked whether these programs perform or plan to perform activities such as refining the minimum set of capabilities to be included in a minimum viable product based on user feedback; conducting integrated, system-level prototype testing with users and stakeholders, in a digital environment, physical environment, or both; and using digital models to maximize efficient production processes to prepare for subsequent design iterations, among other things. Further, we asked these programs whether they use or plan to use digital models, such as digital twins, throughout all iterative cycles of development. We analyzed this information to determine the extent to which MTA to MCA programs and current MTA programs and future major weapon acquisitions are taking an iterative approach to development; the extent to which they use or plan to use the leading practices associated with this approach; and the extent to which they use or plan to use digital models.

We also analyzed MTA rapid prototyping programs' acquisition strategies to assess the extent to which MTA rapid prototyping programs identify an initial capability prior to transitioning from the MTA rapid prototyping pathway to the MCA pathway, a new MTA rapid fielding effort, or operations and sustainment. We identified whether the acquisition strategies contained a transition plan and whether this transition plan identified an initial capability to be fielded. We further analyzed MTA rapid prototyping programs' acquisition strategies to determine whether MTA rapid prototyping programs identify an iterative approach to product development and incorporate leading practices associated with this approach. We searched each acquisition strategy document for key terms and concepts related to the common elements of an iterative structure identified in our prior work—continuous user feedback that informs

[83]GAO, *Leading Practices: Iterative Cycles Enable Rapid Delivery of Complex, Innovative Products,* GAO-23-106222 (Washington, D.C.: July 27, 2023).

development; identification of a minimum viable product or initial fieldable capability; and the use of digital engineering tools, such as automation, digital twins, and digital modeling.[84]

Implementation of Software Development Approaches and Cybersecurity Practices

To report on MDAP and MTA programs' software development approaches, we included related questions in our questionnaire.[85] We identified programs that reported the use of a modern software development approach—which we define for this assessment as Agile, DevOps, DevSecOps or an iterative development (other than Agile) approach. We summarized the number of programs that reported using any modern approach, those that reported only traditional approaches, and those that did not report a specific approach, and compared this with data from our 2021, 2022, and 2023 reports.[86]

To assess the extent to which selected programs were soliciting regular feedback on software from the intended end users of their systems, we included questions in the questionnaire on several aspects of feedback. These questions included whether the programs reported obtaining any end user feedback and the frequency with which they solicited and received feedback. We then aggregated program responses on obtaining end user feedback and the frequency of this feedback.

To report on modular contracting, we reviewed related DOD policy and guidance, and our *Agile Assessment Guide*.[87] We used our questionnaire data to assess the extent to which selected programs reported that they had implemented this acquisition strategy.

[84]GAO-23-106222.

[85]We also sent questionnaires to future major weapon acquisitions covering software approach, frequency of end user evaluation, and software costs. We did not include aggregate future major weapon acquisitions software data in our analysis because programs reported this information was largely unavailable, in part because programs were early in their life cycles.

[86]GAO-23-106059; *Weapon Systems Annual Assessment: Challenges to Fielding Capabilities Faster Persist*, GAO-22-105230 (Washington, D.C.: June 8, 2022); and GAO, *Weapon Systems Annual Assessment: Updated Program Oversight Approach Needed*, GAO-21-222 (Washington, D.C.: June 8, 2021).

[87]Department of Defense, *Operation of the Software Acquisition Pathway*, DOD Instruction 5000.87 (Oct. 2, 2020). Office of the Under Secretary of Defense for Acquisition and Sustainment, *Contracting Considerations for Agile Solutions, Key Agile Concepts and Sample Work Statement Language*, Version 1.0 (Washington, D.C.: Nov. 18, 2019). GAO, *Agile Assessment Guide: Best Practices for Adoption and Implementation,* GAO-24-105506 (Washington, D.C.: Dec. 15, 2023).

To assess selected programs' progress in implementing software development and acquisitions practices recommended by the Defense Science Board it its 2018 report, we included a question on the practices used.[88] We compared the portion of our assessed programs that reported they were implementing these practices with the portion of programs reporting implementation in our 2021, 2022, and 2023 reports. We analyzed these trends and reported whether the change from 2023 improved or declined.

To report on selected programs use of the software acquisition pathway, we reviewed DOD Instruction 5000.87, *Operation of the Software Acquisition Pathway*—which establishes policies and procedures for programs using the software acquisition pathway—and included questions in the questionnaire on programs' current and future plans to utilize the pathway for their software efforts, as well as rationales for their plans.[89]

To determine the extent to which selected programs' cybersecurity practices generally aligned with DOD's established cybersecurity policy and guidance, we identified specific DOD policy and guidance pertaining to cybersecurity in weapon systems, including DOD Instruction 5000.89, *Test and Evaluation*, effective November 2020, and DOD's *Cybersecurity Test and Evaluation Guidebook*, issued July 2015 and last updated in February 2020.[90] We included a number of cybersecurity-related questions in our questionnaire, including whether programs had approved cybersecurity strategies and had cybersecurity in requirements planning. We then summarized programs' responses and compared them with the DOD policy or guidance as appropriate.[91]

We assessed whether MDAPs had completed specific cybersecurity assessments in time to inform key program events as recommended in

[88]Defense Science Board, *Design and Acquisition of Software for Defense Systems* (Washington, D.C.: Feb. 14, 2018).

[89]DOD Instruction 5000.87.

[90]Department of Defense, *Cybersecurity Test and Evaluation Guidebook 2.0, Change 1* (February 2020).

[91]One program reported that it would not have an approved cybersecurity strategy. The program explained that it was not required to develop a stand-alone cybersecurity strategy for approval by the DOD Chief Information Officer (CIO) or Army CIO. However, the program also stated its cybersecurity strategy is included in the program's approved Program Protection Plan. Therefore, we concluded that this program had an approved cybersecurity strategy.

the *Cybersecurity Test and Evaluation Guidebook*. We included questions in the questionnaire on the first completed date for each of the assessment types described in the guidebook, then compared these dates with the program schedule events we collected data on as part of the questionnaire's schedule section.[92] We then separated these responses based on whether the relevant key program schedule event had passed or was in the future.

We also assessed whether MTA programs completed or planned to complete specific cybersecurity assessments before their planned transition date. We included questions in the questionnaire on the program's transition plan and transition date. We assessed transition plans and determined the recommended cybersecurity assessments to be completed before transition. We then compared planned transition dates with the first completed date or planned completion date for the relevant assessments. We then separated these responses based on whether the completed or planned assessment date was before or after the planned transition date.

Assessment of Information Related to DOD's Software Workforce in Acquisition Programs

To report what challenges DOD program offices have identified with the software workforce, we included questions related to software workforce challenges in our questionnaires sent to MDAPs and MTA programs.[93] For the purposes of our review, we utilized the term "software workforce," which comprises two broad categories of professionals—software acquisition professionals, such as program managers or contracting officers; and software practitioners, such as software developers and software engineers. We relied on program office responses to these questions to determine how many weapon programs experienced hiring or retention challenges with their software workforce in recent years, the types of challenges they experienced, and what factors contributed to these challenges. We also asked program offices what areas of expertise were most difficult to hire, and what initiatives, if any, program offices undertook to increase hiring or retention. Further, we drew explanatory

[92]For example, we compared a program's reported completion for their Cooperative Vulnerability Identification assessment with the program's production start date (Milestone C) to determine if the assessment was completed before the production start date, as recommended by DOD guidance. Our analysis excluded program events that occurred before the Department of Defense originally published its *Cybersecurity Test and Evaluation Guidebook* on July 1, 2015.

[93]For questions specific to the software workforce, we reviewed responses from 35 MDAPs and 18 MTA programs. We excluded data from some weapon programs that are included in other sections of this report because those programs reported not having significant software development efforts.

responses from the questionnaires to expand on the program's hiring, retention, and training efforts and challenges.

To identify related efforts DOD has undertaken to address software workforce challenges, we reviewed the National Defense Authorization Act (NDAA) from fiscal years 2020 to 2023 to identify provisions related to DOD's software workforce in acquisition programs.[94] We also reviewed DOD documentation, such as the 2021 *Report to Congress on FY20 NDAA Section 862(b)(1)(B)* to obtain more information about DOD's efforts and leveraged our past related work.[95] Further, we met with officials from USD(A&S) and the Defense Acquisition University (DAU) to discuss OSD's plans to address the selected provisions and any organizational and policy changes since the NDAA for Fiscal Year 2020 that relate to the software workforce.

Finally, we compared DOD's efforts to establish its software cadre with our past work on evidence-based policymaking. This criteria identifies the practices needed to help organizations, such as DOD, manage and assess their policymaking efforts.[96] Specifically, we compared DOD's planning documentation and statements from officials responsible for planning efforts to practices recommended by our past work. Given the stage of DOD's efforts, we focused on the group of practices in our past work related to planning for results.

Individual Assessments of Weapon Programs

[94]National Defense Authorization Act for Fiscal Year 2020, Pub. L. No. 116–92 (2019); William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116-283 (2021); National Defense Authorization Act for Fiscal Year 2022, Pub. L. No. 117–81 (2021), and James M. Inhofe National Defense Authorization Act for Fiscal Year 2023, Pub. L. No.117-263 (2022). We assessed changes starting with the NDAA for fiscal year 2020 because it directed DOD to establish software development and software acquisition training and management programs for all software acquisition professionals, software developers, and other appropriate individuals.

[95]Department of Defense *Report to Congress on FY20 NDAA Section 862(b)(1)(B) Software Development and Software Acquisition Training and Management Program* (January 2021). GAO, *Software Acquisition: Additional Actions Needed to Help DOD Implement Future Modernization Efforts*, GAO-23-105611 (Washington, D.C.: Apr. 5, 2023).

[96]GAO, *Evidence-Based Policymaking: Practices to Help Manage and Assess the Results of Federal Efforts*, GAO-23-105460 (Washington, D.C.: July 12, 2023).

Appendix I of this report presents assessments of 70 current and future weapon programs.[97]

- Thirty-four assess MDAPs—in development or early production—in a two-page format discussing each program's knowledge about technology, design, and manufacturing as well as software and cybersecurity, and other program issues. Further, five assess MTA to MCA programs' use of leading practices for product development.
- Sixteen assess future major weapon acquisitions or current MDAPs in a one-page format that describe the program's status. Those one-page assessments include (1) 12 future major weapon acquisitions that have not been formally initiated on an AAF pathway or have recently completed their MTA effort but have yet to transition to the MCA pathway, and (2) four MDAPs that are well into production but introducing new increments of capability or significant changes.
- Nineteen assess MTA programs (one assessment provides combined information on two programs—thus, we assessed a total of 20 MTA programs) in a two-page format discussing each program's completion of business case elements or updates to the program's business case; software development and cybersecurity; transition plan; leading principles for product development, and other program issues.

For all assessments, we obtained the information from sources such as DOD's DAES reports, program office documents, and program office questionnaire responses. This information is presented in the Program Essentials section as well as the cost and quantities sections (MDAP Program Performance, and MTA, MDAP Increment and Future MDAP Cost and Quantities), and Software Development graphics in each one- and two-page assessment. For some data fields, like contract type, we relied on information from previous years unless we received new information. We did not review individual contract documents to verify information in the Program Essentials section.

We obtained the information in the Software and Cybersecurity section of the two-page assessments from program office responses to questionnaires, program office documents, and communications with program officials. In their questionnaire responses, program offices self-identified the software development approach used by the program, frequency of end user evaluation, frequency of testing and feedback, the

[97]The Space Force's Tranche 1 (T1) Transport and Tranche 2 (T2) Transport MTA efforts were reviewed together in one assessment.

software percentage of total program cost, and the percentage of progress to meet current requirements.

The paragraphs below provide supplemental information on how we identified and assessed cost and schedule for MDAPs and future major weapon acquisitions, as well as how we assessed attainment of product knowledge for MDAPs. For MTA programs, we used the approach described earlier to summarize cost and quantity data for 20 MTA programs. For these programs, we reported costs for the current MTA effort only, as reported by the programs. For the 13 MTA programs included in both our current and prior assessment, we determined the change in cost since our June 2023 report.[98]

Cost and Schedule Data for MDAPs and Future Major Weapon Acquisitions

For each MDAP we assessed in a two-page format, we present cost, schedule, and quantity data at the program's first full estimate. The first full estimate is generally the cost estimate established at milestone B—development start. However, for a few programs that did not have such an estimate, we used the estimate at milestone C—production start—instead. For shipbuilding programs, we used their planning estimates when available. For programs that have passed a key decision point and have since been restructured, we continue to assess them against their original cost and schedule estimates. Additionally, we present cost, schedule, and quantity data, primarily from the September 2023 DAES reporting, compared with that reported in our 2023 report to show the one-year cost change.[99]

We took the following steps for the program performance data presented for each two-page MDAP assessment:

- We depicted only the program's main elements of acquisition cost—RDT&E and procurement. However, the total program cost also includes military construction and acquisition-related operation and maintenance costs. Because of rounding and these additional costs, in some situations, total cost may not match the exact sum of the research and development and procurement costs.
- Cost data for all programs was deflated to 2024 dollars using conversion factors as described above. However, in some situations, estimates from the September 2023 DAES reporting were not

[98]GAO-23-106059.

[99]GAO-23-106059.

updated to 2023 inflationary assumptions. Affected programs note this as contributing, in part, to a decrease in total acquisition costs.

- The program unit costs are calculated by dividing the total program cost by the total quantities planned in the acquisition program baseline or the DAES. These costs are often referred to as program acquisition unit costs. In one instance, the data were not applicable because the program does not intend to procure units beyond testing. We annotate this designation by using the term not applicable (NA).
- The quantities listed refer to total quantities, which includes both procurement and development quantities.
- The schedule information is presented as Cycle Time, which is defined as the number of months between program start and the planned or actual achievement of initial operational capability or an equivalent fielding date. In some instances, cycle time is not applicable and we annotate this by using the term NA. In some instances, planned initial operational capability dates have been delayed, but a new planned date had yet to be determined. We annotate this by using the term “to be determined” (TBD).

Cost and quantity information presented in the MDAP increment, and future major weapon acquisitions “Estimated Cost and Quantities” figures is drawn from funding stream information from the program office.

Attainment of MTA Business Case Knowledge

To determine whether MTA programs established a sound business case prior to program initiation, we reviewed prior GAO reports that identified elements that would provide a sound business case for MTA programs. These elements include cost estimates based on an independent assessment, requirements, acquisition strategies, and formal schedule and technology risk assessments.[100] Our decision to use the program initiation date, which is the date that the decision authority signs an acquisition decision memorandum designating the program as an MTA effort, as a key knowledge point was based on prior work on business

[100]GAO, *DOD Acquisition Reform: Leadership Attention Needed to Effectively Implement Changes to Acquisition Oversight,* GAO-19-439 (Washington, D.C.: June 5, 2019); and A*cquisition Reform: DOD Should Streamline Its Decision-Making Process for Weapon Systems to Reduce Inefficiencies,* GAO-15-192 (Washington, D.C.: Feb. 24, 2015).

cases that demonstrated that the most significant point of leverage for a decision-maker is before the decision to start a program.[101]

In our questionnaire, we asked the program offices whether they had these business case elements in place, and if so, when they had been completed. We then compared dates the program offices provided for completion of the five business case elements above against the program's initiation date to determine whether the program had completed the respective elements prior to initiation or afterwards.[102] For current status, we assessed whether or not the program had completed the above five elements as of January 2024, the end of our review period. We clarified the program's reported completion status of business case elements in instances in which the program reported information that was inconsistent with information reported elsewhere in the questionnaire or program documentation.

Assessment of MDAPs' Attainment of Product Knowledge

Our assessment of how well MDAPs adhere to a knowledge-based acquisition approach focuses on knowledge attained by key decision points:

- system development start or detail design contract award for shipbuilding programs,
- critical design review or lead ship fabrication start for shipbuilding programs, and
- production start.[103]

For our attainment of product knowledge tables, we assessed MDAPs' status in implementing the knowledge-based acquisition practices criteria,

[101]GAO-19-439; and *Defense Acquisitions: Joint Action Needed by DOD and Congress to Improve Outcomes*, GAO-16-187T (Washington, D.C.: Oct. 27, 2015). This date differs from the MTA program start date for programs initiated/designated before December 30, 2019, and for certain programs initiated/designated after this date.

[102]For status at initiation, if a program stated it had conducted any of the five activities above within 30 days of initiation, we considered that as having achieved the knowledge for that metric.

[103]We assessed the CVN 78 *Gerald R. Ford* Class Nuclear Aircraft Carrier's resources and requirements knowledge metrics at the time of the construction preparation contract award, rather than the detail design contract award, because that is the point at which the program began CVN 78 development.

as well as the programs' progress in meeting the criteria at the time they reached the three key knowledge points during the acquisition cycle.[104]

- **Knowledge Point 1: Match between requirements and resources.** We asked program officials to report TRLs for their program's critical technologies (see appendix VI for TRL definitions). Our knowledge-based acquisition practices work shows that a TRL 7—demonstration of a technology in its form, fit, and function within a realistic environment—is the level of technology maturity that constitutes a low risk for starting a product development program.[105] For shipbuilding programs, we have recommended that this level of maturity be achieved by the contract award for detailed design.[106] In our assessment, the technologies that have reached TRL 7 are referred to as mature or fully mature. Those technologies that have reached TRL 6, a prototype very close to final form, fit, and function demonstrated within a relevant environment, are referred to as approaching or nearing maturity.[107] In addition, we asked program officials to provide the date of the system-level preliminary design review. We compared this date with the system development start date.
- **Knowledge Point 2: Design stability.** We asked program officials to provide the number of design drawings completed or projected for completion by the critical design review, the production decision, and as of our current assessment in our questionnaire. Completed drawings were defined as the number of drawings released or

[104]We did not include an attainment of product knowledge table for the five MDAPs that transitioned from the MTA pathway. We have ongoing work to refine our leading product development practices associated with iterative development, which we expect will inform our assessments of these types of programs in subsequent reports.

[105]GAO, *Technology Readiness Assessment Guide: Best Practices for Evaluating the Readiness of Technology for Use in Acquisition Programs and Projects*, GAO-20-48G (Washington, D.C.: January 2020); *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*, GAO-01-288 (Washington, D.C.: Mar. 8, 2001); and *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO/NSIAD-99-162 (Washington, D.C.: July 30, 1999). While GAO's leading practices work shows that a TRL 7 is the level of technology maturity that constitutes a low risk for starting development, DOD's guidance generally permits development to start at TRL 6. DOD's guidance is based on a statute that generally prohibits MDAPs from receiving approval for development start until the milestone decision authority certifies—based on an independent review and technical risk assessment—that the technology in the program has been demonstrated in a relevant environment. 10 U.S.C. § 4252(a)(2).

[106]GAO-09-322.

[107]Satellite technologies that have achieved TRL 6 are assessed as fully mature due to the difficulty of demonstrating maturity in a realistic environment—space.

deemed releasable to manufacturing that can be considered the “build to” drawings. For shipbuilding programs, we asked programs whether they had completed 100 percent of basic and functional design using 3D modeling at fabrication start and current status. To gain greater insights into design stability, we also asked programs to provide the date they planned to first integrate and test all key subsystems and components into a system-level integrated prototype. We compared this date with the date of the critical design review. We did not assess whether shipbuilding programs had completed integrated prototypes.

- **Knowledge Point 3: Production maturity.** To gain insights into production maturity, we asked whether programs planned to demonstrate critical manufacturing processes on a pilot production line before beginning low-rate production. We also asked programs on what date they planned to begin system-level developmental testing of a fully configured, production-representative prototype in its intended environment. We compared this date with the production start date. We did not assess production maturity for shipbuilding programs because the Navy does not generally produce ships on production lines or prototype a whole ship due to cost.

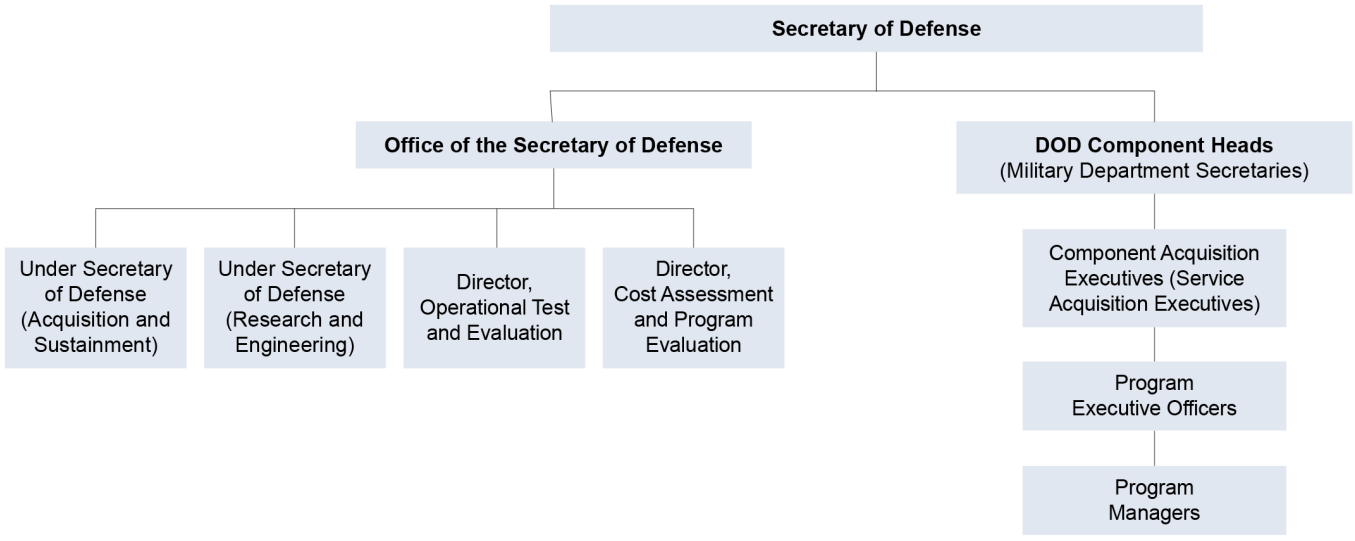
We conducted this performance audit from May 2023 to June 2024 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix III: Department of Defense Responsibilities for Weapon System Acquisitions

Oversight of the Department of Defense's (DOD) costliest weapon systems is shared between several entities within the Office of the Secretary of Defense (OSD) and the military departments. Entities within OSD are responsible for overarching oversight of weapon systems across the department. This includes developing policies that outline oversight responsibilities, providing capabilities to enable reporting and data analysis, conducting or approving independent cost estimates and cost analyses covering the life cycle of major defense acquisition programs (MDAP), and overseeing operational and live fire tests and evaluations.

At the military department level, the component acquisition executives, also referred to as the service acquisition executives, are responsible for implementing DOD acquisition policy within their respective department and serve as the milestone decision authority for most MDAPs. Service acquisition executives at the military department level are also decision authorities for programs using the middle tier of acquisition (MTA) and software acquisition pathways, with some exceptions. Figure 31 depicts the relationship between offices and officials with acquisition oversight responsibilities for the systems we reviewed.

Figure 31: Selected Department of Defense (DOD) Offices and Officials with Acquisition Oversight Roles



Source: GAO analysis of Department of Defense Information. | GAO-24-106831

Table 9 provides a more detailed overview of the specific weapon system acquisition oversight roles for officials across DOD and within the military departments.

Table 9: Summary of Oversight Roles and Responsibilities for Weapon System Acquisitions

Entity	Responsibilities
Office of the Secretary of Defense	
Under Secretary of Defense for Acquisition and Sustainment (USD(A&S))	Establishes policies on and supervises the performance of all matters relating to acquisition (including system design, development, production, and procurement of goods and services) and sustainment (including logistics, maintenance, and materiel readiness). This office has certain oversight responsibilities throughout the acquisition process, such as leading acquisition and sustainment data management and providing capabilities to enable reporting and data analysis. The Under Secretary is the Defense Acquisition Executive and is accountable for the pathways through the defense acquisition system and serves as the milestone decision authority for certain major defense acquisition programs (MDAPs). The Under Secretary also approves the use of the middle tier of acquisition (MTA) pathway for programs that exceed the cost thresholds for designation as a MDAP and maintains responsibility for prototyping activities within the MTA pathway.
Under Secretary of Defense for Research and Engineering (USD(R&E))	Establishes policies on and advises on all aspects of defense research and engineering, technology development, technology transition, developmental prototyping, experimentation, and developmental testing activities and programs. Responsibilities also include advising the USD(A&S) on prototypes that transition to or support acquisition pathways and establishing guidance on the allocation of resources for defense research and engineering. For certain MDAPs, the Under Secretary establishes policy and guidance for the conduct of statutorily required Independent Technical Risk Assessments, which may address areas such as critical technologies. The Under Secretary's office also is to advise USD(A&S) on MTA program technologies, program protection, developmental testing, program risks, and MTA program performance and execution metrics, among other things; and in relation to the software acquisition pathway guides the development of science and technology activities related to next generation software and software reliant systems.
Director, Cost Assessment and Program Evaluation	Conducts or approves independent cost estimates, and cost analyses covering the life cycle of MDAPs, in support of milestone reviews, sustainment reviews, congressional certifications, and budget requests. The Director, Cost Assessment and Program Evaluation also advises USD(A&S) on schedule, resource allocation, affordability, systems analysis, cost estimation, and the performance implications of proposed MTA programs; establishes policies and prescribes procedures for MTA cost data and cost estimates; and conducts an estimate of life-cycle costs for certain MTA programs.
Director, Operational Test and Evaluation	Submits reports of operational and live fire tests and evaluations carried out on MDAPs to the USD(A&S) and USD(R&E), and other senior officials as needed, among other duties.
Military departments	
Military Department Secretaries	Aligns the management of acquisition programs with the principal DOD processes to support affordable design, development, production and sustainment of mission effective capability and services, among other things.

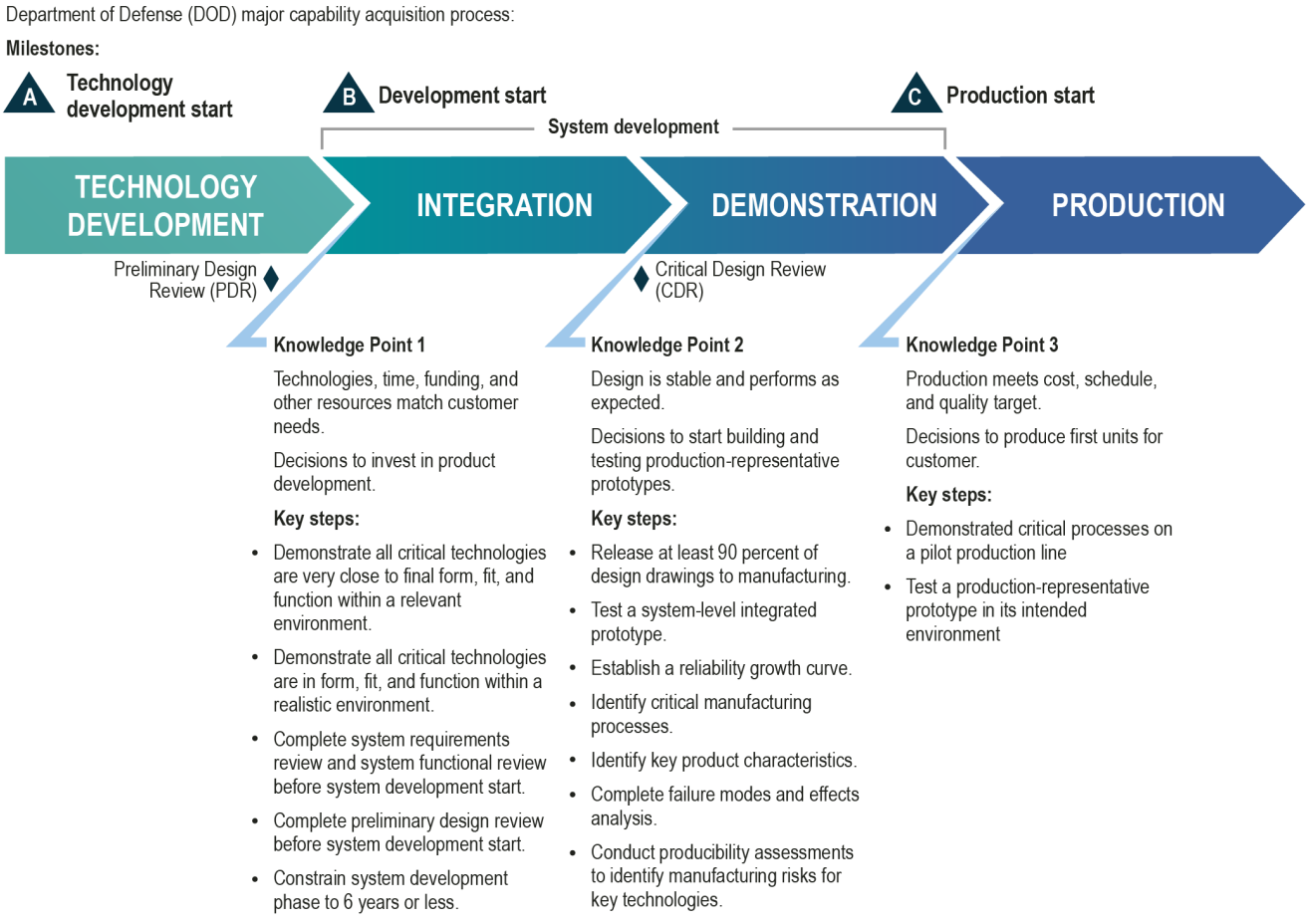
Entity	Responsibilities
Component Acquisition Executive (also referred to as the Service Acquisition Executive)	Implements DOD acquisition policy within their respective component. In the military departments, the officials delegated as Component Acquisition Executives are respectively, the Assistant Secretary of the Army for Acquisition, Logistics, and Technology; the Assistant Secretary of the Navy for Research, Development and Acquisition; and the Assistant Secretary of the Air Force for Acquisition, Technology, and Logistics. Component Acquisition Executives serve as the decision authority for many MDAPs and MTA programs.
Program Executive Officer	Balances the risk, cost, schedule, performance, interoperability, sustainability, and affordability of a portfolio of acquisition programs and delivers an integrated suite of mission effective capability to users.
Program Manager	Under the supervision of the Program Executive Officer and Component Acquisition Executive, plans acquisition programs, prepares programs for key decisions, and executes approved acquisition and production support strategies.

Source: GAO analysis of Department of Defense (DOD) documents. I GAO-24-106831

Appendix IV: Knowledge-Based Acquisition Practices

Our original work on leading product development practices, initiated in the 1990s and updated in subsequent decades, found that successful programs take steps to gather knowledge that confirms their technologies are mature, their designs stable, and that their production processes are in control. These programs ensure a high level of knowledge is achieved at key junctures in development. We characterize these junctures as knowledge points. The Related GAO Products section at the end of this report includes references to the body of work that helped us identify these practices and apply them as criteria in weapon system reviews. Figure 32 summarizes these knowledge points and associated practices.

Figure 32: DOD Major Capability Acquisition Pathway and GAO-Identified Knowledge Points



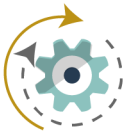
Source: GAO analysis of DOD-provided data, DOD Instruction 5000.85, and GAO's body of knowledge-based acquisition practices. | GAO-24-106831

We are now evolving our work on leading acquisition practices to ensure that our approach to assessing weapon programs keeps up with the challenges facing DOD and other federal agencies. To that end, our latest body of work is focused on assessing the practices used by leading companies to develop innovative products. See appendix V for additional information on these leading practices.

Appendix V: Key Principles for Product Development throughout Iterative Cycles

Leading practices rely on four key principles that, when implemented in a product development, position leading companies to satisfy their customers' needs and deliver complex, innovative products with speed (see fig. 33). These principles propel knowledge gained through iterative cycles of design modeling and simulation, validation, and production (see figs. 34 and 35).

Figure 33: Key Principles Applied During Iterative Cycles Used to Refine Knowledge

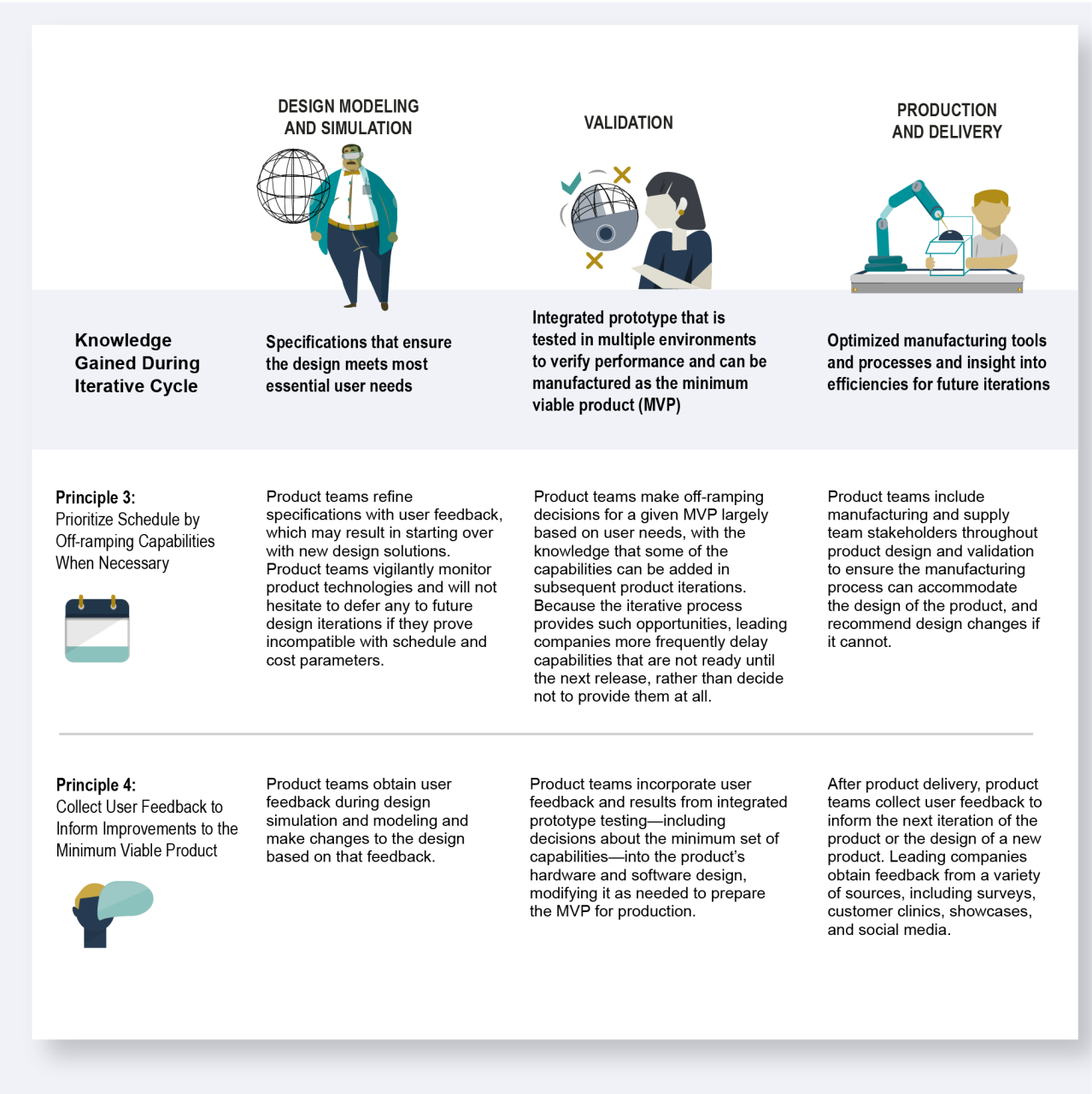
Leading principle	Associated sub-principles
 **Principle 1:** Attain a Sound Business Case that Is Informed by Research along with Collaboration with Users	1. Conduct market research to analyze whether customer and user demand exists or will exist for the product. 2. Solicit input from anticipated customers and users of the product to identify the most important capabilities that the product will need to provide. 3. Plan to allocate funding over time to the product development based on demonstrated progress, including achievement of phased schedule and performance goals. 4. Preserve and rely on institutional memory and corporate knowledge to develop product cost and schedule estimates, avoid repeating earlier mistakes, and build on previous successes. 5. Commit to product delivery and release dates only after collecting sufficient cost, schedule, and performance data needed to instill a high level of confidence that the product iteration can be developed and produced within budget. 6. Employ and empower right-sized teams of multi-disciplined stakeholders that leadership has assessed as having the expertise and experience needed to develop the product. 7. Terminate product development promptly if the product no longer has a sound business case.
 **Principle 2:** Use an Iterative Design Approach that Results in Minimum Viable Products	1. Use modern, digital design tools capable of integrating development of hardware and software. 2. Apply Agile development methodologies to both hardware and software development. 3. Implement iterative design and testing processes to generate a minimum viable product that can be continuously updated and improved after delivery.
 **Principle 3:** Prioritize Schedule by Off-ramping Capabilities When Necessary	1. Implement periodic reviews with senior leadership to keep all stakeholders informed on the product development's progress. 2. Maintain a realistic assessment of product development progress, with a willingness to make difficult decisions about capabilities. 3. Off-ramp capabilities that present a risk to delivering the product on schedule.
 **Principle 4:** Collect User Feedback to Inform Improvements to the Minimum Viable Product	1. Establish a process to facilitate active engagement with customers and users throughout the iterative development process and following product release. 2. Use feedback from customers and users to identify desired improvements to the minimum viable product and inform plans for addressing those in the current and future product releases.

Source: GAO analysis of company information; GAO (icons). | GAO-24-106831

Figure 34: Key Principles to Attain a Sound Business Case and Use Iterative Design Guide Knowledge Gained throughout Iterative Development

Source: GAO analysis of company information; GAO (icons). | GAO-24-106831

Figure 35: Key Principles to Prioritize Schedule and Collect User Feedback Guide Knowledge Gained throughout Iterative Development



Source: GAO analysis of company information; GAO (icons). | GAO-24-106831

Appendix VI: Technology Readiness Levels

Table 10: Technology Readiness Levels (TRL)

TRL	Definition	Description
1.	Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties.
2.	Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative, and there may be no proof or detailed analysis to support the assumption. Examples are still limited to analytical studies.
3.	Analytical and experimental function or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4.	Component or breadboard validation in laboratory environment	Basic technological components are integrated to establish that the pieces will work together. This is relatively low fidelity compared to the eventual system. Examples include integration of ad hoc hardware in a laboratory.
5.	Component or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that they can be tested in a simulated environment. Examples include high fidelity laboratory integration of components.
6.	System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond the breadboard tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in simulated realistic environment.
7.	System prototype demonstration in an operational environment	Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment (e.g., in an aircraft or a vehicle).
8.	Actual system completed and qualified through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.
9.	Actual system proven through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. Examples include using the system under operational conditions.

Source: GAO analysis of Department of Defense information. | GAO-24-106831

Appendix VII: Selected Statutory Provisions That Pertain to the Department of Defense's Software Workforce

We identified two provisions from the National Defense Authorization Acts for Fiscal Years 2022 and 2023 specifically related to the software workforce. Table 11 provides brief summaries of the selected provisions.

Table 11: Selected Statutory Provisions That Pertain to the Software Workforce

Section and title of provision	Brief description of provision
Provisions contained in the National Defense Authorization Act for Fiscal Year 2022	

Sec. 836	• Requires the Secretary of Defense, acting through USD(A&S), to establish a cadre of personnel who are experts in software development, acquisition, and sustainment to improve the effectiveness of software development, acquisition, and sustainment programs or activities of the DOD. Further, it requires USD(A&S) to:
	  • Ensure the cadre has the appropriate number of members.
	  • Establish an appropriate leadership structure and office within which the cadre shall be managed.
	  • Determine the appropriate officials to whom members of the cadre shall report.
	• Further requires the Undersecretary of Defense for Acquisition and Sustainment to establish processes to assign members of the cadre to provide:
	  • Expertise on matters relating to the software development, acquisition and sustainment.
	  • Support for appropriate programs or activities of the DOD.
	• Requires USD(A&S), in coordination with the President of the Defense Acquisition University, to develop a career path, including development opportunities, exchanges, talent management programs, and training for the cadre.
	• In establishing the cadre, requires USD(A&S) to give preference to civilian employees of the DOD.

Section and title of provision	Brief description of provision
Provisions contained in the James M. Inhofe National Defense Authorization Act for Fiscal Year 2023	
Sec. 835	• Requires the President of the Defense Acquisition University to supplement existing training curricula related to software acquisitions and cybersecurity software or hardware acquisitions and offer such curricula to covered individuals to increase digital literacy related to such acquisitions by developing the ability of such covered individuals to use technology to identify, critically evaluate, and synthesize data and information related to such acquisitions. The curricula developed shall provide information on: • Cybersecurity, • Information technology systems, • Computer networks, • Cloud computing, • Artificial intelligence, • Machine learning, • Distributed ledger technologies, • Quantum technologies, • Cybersecurity threats and capabilities • Activities that encompass the full range of threat reduction, vulnerability reduction, deterrence, incident response, resiliency, and recovery policies and activities, including activities relating to computer network operations, information assurance, military missions, and intelligence missions to the extent such activities related to the security and stability of cyberspace, and • The industry best practices relating to software acquisitions and cybersecurity software or hardware acquisitions. • Requires the Secretary of Defense, in consultation with the President of Defense Acquisition University to submit to Congress a comprehensive plan to implement the curricula developed that includes a comparison with similar existing training curricula. The plan is to include a list of resources required for and costs associated with implementation including: • Curriculum development, • Hiring instructors to teach the curriculum, • Facilities, or • Website development. • Requires the President of Defense Acquisition University to offer the developed curricula to covered individuals (which mean an individual serving in a position designated under section 1721(b) of title 10, United States Code, who is regularly consulted for software acquisitions or cybersecurity software or hardware acquisitions. • Requires the Secretary of Defense, in consultation with the President of Defense Acquisition University to submit to Congress a report assessing the costs and benefits of requiring all covered individuals to complete the curricula developed.

Source: GAO analysis of National Defense Authorization Act for Fiscal Year 2022, Pub. L. No. 117–81 and the James M. Inhofe National Defense Authorization Act for Fiscal Year 2023, Pub. L. 117-263. I GAO-24-106831

Appendix VIII: Comments from the Department of Defense

THE ASSISTANT SECRETARY OF DEFENSE
3600 DEFENSE PENTAGON
WASHINGTON, DC 20301-3600

ACQUISITION

Ms. Shelby Oakley
Director, Contracting and National Security Acquisitions
U.S. Government Accountability Office
441 G Street, NW
Washington DC 20548

Dear Ms. Oakley,

This is the Department of Defense (DoD) response to the GAO Draft Report GAO-24-106831, "WEAPON SYSTEMS ANNUAL ASSESSMENT: DoD Is Not Yet Well-Positioned to Field Systems with Speed," dated March 29, 2024 (GAO Code 106831).

The Department partially concurs with Recommendation 1 as written, which would direct the USD(A&S) to update the Middle Tier Acquisition (MTA) transition plan template to ensure that it provides guidance for transition plans included in MTA acquisition strategies to address how the program plans to implement leading practices for product development to deliver fielded capability with speed, within 5 years. A more detailed explanation can be found in our enclosed official written comments, and the Department will concur on this recommendation if it is rewritten to take out reference to the transition plan template and instead directs the guidance to be placed in program acquisition strategies.

The Department concurs with recommendations 2 and 3 regarding fully defining goals for the DoD's Software Cadre and ensuring the USD(A&S) identifies strategies and resources needed to achieve DoD's goals for the Software Cadre.

The Department is also providing technical comments for potential inclusion in the report. These are also enclosed.

The Department appreciates the opportunity to comment on the Draft Final Report. My point of contact for this effort is Ms. Katherine Edgerton, 571-256-1528.

Sincerely,

Cara L. Abercrombie
Assistant Secretary of Defense for Acquisition

Enclosures:
As stated

GAO DRAFT REPORT DATED APRIL 1, 2024
GAO-24-106831 (GAO CODE 106831)

"WEAPON SYSTEMS ANNUAL ASSESSMENT: DOD Is Not Yet Well-Positioned To Field Systems with Speed "

DEPARTMENT OF DEFENSE SUMMARY OF RECOMMENDATIONS

RECOMMENDATION 1: The Secretary of Defense should direct the USD(A&S) to update the Middle Tier of Acquisition (MTA) transition plan template to ensure that it provides guidance for transition plans included in MTA acquisition strategies to address how the program plans to implement leading practices for product development to deliver fieldable capability with speed, within 5 years.

DoD RESPONSE: Partially concur. Transition plans are for the DoD Components to demonstrate they have a process planned to transition successful prototypes to new or existing acquisition programs for production, fielding, and operations and sustainment that will include a timeline for completion within 2 years of all necessary documentation required for transition. The Department is prepared to issue guidance for Middle Tier of Acquisition (MTA) programs requiring programs to document in their acquisition strategies how they will implement leading practices for product development to deliver fieldable capabilities with speed, within 5 years.

RECOMMENDATION 2: The Secretary of Defense should ensure the USD(A&S) fully defines goals for DOD's software cadre, to include long term outcomes and near-term measurable results with timeframes.

DoD RESPONSE: Concur.

RECOMMENDATION 3: The Secretary of Defense should ensure the USD(A&S) identifies strategies and resources needed to achieve DOD's goals for its software cadre, including assessing the internal and external factors that could affect achievement of DOD's goals for its software cadre and how to mitigate them.

DoD RESPONSE: Concur.

Appendix IX: GAO Contact and Staff Acknowledgments

GAO Contact

Shelby S. Oakley, (202) 512-4841 or oakleys@gao.gov

Staff Acknowledgments

Principal contributors to this report were Anne McDonough, Assistant Director; Erin Carson, Assistant Director; Brian Smith, Portfolio Analysis Analyst-in-Charge; Michael H. Moran, Program Assessments Analyst-in-Charge; Peter W. Anderson, Vinayak K. Balasubramanian, Brandon Booth, Gioia Chaouch, Tana M. Davis, Brenna Derritt, Margaret Fisher, Scott W. Hepler, Tonya Humiston, Jaeyung Kim, Wendy P. Smythe, Rachel Steiner-Dillon, Mario D. Tiberie, and Lauren Wright. Other key contributors included Cheryl K. Andrew, David B. Best, Robert Bullock, Raj Chitikila, Christopher R. Durbin, Hans Eggers, Andrea Evans, Marcus C. Ferguson, Laurier R. Fish, Dina Girma, Laura D. Hook, Gina M. Hoover, Justin M. Jaynes, Jessica Karnis, J. Kristopher Keener, Ethan Kennedy, Claire Li, James Madar, Travis J. Masters, Diana Moldafsky, Anh Nguyen, Amanda Parker, John Rastler-Cross, Ronald E. Schwenn, Daniel Singleton, Hunter Stephan, James P. Tallon, Abby C. Volk, and Alyssa B. Weir.

Table 12 lists the staff responsible for individual program assessments.

Table 12: GAO Staff Responsible for Individual Program Assessments

Program name	Primary staff
Air Force Programs	
B-52 Commercial Engine Replacement Program (B-52 CERP)	Megan Setser, Alexis Olson
B-52 Radar Modernization Program (B-52 RMP)	William Reed, Don Springman
E-7A Rapid Prototyping (E-7A RP)	Brian Fersch, Sophia Payind
F-15 Eagle Passive Active Warning Survivability System (F-15 EPAWSS)	Matthew Drerup, Lisa Brown
F-15EX	Jeff Hartnett, Alejandro Coste-Sanchez, Megan Setser
F-22 Rapid Prototyping	Dennis A. Antonio, Sean Seales
Hypersonic Attack Cruise Missile (HACM)	Matthew Ambrose, Mark Luth, Helena Johnson
KC-46A Tanker Modernization (KC-46A)	Jenny Shinn, Ashley Rawson, Maia O'Meara
LGM-35A Sentinel (Sentinel)	Jasmina Clyburn, Ryan Stott, John Crawford
Long Range Standoff (LRSO)	Don Springman, Jean Lee
MH-139A Helicopter (MH-139A)	Gina Flacco, Holly Williams, Julie Kirby
Small Diameter Bomb Increment II (SDB II)	Leigh Ann Haydon, Miranda J. Wickham, Sarah Goubeaux
T-7A Red Hawk (T-7A)	Andrew Redd, Katheryn Hubbell
VC-25B Presidential Aircraft Recapitalization (VC-25B)	LeAnna Parkey, Jenny Shinn, Megha Uberoi
Army Programs	

Program name	Primary staff
CH-47F Block II Modernized Cargo Helicopter (CH-47F Block II)	Wendy Smythe, Margaret Fisher
Extended Range Cannon Artillery (ERCA)	Alexis Olson, Mallory Bryan
Future Attack Reconnaissance Aircraft Program (FARA)	Stephen V. Marchesani, Gioia Chaouch, Christian Burks
Future Long Range Assault Aircraft (FLRAA)	Joe E. Hunter, Stephen V. Marchesani, Joseph Oudin
High Accuracy Detection and Exploitation System (HADES)	Sean Seales, Katheryn Hubbell
Indirect Fire Protection Capability Increment 2 (IFPC Inc 2)	Brian Smith, Brian Tittle
Improved Turbine Engine Program (ITEP)	Jasmina Clyburn, Wendy Smythe
Integrated Visual Augmentation System (IVAS)	Hans Eggers, Megan Stewart
Long Range Hypersonic Weapon System (LRHW)	Matthew L. McKnight, Patrick Breiding, Jacob Wu
Lower Tier Air and Missile Defense Sensor (LTAMDS)	John Rastler-Cross, Michael H. Moran
M10 Booker	Lauren Wright, Sameena Ismailjee, Matthew Whalen
Maneuver Short Range Air Defense Increment 3 (M-SHORAD Inc 3)	Nicole Brockhoff, Joe E. Hunter, Emily Smith
Mid-Range Capability (MRC)	Steven Stern, Michael H. Moran
Precision Strike Missile (PrSM)	Alexandra Schutz, Meghan Kubit, Bobby Younce
XM30 Mechanized Infantry Combat Vehicle (XM30)	Cale Jones, Jennifer Dougherty, Tiaye Wooten
Joint Department of Defense Programs	
F-35 Lightning II (F-35)	Jillena Stevens, Daniel Chandler, Birch Synnott
Navy Programs	
Advanced Anti-Radiation Guided Missile - Extended Range (AARGM-ER)	Adriana Aldgate, Sarah Tempel, Marcus C. Ferguson
Air and Missile Defense Radar (AMDR)	Eli Stiefel, Miranda Wickham, Luke Hagemann
Submarine Tender Recapitalization Program (AS(X))	Kathryn C. Long, Jeffrey Carr
Conventional Prompt Strike (CPS)	Adie Lewis, Matthew L. McKnight
CVN 78 Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)	Burns C. Eckert, Charlie Shivers
DDG 1000 Zumwalt Class Destroyer (DDG 1000)	Timothy Moss, Sean Merrill
DDG 51 Arleigh Burke Class Destroyer, Flight III (DDG 51 Flight III)	Sean Merrill, Eli Stiefel
DDG(X) Guided Missile Destroyer (DDG(X))	Anh Nguyen, Lindsey Cross
E-6B Recapitalization (E-XX)	Brenna Derritt
F/A-18E/F Infrared Search and Track (IRST)	Zachary Sivo, James Cora
FFG 62 Constellation Class Frigate (FFG 62)	Nathan Foster, Taylor Gauthier, Riley Knight
Hypersonic Air-Launched Offensive Anti-Surface Warfare Weapon System (HALO)	Ann Brooks, Victoria Klepacz, Patrick Breiding, Jacob Wu
Large Unmanned Surface Vessel (LUSV)	Natalie Logan, Kya Palomaki
LPD 17 San Antonio Class Amphibious Transport Dock, Flight II (LPD 17 Flight II)	Jeffrey Carr, Hunter Stephan
Medium Landing Ship (LSM)	Jillian Schofield, Andrew Redd
MK 54 MOD 2 Advanced Lightweight Torpedo (ALWT)	Nicolaus R. Heun, Erin Carr, Noelle DuBois
MQ-25 Unmanned Aircraft System (MQ-25 Stingray)	Gioia Chaouch, Jennifer Leone Baker, James Kim

Program name	Primary staff
MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)	Tana Davis, Charlie Shivers
Next Generation Jammer Mid-Band (NGJ MB)	Carmen Yeung, Daniel Glickstein
Orca Extra Large Unmanned Undersea Vehicle (XLUUV)	Joseph Neumeier, Tom Twambly, Schuyler Janzen
Ship to Shore Connector Amphibious Craft (SSC)	Ethan Kennedy, Laura Durbin, Sabrina Riddick
SSBN 826 Columbia Class Ballistic Missile Submarine (SSBN 826)	Brendan K. Orino, Lindsey Cross
SSN 774 Virginia Class Submarine Block V (VCS Block V)	Nathaniel Vaught, Mario Tiberie, Isaac Fifelski
T-AO John Lewis Class Fleet Replenishment Oiler (T-AO 205)	Kya Palomaki, Kathryn C. Long
Space Force Programs	
Deep Space Advanced Radar Capability (DARC)	Jaeyung Kim, Heather Barker Miller
Evolved Strategic SATCOM (ESS)	Andrew Burton, Tanya Waller
Future Operationally Resilient Ground Evolution (FORGE)	Clinton Thurlow, Claire Buck
GPS III Follow-On (GPS IIIF)	Jonathan Mulcare, Matthew Shaffer
Military GPS User Equipment Increment 1 (MGUE Inc 1)	Bonita Oden, Matthew Ambrose
Military GPS User Equipment Increment 2 (MGUE Inc 2)	Leslie Ashton, Aryn Ehlow
National Security Space Launch (NSSL)	Megan Stewart, Desiree E. Cunningham, Erin Roosa
Next Generation Operational Control System (OCX)	Matthew Shaffer, Jonathan Mulcare
Next Generation Overhead Persistent Infrared Geosynchronous Earth Orbit Satellites (Next Gen OPIR GEO)	Claire Buck, Mary Anne S. Sparks
Next Generation Overhead Persistent Infrared Space Polar (Next Gen OPIR Polar)	Claire Buck, Mary Anne S. Sparks
Protected Tactical SATCOM (PTS)	Mary Anne S. Sparks, Brian D. Fersch
Resilient Missile Warning (MW)/Missile Tracking (MT) Medium Earth Orbit (MEO) – Epoch 1	Albirio Madrid, Mary Diop
Tranche 1 Tracking Layer (T1 TRK)	Albirio Madrid, Mary Anne S. Sparks
Tranche 1 and 2 Transport Layers (T1TL and T2TL)	Mary Diop, Albirio Madrid
Weather System Follow-On (WSF)	Nicole Warder, Brenna Derritt

Source: GAO. | GAO-24-106831

Appendix X: Additional Source Information for Images and Figures

This report and appendix contains credit, copyright, and other source information for images, tables, or figures in this product when that information was not listed adjacent to the image, table, or figure.

Front Cover and Highlights Banner:

B-52 Radar Modernization Program (B-52 RMP)
Source: Boeing

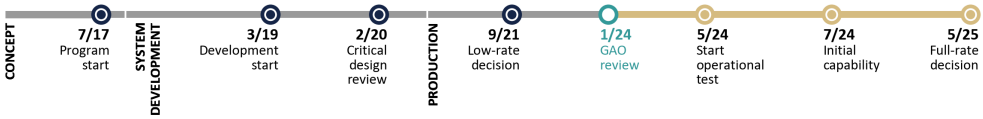
M10 Booker
Source: U.S. Army

Ship to Shore Connector Amphibious Craft (SSC)
Source: U.S. Navy

GPS III Follow-On (GPS IIIF)
Source: Lockheed Martin Corporation

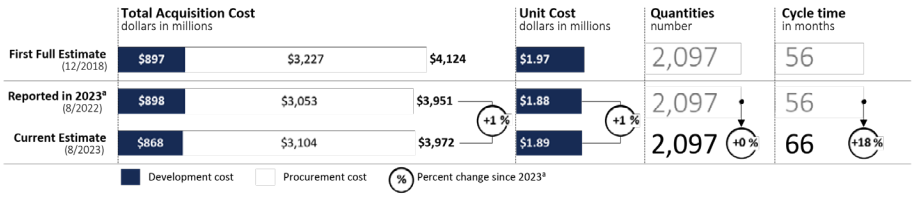
Assessments Graphics:

Timeline:



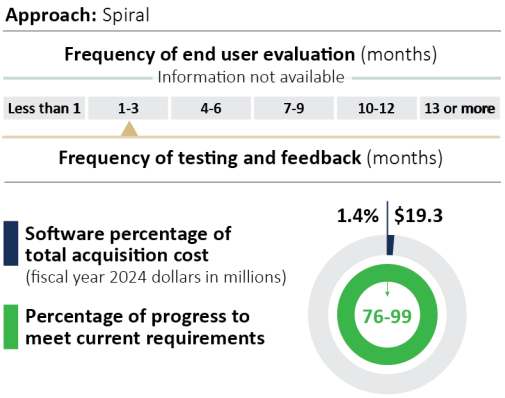
Source: GAO analysis of Department of Defense data.

Program Performance (Major Defense Acquisition Programs):



Source: GAO analysis of Department of Defense data.

Software Development:



Source: GAO analysis of Department of Defense data.

Attainment of Product Knowledge:

Non-shipbuilding program

Attainment of Product Knowledge as of January 2024

Resources and requirements match	Development Start	Current status
Demonstrate all critical technologies in a relevant environment	●	●
Demonstrate all critical technologies in a realistic environment	○	●
Complete a system-level preliminary design review	●	●
Product design is stable	**Design review**	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production start**	
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	○	●

● Knowledge attained ○ Knowledge not attained ··· Information not available NA- Not applicable

Source: GAO analysis of DOD data. | GAO-24-106831

Shipbuilding program

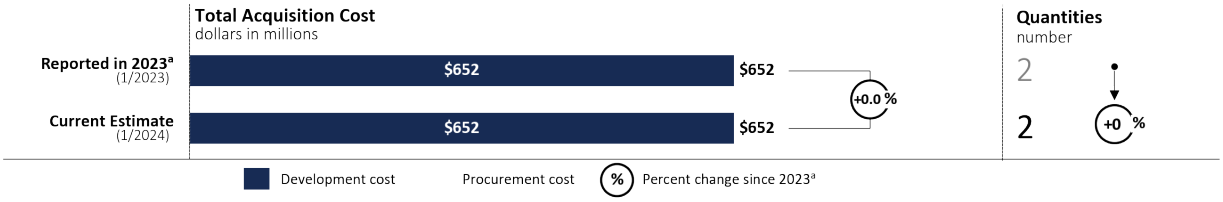
Attainment of Product Knowledge as of January 2024

Resources and requirements match	Detail Design Contract Award	Current status
Demonstrate all critical technologies in a relevant environment	○	○
Demonstrate all critical technologies in a realistic environment	○	○
Complete a system-level preliminary design review	●	●
Product design is stable	**Fabrication start**	
Complete 100 percent of basic and functional design using computer-aided modeling	○	●

● Knowledge attained ○ Knowledge not attained ··· Information not available NA- Not applicable

Source: GAO analysis of Department of Defense data.

Estimated Middle Tier of Acquisition Cost and Quantities:



Source: GAO analysis of Department of Defense data.

Attainment of Business Case Knowledge (MTA programs):

MTA

Attainment of Business Case Knowledge as of January 2024

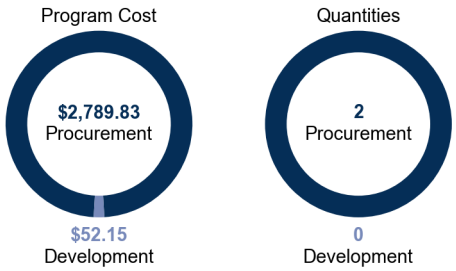
Key Elements of a Business Case	Status at Initiation	Current status
Approved requirements document	●	●
Approved middle tier of acquisition strategy	●	●
Formal technology risk assessment	●	●
Cost estimate based on independent assessment	●	●
Formal schedule risk assessment	●	●

● Knowledge attained ○ Knowledge not attained --- Information not available NA- Not applicable

Source: GAO analysis of DOD data. | GAO-24-106831

Source: GAO analysis of Department of Defense data.

Estimated Cost and Quantities (Future Major Weapon Acquisitions and MDAP Increments):



Source: GAO analysis of Department of Defense data.

Related GAO Products

Annual Weapon Systems Assessments

Weapon Systems Annual Assessment: Programs Are Not Consistently Implementing Practices That Can Help Accelerate Acquisitions. GAO-23-106059. Washington, D.C.: June 8, 2023.

Weapon Systems Annual Assessment: Challenges to Fielding Capabilities Faster Persist. GAO-22-105230. Washington, D.C.: June 8, 2022.

Weapon Systems Annual Assessment: Updated Program Oversight Approach Needed. GAO-21-222. Washington, D.C.: June 8, 2021.

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

Weapon Systems Annual Assessment: Limited Use of Knowledge-Based Practices Continues to Undercut DOD's Investments. GAO-19-336SP. Washington, D.C.: May 7, 2019.

In-Depth Assessments of Selected Weapon Programs or Portfolios

Optionally Manned Fighting Vehicle: Observations on the Objectivity, Validity, and Reliability of the Army's Report. GAO-23-106549. Washington, D.C.: June 27, 2023.

GPS Modernization: Space Force Should Reassess Requirements for Satellites and Handheld Devices. GAO-23-106018. Washington, D.C.: June 5, 2023.

F-35 Joint Strike Fighter: More Actions Needed to Explain Cost Growth and Support Engine Modernization Decision. GAO-23-106047. Washington, D.C.: May 30, 2023.

Advanced Pilot Trainer: Program Success Hinges on Better Managing Its Schedule and Providing Oversight. GAO-23-106205. Washington, D.C.: May 18, 2023.

Missile Defense: Annual Goals Unmet for Deliveries and Testing. GAO-23-106011. Washington, D.C.: May 18, 2023.

Future Vertical Lift Aircraft: Army Should Implement Leading Practices to Mitigate Acquisition Risk. GAO-23-105554. Washington, D.C.: April 17, 2023.

Columbia Class Submarine: Program Lacks Essential Schedule Insight amid Continuing Construction Challenges. GAO-23-106292. Washington, D.C.: January 24, 2023.

Battle Management: DOD and Air Force Continue to Define Joint Command and Control Efforts. GAO-23-105495. Washington, D.C.: January 13, 2023.

Tactical Aircraft Investments: DOD Needs Additional Portfolio Analysis to Inform Future Budget Decisions. GAO-23-106375. Washington, D.C.: December 20, 2022.

Extra Large Unmanned Undersea Vehicle: Navy Needs to Employ Better Management Practices to Ensure Swift Delivery to the Fleet. GAO-22-105974. Washington, D.C.: September 28, 2022.

GPS Alternatives: DOD Is Developing Navigation Systems but Is Not Measuring Overall Progress. GAO-22-106010. Washington, D.C.: August 5, 2022.

Missile Defense: Better Oversight and Coordination Needed for Counter-Hypersonic Development. GAO-22-105075. Washington, D.C.: June 16, 2022.

GPS Modernization: Better Information and Detailed Test Plans Needed for Timely Fielding of Military User Equipment. GAO-22-105086. Washington, D.C.: May 9, 2022.

F-35 Joint Strike Fighter: Cost Growth and Schedule Delays Continue. GAO-22-105128. Washington, D.C.: April 25, 2022.

Navy Shipbuilding: Increasing Supervisors of Shipbuilding Responsibility Could Help Improve Program Outcomes. GAO-22-104655. Washington, D.C.: April 12, 2022.

Uncrewed Maritime Systems: Navy Should Improve Its Approach to Maximize Early Investments. GAO-22-104567. Washington, D.C.: April 7, 2022.

Missile Defense: Addressing Cost Estimating and Reporting Shortfalls Could Improve Insight into Full Costs of Programs and Flight Tests. GAO-22-104344. Washington, D.C.: February 2, 2022.

KC-46 Tanker: Air Force Needs to Mature Critical Technologies in New Aerial Refueling System Design. GAO-22-104530. Washington, D.C.: January 27, 2022.

Acquisition Policy and Reform

Defense Industrial Base: DOD Needs Better Insight into Risks from Mergers and Acquisitions. GAO-24-106129. Washington, D.C.: October 17, 2023.

Research and Development: DOD Benefited from Financial Flexibilities but Could Do More to Maximize Their Use. GAO-23-105822. Washington, D.C.: June 29, 2023.

High-Risk Series: Efforts Made to Achieve Progress Need to Be Maintained and Expanded to Fully Address All Areas. GAO-23-106203. Washington, D.C.: April 20, 2023.

Middle-Tier Defense Acquisitions: Rapid Prototyping and Fielding Requires Changes to Oversight and Development Approaches. GAO-23-105008. Washington, D.C.: February 7, 2023.

Defense Industrial Base: DOD Should Take Actions to Strengthen Its Risk Mitigation Approach. GAO-22-104154. Washington, D.C.: July 7, 2022.

High-Risk Series: Key Practices to Successfully Address High-Risk Areas and Remove Them from the List. GAO-22-105184. Washington, D.C.: March 3, 2022.

Defense Acquisitions: Additional Actions Needed to Implement Proposed Improvements to Congressional Reporting. GAO-22-104687. Washington, D.C.: February 28, 2022.

Software and Cybersecurity in Acquisition Programs

Defense Software Acquisitions: Changes to Requirements, Oversight, and Tools Needed for Weapon Programs. GAO-23-105867. Washington, D.C.: July 20, 2023.

IT Systems Annual Assessment: DOD Needs to Improve Performance Reporting and Development Planning. GAO-23-106117. Washington, D.C.: June 13, 2023.

Software Acquisition: Additional Actions Needed to Help DOD Implement Future Modernization Efforts. GAO-23-105611. Washington, D.C.: April 5, 2023.

Business Systems: DOD Needs to Improve Performance Reporting and Cybersecurity and Supply Chain Planning. GAO-22-105330. Washington, D.C.: June 14, 2022.

Defense Acquisitions: Cyber Command Needs to Develop Metrics to Assess Warfighting Capabilities. GAO-22-104695. Washington, D.C.: March 30, 2022.

Artificial Intelligence: Status of Developing and Acquiring Capabilities for Weapon Systems. GAO-22-104765. Washington, D.C.: February 17, 2022.

GAO Guides

Agile Assessment Guide: Best Practices for Agile Adoption and Implementation. GAO-24-105506. Washington, D.C.: November 2023.

Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Program Costs. GAO-20-195G. Washington, D.C.: March 2020.

Technology Readiness Assessment Guide: Best Practices for Evaluating the Readiness of Technology for Use in Acquisition Programs and Projects. GAO-20-48G. Washington, D.C.: January 7, 2020.

Leading Acquisition Practices

Leading Practices: Iterative Cycles Enable Rapid Delivery of Complex, Innovative Products. GAO-23-106222. Washington, D.C.: July 27, 2023.

Leading Practices: Agency Acquisition Policies Could Better Implement Key Product Development Principles. GAO-22-104513. Washington, D.C.: March 10, 2022.

Defense Acquisitions: Senior Leaders Should Emphasize Key Practices to Improve Weapon System Reliability. GAO-20-151. Washington, D.C.: January 14, 2020.

Navy Shipbuilding: Past Performance Provides Valuable Lessons for Future Investments. GAO-18-238SP. Washington, D.C.: June 6, 2018.

Best Practices: DOD Can Achieve Better Outcomes by Standardizing the Way Manufacturing Risks Are Managed. GAO-10-439. Washington, D.C.: April 22, 2010.

Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding. GAO-09-322. Washington, D.C.: May 13, 2009.

Defense Acquisitions: A Knowledge-Based Funding Approach Could Improve Major Weapon System Program Outcomes. GAO-08-619. Washington, D.C.: July 2, 2008.

Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes. GAO-02-701. Washington, D.C.: July 15, 2002.

Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes. GAO-01-288. Washington, D.C.: March 8, 2001.

Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes. GAO/NSIAD-99-162. Washington, D.C.: July 30, 1999.