United States Government Accountability Office

Report to Congressional Committees

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Weapon Systems Annual Assessment

DOD Leaders Should Ensure That Newer Programs Are Structured for Speed and Innovation

NAVY | ARMY | AIR FORCE | SPACE FORCE

GAO-25-107569

GAO Highlights

Highlights of GAO-25-107569

A Report to Congressional Committees June 2025

Weapon Systems Annual Assessment

DOD Leaders Should Ensure That Newer Programs Are Structured for Speed and Innovation

NAVY ARMY AIR FORCE SPACE FORCE

Future Long Range Assault Aircraft (FLRAA), LGM-35A Sentinel, and GPS III Follow-On (GPS IIIF)

Source: Bell Textron, Inc.; U.S. Air Force; and Lockheed Martin Corporation, respectively. | GAO-25-107569

Why GAO Did This Study

DOD plans to invest nearly $2.4 trillion to develop and acquire its costliest weapon programs. But it continues to struggle with delivering timely and effective solutions to the warfighter. Weapon systems are more complex and software-driven than ever before. DOD implemented recent reforms intended to lead to faster results, but slow, linear development approaches persist.

This report, GAO's 23rd 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 106 of DOD's costliest weapon programs.

It further analyzes selected programs' implementation of leading practices for product development, as described in GAO-23-106222, among other objectives.

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

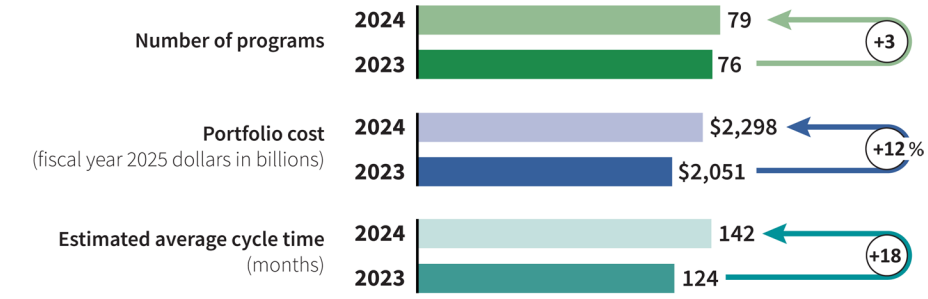
What GAO Found

The Department of Defense (DOD) continues to struggle with delivering innovative technologies quickly and within budget. Since its last annual assessment, GAO found:

- Program development delays and inflation, among other things, contributed to cost growth in the major defense acquisition program (MDAP) portfolio.
- Programs spent development time on efforts with low levels of maturity while using the middle tier of acquisition (MTA) pathway intended for speed.
- Future major weapon acquisitions (newer efforts that have yet to begin on a pathway) did not take full advantage of product development practices that lead to efficiencies.

Program challenges and inflation drove major defense acquisition program portfolio costs. Combined total estimates increased by $49.3 billion for 30 MDAPs also included in last year's report. The Air Force's Sentinel missile program accounted for over $36 billion (73 percent) of this increase.

Major Defense Acquisition Programs Continue to Delay Capability Deliveries



Source: GAO analysis of Department of Defense data. | GAO-25-107569

DOD plans to invest $44.5 billion across 20 of its most expensive MTA programs—intended to be completed in 2 to 5 years. Combined costs increased by about 3 percent for 14 programs we also assessed last year—despite one program reducing the number of units it intended to buy and another program ending earlier than planned.

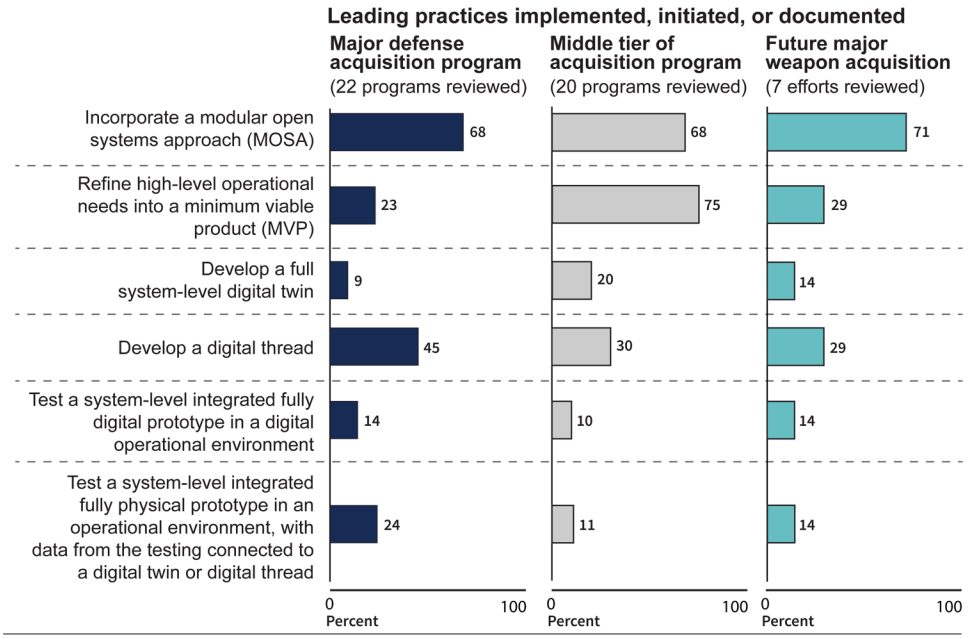
Further, schedule delays persisted. The expected time for MDAPs to provide even an initial capability increased this year by 18 months, up to almost 12 years from the program's start—an average that includes MDAPs that began as MTAs. Several MDAPs reported delays to expected initial operational capability by more than a year, while some MTA programs plan to deliver initial capability to the warfighter multiple years after the current MTA programs end.

Some programs used the MTA pathway to develop critical technologies. Some programs entered the MTA pathway—used for rapid prototyping and rapid fielding efforts—with low levels of technology maturity, resulting in lengthy development instead of the speed for which that pathway was designed. GAO also reviewed seven former MTA programs with low levels of technology maturity at MTA initiation. GAO found that none were ready for production or fielding when the effort ended and will continue to monitor this issue.

Future programs do not plan to fully use leading practices before initiation. Opportunities exist for future major weapon acquisitions that have yet to start on an adaptive acquisition pathway to leverage leading practices during the earliest stages of the program—before they become locked into rigid requirements, budgets, and development approaches. These future programs reported that they intended to incorporate leading practices generally at levels at or below the levels reported by current MDAPs or MTAs. This is because decision-makers in DOD and across the military services do not take steps to ensure that future programs include leading practices (discussed below). Incorporating leading practices prior to formally starting a new program can help programs take full advantage of the efficiencies they provide.

Most programs GAO reviewed do not fully implement leading practices in concert to achieve efficiencies. For example, most programs reported using a modular open systems approach—generally required by statute—which allows them to easily add or replace weapon parts over time. Few, however, reported plans to establish a minimum viable product (an initial set of capabilities that can be iterated upon), use digital twinning (a virtual representation of a physical product), or use digital threads (real-time data to inform decision-making). These practices are most effective when they are used together as part of an iterative approach to product development.

Most Programs GAO Reviewed Do Not Fully Implement Leading Practices, Including Future Efforts That Are Newer and Have Opportunities to Do So



Source: GAO analysis of programs' questionnaire responses. | GAO-25-107569

GAO made seven recommendations in March 2022 and December 2024 for DOD and military services to update acquisition policies and guidance to reflect leading practices that facilitate speed and innovation. DOD concurred with six recommendations and partially concurred with one to the Army, stating that the Army did not consider it fully applicable to a specific pathway. GAO maintains its applicability.

What GAO Recommends

GAO is recommending that DOD leadership take steps to ensure that future major weapon acquisition programs include leading practices for product development during the earliest stages of the programs. DOD concurred with the recommendations.

View GAO-25-107569. For more information, contact Shelby S. Oakley at oakleys@gao.gov.

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Abbreviations

AAF	Adaptive Acquisition Framework
ACAT	acquisition category
COA	course of action
DAES	Defense Acquisition Executive Summary
DAVE	Defense Acquisition Visibility Environment
DOD	Department of Defense
IOC	initial operational capability
MCA	major capability acquisition
MDAP	major defense acquisition program
MTA	middle tier of acquisition
MVP	minimum viable product
MOSA	modular open systems approach
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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Comptroller General
of the United States

June 11, 2025

Congressional Committees

For 15 years as GAO's Comptroller General, I have presented our annual assessment of the Department of Defense's (DOD) most expensive weapon system acquisition programs. I am once again pleased to present our report this year, which is the 23rd annual report issued by GAO. The report measures how effective these efforts are and highlights efficiencies that could save taxpayer dollars on the nearly $2.4 trillion DOD expects to spend across its portfolio. It also provides DOD and congressional leadership with a decision-making tool through a "quick look" of each program's performance and risk, as well as its developmental progress and use of leading practices.

The need for smart spending and increased urgency and innovation in DOD's weapon system acquisitions are national imperatives. Our government can no longer afford to invest billions of dollars to develop less than the most advanced technologies in an environment of mounting federal debt and ascendent near-peer threats. The sophistication of new technologies—like biotechnology and microelectronics—and the rise of artificial intelligence and machine learning models have enabled our adversaries to seize upon rapid innovation and development to be used for military gain.

However, our findings over my 15 years have grown increasingly dire. DOD weapon systems continue to cost more and take even longer to deliver, notwithstanding recent reforms. This year we found that one major defense acquisition program (MDAP)—the Air Force's Sentinel intercontinental ballistic missile program—reported a $36 billion increase. Further, the average expected time for MDAPs to provide the warfighter with an initial capability increased by a year and a half, up to almost 12 years from the program's start. These delays put the warfighter at risk of receiving weapon systems that do not deliver needed capabilities. This average time frame increased despite the inclusion of MDAPs that began on the middle tier of acquisition pathway—an acquisition approach intended to facilitate speed.

DOD has made progress in some areas. Our most recent High-Risk report highlights that DOD is placing more emphasis on securing its

supply chains.[1] It issued its first National Defense Industrial Strategy and implementation plan and released its Acquisition and Sustainment Workforce Framework aimed at building acquisition and sustainment skills and capabilities, among other things. However, we have yet to see actions to back up strategy documents that call for speed and innovation in weapons acquisition. Rather, we see a persistent disconnect between written goals and actions that leaders need to take to ensure change.

Throughout my tenure, I have noted DOD's efforts and its challenges to evolve its approach to these critical acquisitions, particularly as new threat environments challenge its sluggish system. Given the amount of federal funds spent and the critical missions DOD supports, DOD has consistently underscored the importance of acquisition programs achieving efficiencies and effectiveness, and Congress has passed related legislation. DOD has an opportunity to leverage new acquisition approaches, such as the middle tier of acquisition pathway, that could result in cost savings and schedule efficiencies needed to reverse the trend we have reported on for the past 2 decades. This annual report offers DOD and congressional leadership insight to make decisions that invest taxpayer dollars more wisely and deliver weapon systems quicker.

//SIGNED//

Gene L. Dodaro
Comptroller General of the United States

[1]GAO, *High-Risk Series: Heightened Attention Could Save Billions More and Improve Government Efficiency and Effectiveness,* GAO-25-107743 (Washington, D.C.: Feb. 25, 2025).

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In response to title 10, section 3072 of the United States Code, this report provides insight into 106 of the Department of Defense's (DOD) most costly weapon programs.[2] Specifically, this report covers the following sets of programs:

- 79 major defense acquisition programs (MDAP),
- 20 programs currently using the middle tier of acquisition (MTA) pathway, and
- seven future major weapon acquisitions.[3]

This report assesses (1) how DOD's portfolio of its costliest weapon programs and selected programs have performed over time; (2) the extent to which opportunities exist to improve program outcomes using leading product development practices; and (3) the extent to which programs are implementing modern software development approaches and recommended cybersecurity practices.

To conduct our work, we analyzed cost and schedule data from a variety of sources, including 2024 Defense Acquisition Executive Summaries (DAES), December 2023 Modernized Selected Acquisition Reports (the latest available at the time of our review), MTA Program Identification

[2]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 initiatives by March 30 of each year from 2020 through 2029. 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.

[3]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. For the purposes of this report, the phrase "future major weapon acquisitions" includes programs planning to develop their systems on the major capability acquisition pathway, as well as efforts that are yet to be initiated on another pathway whose costs are expected to exceed the threshold for designation as an MDAP. This includes efforts in research and development and programs in pre-system development.

Data, and cost data provided by program offices.[4] We determined that the 2024 DAES data, December 2023 Modified Selected Acquisition Report data, and MTA program cost data were sufficiently reliable for the purposes of reporting program cost and schedule information.

We provided a questionnaire to 69 programs to obtain information on

- programs' schedule performance,
- the extent to which programs were using leading acquisition practices, and
- programs' approach to software development and cybersecurity practices.

These 69 programs represent a subset of the overall 106 programs included in our portfolio analysis.[5] Specifically, it includes seven future major weapon acquisitions, 20 programs using the MTA pathway, and 42 MDAPs and MDAP increments, for which we completed more detailed program assessments (see appendix I).[6]

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

We conducted this performance audit from May 2024 to June 2025 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

[4]Department of Defense, *Operation of the Middle Tier of Acquisition,* DOD Instruction 5000.80 (Dec. 30, 2019) (incorporating change 1, Nov. 25, 2024). 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.

[5]We did not complete a one- or two-page assessment for the remaining 37 MDAPs because those programs have already reached full-rate production or, if there is no full-rate production milestone, initial operational capability.

[6]While we assessed 20 MTA efforts, we completed 17 assessments. Assessments were combined for: 1) Space Force's Tranche 1 and Tranche 2 Transport Layers MTA efforts; 2) Space Force's Tranche 1 and Tranche 2 Tracking Layers MTA efforts; 3) Army's Integrated Visual Augmentation System rapid fielding and rapid prototyping MTA efforts; and 4) Army's Long Range Hypersonic Weapon future major weapon acquisition and MTA effort.

the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Defense Acquisition Pathways

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.[7] 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 also states that the defense acquisition system will be designed to acquire products 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.

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 DOD is acquiring. 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.[8] DOD has issued policy documents to address each of these six acquisition pathways. It has also issued functional policy

[7]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).

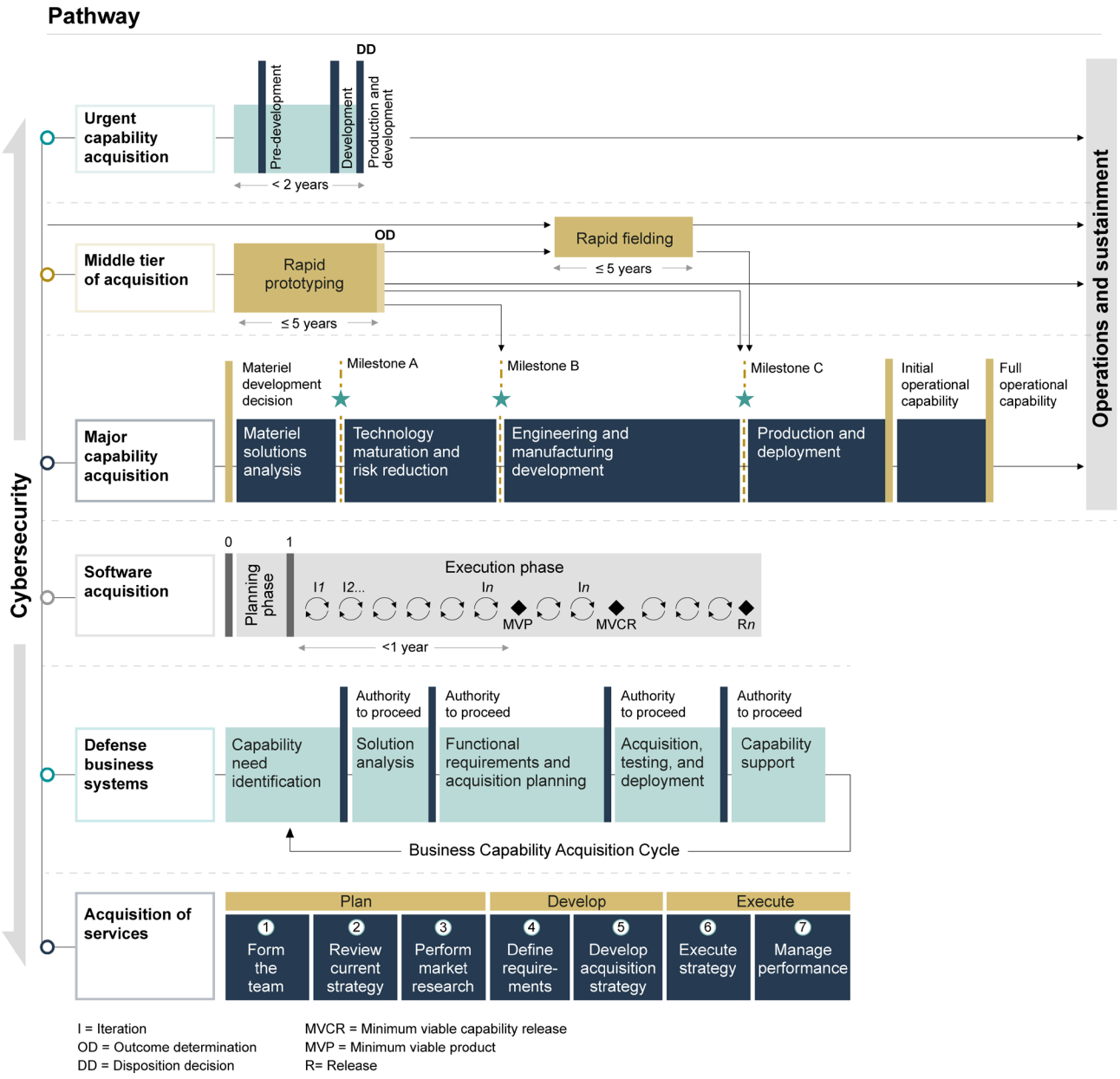
[8]According to DOD Instruction 5000.02, the milestone decision authority is the program decision authority and specifies the decision points and procedures for assigned programs. Milestone decision authorities for MDAPs and major systems will approve, as appropriate, the acquisition strategy at all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

documents in areas such as engineering and test and evaluation.[9] In November 2024, DOD issued updates to the MTA pathway policy.[10] DOD plans to revise the major capability acquisition (MCA) pathway policy. But, as of February 2025, the Office of the Under Secretary of Defense (USD) for Acquisition and Sustainment (A&S) did not have a time frame for these revisions. Figure 1 shows the AAF pathways.

[9]Additional functional policy documents include Department of Defense, *Engineering of Defense Systems*, DOD Instruction 5000.88 (Nov. 18, 2020)*; Test and Evaluation*, DOD Instruction 5000.89 (Nov. 19, 2020); and *Cost Analysis Guidance and Procedures*, DOD Instruction 5000.73 (Oct. 24, 2024).

[10]Department of Defense, *Operation of the Middle Tier of Acquisition*, DOD Instruction 5000.80 (Dec. 30, 2019) (incorporating change 1, Nov. 25, 2024).

Figure 1: Adaptive Acquisition Framework Pathways



Source: GAO analysis of Department of Defense (DOD) data. I GAO-25-107569

In this report, we focus on selected programs using the (1) MCA pathway, used by MDAPs; and (2) MTA pathway, used for rapid prototyping and rapid fielding efforts. We also include selected future major weapon acquisitions that are expected to exceed the MDAP cost threshold but have yet to initiate on, or complete their transition to, an AAF pathway. Lastly, we 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.[11] 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:

- Approval for entry into the technology maturation and risk reduction phase occurs during a milestone A review, which includes, among other things, an acquisition strategy, business approach, cost targets, and program risks and mitigation.
- Approval for entry into the engineering and manufacturing development phase occurs during a milestone B review, which includes, among other things, a demonstration that sources of risk have been adequately mitigated, validated capability requirements, and full funding within the Future Years Defense Program—DOD's annual projection of its needs over a 5-year period.
- Approval for entry into the production and deployment phase occurs during a milestone C review, which includes, among other things, consideration of results from testing, evidence that the production design is stable, the maturity of the software, and any significant manufacturing risks.

[11]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 an 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); 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). Certain programs that meet these thresholds, including programs using the MTA pathway, are not considered MDAPs. See 10 U.S.C. § 4201(b).

In this report, we refer to these three phases as technology development, system development, and production, respectively.

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.[12] 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.[13] The guidance encouraged DOD components using the MTA pathway to develop specific implementation processes and procedures for the interim authority. In December 2019, DOD Instruction 5000.80, *Operation of the Middle Tier of Acquisition*, was issued and formally established the department's MTA policy, assigned responsibilities, and prescribed procedures for the management of the MTA rapid prototyping and rapid fielding paths. In November 2024, DOD Instruction 5000.80 was updated to reflect statutory changes and changes implemented through other policies.[14] In December 2024, Congress passed legislation that codified the MTA pathway and added new provisions affecting the pathway, including requirements related to iterative prototyping and fielding.[15]

DOD's MTA 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. It states that not all programs are appropriate for the MTA pathway. Major systems intended to satisfy requirements that are critical to a major interagency requirement, are primarily focused on technology development, or have significant international partner involvement are discouraged from using the MTA

[12]See Pub. L. No. 114-92, § 804 (2015).

[13]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).

[14]Department of Defense, *Operation of the Middle Tier of Acquisition*, DOD Instruction 5000.80 (Dec. 30, 2019) (incorporating change 1, Nov. 25, 2024).

[15]See Servicemember Quality of Life Improvement and National Defense Authorization Act for Fiscal Year 2025, Pub. L. No. 118-159, § 804 (2024). This statute repealed section 804 of the NDAA for Fiscal Year 2016.

pathway.[16] DOD components can use the pathway to accelerate capability maturation before transitioning to another acquisition pathway or to minimally develop a capability before rapid fielding, which is discussed below.

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 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, complete fielding within 5 years of the MTA program's start date, and enter into operations and sustainment.[18]

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

[16]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; or (3) the agency head responsible for the system designates the system as a major system. See 10 U.S.C. § 3041(a)-(c); DOD Instruction 5000.85 (reflecting statutory major system cost thresholds in fiscal year 2020 constant dollars).

[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 the MTA pathway are outlined in title 10, section 3602 of the U.S. Code.

were first obligated—the metric established in DOD's 2018 Interim Guidance.

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

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. 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 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.

As previously mentioned, DOD issued updates to DOD Instruction 5000.80 in November 2024. Among the changes are

- clarification that when determining if an MTA program's costs meet the threshold for designation as an MDAP, the statutory thresholds in title 10, section 4201 of the U.S. Code should be applied to the total estimated MTA cost over the MTA period, which should not exceed 5 years;

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

- references to the Defense Acquisition University's (DAU) Adaptive Acquisition Framework Document Identification tool;[20] and
- encouragement to use modern software practices, such as Agile, as well as Agile metrics and value assessments, where appropriate.

Software Acquisition Pathway

The software acquisition pathway is governed by title 10, section 3603 of the U.S. Code and 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. DOD's policy does not require weapon programs to use the software acquisition pathway when they develop software.

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.[21] The pathway requires several features of modern software development, such as the use of modern iterative software development methodologies, as well as early and frequent end user feedback. In 2023, we found that the requirements processes used by weapon programs developing software outside of the software acquisition pathway generally do not incorporate Agile principles. By not incorporating Agile principles into requirements processes, these programs risk developing capabilities that may not reflect changing user needs or threats. We recommended that DOD

[20]DAU created this resource to support acquisition officials in their efforts to identify applicable statutory and regulatory documentation requirements for each of the six pathways within the AAF, including the MTA pathway. However, in 2023, we found several instances in which the guidance provided in this tool did not consistently reflect the actual MTA documentation requirements outlined in policy and statute. DOD concurred with our recommendation that it work with DAU to update this tool to accurately reflect MTA documentation requirements. While the recommendation remains open, DAU has taken steps to update the tool to reflect MTA pathway requirements and we are coordinating with it to substantiate its progress. See 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).

[21]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).

incorporate Agile principles into requirements policy and guidance for all programs using Agile for software development. DOD partially concurred with this recommendation and said that it is planning to update requirements policy for software embedded in platforms.[22]

In March 2025, a memorandum from the Secretary of Defense directed DOD components to adopt the software acquisition pathway as the preferred pathway for all software development components of weapon systems.[23] The memorandum stated that it is a top priority for DOD to reform its acquisition processes to acquire, deliver, and iterate on weapon systems at speed and scale for the warfighter. We will continue to monitor DOD's implementation plan and subsequent efforts in response to this memorandum in future work.

Defense Acquisition Pathway Oversight

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. 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 departments.

The service acquisition executives serve as the milestone decision authority for most MDAPs and are also the decision authorities for programs using the MTA pathway, with some exceptions. More specifically, service acquisition executives approve MDAPs at milestone A for entry into technology development and at each of the subsequent milestones. They also validate a program's rationale for using the MTA pathway and sign an acquisition decision memorandum. Space Force acquisition programs are under the authority of the Assistant Secretary of the Air Force for Space Acquisition and Integration. Appendix III provides more detail on oversight responsibilities for DOD weapon systems.

Leading Practices for Product Development

In July 2023, we reported that leading companies use iterative cycles to design, validate, and deliver complex cyber-physical products with

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

[23]Department of Defense, *Directing Modern Software Acquisition to Maximize Lethality* (Mar. 6, 2025).

speed.[24] Cyber-physical systems—sometimes called hybrid systems—are co-engineered networks of hardware and software that combine computation, communication, sensing, and actuation (the process of accepting a signal and converting it to a physical action) with physical systems.[25] 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, robotic autonomous systems, 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 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.

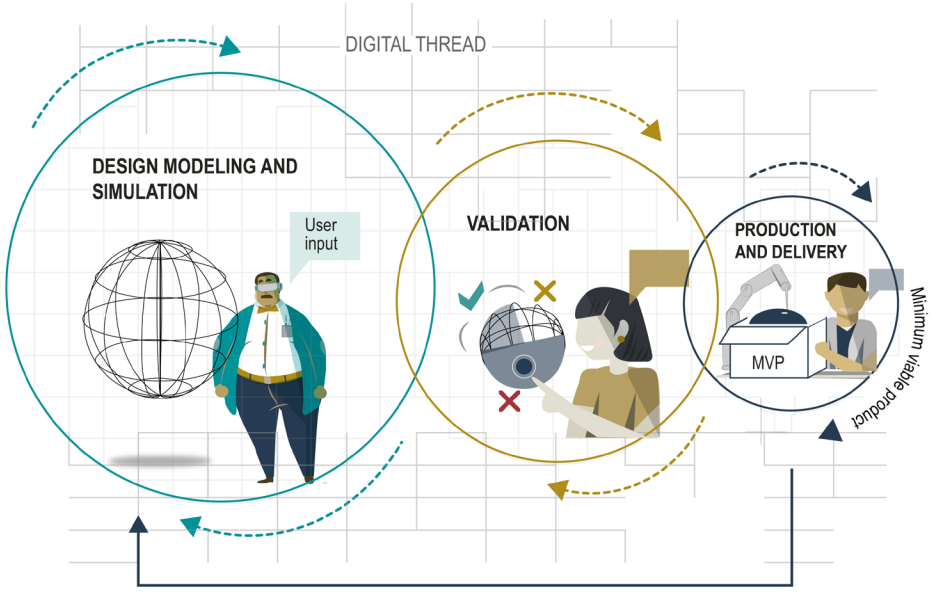
Source: GAO analysis. I GAO-25-107569

[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.

[25]Internet of Things is a related concept that overlaps with cyber-physical systems. The National Institute of Standards and Technology has noted that cyber-physical systems and Internet of Things are converging over time to include a common emphasis on hybrid systems of interacting digital, analog, physical, and human components. U.S. Department of Commerce, National Institute of Standards and Technology, *Framework for Cyber-Physical Systems: Volume 1, Overview, Version 1.0*, NIST Special Publication 1500-201 (June 2017). See also GAO, *Weapon Systems Cybersecurity: DOD Just Beginning to Grapple with Scale of Vulnerabilities*, GAO-19-128 (Washington, D.C.: Oct. 9, 2018).

Activities in these iterative cycles often overlap as the design undergoes continuous user engagement and testing. As the cycles proceed, product teams at leading companies refine the design to achieve a minimum viable product—one with the initial set of capabilities needed for customers to recognize value suitable for them to field 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 2 depicts key elements of this approach.

Figure 2: Leading Companies Progress Through Iterative Design, Validation, and Production Cycles to Develop a Minimum Viable Product



Source: GAO analysis and illustration of company information. | GAO-25-107569

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.

- **Digital threads:** a common source of information that connect stakeholders with real-time data across the product life cycle to help inform decisions.
- **Modularity:** allows common elements to be combined and reused while retaining security and reliability.

Table 2 provides more detail on the feedback and knowledge acquired within the iterative development cycles.

Table 2: Product Development Cycles Characterized by User Feedback and Refined Knowledge Captured Within a Digital Thread

	Product Development Cycles		
	Design modeling and simulation cycle	**Validation cycle**	**Production and delivery cycle**
User feedback	Users provide input to define design specifications for the minimum viable product, using multiple iterations as needed	Users agree design meets needs for minimum viable product, or design returns to modeling and simulation	Users provide feedback on desired product improvements to inform subsequent iterations
Knowledge captured within a digital thread	Specifications that ensure the design meets most essential user needs	Validated performance in multiple environments captured by testing integrated prototypes. Evidence the minimum viable product can be manufactured.	Optimized manufacturing tools and processes and insight into efficiencies for future iterations

Source: GAO analysis of company information. I GAO-25-107569

The iterative cycles of designing, validating, and delivering cyber-physical products are underpinned by four key principles (see fig. 3).[26] These principles are not a sequential process. Rather, they are established early in product development and are revisited and refreshed constantly thereafter.

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

Figure 3: 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 and illustration of company information. | GAO-25-107569

We previously found that DOD's primary, department-wide acquisition policies do not fully implement these principles and most of their associated sub-principles (see appendix IV for listing of sub-principles).[27] Our work found that DOD's 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 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 would consider implementing the leading product development principles when it updates its acquisition policies. However, in February 2025, we reported that DOD had not updated its acquisition policies to fully incorporate leading practices.[28] The revised MTA policy that DOD issued in November 2024 did not fully implement leading practices to achieve positive outcomes, and DOD has yet to revise its MCA policy. For example, the revised MTA policy does not emphasize iterative development approaches or incorporating feedback from end users. Therefore, these recommendations remain open as of March 2025.

In February 2023, we similarly found that component-level MTA policies from the Air Force, Army, Navy, and U.S. Special Operations Command

[27]GAO-22-104513.

[28]GAO-25-107743.

partially, rather than fully, implemented some of the aforementioned principles.[29] 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 2025.

Finally, in a December 2024 report, we found that the military services' policies for the software acquisition pathway included an iterative development structure intended to facilitate speed and innovation.[30] However, neither their policies nor guidance for the MTA, MCA, and urgent capability acquisition pathways included this structure. Officials for the programs that we reviewed also did not consistently demonstrate a clear understanding of how to implement iterative development in their efforts, which may cause them to miss opportunities to deliver capabilities with speed and innovation. We recommended, among other things, that the Secretaries of the Air Force, Army, and Navy revise their acquisition policies and relevant guidance to reflect leading practices that facilitate speed and innovation, including continuous iterative cycles that ensure the design meets user needs, the development of a minimum viable product, and the optimization of processes to produce further iterations. The Air Force and Navy concurred with the recommendations. The Army partially concurred, stating that it agreed with the recommendation for all pathways except for the urgent capability acquisition pathway, because that pathway intends to deliver capabilities as quickly as possible and should not require substantial development. The Army further stated that it could consider iterative design approaches for programs on the urgent capability acquisition pathway once those programs transition to another pathway after successfully addressing an urgent or emergent need. We maintain that there are elements of leading practices that are applicable to programs on the urgent capability acquisition pathway, such as applying user feedback to ensure the capability meets those urgent needs.

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

[29]GAO-23-105008.

[30]GAO, *DOD Acquisition Reform: Military Departments Should Take Steps to Facilitate Speed and Innovation*, GAO-25-107003 (Washington, D.C.: Dec. 12, 2024).

Modular Open Systems Approach

A modular open systems approach (MOSA) for weapon systems includes a combination of engineering and business practices in which weapon systems are designed with modular components that are linked by clearly defined system interfaces. The components can be acquired from independent vendors.[31] Modern weapon systems consist of a major system platform—like an aircraft—that is composed of major system components like engines and optical sensors.[32] The connections between the platform's components are referred to as interfaces.

Systems designed with a MOSA use a modular design for their components and connect these components via open interfaces.

- A modular system design isolates functions in individual component modules. This design makes the system easier to develop, maintain, and modify because components can be changed without majorly affecting the remainder of the system.
- MOSA systems use widely supported standards for the key interfaces, or connections between the components. Interface standards specify the physical, power, data, and other connections between components. All interfaces in a system do not need to use open standards for a system to be considered "open," as it can be costly and impractical to manage hundreds or thousands of interfaces within a system. Rather, programs should identify open standards at key interfaces between the modules that are likely to change, may frequently fail or need to be replaced, or are needed for interoperability.[33]

An open system enables DOD to acquire warfighting capabilities with more flexibility and opportunities for competition by allowing independent suppliers to build components that can plug into the existing system through the open connections. We have previously reported on the

[31]For the current statutory definition of a MOSA, see 10 U.S.C. § 4401(c)(1).

[32]For the current statutory definitions of major system components and major system platforms, see 10 U.S.C. § 4401(c)(2)-(3).

[33]GAO, *Defense Acquisitions: DOD Efforts to Adopt Open Systems for Its Unmanned Aircraft Systems Have Progressed Slowly*, GAO-13-651 (Washington, D.C.: July 31, 2013).

benefits of a MOSA for weapons programs.[34] These include the potential to reduce operating and sustainment costs—which account for approximately 70 percent of a weapon system's total life-cycle cost. All defense acquisition programs are required by statute to be designed and developed, to the maximum extent practicable, with a MOSA to enable incremental development and enhance competition, innovation, and interoperability.[35]

In January 2025, we found that the programs that we reviewed were not conducting a formal analysis of costs and benefits for a MOSA because DOD's policy did not explicitly require one.[36] We also found that most programs that we reviewed did not address all key MOSA planning elements in acquisition documents, in part, because the military departments did not take effective steps to ensure they did so. We recommended that DOD develop a process to analyze MOSA costs and benefits; take steps to improve military department processes for ensuring quality MOSA planning in acquisition documents and for coordinating MOSA implementation across programs; and address gaps in MOSA policy and guidance. DOD concurred with these recommendations. They remain open as of March 2025.

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's acquisition programs employ a wide range of software development approaches, including Agile frameworks and various incremental models.[37] Table 3 provides

[34]GAO, *Weapon Systems Acquisition: DOD Needs Better Planning to Attain Benefits of Modular Open Systems*, GAO-25-106931 (Washington, D.C.: Jan. 22, 2025); *Weapon System Sustainment: Aircraft Mission Capable Goals Were Generally Not Met and Sustainment Costs Varied by Aircraft*, GAO-23-106217 (Washington, D.C.: Nov. 10, 2022); and GAO-13-651.

[35]10 U.S.C. § 4401(a).

[36]GAO-25-106931.

[37]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).

descriptions of key modern software development approaches employed by DOD's acquisition programs.

Table 3: Key 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 *Agile Assessment Guide* and GAO analysis of Department of Defense and software industry documentation. I GAO-25-107569

We have highlighted that DOD continues to face challenges in executing modern approaches and rapidly delivering software to users, which senior DOD leaders have acknowledged.[38] 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.[39]

DOD issued a *Software Science and Technology Strategy Implementation Plan* in August 2024, which outlines its goals and activities related to software modernization.[40] Among these goals is to shift engineering and software development earlier in the acquisition life cycle by establishing strong collaborative teaming between DOD's research scientists and the engineering community. This partnership is

[38]GAO, *Software Acquisition: Additional Actions Needed to Help DOD Implement Future Modernization Efforts*, GAO-23-105611 (Washington, D.C.: Apr. 5, 2023); and GAO-23-105867.

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

[40]Department of Defense, *Software Science and Technology Strategy Implementation Plan* (Washington, D.C.: Aug. 2024).

intended to provide a means to transition the research quickly and accurately into a deliverable capability to program offices.

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.[41] It is also linked to reducing risk, enhancing customer commitment, and improving technical staff motivation. Continual involvement on a regular, recurring basis throughout development is a characteristic of effective user engagement.[42]

Consistent with this practice, DOD policy requires programs using the software pathway to create user agreements.[43] These agreements are a commitment between the sponsor and program manager for continuous user involvement. They also assign decision-making authority in the development and delivery of software capability. Decisions include defining and prioritizing required capabilities, tradeoffs of software features and cadence, user acceptances, and readiness for operational deployment. The user agreements help to ensure the user community is represented and engaged throughout software development by defining responsibilities and expectations for involvement and interaction of users and developers. This involvement helps ensure that developers consider detailed low-level requirements during development. In July 2023, we recommended, among other things, that DOD incorporate Agile principles into requirements policy and guidance for all programs using Agile for

[41]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).

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

[43]Department of Defense, Office of the Under Secretary of Defense for Acquisition and Sustainment, *Operation of the Software Acquisition Pathway*, DOD Instruction 5000.87 (Oct. 2, 2020).

software development, including a user agreement.[44] DOD partially concurred with this recommendation. In its written comments, DOD agreed to clarify requirements policy to provide guidance on using an acquisition Capability Needs Statement and User Agreement for development of software that is embedded within an already validated requirements document without needing additional requirements validation. This recommendation remains open as of March 2025.

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.[45] The Defense Science Board made recommendations to help DOD modernize its software development and acquisition approach, which included several software development practices, as listed in table 4.

Table 4: Selected Software Practices Recommended by the Defense Science Board in February 2018

Recommended practice	Description
Use of software factory	A cloud-based computing technique used to assemble a set of software tools enabling developers, users, and management to work together daily. The Defense Science Board recommended that all current programs plan a transition to the use of a software factory.
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.
Delivery of minimum viable product[a]	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-25-107569

[a]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.

[44]GAO-23-105867.

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

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.

Agile Software Metrics and Management Tools

In December 2023, we issued our updated *Agile Guide* to help organizations assess their readiness to adopt Agile methods as well as to enable assessment of an agency's use of these methods.[46] The *Guide* describes best practices, including metrics and management tools, that programs are encouraged to use when pursuing Agile software development. These metrics and management tools are used to measure performance and outcomes intended to help meet customer needs and are best practices for Agile adoption and implementation. Additionally, the *Guide* describes management tools that programs may use to help capture the metrics and support decision-making. Several of these metrics and management tools are consistent with those required in DOD's guidance.[47] See tables 5 and 6 for overviews of these metrics and tools.

Table 5: Metrics Identified in GAO's Agile Assessment Guide

Metric	Description
Number of defects or bugs	The number of defects identified after deploying a product into the production environment.
Customer satisfaction	The level of satisfaction measured by customers and monitored throughout the development cycle.
Time required to restore service after outage	A measure of time to restore service after an outage.
Features or user stories delivered[a]	The number of user stories completed in an iteration and whether any were carried over to the next iteration.
Time required for full regression test	A measure of time to complete a full regression test—a type of software testing that verifies whether software that was previously developed and tested still performs correctly after it was changed or interfaced with other software.
Velocity	The volume of work accomplished in a specific time by a team, compared against a metric that quantifies the work developers can deliver in each iteration.
Measurement of a team's adherence to Agile best practices	A measure of a team's effort to adhere to Agile software development practices.

[46]GAO, *Agile Assessment Guide: Best Practices for Adoption and Implementation*, GAO-24-105506 (Washington, D.C.: Dec. 15, 2023).

[47]Department of Defense, *Agile Metrics Guide; Strategy Considerations and Sample Metrics for Agile Development Solutions*, Version 1.2 (Washington, D.C.: Nov. 11, 2020); and *DevSecOps Fundamentals Guidebook* (March 2021).

Metric	Description
Cumulative flow	The flow of work over a period of time that is represented by a cumulative flow diagram or by reporting the number of features or capabilities delivered in each iteration or release.

Source: GAO *Agile Assessment Guide.* I GAO-25-107569

[a]User stories are high-level requirements definitions written in everyday or business language. They are communication tools written by or for users to guide developers, although they can also be written by developers to express non-functional requirements (e.g., security, performance, quality). User stories are weighted for complexity using story points (i.e., units of measure for expressing the overall size of a user story, feature, or other piece of work).

Table 6: Management Tools Identified in GAO's Agile Assessment Guide

Tool	Description
Sprint plans	A list of work to be done and the responsibilities of each team member.
Sprint backlog	An ordered list of tasks to be accomplished during the sprint.
Product backlog	A high-level backlog that contains all the requirements for the entire program.
Release plan	A plan that identifies different sets of usable functionality or products scheduled for delivery to the customer.
Burn up or burn down chart	A visual tool displaying progress via a simple line chart representing work accomplished or remaining work over time.
Cumulative flow diagram	An analytical tool that allows teams to visualize their effort and a program's progress.
Budget baseline	A cost baseline used to measure program performance.

Source: GAO *Agile Assessment Guide.* I GAO-25-107569

In this report, we assess the extent to which selected DOD weapon programs use these metrics and management tools for Agile software development.

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.[48] Modular contracting can eliminate the delay between when the government defines its requirements and when the contractor begins

[48]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 39.103.

delivering workable solutions.[49] 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.[50] 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.[51] Although generally associated with the acquisition of IT systems or software, modular contracting practices—such as contracting for successive, interoperable increments—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.

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.[52]

In November 2020, DOD Instruction 5000.89 was issued and established policy and procedures for test and evaluation across five of the six AAF pathways—including the MCA and MTA pathways. The policy also

[49]GAO-24-105506.

[50]Federal Acquisition Regulation 39.103. Modular contracting was established in title 41, section 2308 of the U.S. Code.

[51]Department of Defense, Office of the Under Secretary of Defense for Acquisition and Sustainment, *Operation of the Software Acquisition Pathway*, DOD Instruction 5000.87 (Oct. 2, 2020).

[52]GAO-19-128.

addresses cybersecurity planning and execution.[53] In particular, the instruction requires all of DOD's acquisition programs and systems, regardless of acquisition pathway, to execute an iterative cybersecurity test and evaluation process. This process is detailed in the DOD *Cybersecurity Test and Evaluation Guidebook*.[54] Table 7 outlines the DOD cybersecurity test and evaluation phases from the guidebook.

Table 7: 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 an adversary may use to attack 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 trained and equipped with a system in an operational environment, as well as the effectiveness of the unit's defensive capabilities.

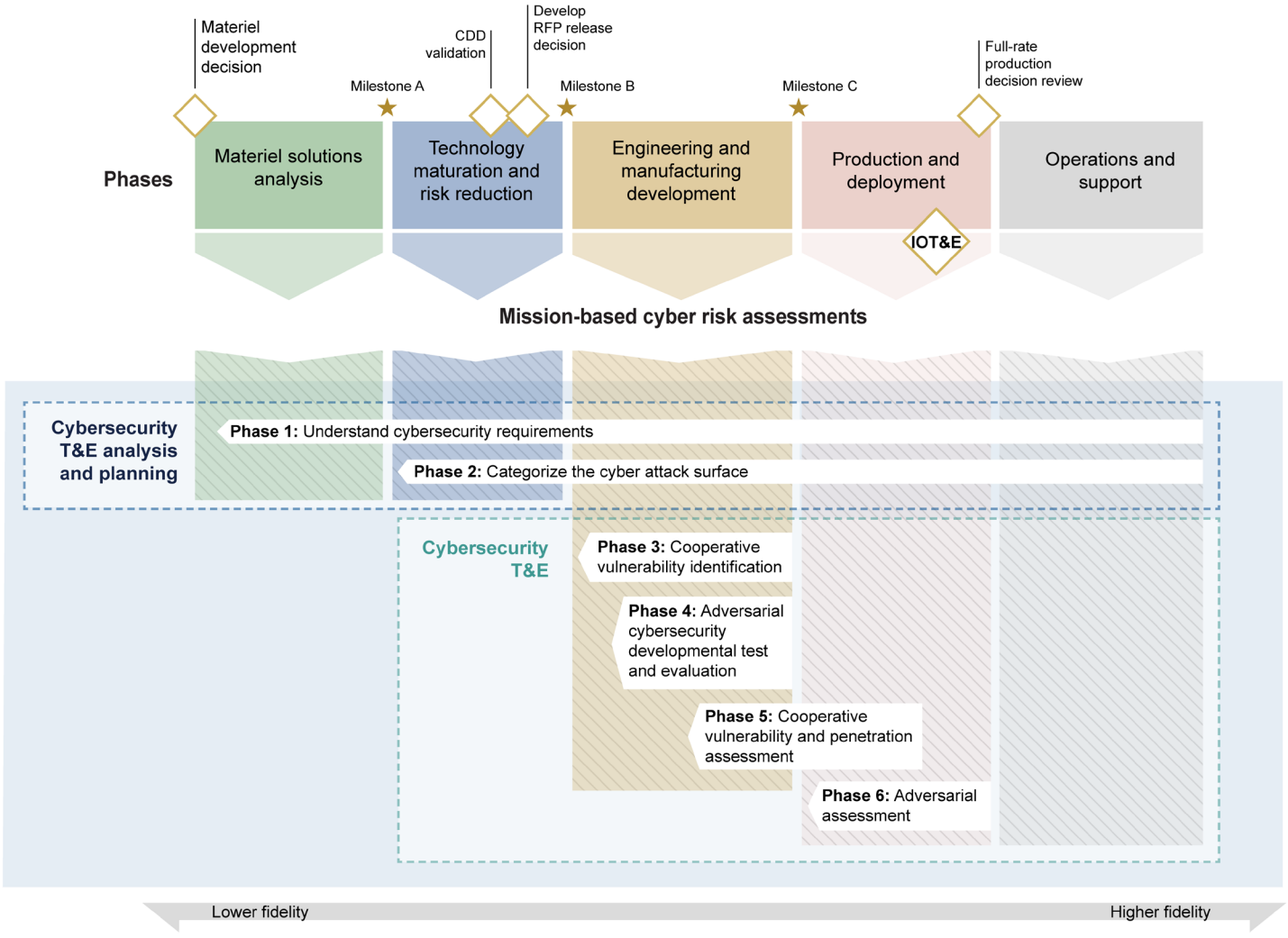
Source: GAO analysis of Department of Defense *Cybersecurity Test and Evaluation Guidebook*. I GAO-25-107569

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's guidance applies to programs using the MCA pathway.

[53]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. Portions of DOD Instruction 5000.89 relating to operational test and evaluation and live fire test and evaluation were superseded by DOD Instruction 5000.98 in December 2024.

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

Figure 4: DOD's 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-25-107569

Additionally, DOD issued a policy on cybersecurity in December 2020, which establishes procedures to manage cybersecurity risk.[55] The policy also highlights the need to incorporate cybersecurity into all aspects of the defense acquisition system and operations.

DOD's guidance generally states that MDAPs are to develop a cybersecurity strategy by milestone A (technology development start) and update the strategy at subsequent milestones. 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's guidance for MTA programs requires components to develop a process for demonstrating performance and evaluating proposed products and technologies for current operational purposes. This process will result in a test strategy or an assessment of test results in the acquisition strategy, which should document the evaluation of the demonstrated operational performance, to include validation of required non-kinetic threats, including cybersecurity.[56]

Zero Trust Cybersecurity

Zero trust is a set of cybersecurity principles that are founded on the concept that no actor, system, network, or service operating outside of or within an organization's security perimeter should be trusted. Instead, the principles suggest that organizations must verify anything and everything that attempts to establish access to their systems, services, and networks.

A May 2021 executive order highlighted the need for the U.S. government to take steps to modernize its approach to cybersecurity and to adopt best practices. The order required that agencies, including DOD, develop a plan to implement a zero trust architecture.[57] In addition, the National Defense Authorization Act for Fiscal Year 2022 directed DOD to develop a zero trust strategy, a model architecture, and implementation plans.[58] While the concepts behind zero trust are not new, the implications of

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

[56]Department of Defense, *Operation of the Middle Tier of Acquisition*, DOD Instruction 5000.80 (Dec. 30, 2019) (incorporating change 1, Nov. 25, 2024).

[57]The White House, *Improving the Nation's Cybersecurity*, Executive Order 14028 (Washington, D.C.: May 12, 2021).

[58]Pub. L. No. 117-81, § 1528 (2021).

shifting away from perimeter-based security are new to most enterprises and many federal agencies, including DOD.[59]

In January 2023, DOD published the *Zero Trust Capability Execution Roadmap – Course of Action 1 (COA 1)*.[60] We previously reported that DOD is developing complementary capability roadmap courses of action, including those that will cover commercial and government-owned cloud-based enterprise services (i.e., COA 2 and COA 3, respectively), to accelerate zero trust adoption.[61] The capability roadmap courses of action will lay out the department's vision for achieving zero trust target levels by progressively implementing outcomes and activities.[62] The COA 1 roadmap describes a timeline where all DOD organizations achieve the planned zero trust targets by 2027. Given the increasing reliance of DOD's weapon systems portfolio on network and application-based capabilities, we will continue to monitor DOD's efforts to implement zero trust cybersecurity within individual weapon programs.

[59]Perimeter-based security refers to conventional network security practices in which, once a user is inside of an organization's network, that user is considered trusted and is often given broad access to multiple resources.

[60]Department of Defense, *DOD Zero Trust Capability Execution Roadmap (COA 1)* (Jan. 06, 2023).

[61]GAO, *IT Systems Annual Assessment: DOD Needs to Strengthen Software Metrics and Address Continued Cybersecurity and Reporting Gaps,* GAO-24-106912 (Washington, D.C.: July 11, 2024).

[62]A Zero Trust target level includes the minimum set of capability outcomes and activities necessary to secure and protect DOD's data, applications, assets, and services to manage risks from currently known threats. It is the level set by the department's Zero Trust Portfolio Management Office, which all of DOD must minimally achieve.

Mid-Range Capability (MRC)

Source: Lockheed Martin with edits from U.S. Army RCCTO. | GAO-25-107569

OVERVIEW

DOD Weapon Portfolio for 2025

DOD plans to invest nearly $2.4 trillion in its weapon portfolio.

The weapon systems portfolio we assessed continues to grow both in cost and number of programs. It consists of 106 programs: 79 MDAPs, 20 MTA programs, and seven future major weapon acquisitions not currently on an AAF pathway (see table 8). These figures do not include total life-cycle sustainment costs or classified programs, which constitute a substantial portion of military department spending. Figure 5 highlights 1-year changes in DOD's MDAP portfolio.

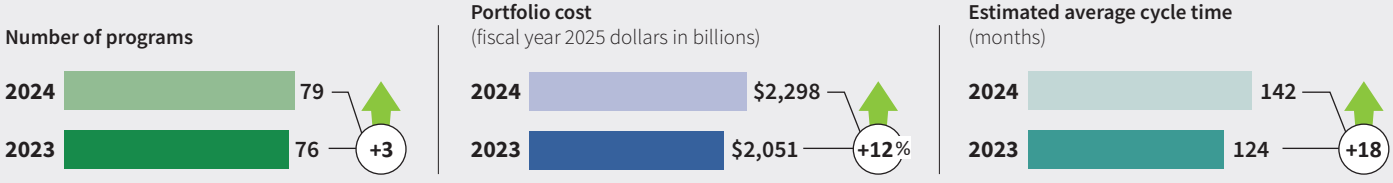
Table 8: Department of Defense Planned Investments in Selected Weapon Acquisitions (fiscal year 2025 dollars in billions)

Type of program	Number of programs reviewed	Total planned investment	Air Force	Army	Navy	Space Force	Joint DOD
Major defense acquisition programs (MDAP)	79	$2,298.2[a]	15	17	37	9	1
Middle tier of acquisition programs (MTA)	20	$44.5[b]	3	8	2	7	0
Future major weapon acquisitions	7	$25.2[c]	0	2	5	0	0
Total	**106**	**$2,367.9**	**18**	**27**	**44**	**16**	**1**

Source: GAO analysis of Department of Defense data. | GAO-25-107569

[a]Planned investment amounts for MDAPs do not include three programs that have yet to provide official cost estimates since transitioning from the MTA pathway—B-52 Commercial Engine Replacement Program, Deep Space Advanced Radar Capability, and Protected Tactical SATCOM.
[b]Planned investment amounts for MTA programs reflect the current costs reported by those programs, many of which are planning follow-on efforts that are not included in these costs.
[c]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: Comparison of DOD's 2023 and 2024 Major Defense Acquisition Program Portfolios



Source: GAO analysis of Department of Defense data. | GAO-25-107569

Note: Portfolio costs do not include three new major defense acquisition programs that have yet to provide official cost estimates. Estimated cycle time is defined as the number of months between program start and the planned achievement of initial operational capability. For MDAPs that began on the MTA pathway, program start is when the MTA effort began.

DOD MDAP Portfolio

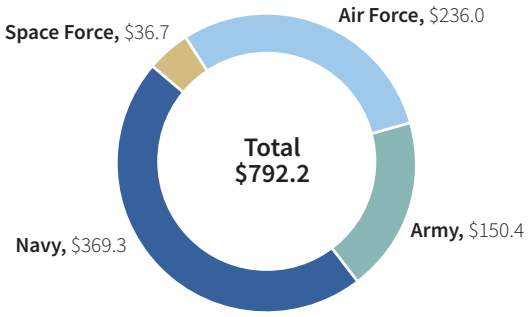
COST OVERVIEW

Costs of MDAPs increased.

The estimated cost change of programs that were included in DOD's MDAP portfolio last year increased by $119.9 billion.[63] Among the 76 MDAPs for which cost data was available, half of the programs (38 of 76) reported cost increases totaling $133.4 billion. Thirty programs reported decreases of $13.5 billion.

DOD plans to invest $792.2 billion to develop and produce the 36 MDAPs that, as of January 2025, were generally between the start of development and the early stages of production—over a third of DOD's total estimated MDAP costs (see figs. 6 and 7 for breakdowns by military service and commodity).[64] We reported on 30 of these 36 programs in our last report. This year, the combined costs increased, in part, due to one program's breach of a statutory critical cost growth threshold.

Figure 6: Estimated Cost by Military Service of 36 Current Major Defense Acquisition Programs GAO Assessed (fiscal year 2025 dollars in billions)

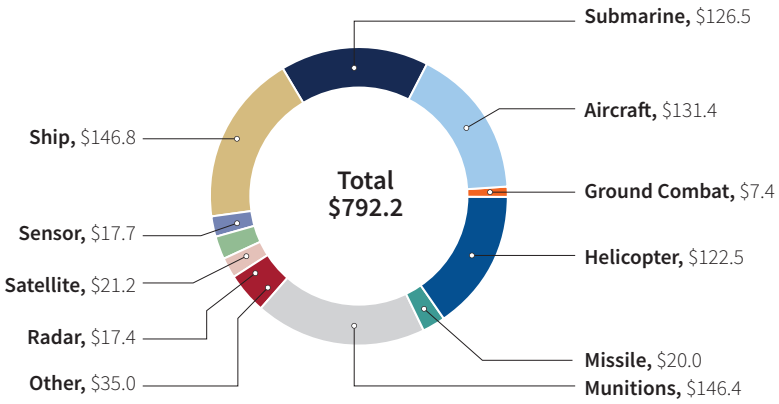


Source: GAO analysis of Department of Defense data. | GAO-25-107569

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

Total estimated costs for the Army's MDAP portfolio increased since our last report following the addition of the Future Long Range Assault Aircraft program, which transitioned from the MTA pathway.

Figure 7: Estimated Cost by Commodity of 36 Major Defense Acquisition Programs GAO Assessed (fiscal year 2025 dollars in billions)

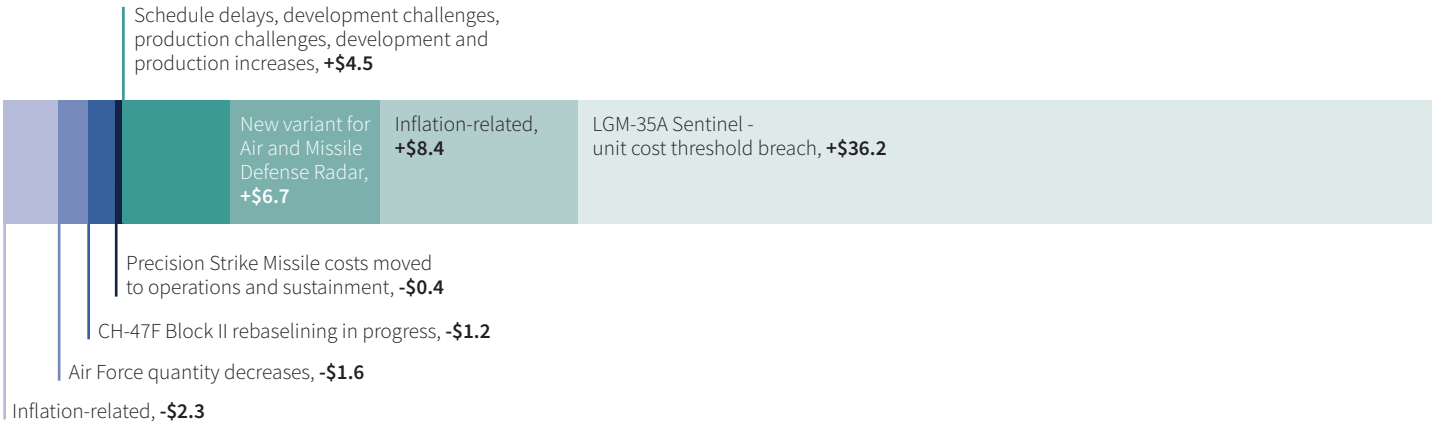


Source: GAO analysis of Department of Defense data. | GAO-25-107569

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

Combined total cost estimates increased by $49.3 billion—or 8.3 percent—in the past year for 30 MDAPs that we also assessed in our 2024 report. This increase was driven primarily by the **Air Force's LGM-35A Sentinel** missile program, which reported a cost increase of over $36 billion following a breach of a statutory critical unit cost growth threshold—known as a Nunn-McCurdy breach—in January 2024 (see fig. 8). The program continues to evaluate its options and develop a new schedule as part of restructuring efforts, and costs could swell further. According to the Office of the Director, Cost Assessment and Program Evaluation, a reasonably modified Sentinel program could cost approximately $170 billion—$40 billion more than we are currently reporting.[65]

Figure 8: Notable Factors Contributing to the Largest 1-Year Cost Changes Across 30 Major Defense Acquisition Programs Assessed by GAO (fiscal year 2025 dollars in billions)



Source: GAO analysis of Department of Defense data. | GAO-25-107569

Note: Some program costs increased or decreased due to changes in calculation assumptions about the effect of inflation. For example, one program stated it removed contingency costs for inflation after determining they were no longer necessary, while another program's inflation indices exceeded what was forecasted at contract award.

[63]MDAP portfolio cost change does not include new programs or programs that exited the portfolio.

[64]The total planned investment of MDAPs for which we produced individual assessments decreased substantially since our last report due to the removal of DOD's F-35 Lightning II program, which has a current estimated acquisition cost of $482.7 billion. GAO assessed 39 MDAPs, but cost information is available for only 36 of those programs because three new MDAPs have yet to provide official cost estimates. Costs for three MDAP Increments that we assessed are also not included on this page.

[65]Costs are reported in fiscal year 2025 dollars.

DOD MDAP Portfolio

COST CHANGES

Some costs decreased among MDAPs due to factors unrelated to savings.

Among the 30 MDAPs assessed in both our current and last report, 16 programs reported a cost decrease and 13 reported an increase in the last year (see fig. 9). Of the 16 programs that reported a decrease, three were due to reduced quantities. Program officials for the **Navy's FFG 62**—the program with the largest cost decrease—attributed the decrease to accounting changes, not savings from efficiencies. Specifically, these officials noted that the cost decrease is due, in part, to the Navy's revised approach for accounting for inflation. The **Army's CH-47F** program—the second largest decrease—is updating its cost estimates as part of a new program baseline.

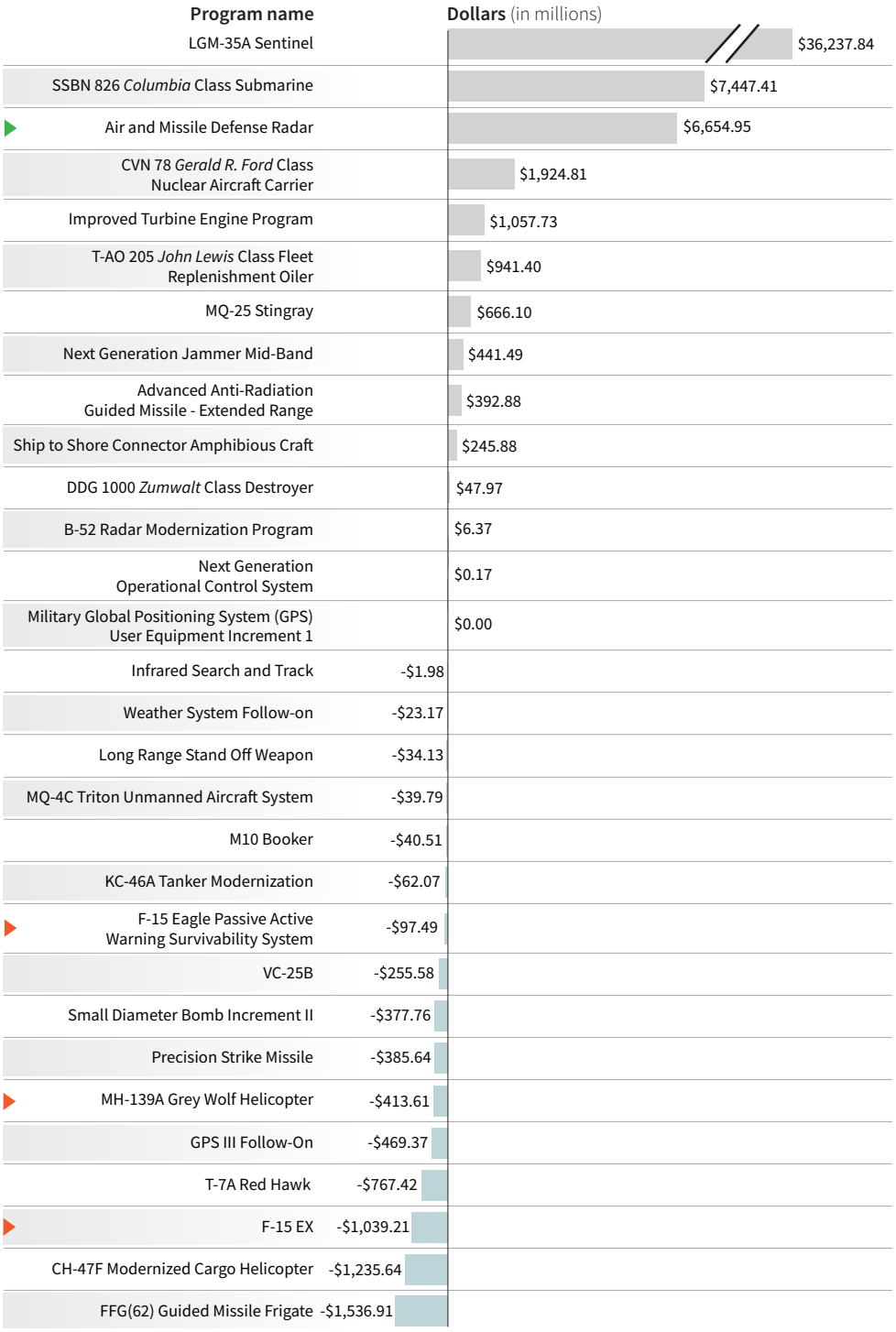
Examples of Factors Driving Large Costs Changes Since Our Last Report

The **Navy's SSBN 826 *Columbia* Class Ballistic Missile Submarine** program attributed its $7.4 billion cost increase, in part, to inflation, which is affecting contractor- and government-furnished equipment, materials, and labor. Last year, the program stated that its calculations to account for inflation resulted in a decrease of almost $7 billion. A new cost estimate is in progress, and the program expects it to better reflect challenges with shipbuilder performance and inflation effects. Further, in November 2024, the Navy declared a schedule breach and is updating *Columbia's* acquisition program baseline.

The **Navy's CVN 78 *Gerald R. Ford* Nuclear Aircraft Carrier** program reported unit cost increases of about $480 million (3 percent) since last year. Changes to CVN 79's delivery strategy account for approximately half of this increase but include funds the Navy had previously planned and budgeted for post-delivery activities and are not new program costs. CVN 80 delays and cost increases for CVN 81, 82, and 83, among other costs, account for the rest of the increase, according to program officials.

The **Navy's T-AO 205 *John Lewis* Class Fleet Replenishment Oiler** program reported a cost increase of over $900 million, which it attributed to increased overhead, labor, and material costs. The program office stated that its budgets are based on global forecasting, and those forecasts projected a steeper downturn in the economy than what occurred. The Navy also estimates T-AO 211 through 213 to experience cost growth due to current inflation indices exceeding what was forecasted at contract award.

Figure 9: Reported 1-Year Cost Changes in 30 Major Defense Acquisition Programs GAO Reviewed (fiscal year 2025 dollars in millions)



Cost increase related to quantity increase
Cost decrease related to quantity reduction

Source: GAO analysis of Department of Defense data. | GAO-25-107569

Note: As of November 2024, DOD is restructuring Military GPS User Equipment Increment 1 into a new program. The figure reflects no cost change since last year because the program is no longer required to submit the reporting that we use.

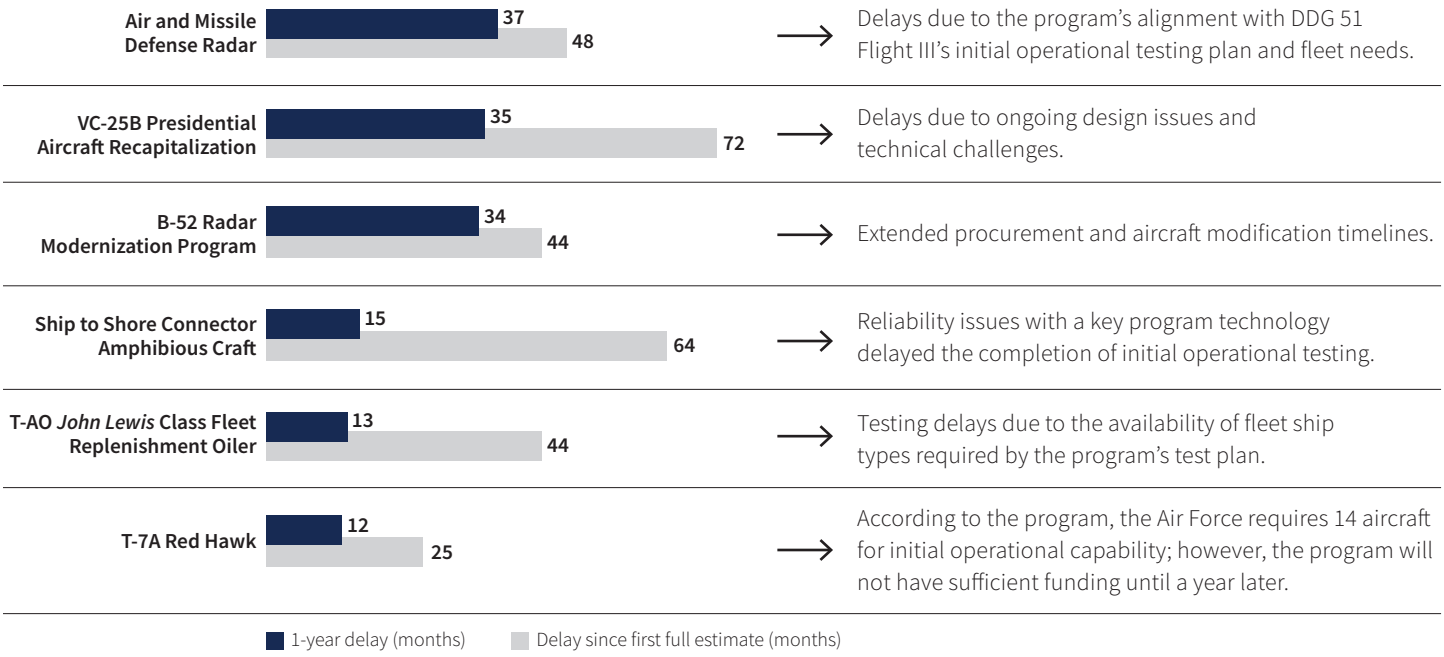
DOD MDAP Portfolio

SCHEDULE

Schedule lags persist for some MDAPs, delaying capability.

Over the past year, six programs in our review experienced delays of approximately 12 months or more to expected initial operational capability (IOC) dates. These six programs have also reported delays previously (see fig. 10). Among the 30 MDAPs overall that have yet to achieve IOC, 24 have delayed their expected time frames since first full estimate. Included in the six MDAPs that have not delayed their time frames are five that entered the major capability acquisition pathway in the past 3 years.

Figure 10: Delays of Approximately 12 Months or More to Planned Initial Operational Capability over the Past Year (months)



Source: GAO analysis of Department of Defense data. | GAO-25-107569

Six programs that have previously reported delays to IOC dates are developing new estimates (see fig. 11). For example, the **Army's CH-47F** program has reported since 2022 that its IOC date is to be determined. The **Air Force's LGM-35A Sentinel** program continues to undergo a schedule review, following a breach of a statutory critical unit cost growth threshold. And, in November 2024, the Navy declared a schedule breach for its **SSBN 826 *Columbia* Class** program and is planning to update the program baseline by September 2025.

Figure 11: Programs Continue to Delay Initial Operational Capability and Have Yet to Establish New Dates

Air Force

KC-46A Tanker Modernization[a]

LGM-35A Sentinel[a]

Army

CH-47F Block II Modernized Cargo Helicopter[a]

Navy

Advanced Anti-Radiation Guided Missile - Extended Range

FFG 62 *Constellation* Class Frigate[a]

SSBN 826 *Columbia* Class Submarine

Source: GAO analysis of Department of Defense data. | GAO-25-107569

[a]These programs also did not provide an initial operational capability date in our 2024 report.

F-15EX

Source: U.S Air Force. | GAO-25-107569

The **Air Force's F-15EX** program achieved initial operational capability in July 2024, following the delivery of eight aircraft along with training equipment and material, support equipment, spares, and technical data.

The F-15EX program is based on a current foreign military sales aircraft design that will be upgraded with capabilities unique to the U.S. The program began as an MTA effort in September 2019.

COST

DOD plans to invest at least $44.5 billion across 20 of its largest MTA programs.

E-7A Rapid Prototyping

Source: Boeing Defense, Mobility, Bombers, and Surveillance. | GAO-25-107569

Programs with Notable Cost Estimate Changes since 2024 Assessment

⊕ The Air Force's **E-7A Rapid Prototyping** program reported an $884 million (33 percent) increase since our last report. Program officials attributed the increase to higher-than-expected costs for updating hardware and software.

⊖ The Army's **Integrated Visual Augmentation System's (IVAS)** rapid fielding effort reported a $169 million (11 percent) decrease since our last report. The program continued to reduce its planned quantities since our prior assessment—from 13,500 units to 10,000 units. The program attributed last year's quantity change to refocusing on developing and fielding its full-rate production model, version 1.2.

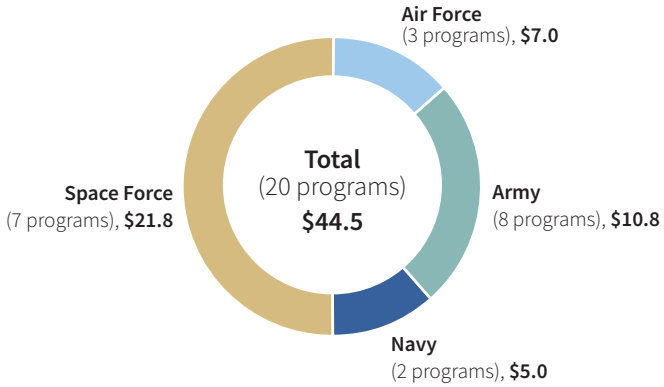
◀ Source: U.S. Army. | GAO-25-107569

⊖ The Navy's **Hypersonic Air Launched Offensive Weapon (HALO)** program reported a $109 million (20 percent) cost decrease since our prior assessment. According to program officials, HALO's MTA costs decreased because the program planned to transition to the major capability acquisition pathway earlier than originally planned. This does not reflect a decrease in the expected costs for the entire HALO acquisition effort. HALO's transition plans are on hold due to budget concerns.

Combined costs for 14 MTA programs included in both this year and last year's assessment trended up slightly by $748 million (3 percent).[66] Large cost decreases for two programs (discussed below) are due to quantity reductions and a program ending its MTA effort earlier than planned. The Space Force's seven MTA efforts account for nearly 50 percent of all MTA costs, as shown in figure 12. Six of the Space Force's MTAs are satellite programs, which, as in prior years, account for about half of MTA costs (see fig. 13).

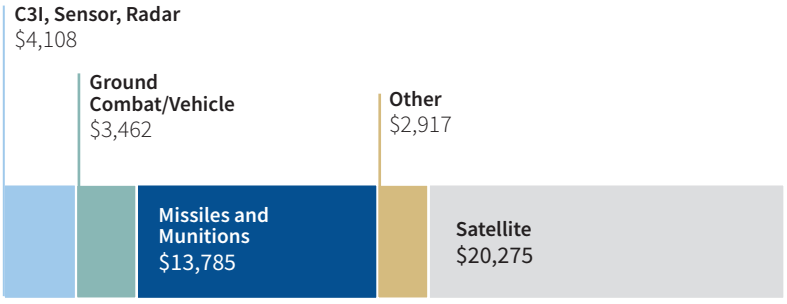
MTA costs include ongoing efforts only and do not include any further investments DOD may make to develop or acquire a capability after the current MTA effort concludes. We previously reported that these costs can be substantial. As in past years, MTA programs reported inconsistent cost data for some programs—complicating DOD's efforts to maintain oversight of MTA programs' costs. In 2023, we recommended that the Secretaries of the Air Force, Army, and Navy identify and implement additional actions to improve the reliability of MTA program data.[67] The recommendations to the Secretaries of the Army and Navy remain open as of March 2025.

Figure 12: Estimated Cost of 20 Current Middle Tier of Acquisition Programs GAO Reviewed by Service (fiscal year 2025 dollars in billions)



Source: GAO analysis of Department of Defense data. | GAO-25-107569

Figure 13: Estimated Cost of 20 Current Middle Tier of Acquisition Programs GAO Reviewed by Commodity (fiscal year 2025 dollars in millions)



Source: GAO analysis of Department of Defense data. | GAO-25-107569

[66]The Navy's Conventional Prompt Strike was also included in our last report, but changes in its cost estimating methodology prevented a cost comparison to last year.

[67]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).

DOD MTA Portfolio

TECHNOLOGY DEVELOPMENT

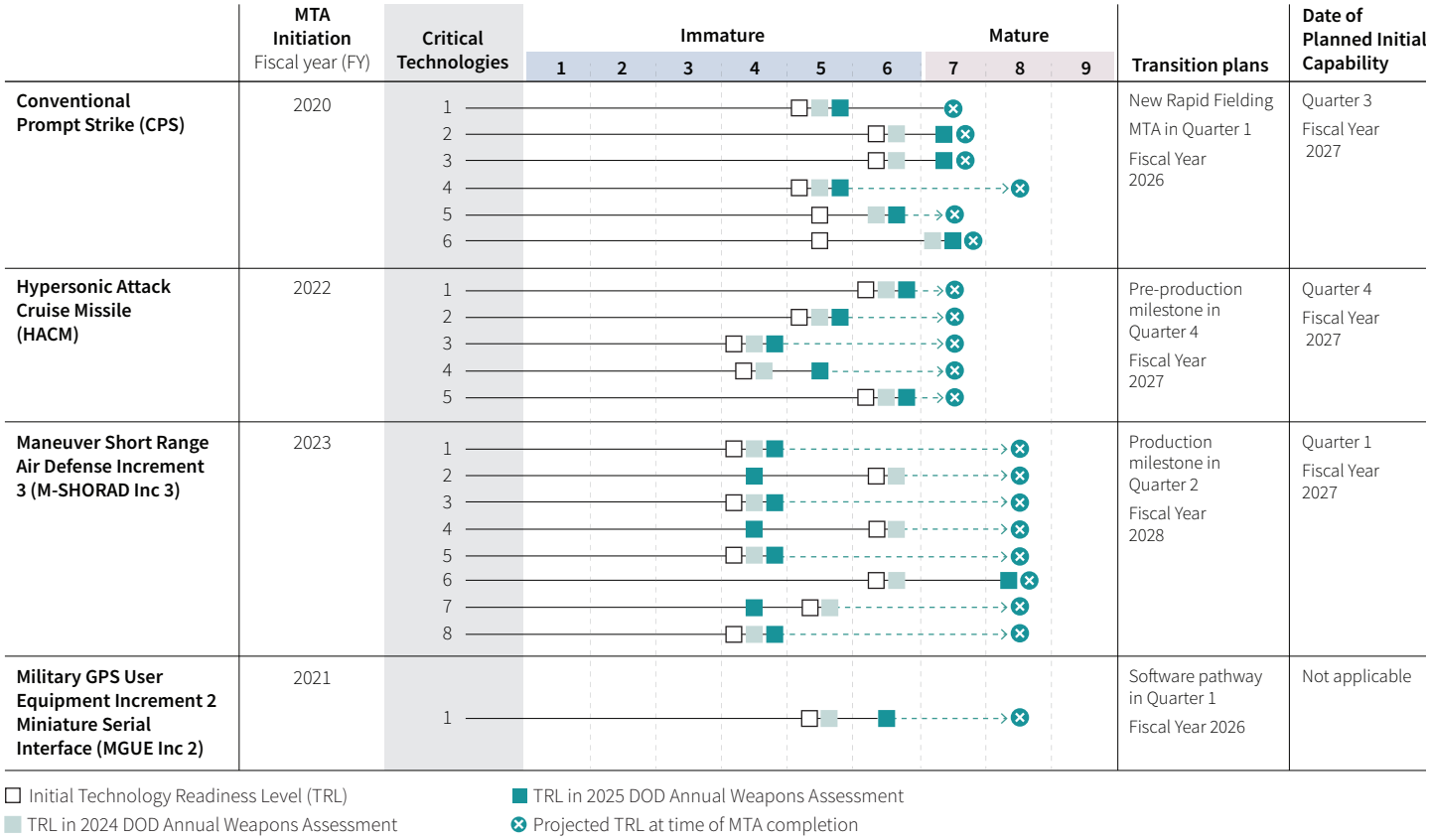
MTA programs that initiated with immature critical technologies reported limited development progress.

The 10 MTA programs with critical technologies that we reviewed in both last year and this year's assessments varied in their progress toward maturing them.[68] For example, six programs reported that they have matured all their technologies.[69] However, we found that several programs that initiated with immature technologies still need significant work before reaching the end of their MTA effort and before delivering initial capability (see fig. 14).

One of these programs—the Army's **M-SHORAD Inc 3**—still has seven immature critical technologies, including three that the program downgraded this year, increasing risk to the program's plans to transition to production in 2028. In addition, the Space Force's **MGUE Increment 2** program changed its acquisition strategy in January 2025 to transition to the software pathway at the end of the 5-year MTA rapid prototyping time frame. Vendors needed more than the 5-year timeline to deliver a prototype that meets requirements.

Our prior work has shown that increasing even one technology readiness level (TRL) can take multiple years and becomes more challenging as the technology approaches maturity. We have also found that MTA programs that reach the end of their MTA effort and transition with immature technologies may risk additional costly and time-intensive redesign work for the overall effort. See appendix V for additional information on TRLs.

Figure 14: Selected Middle Tier of Acquisition Programs' Progress in Maturing Critical Technologies Since 2024



Source: GAO analysis of programs' questionnaire responses. | GAO-25-107569

Note: MGUE Increment 2 reported that there is an initial capability date only for the broader system of which it will be a part.

We also reviewed MTA programs included in our prior weapon systems assessments that have since completed their 5-year MTA efforts. We found that programs initiating with less mature technologies needed additional development before they could move into production. Of note:

- None of the seven programs that entered the MTA pathway with technologies as low as TRL 3, 4, or 5 transitioned to the production phase on the MCA pathway or to a MTA rapid fielding effort to produce a fieldable capability.
- Of the four programs that had no critical technologies, one transitioned into development, one into production, and one to the software pathway. The fourth program restructured into two MTA programs.

[68]We reviewed 15 MTAs in both our current and last assessment. Of these, two programs reported having no critical technologies, and three additional programs reported they have yet to identify critical technologies.

[69]We consider critical technologies as mature when they have reached a technology readiness level of 7. However, satellite technologies that have achieved a technology readiness level of 6 are assessed as fully mature due to the difficulty of demonstrating maturity in a realistic environment (space).

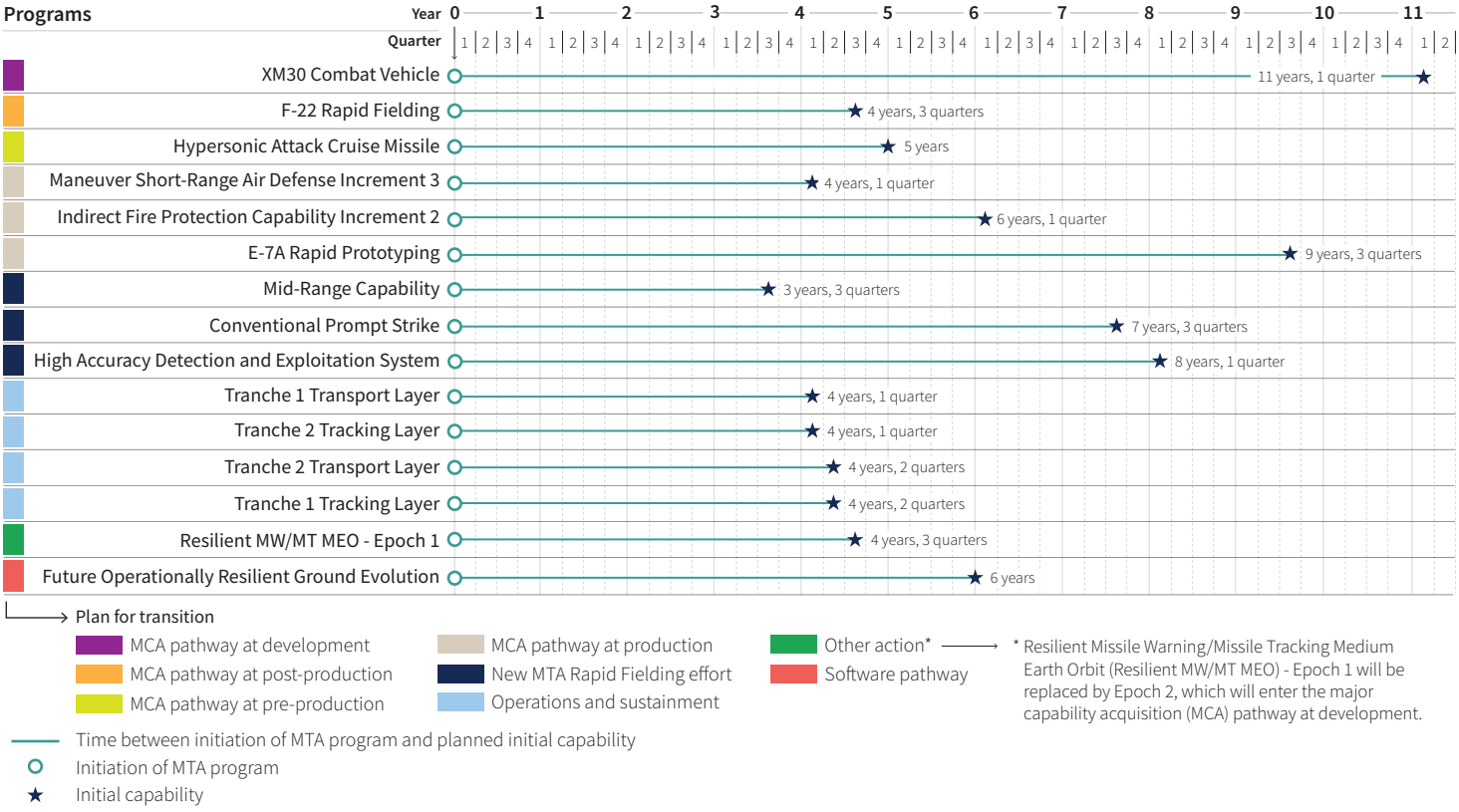
DOD MTA Portfolio

SCHEDULE

MTA programs report a wide range of time frames for delivering capabilities.

MTA programs that we reviewed reported a wide range of time frames for delivering initial capability. Last year, 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 total of 10 years on average from MTA initiation. This year, more programs are planning to transition to the MCA pathway at production start, operations and sustainment, or to an MTA rapid fielding effort, shortening their overall planned time to capability. However, of the 15 programs that reported plans to achieve an initial capability, six programs still plan to develop capabilities for multiple years after ending the current MTA efforts (see fig. 15).[70] For example, the **XM30 Combat Vehicle** reported plans for at least 11 years (134 months) of development before fielding a capability.

Figure 15: Planned Time Between Initiation and Initial Capability for Selected Middle Tier of Acquisition (MTA) Programs



Source: GAO analysis of programs' questionnaire responses. | GAO-25-107569

Note: The planned time frame to achieve an initial capability begins at the date that funds were first obligated for XM30 and Conventional Prompt Strike, consistent with the Department of Defense's MTA policy for programs designated before December 30, 2019. For all other programs, the planned time frame begins at the date when the decision authority signs an acquisition decision memorandum. We used the phrase initial capability to refer to the envisioned initial operational capability, initial warfighting capability, or its equivalent, including any anticipated efforts on other pathways.

Conventional Prompt Strike (CPS)

Source: U.S. Navy. | GAO-25-107569

Whether programs can achieve these plans remains to be seen. In practice, we have observed MTA programs approach the end of their MTA effort only to postpone transition to another pathway or require additional development. For example, the Navy's **Conventional Prompt Strike (CPS)** and the Army's **XM30 Combat Vehicle** each delayed transition over the past year by 1 year and 1 quarter due to testing issues and contractor delays, respectively. As previously discussed, **CPS** still must mature critical technologies.

The Army's **Indirect Fire Protection Capability Increment 2** and the Space Force's **Tranche 1 Tracking Layer (T1 TRK)** have reported cumulative delays to their operational demonstrations—a key event to demonstrate capability—of 13 months and 15 months, respectively. In addition, we found that **Tranche 1 Transport Layer and T1 TRK** may not provide the capability needed to maintain the constellation.[71]

[70]We asked MTA programs to provide the current estimated date for initial operational capability (IOC), initial warfighting capability, or equivalent. Five programs did not provide an expected date. For example, MGUE Inc 2 reported that there is an IOC date only for the broader system that it fits into. IVAS Rapid Prototyping does not expect to have a date until after its MTA transition briefing in the second quarter of fiscal year 2025. Long Range Hypersonic Weapon and IVAS Rapid Fielding have yet to determine a date. One program did not provide an explanation.

[71]GAO, *Laser Communications: Space Development Agency Should Create Links Between Development Phases*, GAO-25-106838 (Washington, D.C.: Feb. 26, 2025).

DOD MTA Portfolio

TRANSITION PLANS

Twelve MTA programs plan to transition in fiscal years 2025 or 2026.

Over half (12 of 20) of the MTA programs that we reviewed plan to conclude their MTA programs during fiscal years 2025 or 2026, as shown in figure 16. We will continue to monitor these transitions to other acquisition pathways and MTA efforts in our future assessments to provide additional insight on the effects of the MTA pathway on the overall timeliness of capability delivery.

Figure 16: Planned Transition Date for Selected Middle Tier of Acquisition Programs GAO Reviewed

2025	Q1	
	Q2	Indirect Fire Protection Capability Increment 2 Mid-Range Capability
	Q3	XM30 Combat Vehicle
	Q4	Future Operationally Resilient Ground Evolution Tranche 1 Transport Layer
2026	**Q1**	Conventional Prompt Strike Integrated Visual Augmentation System, Rapid Fielding Integrated Visual Augmentation System, Rapid Prototyping Military Global Positioning System User Equipment Increment 2 Miniature Serial Interface
	Q2	High Accuracy Detection and Exploitation System
	Q3	
	Q4	F-22 Sensor Enhancements Rapid Fielding Tranche 1 Tracking Layer
2027	Q1	
	Q2	
	Q3	
	Q4	Hypersonic Attack Cruise Missile Resilient Missile Warning/Missile Tracking Medium Earth Orbit - Epoch 1
2028	**Q1**	Tranche 2 Tracking Layer
	Q2	E-7A Rapid Prototyping Maneuver Short Range Air Defense Increment 3
	Q3	
	Q4	Long Range Hypersonic Weapon System Tranche 2 Transport Layer

Source: GAO analysis of programs' questionnaire responses. | GAO-25-107569

Note: The Navy's Hypersonic Air Launched Offensive Anti-Surface Warfare (HALO) planned to transition to the major capability acquisition pathway during the second quarter of fiscal year 2025. However, HALO has put its transition on hold and is restructuring.

We reported in our last assessment that five MTA programs planned to transition in fiscal year 2024. Of those five, four programs—the Army's **Future Long Range Assault Aircraft**, the Air Force's **F-22 Rapid Prototyping**, as well as the Space Force's **Deep Space Advanced Radar Capability** and **Protected Tactical SATCOM**—transitioned in fiscal year 2024 to their respective pathways. The Navy's **Conventional Prompt Strike** delayed its transition to the second quarter of fiscal year 2025 due to testing complexities.

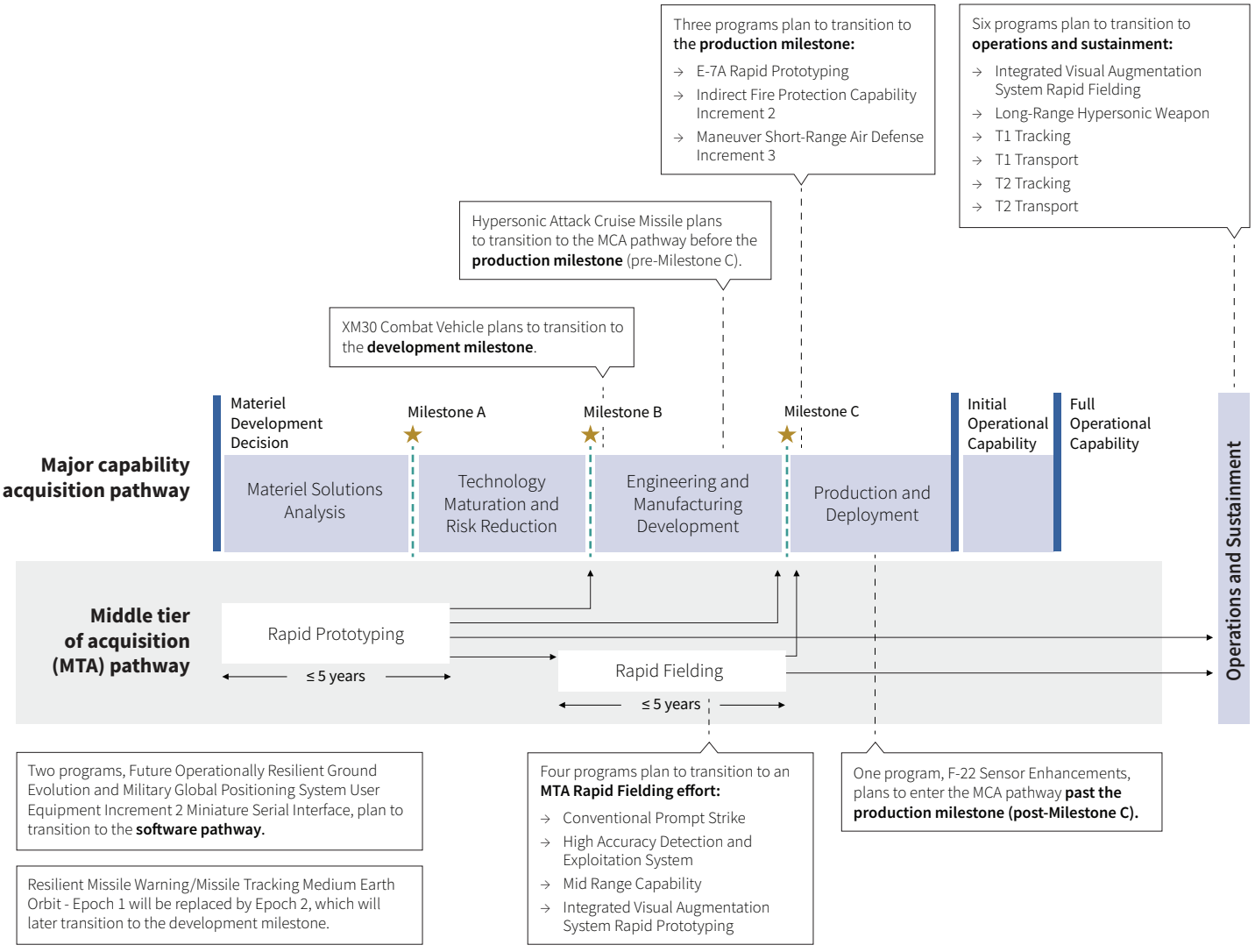
DOD MTA Portfolio

TRANSITION PLANS

MTA programs plan to transition to various pathways and life-cycle points.

Of the 18 MTA programs that identified a specific transition plan, six programs plan to move directly into operations and sustainment. Six programs expect to transition to the MCA pathway—including two programs that plan to enter at or during development. See figure 17.

Figure 17: Planned Transition Pathway of Current MTA Programs That GAO Reviewed



Source: GAO analysis of programs' questionnaire responses. | GAO-25-107569

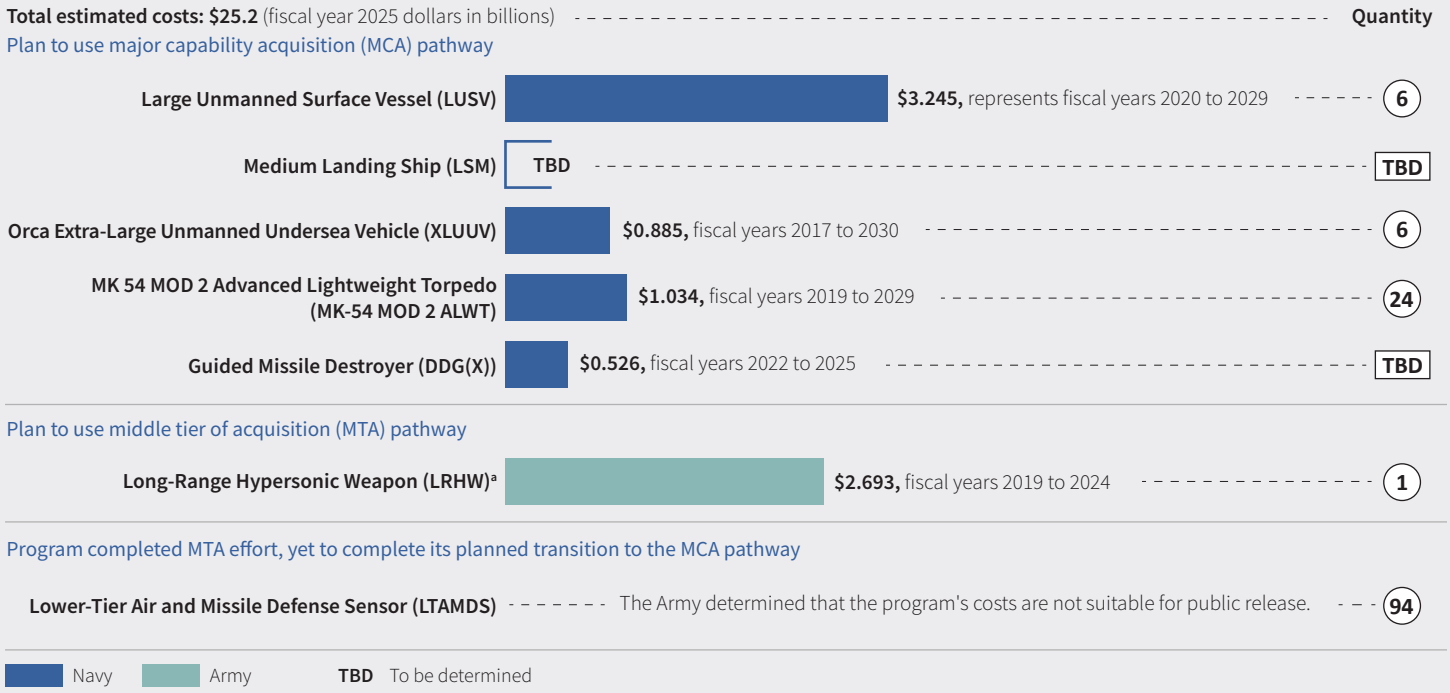
Future Major Weapon Acquisitions

EFFORTS OUTSIDE OF AAF PATHWAYS

DOD lacks consistent insight into costly efforts that are not currently on AAF pathways.

While DOD has taken steps to improve its acquisition reporting, it continues to lack insight into future major weapon programs that have yet to initiate on a pathway.[72] Among the seven future major weapon acquisitions that we reviewed, estimated costs reported to us by the individual efforts totaled $25.2 billion. DOD does not formally collect this data, and costs may not reflect the full scope of these efforts (see fig. 18). These efforts are intended to provide a range of capability needs for the warfighter—from developing robotic autonomous underwater systems to air and missile defense radars—and plan to initiate at various points on different pathways (see fig. 19).

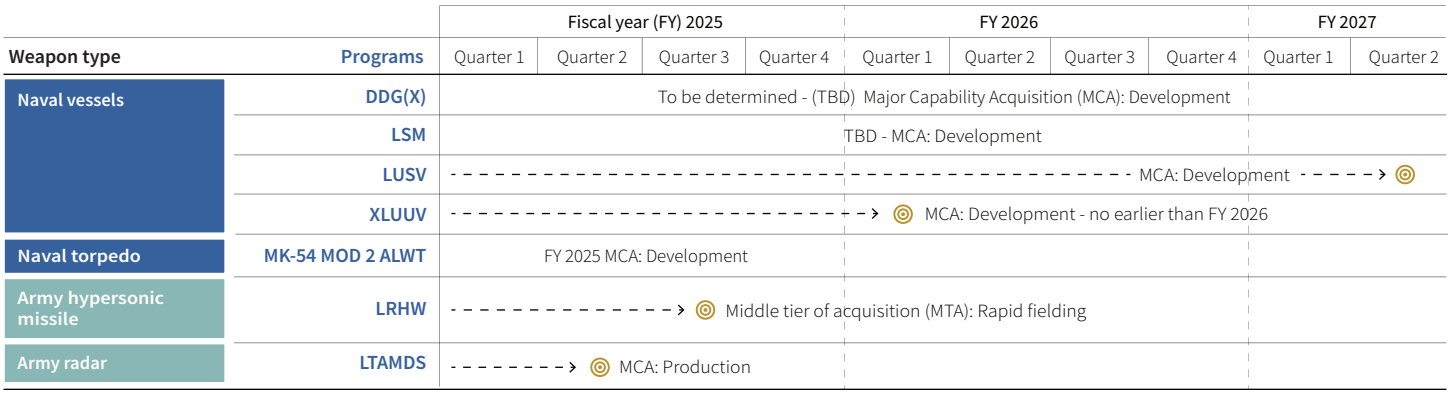
Figure 18: Estimated Costs and Quantities of Future Major Weapon Acquisitions



Source: GAO analysis of Department of Defense data. | GAO-25-107569

[a]LRHW costs only include funding for the first future acquisition effort, Battery 1, not their MTA effort.

Figure 19: Future Major Weapon Acquisition Plans for Transitions to Acquisition Pathways



DDG (X) Guided Missile Destroyer
LSM Medium Landing Ship
LUSV Large Unmanned Surface Vehicle
XLUUV Extra-Large Unmanned Undersea Vehicle
MK-54 MOD 2 ALWT Mark 54 MOD 2 Advanced Lightweight Torpedo
LRHW Long-Range Hypersonic Weapon
LTAMDS Lower-Tier Air and Missile Defense Sensor

Source: GAO analysis of Department of Defense data. | GAO-25-107569

[72]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 the Under Secretary of Defense for Acquisition and Sustainment 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.

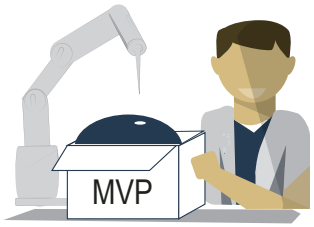
Leading Practices for Product Development

USE OF LEADING PRACTICES

Programs are missing opportunities to deliver capability with speed.

More MTA programs than MDAPs in development reported having plans to develop and deliver a minimum viable product (MVP) with speed (see fig. 20). However, even among those programs with plans to do so, most could still take additional steps to make their efforts more effective. For example:

- Less than half (9 of 22) of the programs reporting that they would be developing an MVP have a user agreement in place to formalize end user feedback during development.
- Few programs plan to develop a full system-level digital twin.
- Future major weapon acquisitions are not incorporating leading practices before initiation.

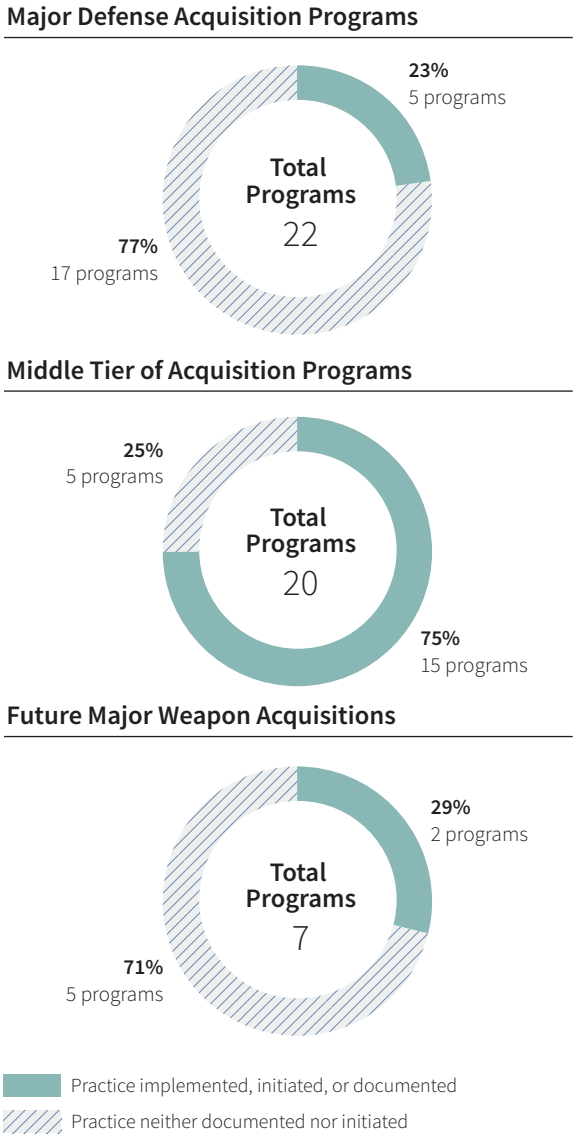


Source: GAO illustration. | GAO-25-107569

We asked the programs in our review whether they identified or plan to identify an MVP that incorporates the following four elements:

- → Refines high-level operational needs into an initial set of capabilities
- → Prioritizes capabilities that can be fielded most quickly to meet user needs
- → Incorporates both stakeholder and end user feedback
- → Accommodates successive updates[73]

Figure 20: Programs Planning to Develop a Minimum Viable Product



Source: GAO analysis of programs' questionnaire responses. | GAO-25-107569

Iterative development relies on regular user feedback to prioritize capabilities and identify the MVP. However, among the 22 programs that we reviewed that reported using or planning to use an iterative approach, only nine have user agreements in place for development.

Our prior work on **Agile software development**—an iterative approach that results in a minimum viable capability release, similar to an MVP—found that DOD's software pathway policy requires programs to create user agreements. This agreement is a commitment between the sponsor and program manager to define responsibilities and expectations and ensure that feedback is implemented as effectively as possible.[74] Iterative programs on other pathways are not required to do so. We reported that, without the expectation of regular user involvement during development, programs risk falling into the traditional approach of users helping to determine requirements and then having limited insight or contributions until capability delivery years later.

We recommended in July 2023 that DOD update its policies to incorporate user agreements for all programs using Agile for software development, among other things. DOD partially concurred and, in June 2024, noted that it planned to update its requirements policy for software development efforts embedded in weapon acquisition programs by December 2024. However, this recommendation remains open as of March 2025. We will continue to monitor program incorporation of user feedback for all aspects of development.

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

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

Leading Practices for Product Development

USE OF LEADING PRACTICES

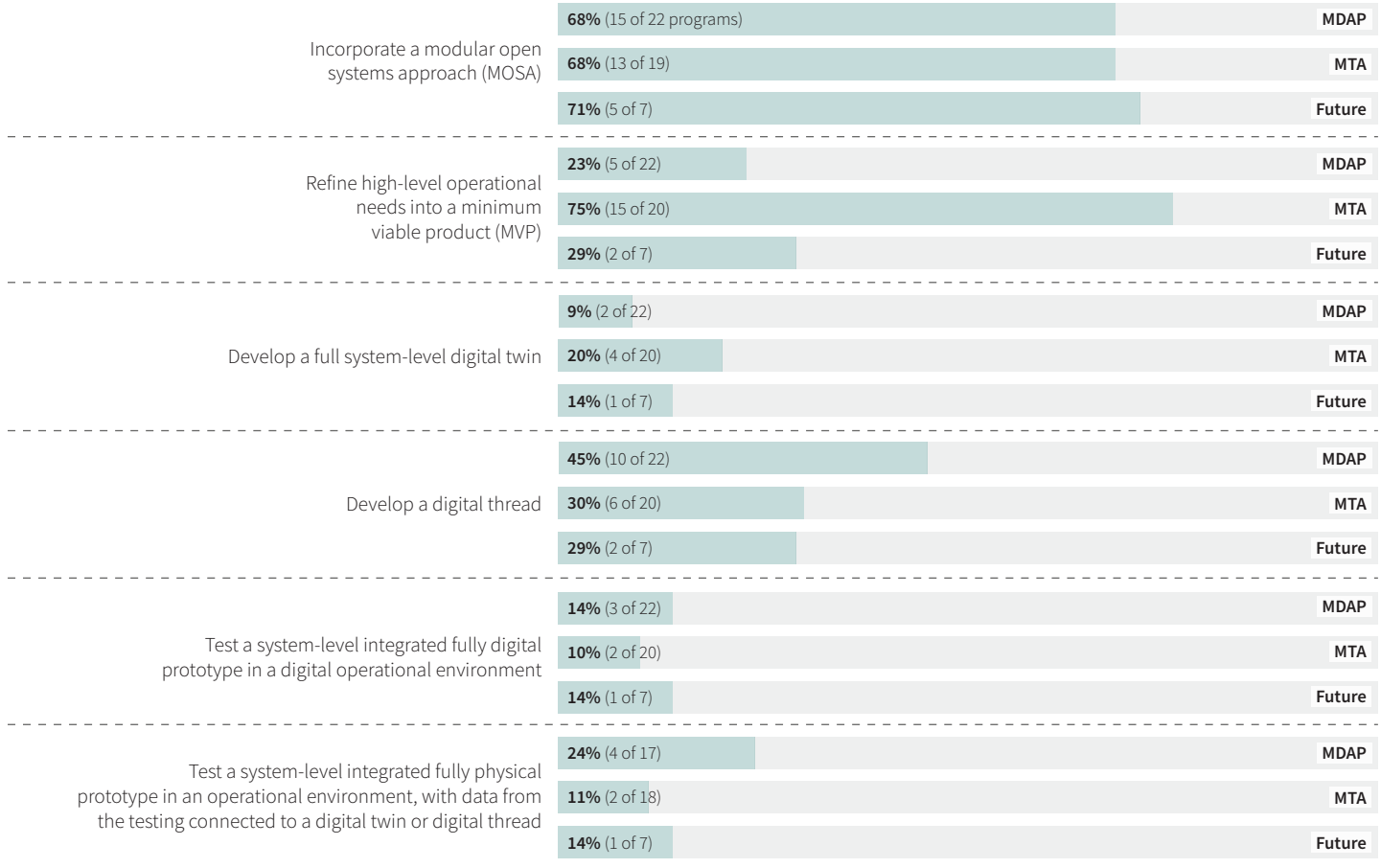
Programs report incorporating a MOSA but are not leveraging other leading practices to maximize outcomes.

We found that most programs expect to use a modular open systems approach (MOSA) (see fig. 21). Our prior work found that leading companies gain efficiencies and flexibilities through modularity in both design and manufacturing, and collect feedback to continue improving products in subsequent iterations. However, these same programs are not consistently utilizing the other leading practices that could help maximize the effectiveness of a MOSA. These practices include establishing digital twins (a virtual representation of a physical product) to help to ensure different systems and subsystems work together effectively; prototyping and testing new technologies in a virtual environment before physical implementation; and planning to develop an MVP followed by subsequent iterations of capability. We found that these practices are most effective when they are used together as part of an iterative approach.

Legislation enacted over the past several years required DOD to change the way it buys and designs weapon systems by implementing a MOSA to the maximum extent practicable.[75] A MOSA, which includes a modular design and standard interfaces, allows programs to easily replace components of a product. This approach allows the product to be upgraded with new, improved components that can be made by a greater variety of suppliers and increase opportunities for competition.

We previously found that programs that reported implementing a MOSA did so with varying degrees of modularity and openness.[76] We found that DOD's approach to planning for, coordinating, and resourcing MOSAs, along with incomplete policies, guidance, and regulations, hinders it from fully realizing MOSA benefits. We made 14 recommendations to DOD, including that it improve military department processes for ensuring quality MOSA planning documents. While DOD agreed, these recommendations remain open as of March 2025.

Figure 21: Most Programs Are Not Leveraging Other Leading Practices to Maximize a Modular Open Systems Approach



Source: GAO analysis of programs' questionnaire responses. | GAO-25-107569

Notes: The total number of programs may vary across practices but within the same program type (MDAP, MTA, future), because some programs were not assessed against all practices. For example, testing a system-level integrated physical prototype in an operational environment was deemed not applicable for certain programs due to the difficulty of conducting tests in the operational environment—space.

[75]In the National Defense Authorization Act for Fiscal Year 2017 (NDAA), Congress mandated that all major defense acquisition programs entering technology development or system development—milestones A or B, respectively—after January 1, 2019, implement MOSA to the maximum extent practicable. The William M. (Mac) Thornberry NDAA for Fiscal Year 2021 expanded this requirement mandating that all other acquisition programs also implement MOSA to the maximum extent practicable.

[76]GAO, *Weapon Systems Acquisition: DOD Needs Better Planning to Attain Benefits of Modular Open Systems*, GAO-25-106931 (Washington, D.C.: Jan. 22, 2025).

Leading Practices for Product Development

MDAPs

MDAPs in development reported limited use of leading practices.

Twenty-two MDAPs that have yet to enter production are not widely using leading practices that could enable the delivery of capability with speed. While many of these programs expect to incorporate a MOSA, no more than half are using any of the other practices employed by leading companies, limiting the weapon system's ability to evolve to future threats if needed (see fig. 22). Even though the MDAPs we reviewed cited constraints because they have already initiated development, we found that the adoption of these tools and methods can still help optimize production and ensure that the capability will work as intended in an operational environment to meet user needs.

Figure 22: Extent to Which Major Defense Acquisition Programs (MDAPs) Are Implementing Leading Practices for Product Development

Refine high-level operational needs into a minimum viable product (MVP)

Of the 17 programs not planning to develop an MVP, 11 reported adhering to highly detailed system requirements to meet a specific materiel solution—reflecting the linear approach that the Department of Defense has long followed. In contrast, our prior work found that leading companies progressively refine a high-level need statement or idea into distinct requirements.

- The **Army's Improved Turbine Engine Program** reported it does not plan to have an MVP because it will deliver the full required capability upon delivery of the first engines to the warfighter.
- The **Air Force's VC-25B Presidential Aircraft Recapitalization program** reported it has a detailed requirement and its end user expects full functionality at initial operational capability.

Develop a full system-level digital twin

Develop a digital thread

Just under half of the programs (10 of 22) have at least documented a plan to develop a digital thread—a common source of information that connects stakeholders with real-time data across the product life cycle. Far fewer programs plan to use digital twinning, which leading companies use to, among other things, test and validate a product's design with greater efficiency.

- The **Air Force's B-52 Radar Modernization Program (B-52 RMP)** stated it had neither a requirement nor funding for a digital twin or digital thread, while the **T-7A Red Hawk program** stated that it had a fixed-price contract and the data required for these tools would be considered a scope increase.
- The **Space Force's Next Generation Overhead Persistent Infrared Geosynchronous Earth Orbit Satellites (Next Gen OPIR GEO) program** reported that digital twins were previously dropped from its baseline due to schedule and cost considerations.

Test a system-level integrated fully digital prototype in a digital operational environment

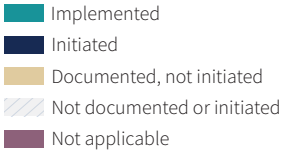
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread

The low prevalence of digital twins and digital threads among MDAPs meant few programs would be validating hardware and software in conjunction with these digital tools.

Over half of the programs still plan to test physical prototypes in an operational environment—in line with our long-standing knowledge-based best practices.

- The **Army's Future Long Range Assault Aircraft and Precision Strike Missile (PrSM) programs** expect to follow each of these system-level prototyping practices.

Incorporate a modular open systems approach (MOSA)



Systems with modular designs and open interfaces are better positioned to accept upgrades rapidly and affordably as part of future iterations. However, few programs are developing MVPs and planning subsequent iterations.

- The **PrSM** program's acquisition strategy expects its MOSA will enable the program to perform continuous technology insertions, among other things.
- **B-52 RMP** stated that it is not using MOSA because it is cost-prohibitive to redesign off-the-shelf subsystems.

Source: GAO analysis of programs' questionnaire responses. | GAO-25-107569

Note: Testing a system-level integrated physical prototype in an operational environment was deemed not applicable for four programs due to the difficulty of conducting tests in the operational environment—space. A fifth program is primarily software.

Leading Practices for Product Development

MDAPs IN PRODUCTION

More MDAPs could better integrate industrial base information prior to production.

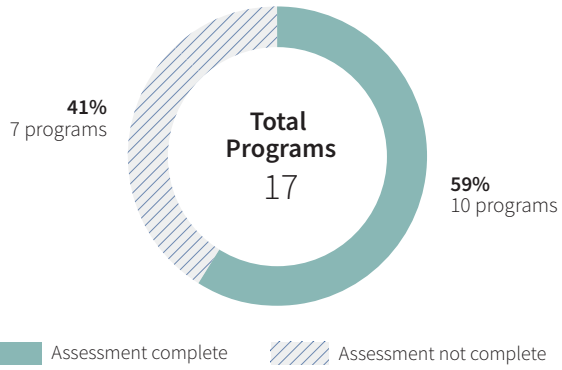
Ten of the 17 MDAPs in production (59 percent) reported assessing the defense industrial base to identify potential manufacturing capacity and capability risks (see fig. 23). The defense industrial base includes companies that develop and manufacture weapon systems, such as contractors, subcontractors, and suppliers of parts, components, and raw materials. Assessing related risks is consistent with leading practices. This number is up slightly from our 2022 report, which found that 15 of 28 MDAPs (54 percent) either completed or were scheduled to complete such an assessment. In 2022, we also recommended that, among other things, DOD report its progress toward mitigating industrial base risks.[77] DOD concurred with this recommendation and identified actions that it plans to take through July 2026.

However, only five of 17 programs reported incorporating feedback from both manufacturers and suppliers prior to moving into production, an approach that leading companies take to ensure that the product under development is manufacturable (see fig. 24).

Leading companies start production planning while they are still designing the MVP. Leading companies' product design teams include those designing the product as well as stakeholders producing it after testing and validation. Manufacturer and supplier stakeholders are involved throughout product design to ensure the manufacturing process can accommodate the design of the product. This includes analysis of the industrial base.

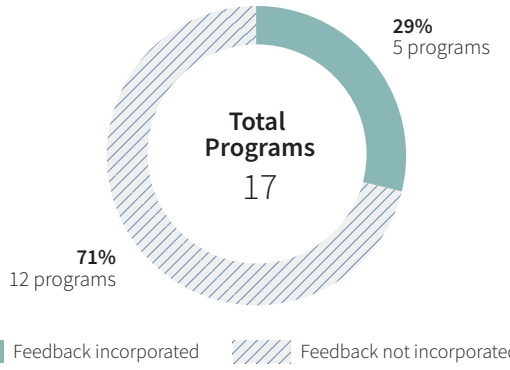
It is generally DOD's practice to delegate risk mitigation activities to the lowest level possible—the program offices—as these offices are the most knowledgeable about the changing risks and must address them to help meet cost, schedule, and performance goals. Program offices are instructed by policy to incorporate industrial base analyses into their acquisition planning.[78] We will continue to monitor programs' industrial base assessments and associated efforts to incorporate manufacturer and supplier feedback throughout development and prior to production.

Figure 23: Most Major Defense Acquisition Programs Currently in Production Completed an Industrial Base Assessment



Source: GAO analysis of programs' questionnaire responses. | GAO-25-107569

Figure 24: Few Major Defense Acquisition Programs Reported Incorporating Feedback from Both Manufacturers and Suppliers Prior to Production



Source: GAO analysis of programs' questionnaire responses. | GAO-25-107569

Small Diameter Bomb Increment II
Source: © 2009 Raytheon Company. | GAO-25-107569

The Air Force's **Small Diameter Bomb Increment II** (left) program has experienced production delays related to obsolescence and part shortages. The program conducted an industrial base assessment in 2013 but did not involve manufacturer and supplier feedback throughout product design to begin planning for production. This early planning could have reduced the risk that manufacturing issues would delay delivery. The program has taken steps, such as identifying additional suppliers, to make up delivery time and minimize further delays and expects to resolve these challenges by the third quarter of fiscal year 2025.

Similarly, the Navy's **Advanced Anti-Radiation Guided Missile—Extended Range** missile program has experienced significant delays due to rocket motor, structural, and software issues discovered during testing, delaying a full-rate production decision by 10 months. Program officials also attributed production delays to supply chain challenges and construction delays on a new facility. The program did not conduct an industrial base assessment or incorporate feedback from manufacturers or suppliers prior to entering production.

[77]GAO, *Defense Industrial Base: DOD Should Take Actions to Strengthen Its Risk Mitigation Approach*, GAO-22-104154 (Washington, D.C.: July 7, 2022).
[78]Department of Defense, *Major Capability Acquisition*, DOD Instruction 5000.85 (Aug. 6, 2020) (incorporating change 1, Nov. 4, 2021).

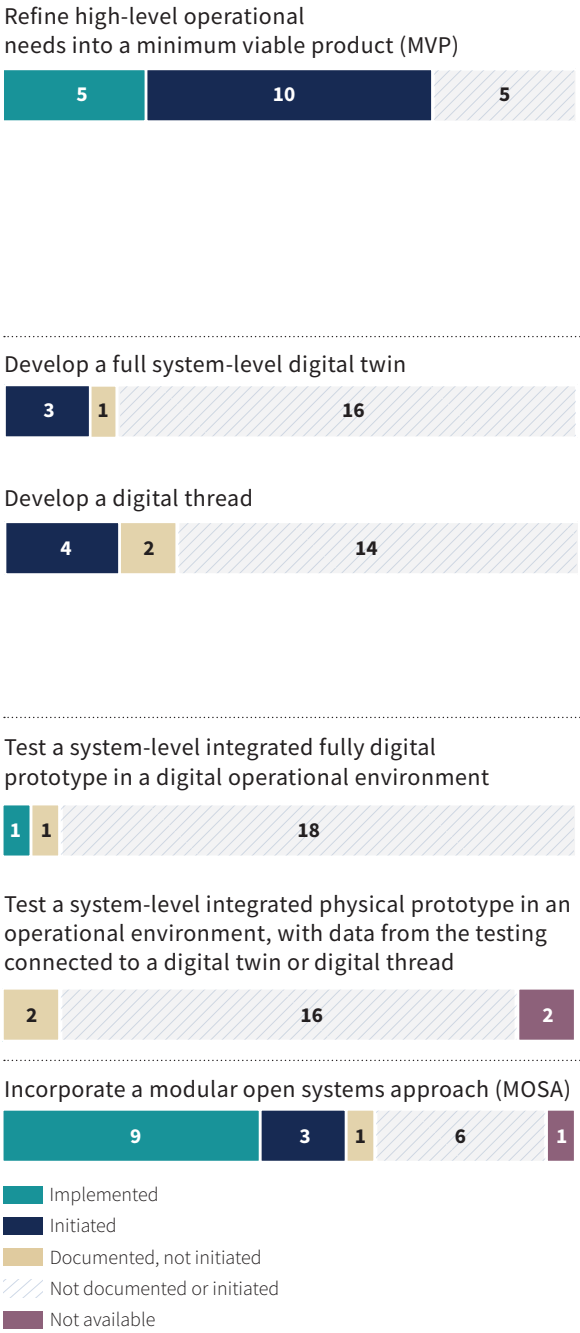
Leading Practices for Product Development

MTAs

MTA programs are not consistently implementing digital engineering practices.

The MTA programs that we assessed are not fully benefitting from implementing multiple leading practices together to deliver complex systems with speed. Most MTA programs (15 of 20) reported working to refine or have already refined high-level operational needs into an MVP. Over half of MTA programs (12 of 20) plan to or are incorporating a MOSA. However, these programs do not currently plan to adopt the digital engineering tools that facilitate efficiencies to the same extent (see fig. 25). Programs cited obstacles to adopting digital engineering tools and implementing leading practices more broadly—in part due to limited staffing, budget constraints, and contractual issues, as well as other decisions made prior to program initiation. We previously found that using digital tools such as digital twins and digital threads provides real-time data to inform decision-making throughout the product life cycle; increases efficiencies throughout development and production; and helps to maximize the effectiveness of a modular approach.

Figure 25: Extent to Which Middle Tier of Acquisition (MTA) Programs Are Implementing Leading Practices for Product Development



Fifteen of 20 MTA programs reported developing an MVP. One program cited fixed requirements as a challenge to doing so.

- The **Space Force's Future Operationally Resilient Ground Evolution (FORGE)** reported that it delivered the minimum viable product and that it continues to develop subsequent releases as it plans its transition to the software pathway in the fourth quarter of fiscal year 2025.
- The **Army's Maneuver Short Range Air Defense Increment 3 (M-SHORAD Inc 3) program** stated that, as a missile program, it could not develop an MVP because all functions are critical to meeting requirements.

Three programs—the **Navy's Hypersonic Air-Launched Offensive Anti-Surface Warfare Weapon System** and the **Space Force's FORGE** and **Resilient MW/MT MEO**—reported initiating development of a digital twin. Other programs cited multiple challenges to using these tools, including financial, staffing, and contractual issues.

- The **Air Force's Hypersonic Attack Cruise Missile program**, and the **Army's M-SHORAD Inc 3** and **Long-Range Hypersonic Weapon** programs cited limited resources, including financial or staffing constraints.
- Two programs reported challenges with contractors, such as contractors' reluctance to move to digital tools or issues obtaining data rights.

Only two MTA programs reported testing or plans to test fully digital prototypes in a digital environment. Two additional MTA programs reported having plans to test physical prototypes connected to digital twins or threads but have yet to do so.

- The **Space Force's FORGE** program reported that it tested an integrated, fully digital prototype in a digital environment with replicated operational hardware, infrastructure, and platforms in 2024.
- Seventeen programs reported plans to test a physical prototype in an operational environment—in line with our long-standing knowledge-based best practices.

Over half of MTA programs in our portfolio have implemented MOSA or are in the process of doing so.

- Some MTAs that are not incorporating a MOSA reported that the system is designed to interface with other weapon systems (such as the **Space Force's Military GPS User Equipment Increment 2**) or have specific existing interfaces (such as the **Air Force's F-22 Sensor Enhancements**).

Source: GAO analysis of programs' questionnaire response. | GAO-25-107569

Note: Testing a system-level integrated physical prototype in an operational environment was deemed not applicable to one program due to the difficulty of conducting tests in the operational environment—space, and a second program that is primarily software. Incorporating a modular open systems approach was deemed not applicable to one program because it is a component designed for use with multiple weapon systems.

Leading Practices for Product Development

FUTURE MAJOR WEAPON ACQUISITIONS

Few programs plan to implement multiple leading practices that could speed development.

While the seven future major weapon acquisitions in our review reported using some leading practices for product development, most of these efforts do not use or plan to use multiple practices together that would enable the efficiencies the practices provide (see fig. 26). For example, DOD officials previously told us that digital engineering tools help programs document key MOSA decisions, use templates to easily implement consensus-based standards, and continuously evaluate the design process in real time.[79] However, only two future programs implementing a MOSA also have plans to use a digital thread or digital twin.

Our leading practices found that iterative processes begin early in development and use modern tools and other concepts in concert to design, validate, and deliver capability with speed. Future major weapon acquisitions are early enough in the acquisition process that there are still opportunities to implement leading practices and enable an iterative approach before entering an acquisition pathway, after which it can be harder for the program to restructure.

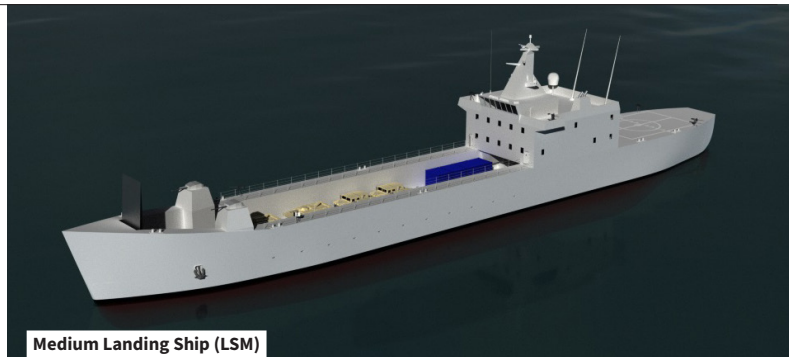
Figure 26: Future Major Weapon Acquisitions Are Not Using Multiple Leading Practices Together

	Programs	Minimum Viable Product	Full System-Level Digital Twin Digital Thread	Test Digital Prototype[a] Test Physical Prototype[b]	MOSA Incorporated
		Leading practices			
Naval vessels	Guided Missile Destroyer ((DDG(X))	○	○ ◐	○ ○	○
Naval vessels	Medium Landing Ship (LSM)	○	○ ○	○ ○	◔
Naval vessels	Large Unmanned Surface Vessel (LUSV)	○	○ ◐	○ ○	●
Naval vessels	Extra-Large Unmanned Undersea Vehicle (XLUUV)	○	○ ○	○ ○	○
Naval munition	Mark 54 MOD 2 Advanced lightweight torpedo (Mk-54 MOD 2)	◐	○ ○	◔ ○	●
Army munition	Long-Range Hypersonic (LRHW)	●	○ ○	○ ○	●
Army radar	Lower-Tier Air and Missile Defense Sensor (LTAMDS)	○	◐ ○	○ ◐	●

● Practice implemented
◐ Practice initiated
◔ Practice documented but not initiated
○ Practice neither documented nor initiated
MOSA = Modular Open Systems Approach

Source: GAO analysis of programs' questionnaire responses. | GAO-25-107569

[a]Test a system-level integrated fully digital prototype in a digital operational environment.
[b]Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread.



Medium Landing Ship (LSM)

Source: U.S. Navy. | GAO-25-107569

Long Range Hypersonic Weapon Program (LRHW)

Source: U.S. Army. | GAO-25-107569

Decisions made during the earliest phases of the program may prevent the subsequent implementation of leading product development practices and restrict development options for years to come.

For example, Congress required by law the Secretary of the Navy to certify that **LSM's** basic and functional design were complete before entering a contract for the lead ship's construction—which we previously identified as a ship design leading practice—but LSM's acquisition strategy did not require it. The Navy subsequently canceled its detail design and construction solicitation because the offers came in hundreds of millions of dollars higher than budgeted.

Other programs cited budget constraints and finalized contracts as reasons for not adopting leading practices, among other reasons.

[79]GAO, *Weapon Systems Acquisition: DOD Needs Better Planning to Attain Benefits of Modular Open Systems*, GAO-25-106931 (Washington, D.C.: Jan. 22, 2025).

Leading Practices for Product Development

IMPACTS OF FUTURE WEAPON ACQUISITION DECISIONS

DOD and military services miss opportunities to ensure successful implementation of leading practices.

Weapon acquisitions are not incorporating leading practices during the earliest stages of the program—before they become locked into rigid requirements, budgets, and development approaches for multiple decades. We previously recommended that DOD and the military services update acquisition policies to reflect leading practices that facilitate speed and innovation.[80] In addition, our prior work on ship design and hypersonic weapons found that using an iterative approach could help programs develop systems that deliver the most critical capabilities needed and reduce cost and schedule risk.[81] DOD concurred with our recommendations and is taking steps to implement them.

Decision authorities in DOD and across the military services are not ensuring that the use of leading product development practices are included in planned strategies for future major weapon acquisitions before their initiation on an AAF pathway. Until DOD and the military departments make a concerted effort to emphasize leading practices prior to program initiation, they will not be well-positioned to ensure programs are structured to execute iterative development and achieve speed in delivering capability. By incorporating leading practices for product development early and prior to program start, future major weapon acquisitions can take full advantage of the efficiencies the practices provide to design, validate, and deliver essential capability with speed, ultimately avoiding a decades-long acquisition that is not Agile, flexible, or responsive to changing threats and warfighter needs. The decision authorities in DOD and the military services are positioned to ensure, during their review of early acquisition documentation, that future major weapon acquisitions fully incorporate leading product development practices.

MDAPs and MTA programs reported limited implementation of leading product development practices, missing opportunities to improve program outcomes, in part, due to requirements, budget, and other acquisition decisions made prior to their initiation. For example:

T-AGOS 25 *Explorer* Class Ocean Surveillance Ship

The Navy's **T-AGOS 25 *Explorer* Class Ocean Surveillance Ship** program, an MDAP, reported that digital engineering is not included in its requirements, even though these digital practices can lower the risk of costly redesign work during construction.

F-22 Sensor Enhancements

The Air Force's **F-22 Sensor Enhancements** MTA program reported that, while it applied leading practices during rapid prototyping, it did not plan to do so for rapid fielding. The program is missing opportunities to refine requirements based on feedback from users and stakeholders into subsequent iterations of capability.

Source: Defense Visual Information Distribution Service. | GAO-25-107569

Source: U.S. Navy. | GAO-25-107569

Indirect Fire Protection Capability Increment 2

The Army's **Indirect Fire Protection Capability Increment 2** MTA program is not implementing leading practices. The program stated this is due to requirements identifying a specific material solution. This approach misses opportunities to evolve original requirements in concert with demonstrated achievement.

Tranche 1 and Tranche 2 Transport and Tracking Layers

Space Force's MTA **Tranche 1 and Tranche 2 Transport Layers** and **Tranche 1 and Tranche 2 Tracking Layers** reported an acquisition structure that is implementing some elements of leading practices but not in a way that will achieve efficiencies from iterative development. The program stated that it identified an MVP but its plans do not include the important step of fully demonstrating the MVP before moving forward with the next iterations, resulting in the missed opportunity to validate planned capabilities.

[80]GAO, *DOD Acquisition Reform: Military Departments Should Take Steps to Facilitate Speed and Innovation*, GAO-25-107003 (Washington, D.C.: December 12, 2024); and *Leading Practices: Agency Acquisition Policies Could Better Implement Key Product Development Principles*, GAO-22-104513 (Washington, D.C.: Mar. 10, 2022).

[81]GAO, *Hypersonic Weapons: DOD Could Reduce Cost and Schedule Risks by Following Leading Practices*, GAO-24-106792 (Washington, D.C.: July 29, 2024); *Navy Frigate: Unstable Design Has Stalled Construction and Compromised Delivery Schedules*, GAO-24-106546 (Washington, D.C.: May 29, 2024); and *Navy Shipbuilding: Increased Use of Leading Design Practices Could Improve Timeliness of Deliveries*, GAO-24-105503 (Washington, D.C.: May 2, 2024).

DOD Software Development

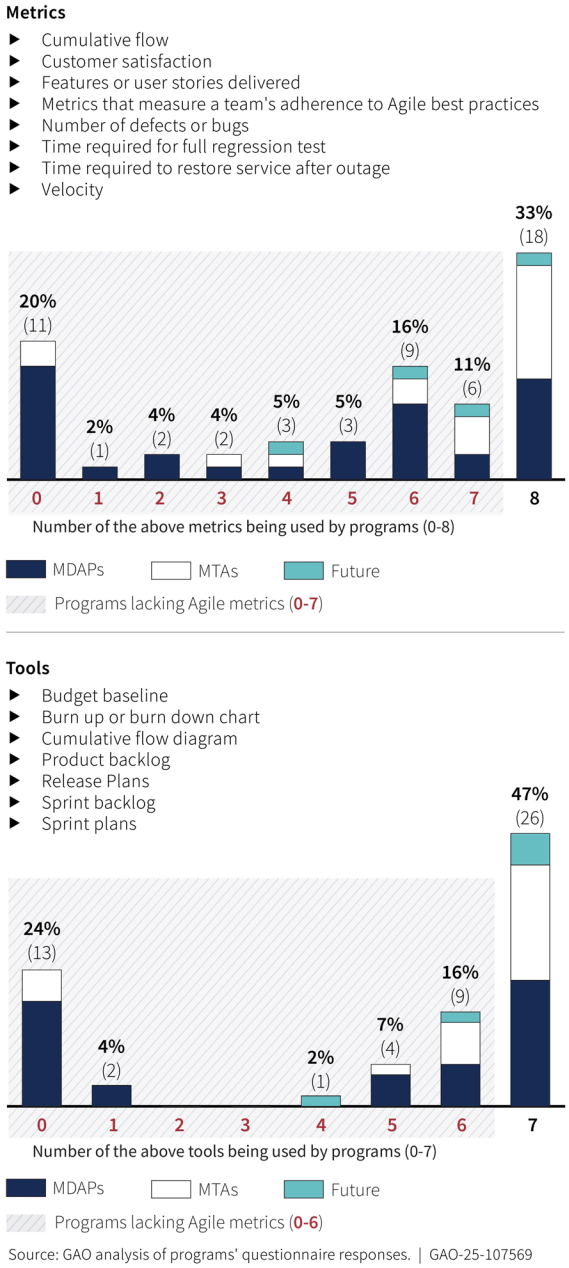
IMPLEMENTATION OF MODERN APPROACHES

Programs could improve oversight of software development.

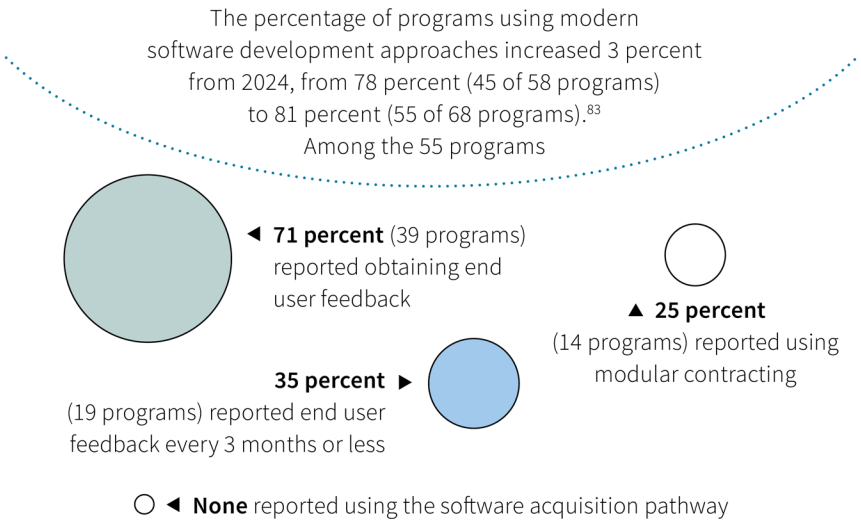
Most programs that reported using modern software approaches lack some of the metrics and tools recommended by our Agile Guide and DOD guidance (fig. 27). As a result, these programs are missing opportunities for increased visibility into software performance. In addition, 11 programs reported using none of the recommended metrics or tools. A majority of these programs told us that they had no insight into how the contractors were tracking software development. Programs also reported that software was close to completion or that metrics were not required by the contract.

We previously found that lacking visibility into software progress may delay delivery of software packages, increase costs and rework, and potentially lead to a higher risk of not providing the required functionality. We recommended that DOD incorporate oversight tools, such as metrics, into acquisition policy and guidance for all programs using Agile software development approaches.[82] This recommendation remains open as of March 2025. We will continue to monitor these efforts.

Figure 27: Use of Recommended Agile Metrics and Tools Among Programs Reporting Modern Software Development Approaches

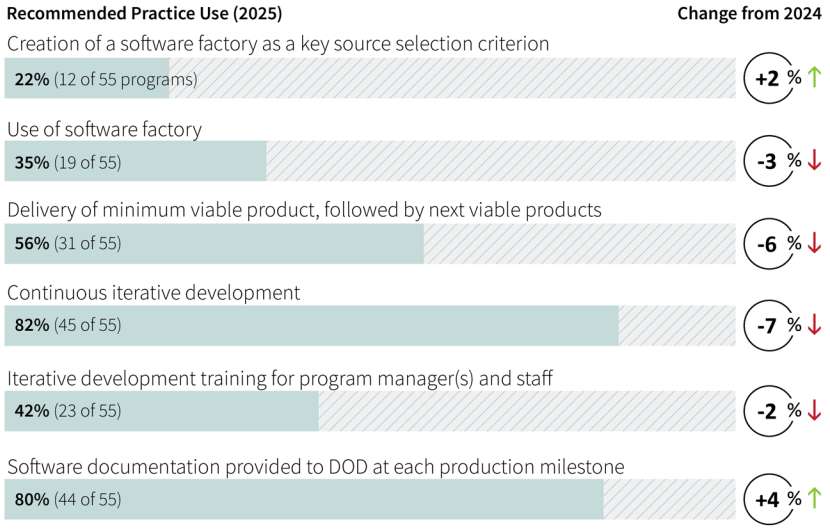


Source: GAO analysis of programs' questionnaire responses. | GAO-25-107569



The use of practices recommended by the Defense Science Board—which we have reported on for the past 4 years—declined in four out of six areas (see fig. 28).

Figure 28: Implementation of 2018 Defense Science Board Recommended Practices by Programs That Reported Using a Modern Software Development Approach



Source: GAO analysis of programs' questionnaire responses. | GAO-25-107569

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

DOD Cybersecurity

CYBERSECURITY PRACTICES AND ASSESSMENTS

Programs continue to inconsistently execute early cybersecurity testing.

Fewer MDAPs and MTAs are conducting cybersecurity assessments prior to key program events as compared to last year (see figs. 29 and 30).

- The number of MDAPs completing cybersecurity assessments before key program events decreased for three of the four assessments that we reviewed.
- Consistent with last year, most MTA programs do not complete, or plan to complete, recommended cybersecurity assessments before transitioning to another pathway. Only three of 12 MTA programs reported doing so.

As discussed in previous reports, early and regular discovery of mission-impacting system vulnerabilities are used to make informed program decisions, to fix vulnerabilities more easily, and to reduce risk to schedule.[84] In 2023, we released a restricted report that made recommendations related to early cybersecurity testing for MDAPs.[85]

Figure 29: Number of Major Defense Acquisition Programs Completing Key Cybersecurity Assessments Before Applicable Program Event

Cybersecurity assessment	Applicable program event	2025	Change from 2024
Cooperative Vulnerability Identification	Start of production (Milestone C)	**50%** (5 of 10)	**Declined**
Adversarial Cybersecurity Developmental Test and Evaluation	Start of production (Milestone C)	**25%** (2 of 8)	**Declined**
Cooperative Vulnerability and Penetration Assessment	Initial operational test and evaluation	**67%** (6 of 9)	**Unchanged**
Adversarial Assessment	Full-rate production decision	**60%** (3 of 5)	**Declined**

Source: GAO analysis of programs' questionnaire responses. | GAO-25-107569

Note: Major Defense Acquisition Program increments and programs with unreported data are not included.

Figure 30: Number of Middle Tier of Acquisition 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 in 2025 completing or planning to complete all recommended assessments before transition	Change from 2024
To MDAP production start (Milestone C)	CVI, ACD	**33%** (1 of 3)	**Unchanged**
To MTA rapid fielding	CVI, ACD, CVPA, AA	**0%** (0 of 4)	**Unchanged**
To operations and sustainment	CVI, ACD, CVPA, AA	**40%** (2 of 5)	**Declined**

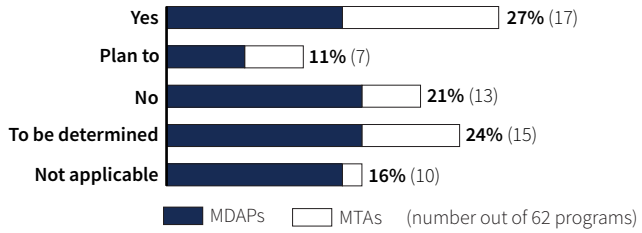
CVI Cooperative Vulnerability Identification **ACD** Adversarial Cybersecurity Developmental Test and Evaluation **CVPA** Cooperative Vulnerability and Penetration Assessment **AA** Adversarial Assessment **MDAP** Major defense acquisition program **MTA** Middle tier of acquisition

Source: GAO analysis of programs' questionnaire responses. | GAO-25-107569

Note: Eight MTA programs were not evaluated due to unreported data, transitioning before or between milestone listed, or to the software acquisition pathway.

Zero trust is a set of cybersecurity principles that are founded on the concept that nothing operating outside of or within an organization's IT security perimeter should be trusted, and anything that attempts to establish access to the systems, services, and networks should be verified. DOD plans for all of its IT organizations to adopt zero trust cybersecurity principles by 2027. DOD weapon systems are increasingly reliant on software for developing and maintaining capability. See figure 31.

Figure 31: Major Defense Acquisition Programs and Middle Tier of Acquisition Programs That Have a Zero Trust Strategy



Source: GAO analysis of programs' questionnaire responses. | GAO-25-107569

Programs provided a variety of reasons for not adopting zero trust principles. These included not being part of their requirements, the program already being in the production stage, and resource limitations. Other programs reported that zero trust was not applicable because of their use of commercial off-the-shelf software, or that the strategy did not apply when there are no user accounts or network connections. We will continue to monitor DOD acquisition programs' adoption of zero trust principles.

[84]GAO, *Weapon Systems Annual Assessment: DOD Is Not Yet Well-Positioned to Field Systems with Speed [Reissued with revisions on Jul. 18, 2024]*, GAO-24-106831 (Washington, D.C.: June 17, 2024); and *Weapon Systems Annual Assessment: Programs Are Not Consistently Implementing Practices That Can Help Accelerate Acquisitions*, GAO-23-106059 (Washington, D.C.: June 8, 2023).
[85]GAO, *Weapon Systems Cybersecurity: DOD Should Increase Testing during Development*, GAO-23-105654SU (Washington, D.C.: Sept. 26, 2023).

Conclusions

For decades, DOD has fallen short in consistently delivering capability to the warfighter on time and within budget—wasting billions of taxpayer dollars and often running years over schedule. In recent years, it is increasingly struggling to keep pace with technologically advanced adversaries, including China and Russia. Yet, DOD can take immediate action to begin to fix these urgent problems.

One root cause of DOD's consistent cost and schedule overruns is its persistent slow, linear development approaches. The department and Congress alike have acknowledged in recent years the limits of DOD's existing acquisition system. Our recent work on leading practices for product development identifies a structural approach and associated practices that facilitate delivering complex systems with speed. This includes using commercial design concepts—such as digital twinning—to enable rapid iterative cycles of design, development, and delivery.

Future weapon system programs that have yet to enter a formal pathway have an opportunity to take a different path from legacy acquisition programs—which are largely constrained by rigid requirements and archaic development approaches. But these programs are not fully using leading practices for product development early enough in the acquisition process. The decision authorities who ultimately approve these programs for initiation and weigh in during the earliest junctures can help structure them to deliver capability with speed. Without doing so, programs may continue to fall short of their goals with systems that arrive later and more expensive than originally expected.

As DOD moves forward with new multibillion-dollar ventures in pursuit of more advanced capabilities, the significance of starting with an acquisition structure that allows for iterative solutions to keep pace with evolving warfighter needs cannot be overstated. DOD can implement early approaches that facilitate iteration—like starting with high-level capability needs, planning for digital twins and threads, and using modular open systems approaches—that provide a logical starting point for achieving better, more consistent outcomes.

Recommendations for Executive Action

We are making a total of four recommendations, including one to the Under Secretary of Defense for Acquisition and Sustainment; one to the Secretary of the Air Force; one to the Secretary of the Army; and one to the Secretary of the Navy. Specifically:

The Under Secretary of Defense for Acquisition and Sustainment should ensure that it takes steps as the defense acquisition executive during the

review of relevant acquisition documentation to determine whether future major weapon acquisitions fully incorporate leading product development practices early enough to influence the acquisition approach. (Recommendation 1)

The Secretary of the Air Force should ensure the decision authorities within the department, including those related to the Space Force, take steps during the review of relevant acquisition documentation to determine whether future major weapon acquisitions fully incorporate leading product development practices early enough to influence the acquisition approach. (Recommendation 2)

The Secretary of the Army should ensure the decision authorities within the department take steps during the review of relevant acquisition documentation to determine whether future major weapon acquisitions fully incorporate leading product development practices early enough to influence the acquisition approach. (Recommendation 3)

The Secretary of the Navy should ensure the decision authorities within the department take steps during the review of relevant acquisition documentation to determine whether future major weapon acquisitions fully incorporate leading product development practices early enough to influence the acquisition approach. (Recommendation 4)

Agency Comments

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

We are sending copies of this report to the appropriate congressional committees 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 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 VII.

//SIGNED//

Shelby S. Oakley
Director, Contracting and National Security Acquisitions

List of Committees

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

The Honorable Mitch McConnell
Chair
The Honorable Christopher Coons
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
Chairman
The Honorable Betty McCollum
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Appendix I: Program Assessments

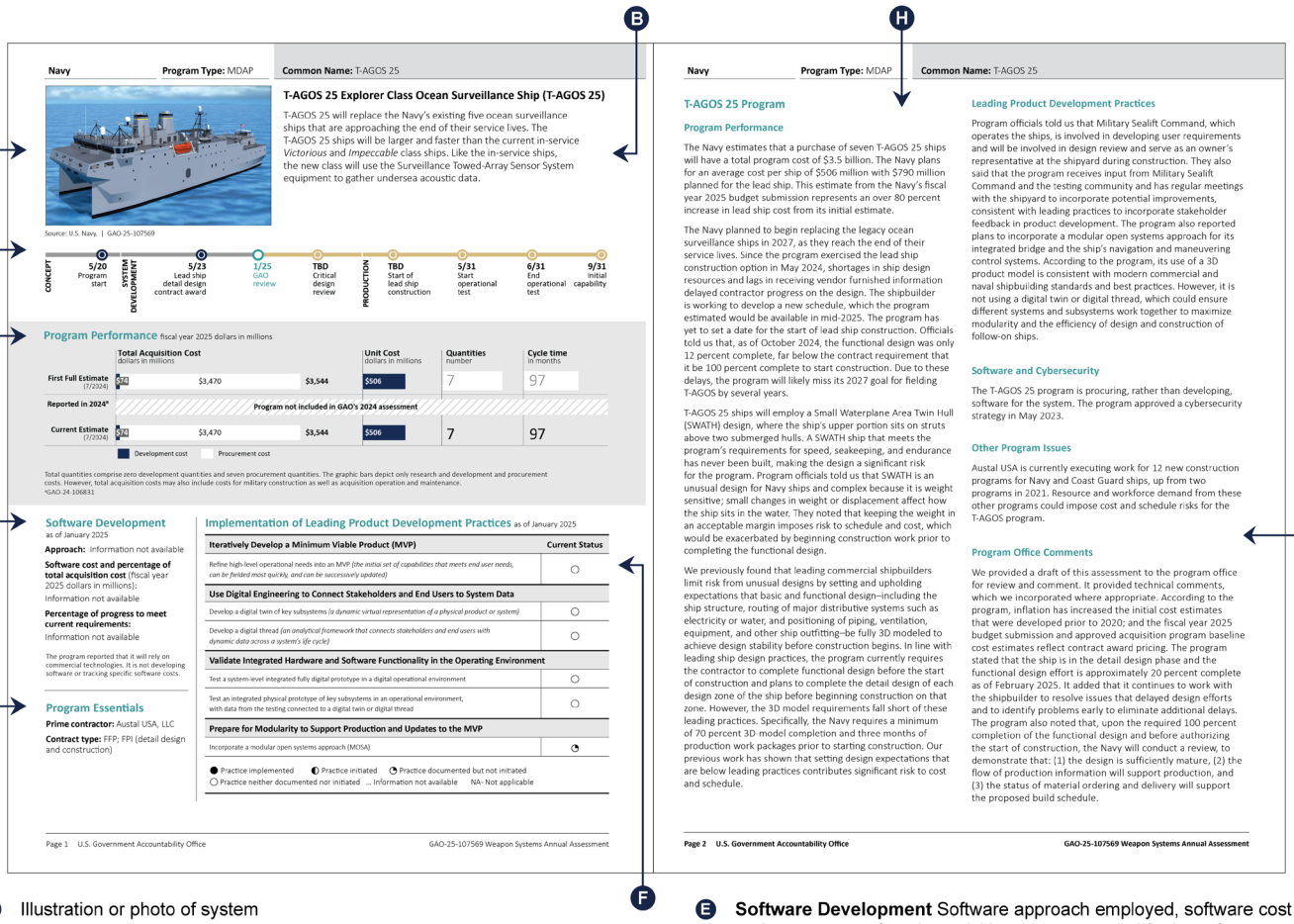
This section contains 65 assessments of 69 weapon programs.[86]

For 22 MDAPs in development, we produced two-page assessments discussing program performance including cost and schedule performance, leading product development practices, software and cybersecurity efforts, and other program issues.[87] For these MDAPs, we also assessed program implementation of selected leading product development practices. See Figure 32 for an illustration of the layout of each two-page assessment.

[86]We reviewed 69 total programs. We present 65 assessments because the Space Force's Tranche 1 Tracking Layer (T1 TRK) and Tranche 2 Tracking Layer (T2 TRK); Tranche 1 Transport Layer (T1TL) and Tranche 2 Transport Layer Transport Layer (T2TL); and the Army's IVAS efforts were reviewed together in consolidated MTA assessments. Additionally, the Army's Long Range Hypersonic Weapon System (LRHW) assesses a future major weapon acquisition program and an MTA effort. 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). Additionally, we abbreviated Department of Defense (DOD), middle tier of acquisition (MTA), minimum viable product (MVP), and modular open systems approach (MOSA).

[87]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.

Figure 32: Illustration of Two-Page Major Defense Acquisition Program Assessment

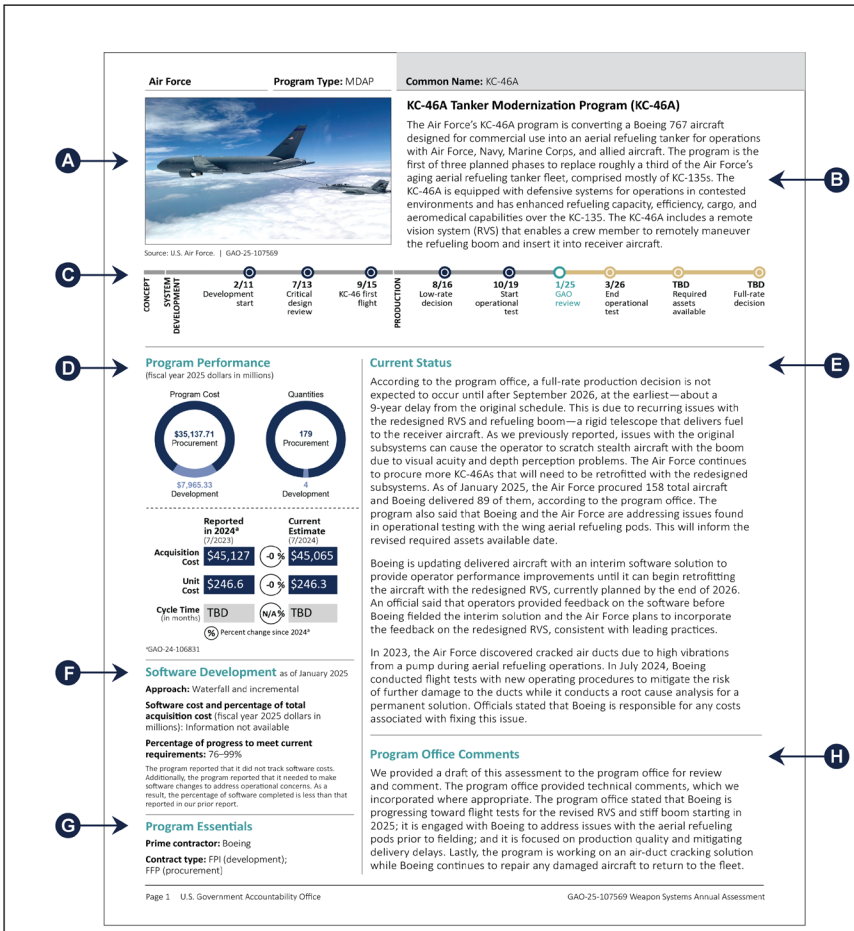


- **A** Illustration or photo of system
- **B** Program description
- **C** Timeline identifying key dates for the program including, the start of development, major decision reviews, production decision and planned operational capability. Where applicable, "major capability transition" indicates when 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), estimate as of last year (GAO's 2024 assessment) and current estimate. We depict only the program's main elements of acquisition cost – research and development and procurement. However, total program costs may 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, software cost and percentage of total acquisition cost accounted for by software development, and percentage of progress to meet current requirements
- **F** **Implementation of Leading Product Development Practices**
  Depiction of selected leading product development 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 performance, implementation of leading product development practices, 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-25-107569

For the 17 MDAPs that reached production as of May 2024, we produced one-page assessments discussing the program's cost and schedule performance as well as the current status of the program.[88] See Figure 33 for an illustration of the layout of each one-page assessment.

Figure 33: Illustration of One-Page Major Defense Acquisition Program Assessment



- **A** Illustration or photo of system
- **B** Program description
- **C** Timeline identifying key dates for the program such as program initiation, contract award, and significant relevant programmatic decision points. 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 current estimate and estimate as of last year (GAO's 2024 assessment). We depict only the program's main elements of acquisition cost – research and development and procurement. However, total program costs may 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** **Current Status** Updated status of the program
- **F** **Software Development** Software approach employed, software cost and percentage of total acquisition cost accounted for by software development, and percentage of progress to meet current requirements
- **G** **Program Essentials** Programmatic information including prime contractor (or other identified contractors) and contract type
- **H** **Program Office Comments** General comments provided by the cognizant military service or program office

Source: GAO. | GAO-25-107569

[88]For shipbuilding programs, our work identifies detail design and construction as the point at which programs typically award construction of the lead ship.

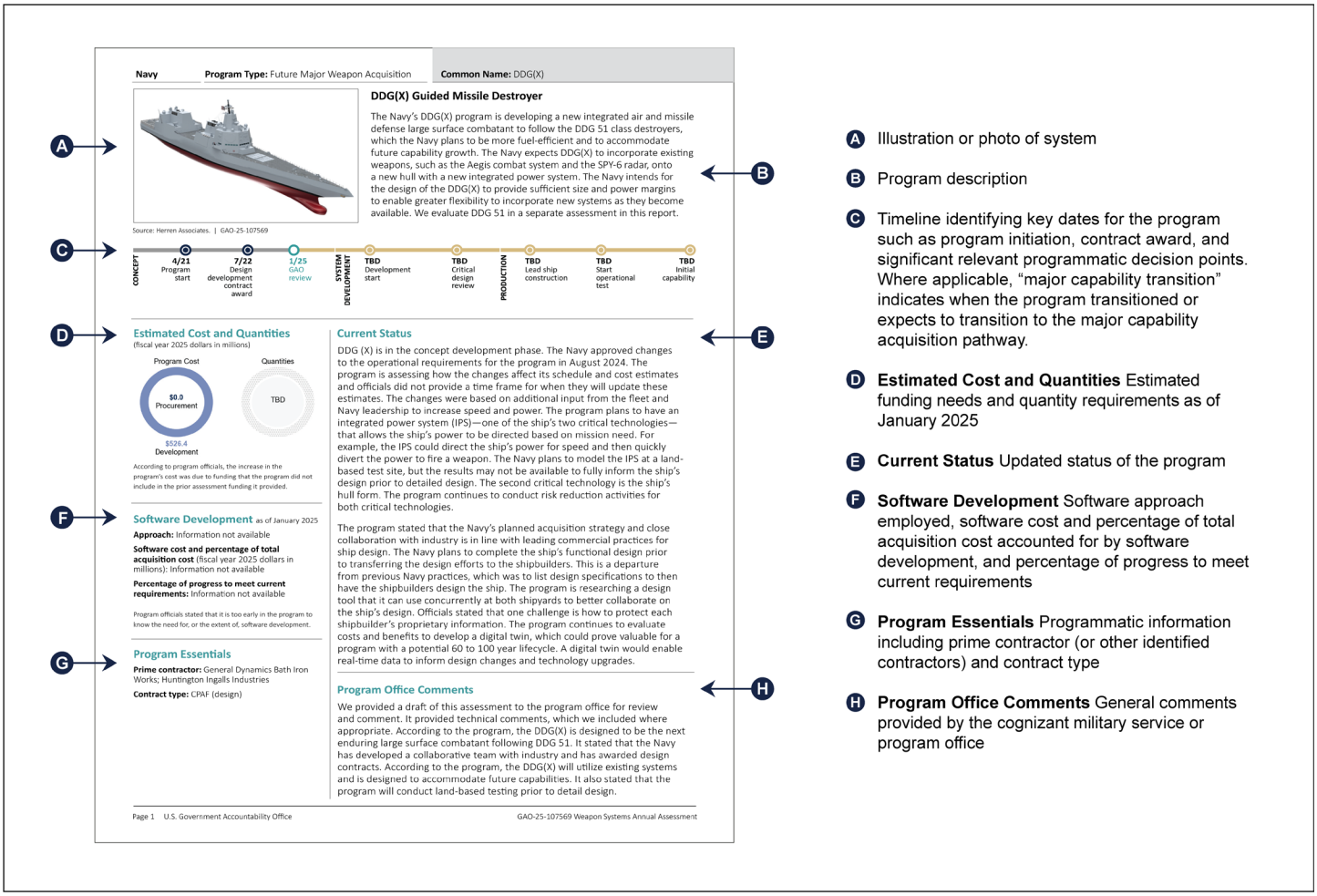
In addition, we produced nine one-page assessments:

- six future major weapon acquisitions, and
- three MDAPs that were well into production, but planned to introduce new increments of capability, which we refer to as MDAP increments.[89]

See Figure 34 for an illustration of the layout of each one-page assessment.

[89]One additional future major weapon acquisition program, LRHW, is combined with the MTA effort into one assessment.

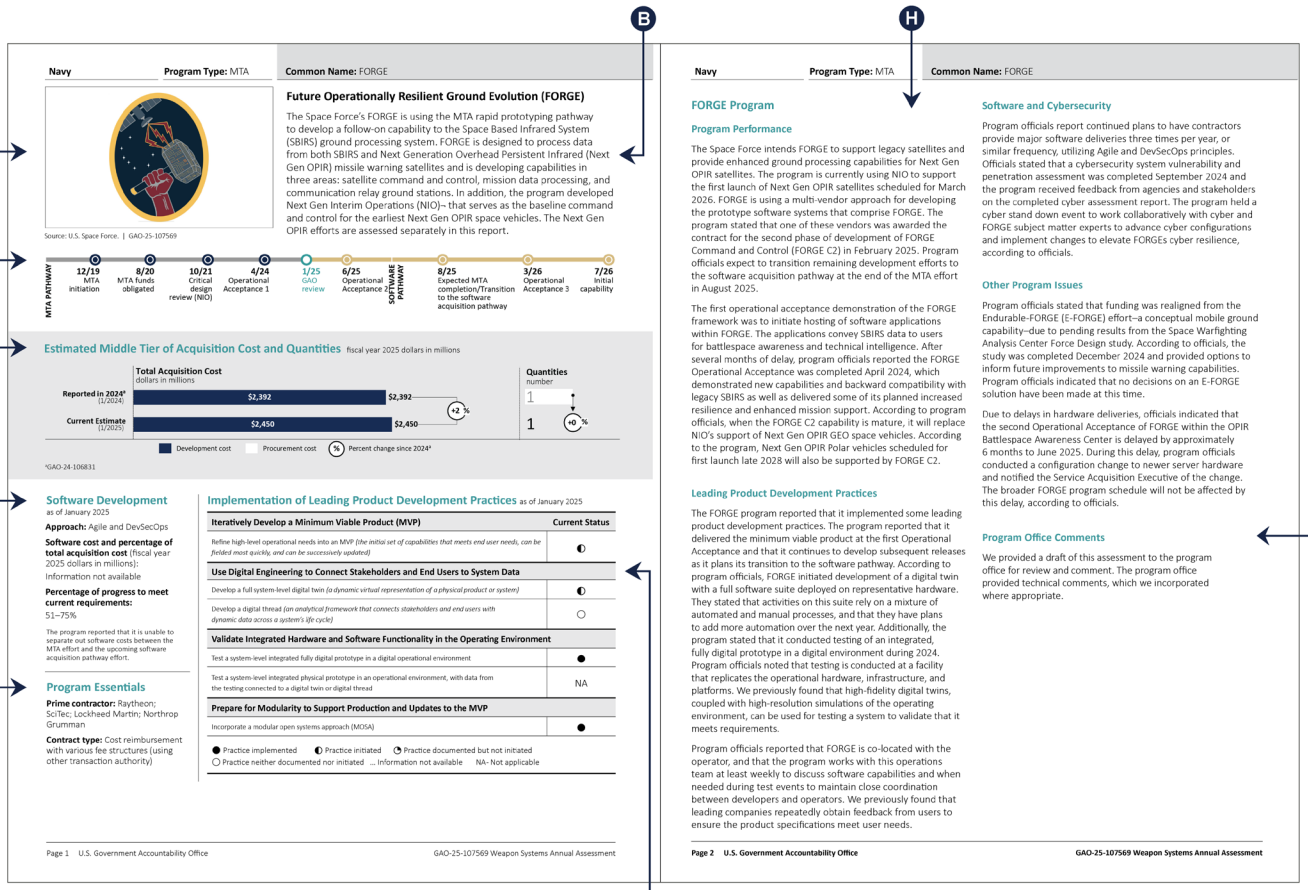
Figure 34: Illustration of One-Page Future Major Weapon Acquisition or Major Defense Acquisition Program Increment Assessment



Source: GAO. | GAO-25-107569

We produced 17 two-page assessments for 20 programs using the MTA acquisition pathway. These two-page assessments discussing program performance including cost and schedule performance, leading product development practices, software and cybersecurity efforts, and other program issues. See Figure 35 for an illustration of the layout of each two-page MTA program assessment.

Figure 35: 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, initial capability, and significant relevant programmatic decision points. Where applicable, "major capability transition" indicates when the program expects to transition to the major capability acquisition pathway. "Initial capability" refers to the envisioned initial operational capability, initial warfighting capability, or equivalent
- **D** **Estimated Middle Tier of Acquisition Cost and Quantities** Comparison of current cost and quantity estimates as of January 2025, and the estimates as of last year (GAO's 2024 assessment)
- **E** **Software Development** Software approach employed, cost and percentage of total acquisition cost accounted for by software development, and percentage of progress to meet current requirements
- **F** **Implementation of Leading Product Development Practices** Depiction of selected leading product development practices and the program's progress in attaining that knowledge as of January 2025
- **G** **Program Essentials** Programmatic information including prime contractor (or other identified contractors) and contract type
- **H** Assessment of program performance and implementation of leading product development practices, 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-25-107569

For 42 of our 69 assessments, we used scorecards to depict the extent of the program's implementation of leading practices.[90] These scorecards display key leading practices that we found enables complex systems to be developed and delivered with speed to meet warfighter needs.

For each scorecard, we used the following scoring conventions:

- A closed circle to denote a leading product development practice the program implemented.
- A half-closed circle to denote a leading product development practice has been initiated.
- A quarter-closed circle to denote a leading product practice has been documented but not implemented.
- An open circle to denote a leading product development practice has been neither documented nor initiated.
- 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.

We used explanatory notations for the scorecards where appropriate. Appendix II provides additional detail on our scorecard methodology. Figure 36 provides examples of the knowledge scorecards we used in our assessments.

[90]We used leading practices scorecards for 22 MDAPs and 20 MTA programs. We did not use scorecards for 17 MDAP one-page assessments and the three MDAP increments we assessed, because these programs are well into production; or, for the seven individual future major weapon acquisitions, although future major weapon acquisitions were included in the macroanalysis. We assessed some leading product development practices for ships differently than for other programs. These shipbuilding practices were informed by our prior work on leading ship design practices, such as using digital twins. See GAO, *Navy Shipbuilding: Increased Use of Leading Design Practices Could Improve Timeliness of Deliveries*, GAO-24-105503 (Washington, D.C.: May 2, 2024).

Figure 36: Examples of Scorecards on Two-Page Major Defense Acquisition Program and Middle Tier of Acquisition Assessments

Non-shipbuilding program

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	○

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated … Information not available NA- Not applicable

Shipbuilding program

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a digital twin of key subsystems *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test an integrated physical prototype of key subsystems in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	○

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated … Information not available NA- Not applicable

Source: GAO analysis of DOD data. | GAO-25-107569

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AIR FORCE

Program Assessments

▲ LGM-35A Sentinel (Sentinel)

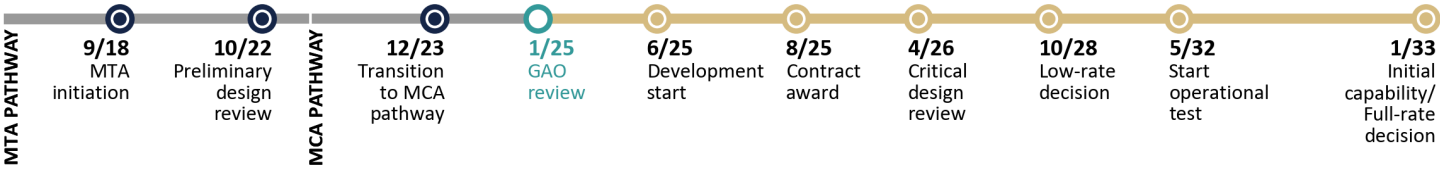
Program name	Assessment type
B-52 Commercial Engine Replacement Program (B-52 CERP)	MDAP
B-52 Radar Modernization Program (B-52 RMP)	MDAP
E-7A Rapid Prototyping (E-7A RP)	MTA
F-15 Eagle Passive Active Warning Survivability System (F-15 EPAWSS)	MDAP
F-15EX	MDAP
F-22 Sensor Enhancements (F-22SeE)	MTA
Hypersonic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

Source (previous page image): U.S. Air Force. | GAO-25-107569

Source: U. S. Air Force. | GAO-25-107569

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

The Air Force's 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 2025 dollars in millions

	Total Acquisition Cost (dollars in millions)	Unit Cost (dollars in millions)	Quantities (number)	Cycle time (in months)
First Full Estimate (1/2025)	Program has not developed formal cost or schedule estimates			
Reported in 2024[a]	Program had not developed formal cost or schedule estimates for GAO's 2024 assessment			
Current Estimate (1/2025)	Program has not developed formal cost or schedule estimates			

[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Agile and Incremental

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$112.04 | Percentage not available due to lack of formal cost estimate

Percentage of progress to meet current requirements: 1-25%

Program Essentials

Prime contractor: Boeing; Rolls Royce

Contract Type: CPIF; CPFF; FFP

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	◐
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	○

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

B-52 CERP Program

Program Performance

In December 2023, the program received Air Force approval to transition to the MCA pathway before development start, but development start has been delayed by nearly a year—to June 2025. According to the program, delays stem from ongoing engine inlet issues the program found during design testing and from Boeing's lag in submitting proposals needed for maturing the program's cost and schedule baselines. Officials stated that Boeing submitted qualified proposals in summer 2024 that the program is currently reviewing.

As part of ongoing design work, officials identified a critical issue regarding engine inlet distortion—a non-uniform flow of air that can affect the engine's performance and operability—resulting in a redesign of the engine inlet. While the program used a digital model during the rapid prototyping effort that simulated how prospective contractors' engines would fit in the aircraft, officials said performance data from testing showed that the design did not meet requirements. Officials stated that Boeing will complete wind tunnel testing to fully verify the design in summer 2025. Officials stated that these data are essential to completing the critical design review, planned for April 2026, 3 years later than originally planned.

Leading Product Development Practices

The program implemented some digital engineering and virtual prototyping practices during its rapid prototyping effort. But, officials stated that the current effort is not fully implementing leading practices because it is a sustainment effort affecting a legacy platform. However, our prior work on leading practices found that leading companies apply these practices throughout a product's life cycle.

The program is currently using some digital models, including aviation performance, system, and computational fluid dynamics models to support design decisions and develop the engine modification. These models are not digital twins that incorporate real-time performance data that would allow the program to take full advantage of digital engineering efficiencies, like the ability to optimize manufacturing efficiencies and reduce costs. Officials said that it can be difficult to incorporate digital engineering practices on legacy systems. They plan to use a digital thread in testing to serve as the single source of information for B-52 data and make it accessible to external stakeholders. However, this digital thread will not provide decision-makers with real-time data provided by automatic updates from a digital twin.

The program is leveraging an open systems architecture where possible, including standard interface protocols, but most new components are modified commercial items that cannot be modularized, according to officials.

Software and Cybersecurity

Software coding began in November 2022. Officials reported that software deliveries are expected every 7 to 9 months after the first delivery in March 2025—6 months later than previously reported. The first software delivery will be a system simulation software suite to be used in the development systems integration laboratory. Officials stated that end users—aircrew and ground support personnel—will provide feedback on subsequent software deliveries.

The program's cybersecurity strategy was approved in July 2023, and the program reported a successful cybersecurity tabletop exercise in April 2024. The next cybersecurity assessment is planned for February 2026. However, the program plans to conduct a key adversarial cybersecurity test after the start of production. DOD guidance recommends this testing to occur earlier. Late testing makes it much more difficult to fix system vulnerabilities due to lack of time and funding before fielding or deployment.

Other Program Issues

As previously reported, the program does not plan to conduct integrated, systems-level testing in an operational environment prior to awarding the first production lot contract. Officials stated that component and lab testing will allow them to mitigate technical risks prior to the first production decision. Further, they stated that they are managing risk by implementing decision points for each lot, to allow decision-makers more opportunities to evaluate hardware maturity and production readiness. Without the integrated testing, the program faces increased risk of costly and time intensive design changes and retrofits if issues are discovered in flight testing.

Program Office Comments

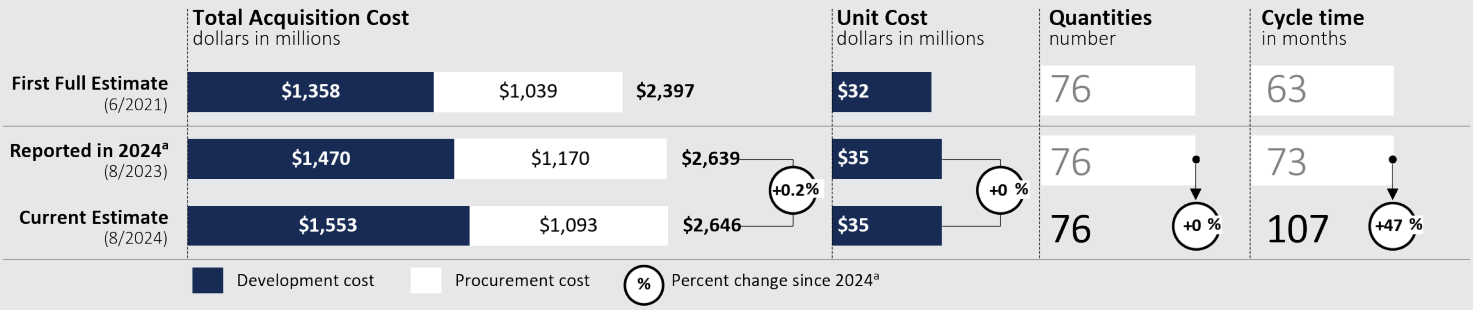
We provided a draft of this assessment to the program office for review and comment. It provided technical comments, which we incorporated where appropriate. The program stated that B-52 CERP uses digital engineering best practices where practical to integrate modern systems into the B-52, and that it used digital modeling and digital engineering to assist the inlet redesign completed in December 2024. According to the program, analysis shows the inlet now meets performance and operability requirements. It added that recent contract actions increased cost and schedule maturity and that B-52 CERP is progressing toward development start in 2025. The program noted that the production strategy strikes a balance between risk and urgency; involves extensive component and subsystem testing in integration laboratories and is augmented by digital modeling; and is structured to reduce risk prior to production. It stated that the production decision will occur after two test aircraft are delivered, and flight testing will be underway for 18 months prior to beginning the first production aircraft modification.

Source: U.S. Air Force. | GAO-25-107569

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 2025 dollars in millions



Total quantities comprise two 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-24-106831.

Software Development

as of January 2025

Approach: Incremental

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$145.86 | 5.51%

Percentage of progress to meet current requirements: 26–50%

Program Essentials

Prime contractor: Boeing

Contract Type: CPIF

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	○

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

B-52 RMP Program

Program Performance

B-52 RMP continues to struggle with schedule delays while mitigating cost increases. Since our last assessment, the program office notified the Air Force senior acquisition executive that it will breach the baseline schedule for production start and initial operational capability. Program officials delayed the first and second low-rate production decisions by 11 months each. They are now planned for the fourth quarter of fiscal year 2026 and second quarter of fiscal year 2027, respectively. Program officials stated that challenges related to environmental qualification, parts procurement, and software contributed to these delays, and acknowledged the delays will result in cost increases. Program officials also noted a revised cost estimate will not be available until summer 2025.

The program stated that it is using two integration and development labs to test developmental hardware. Since our last assessment, the radar development lab received its authority to operate in August 2024, and the radar system integration lab is expected to receive authority to operate approval in May 2025.

Leading Product Development Practices

The program office stated that, in October 2024, the Air Force directed it to address and correct expanding development timelines and increased costs, while also delivering a minimum viable capability. This pivot could provide the program with an opportunity to embrace an iterative development effort, wherein the minimum viable product's design matures with each iteration, resources are based on demonstrated achievement, and potential problems are identified early through collaboration with stakeholders. We will continue to monitor these efforts.

However, B-52 RMP is not employing digital engineering leading practices such as creating a digital twin or using a digital thread, which can provide predictive knowledge about a system's performance and allow for faster design iterations. Program officials explained that a digital twin or thread is difficult and costly to develop, largely due to 20-year-old radar hardware design. We have found that the adoption of modern tools and methods could help optimize production, ensure the system works as intended, and increase future agility to ensure the system remains relevant and effective. For example, knowledge in the digital thread informs decision-making through the product life cycle, such as whether to make certain changes to the product's design.

The program is also not validating integrated hardware and software in an operational environment prior to production. Officials stated that they are updating the program's acquisition strategy so that the first low-rate production lot will be procured in the fourth quarter of fiscal year 2026 after the first low-rate production decision. However, the production decision will occur about 2 years before system-level flight testing or a system verification review is complete. The program office explained that the first low-rate production decision requires that a manufacturing readiness assessment be conducted and hardware maturity be demonstrated. However, these demonstrations will be limited to ground testing and a small amount of flight testing.

Additionally, the program's plans to test a physical prototype after making a production decision—and its decision to begin Lot 1 production based on immature software functionality—increases the risk of costly, time-intensive rework if the program discovers issues later.

Software and Cybersecurity

The program's decision to begin production in the fourth quarter of fiscal year 2026 is at risk due to software challenges. However, officials stated that the milestone decision authority will assess the risk in software to determine if it is sufficiently mitigated before approving the first low-rate production decision. Program officials currently assess software development and integration as high risk, due to the need for mature software before flight testing. According to the program office, delays in software development are due to a lack of integration lab hardware and a higher-than-expected number of defects. The completion of some risk mitigation steps was delayed and will consequently be 3 months late to need. In addition, according to program officials, these challenges, along with lower-than-expected contractor performance, resulted in an increase in software costs.

The program office stated that it completed an updated mission-based risk assessment process report for cybersecurity in May 2024, which includes significant assessment updates since the report's 2021 issuance.

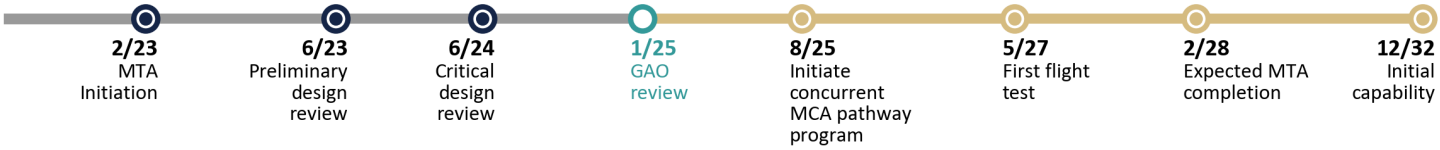
Program Office Comments

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 B-52 RMP addresses an urgent need to replace the aging and increasingly unsustainable APQ-166 and that fielding a reliable all-weather navigation and targeting capability is critically important to provide a viable, credible deterrent through 2050. It added that B-52 RMP is in development and working through known risks of lab availability, software development, and production affordability. Finally, the program office stated that given the perturbations in the B-52 RMP program schedule, the program is considering new development approaches to strike an effective balance between cost, risk, and timely delivery of capability to the warfighter.

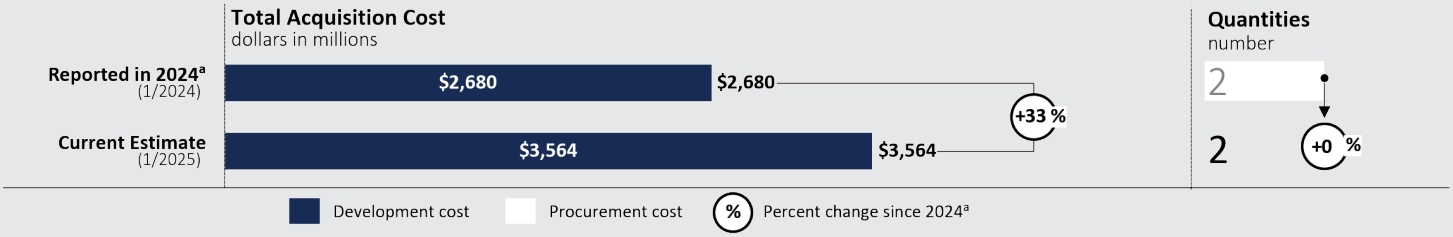
Source: Boeing Defense, Mobility, Bombers, and Surveillance. | GAO-25-107569

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

The Air Force's E-7A RP program plans to modify an existing aircraft design to replace the aging E-3 Sentry aircraft. The Air Force initiated the MTA rapid prototyping effort in February 2023 to build two prototypes to demonstrate enhanced airborne warning and control system aircraft with advanced detection, tracking, identification, and targeting capabilities. The Air Force expects the prototypes to support flight testing and deliver residual operational capability.



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2025 dollars in millions



[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Agile and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$369.86 | 10.38%

Percentage of progress to meet current requirements: 26–50%

The program reported that the software cost increase was due to scope increases.

Program Essentials

Prime contractor: Boeing

Contract Type: CPIF

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	●
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	◐
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	●

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

E-7A RP Program

Program Performance

The Air Force is using the MTA pathway for rapid prototyping before transitioning to another acquisition pathway for production because it is modifying an existing system used by international partners, officials noted. Air Force officials said that they now plan to begin production by the second quarter of fiscal year 2026 before completing the E-7A RP MTA rapid prototyping effort by initiating a separate, concurrent program on the major capability acquisition pathway. They said that it was necessary to begin production concurrently with the E-7A RP rapid prototyping effort to offset the lead time associated with the build and subsequent modification of the aircraft.

The program definitized its contract with Boeing since our last assessment. After the contract was definitized, Boeing delayed the first flight test by 9 months to May 2027. According to Air Force officials, the delay was due to a late-breaking, required critical security architecture change that affected the procurement of parts, qualification testing, and modification of the airframe.

Leading Product Development Practices

The E-7A RP program initiated its effort with defined minimum system requirements with the goal of delivering systems meeting those requirements quickly, program officials noted. To accomplish this, the Air Force identified an existing design that it planned to modify based on additional prioritized requirements to develop a minimum viable product. The program reported that it intends to enable continued iterative development by using a modular open systems approach and re-architecture of mission system software.

Program officials also said that they plan to use an iterative design approach based on feedback from users for certain components of the system, such as software and other mission systems. For example, the E-7A RP program office made an agreement with end users in December 2023 to ensure that certain end users, such as air battle managers who provide airborne command and control, were available to provide input during the development process. For example, if a frequently used command was nested several layers down in the menu system, an operator could suggest bringing that command higher in the stack to improve efficiency.

The program reported it has begun developing a digital thread that sustains authoritative data throughout the life of the program, but not a digital twin—a virtual representation of the physical product. Our prior work found that digital twins and threads provide real-time data to inform production decisions and provide efficiencies throughout development, operations, and sustainment.

Software and Cybersecurity

Program officials said 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. The program office reported that software development is a moderate risk, due in part to the time frames to complete development before developmental testing. The contractor is leading the software development effort and is supported by Air Force software developers.

According to the program, its cybersecurity strategy includes a Zero Trust foundation, with provisions to support additional improvements in overall cybersecurity while minimizing the need for hardware modifications. It stated that it plans to conduct cybersecurity assessments iteratively throughout the software development cycle.

Other Program Issues

Air Force officials said costs increased on the MTA rapid prototyping effort due to higher-than-expected estimates for updating hardware and software.

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.

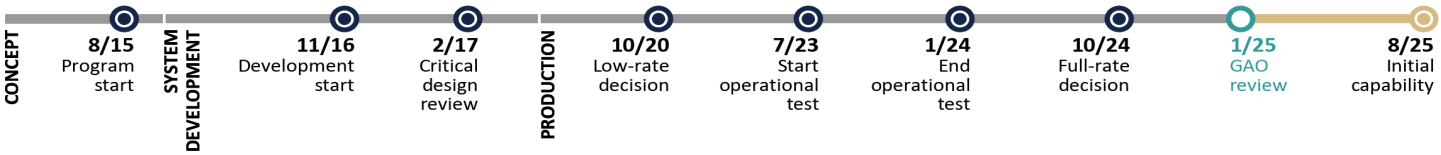
The program stated that the Air Force definitized the MTA rapid prototyping effort contract in August 2024 to deliver two operationally capable E-7A prototype aircraft in fiscal year 2028. It noted that the Air Force will use information from the effort to seek approval to enter E-7A production by the end of 2025. In addition, the program stated that the Air Force is focused on delivering the E-7A RP aircraft and preparing to procure a fleet of E-7A aircraft to meet warfighter airborne command and control and moving target requirements.

The program added that the total acquisition cost increase of 33 percent resulted from updated methodologies to include additional scope related to non-recurring engineering, with the primary drivers being software and air vehicle subsystems.

Source: U.S. Air Force. | GAO-25-107569

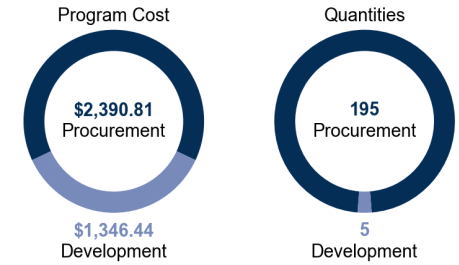
F-15 Eagle Passive Active Warning Survivability System (F-15 EPAWSS)

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.



Program Performance

(fiscal year 2025 dollars in millions)



	Reported in 2024[a] (8/2023)	(%)	Current Estimate (8/2024)
Acquisition Cost	$3,835	-3 %	$3,737
Unit Cost	$18.6	+0 %	$18.7
Cycle Time (in months)	120	+0 %	120

(%) Percent change since 2024[a]

The current estimate total quantity includes five developmental units, and 99 F-15E and 96 F-15EX production units. According to the program, the decrease in the total acquisition cost estimate was primarily due to inclusion of more actual cost data and updates to production hours and rates. A decrease in quantities contributed to the increase in unit costs.

[a]GAO-24-106831.

Software Development as of January 2025

Approach: Agile and Waterfall

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions): Information not available

Percentage of progress to meet current requirements: 100%

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)

Current Status

The Air Force fielded the first two EPAWSS-equipped F-15Es to test and training centers. According to officials, the full-rate production decision was delayed due to longer than expected modification timelines. The Air Force reported awarding the related contract in January 2025.

The program continues to experience installation schedule and supply risks noted in our last assessment. According to program officials, the prime contractor made improvements to address delays installing EPAWSS modifications on F-15E aircraft, but it faces bottlenecks in the process due to workforce issues and legacy aircraft issues discovered during the modification process. As a result, the program has been challenged with establishing a predictable installation schedule. To offset these delays at the prime contractor, the Air Force started installing EPAWSS during planned F-15E depot maintenance periods in 2024. The program continues to track diminishing manufacturing sources (DMS) and reported an additional eight DMS notifications from suppliers since October 2023.

The program did not identify a minimum viable product during system development. Program officials stated that this was because the EPAWSS's performance parameters were already defined in a development contract, reducing flexibility. Officials added that future upgrades to fielded units will use a continuous development and integration approach where the content of the upgrades can change based on user needs and software maturity. The program reported plans to incorporate a modular open systems approach for a signal processor with the aim to facilitate upgrades.

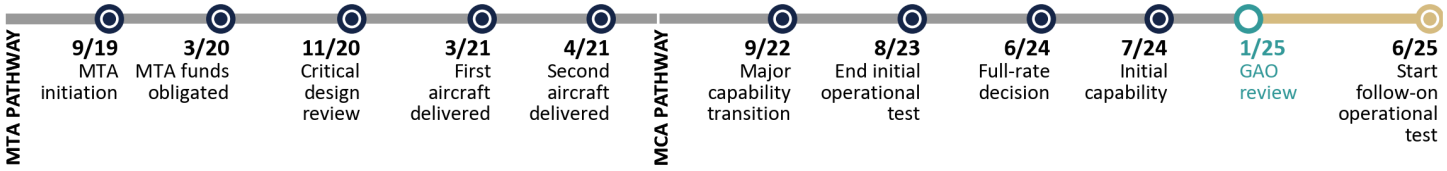
Program Office Comments

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, due to legacy maintenance issues and poor contractor performance, it expects an updated delivery schedule for eight aircraft undergoing modification. It noted that another two aircraft are proceeding on or ahead of their modification schedules, with the first delivery expected in spring 2025.

Source: U.S Air Force. | GAO-25-107569

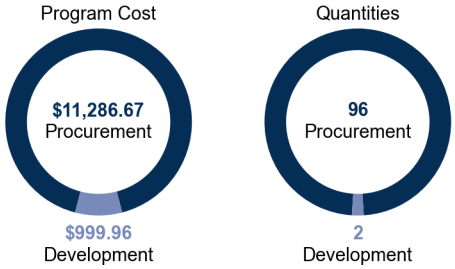
F-15EX

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.



Program Performance

(fiscal year 2025 dollars in millions)



	Reported in 2024[a] (12/2023)		Current Estimate (9/2024)
Acquisition Cost	$13,326	-8 %	$12,287
Unit Cost	$128.1	-2 %	$125.4
Cycle Time (in months)	49	+6 %	52

(%) Percent change since 2024[a]

The program office identified the reduction of total quantities as the source for the program's lowered acquisition cost.

[a]GAO-24-106831.

Software Development as of January 2025

Approach: Information not available

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

Information not available

Percentage of progress to meet current requirements: Information not available

The program reported that software is developed by a separate F-15 program.

Program Essentials

Prime contractor: Boeing

Contract type: IDIQ; FPI Lot 1-5 definitized production orders; CPFF/CPIF/FPI/FFP (development and production support)

Current Status

Since our last assessment, the F-15EX program achieved full-rate production and initial operational capability 2 to 3 months later than planned. It delivered the final two aircraft in Lot 1B (EX-7/EX-8) in June 2024, and placed a Lot 5 production order in July 2024 and a Lot 6 production order in January 2025. This brings the total aircraft on contract to 98. Lot 2 aircraft are expected to begin delivery in early 2025. The Air Force decreased its planned total quantities from 104 to 98 as it refines its investment priorities.

The F-15EX program is tracking three risks. First, Boeing must increase its production rate from one to two aircraft per month by April 2026 to meet its future delivery requirements. Boeing experienced quality deficiencies—due, in part, to fuselage manufacturing processes—on Lot 1B aircraft that required time-consuming rework, which it took steps to mitigate. Program officials stated that Boeing reduced the amount of rework from 25 percent in August 2023 to 8 percent in September 2024, but noted further reductions are needed.

In addition, parts shortages—including display screens, a gun system, ejection seat propellant devices, and titanium components—remain a production risk. To address these shortages, program officials said that they continue to visit suppliers to negotiate prioritization of F-15EX orders, the purchase of remaining supply stocks, and other steps to obtain needed parts.

Finally, program officials recognized that the F-15EX design may not meet Air Force cybersecurity requirements because the original aircraft design—used in foreign military sales—was not required to do so. The program completed cyber vulnerability testing in June 2024 on Lot 1B aircraft, which officials said reduced this risk. The program plans to conduct additional cyber testing in early 2025 on Lot 2 aircraft to further characterize and mitigate this risk.

Program officials said that they started implementing leading product development practices. For example, they applied user feedback from Air Force F-15EX pilots and designed the F-15EX to accommodate future upgrades.

Program Office Comments

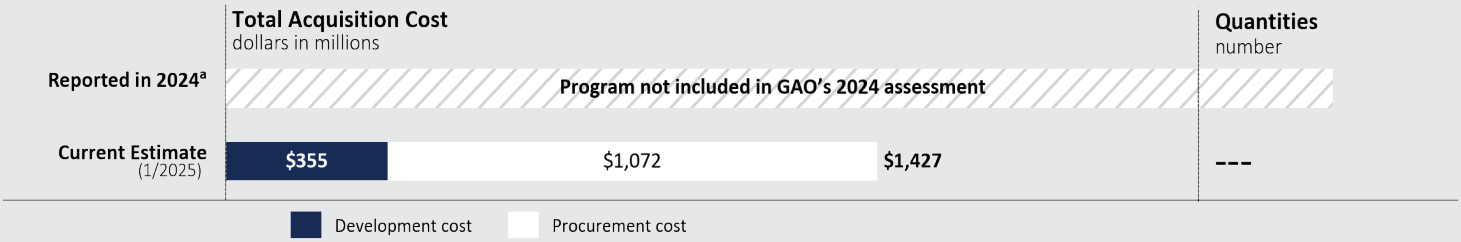
We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

Source: Defense Visual Information Distribution Service. | GAO-25-107569

F-22 Sensor Enhancements (F-22 SeE)

The Air Force's F-22 SeE program, using the MTA rapid fielding pathway, intends to complete development and initial fielding of sensor enhancements on F-22 aircraft. These enhancements are expected to extend adversary detection and tracking. The Air Force is using the MTA pathway to begin production of these enhancements as quickly as possible while it works to transition to the major capability acquisition pathway.

Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2025 dollars in millions



The Air Force determined that the program's quantities are not suitable for public release.

[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Agile, DevOps, and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$17.23 | 1.21%

Percentage of progress to meet current requirements: 76–99%

Program Essentials

Prime contractors: Lockheed Martin Aerospace; Raytheon

Contract Type: CPFF (tech demo and development); FPIF (production); CPAF (software development)

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	○

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

F-22 SeE Program

Program Performance

The Air Force initiated the F-22 SeE rapid fielding effort in August 2024 as a follow-on MTA effort to the F-22 Rapid Prototyping (F-22 RP) effort, which we reported on last year. F-22 RP ended in August 2024 after supporting the development, integration, and demonstration of various hardware and software capabilities for F-22 aircraft, including prototyping sensor enhancements.

Prior to its conclusion, F-22 RP conducted six flight demonstrations with the sensor enhancements in 2024. F-22 officials said that the sensor enhancement hardware used during these demonstrations was not integrated with the aircraft but operated independently from other systems. Officials said that these demonstrations determined that the sensor enhancement hardware could perform in an F-22 environment, which met the Air Force's criteria for moving from rapid prototyping to rapid fielding.

In August 2024, the program reported awarding a contract that it said was to produce the first batch of hardware. The program plans to conduct a flight test with the sensor enhancements integrated with F-22 aircraft in 2026. Officials reported that the program is planning to transition to the major capability acquisition pathway for sensor enhancements in fiscal year 2026. Then, the program is expected to make the full-rate production decision in fiscal year 2027. After making this decision, the program expects to complete receiving deliveries of F-22 hardware planned under the rapid fielding effort. According to the program, it has yet to transition to the major capability acquisition pathway because it still needs flight test data to support a production decision. In the meantime, it is using the MTA pathway to mitigate production schedule gaps.

Leading Product Development Practices

The program reported this year that the F-22 SeE effort is not continuing to incorporate leading practices that it implemented in the F-22 RP effort. For example, it stated that it has limitations refining requirements based on feedback from users and stakeholders into subsequent iterations of capability—the foundation of an iterative approach. The program stated that it considers its development approach iterative in that it performs monthly tests of software releases, conducts flight tests to fix defects, and implements pilot feedback prior to fielding capability. In addition, it said it has plans to continue aircraft and sensor software development in follow-on releases. Even so, it acknowledged that the high concurrency of hardware and software development within the program limits the timely discovery of integration issues, and its ability to refine design. We previously reported that in modern iterative development, requirements are defined in concert with demonstrated achievement and development is focused on users and mission effect.

The program plans to validate design with a system-level integrated physical prototype in 2027. But, it will not connect data from the test to a digital twin or digital thread because it does not plan to have either of those digital tools. It stated that F-22 platform-level efforts exist for digital modeling and simulation and that its long-term plan would include modeling legacy functionality for ongoing modernization efforts. The program noted that considerable investment would be needed to develop digital tools. Our prior work found that digital twins and threads provide real-time data to inform production decisions and could reduce the program's concurrency risk of proceeding with multiple acquisition phases at the same time.

Cybersecurity

The program reported that it received approval of a cybersecurity strategy in October 2024 but has yet to conduct some cybersecurity assessments, such as cyber tabletop exercises and adversarial assessments. The program plans to complete these assessments in 2027. We previously reported that early and regular discovery of mission-impacting system vulnerabilities reduces risk to schedule, among other things.

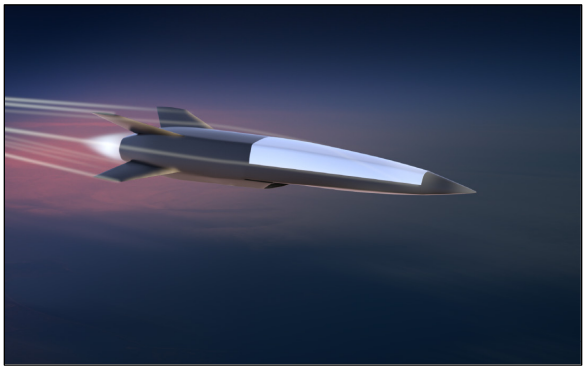
Other Program Issues

The program is managing concurrent development and production of hardware that is needed for developmental and operational testing in the 2026 and 2027 time frame. Program officials said that they took on risk by buying the hardware in advance to have it readily available. Until it produces this hardware, the program remains uncertain about when it will start testing and said that delayed testing could delay the fielding of sensor enhancements as planned.

F-22 officials said that supply chain issues, particularly for computer chips, could affect the delivery schedule. They noted the high demand for these chips, complicated military technology, and competition from commercial enterprises as contributing to the risk. To mitigate this risk, officials plan to work across program offices to improve the capability of commercial suppliers and production capabilities.

Program Office Comments

We provided a draft of this assessment to the program office for comment and incorporated its technical comments where appropriate.

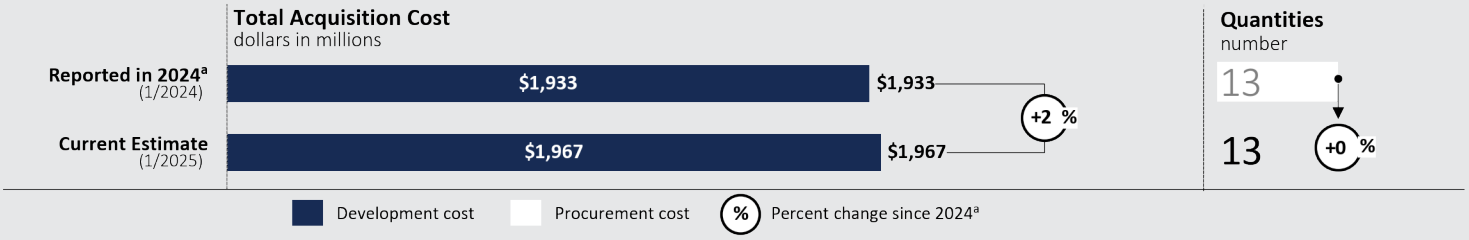


Source: Raytheon. | GAO-25-107569

Hypersonic Attack Cruise Missile (HACM)

The Air Force's HACM program, an MTA rapid prototyping 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 build 13 missiles during the rapid prototyping effort, including test assets, spares, and rounds for initial operational capability. The Air Force plans to initiate a rapid fielding effort in fiscal year 2027 to field additional missiles and iterate on the missile's design prior to making a full production decision. We assessed the rapid prototyping effort.

Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2025 dollars in millions



[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Agile and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$89.77 | 4.56%

Percentage of progress to meet current requirements: 26–50%

Program Essentials

Prime contractor: Raytheon Missiles and Defense

Contract Type: CPFF

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	◐
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	◐
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	◔
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	○

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

HACM Program

Program Performance

The HACM program is behind schedule and working with the prime contractor to develop a new schedule baseline that still adheres to the 5-year time frame for rapid prototyping efforts. The program planned to hold its first design review in March 2024, but delayed it 6 months until September 2024. According to officials, the program needed more time to finalize the hardware design. Officials said that the purpose of the delayed review was to validate an initial configuration of the system for use in the first flight test. According to officials, another review, scheduled for 2025, would validate the fully operational configuration for use in the final flight tests. Program officials said that the delays will reduce the number of flight tests the program can conduct during the 5-year rapid prototyping effort from seven to five. These officials said that the program will still be able to establish sufficient confidence in the missile to declare it operational and to meet all the MTA's objectives with the reduced number of tests.

In addition to being behind schedule, the contractor is also projecting that it will significantly exceed its cost baseline. However, program officials reported that removing plans for two flight tests will reduce the scope of work and provide some cost savings.

Leading Product Development Practices

The HACM program is implementing some of the leading product development practices that companies employ to successfully develop and deliver products at speed. Specifically, the program is prioritizing capabilities that can be fielded quickly and is currently refining requirements to define the capabilities that it will incorporate into a minimum viable product. The program expects to define this initial set of capabilities with the conclusion of its final design review in 2025. Officials stated that the program has solicited user feedback on the missile's design. The acquisition strategy also creates opportunities to incorporate successive updates.

The program implemented the use of a digital thread to connect stakeholders with data about the system, but it does not plan to implement a true digital twin—a dynamic, virtual representation of the physical product. However, officials said that they were implementing other digital tools in the design phase, including maintaining high-fidelity digital information for every part with a serial number that goes into the design. Officials said they can then assemble these digital components into a digital model of the prototype, which can be run through performance-based simulations.

Software and Cybersecurity

The program rated software development as a higher risk than it was last year. Officials said that the program is working with other DOD programs on software development and integration to save time and money. These savings can only be realized if the participating efforts' schedules remain aligned and the contractor provides the necessary staffing, which the program office stated has not occurred.

The program reported that its cybersecurity strategy was signed and approved in April 2024.

Other Program Issues

According to program officials, the HACM program has revised its transition strategy to align with Air Force goals for having a larger inventory of missiles sooner, while simultaneously improving the manufacturability of the design and expanding the capacity of the industrial base. Air Force officials reported ordering additional missiles, separate from the rapid prototyping effort, to allow them to continue to improve the design and prevent a break in production between the rapid prototyping and rapid fielding efforts. The Air Force plans to initiate the rapid fielding effort in fiscal year 2027. According to program officials, the purpose of the rapid fielding effort is to quickly field the missiles developed from the rapid prototyping effort and iterate on the missile's design, while also making it easier to produce. The work will feed into an overlapping major capability acquisition pathway program that the Air Force plans to start at production in fiscal year 2029.

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 based on global power competition and urgency to address threats, the Air Force changed the focus of the HACM program from a prototype demonstration to a program that would deliver operational capability in fiscal year 2027. The program stated that, with this shift, it is focused on meeting schedule as the priority and maintaining velocity toward fielding an operationally relevant capability—the minimum viable product that meets user-defined performance requirements—in fiscal year 2027. According to the program, it is using modelling and simulation, ground test, and flight test data to verify and validate system performance across the range of operational scenarios. Finally, the program nonconcurred with our assessment that it is not incorporating MOSA. The program stated that it is employing a version of the Weapons Open System Architecture standard which meets many of the criteria for MOSA.

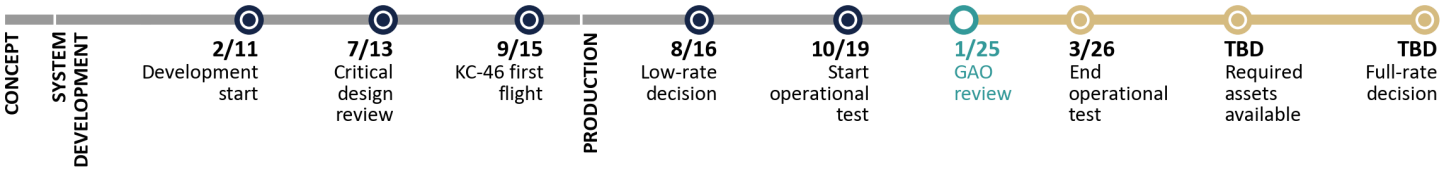
GAO Response

We stand by our assessment of the HACM program's MOSA implementation because it lacks a requirement for physical modularity.

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

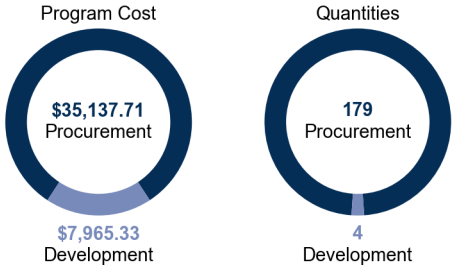
Source: U.S. Air Force. | GAO-25-107569

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. It includes a remote vision system (RVS) that enables a crew member to remotely maneuver the refueling boom and insert it into receiver aircraft.



Program Performance

(fiscal year 2025 dollars in millions)



	Reported in 2024[a] (7/2023)		Current Estimate (7/2024)
Acquisition Cost	$45,127	-0 %	$45,065
Unit Cost	$246.6	-0 %	$246.3
Cycle Time (in months)	TBD	N/A %	TBD

(%) Percent change since 2024[a]

[a]GAO-24-106831.

Software Development as of January 2025

Approach: Waterfall and incremental

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions): Information not available

Percentage of progress to meet current requirements: 76–99%

The program reported that it did not track software costs. Additionally, the program reported that it needed to make software changes to address operational concerns. As a result, the percentage of software completed is less than that reported in our prior report.

Program Essentials

Prime contractor: Boeing

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

Current Status

According to the program office, a full-rate production decision is not expected to occur until after September 2026, at the earliest—about a 9-year delay from the original schedule. This is due to recurring issues with the redesigned RVS and refueling boom—a rigid telescope that delivers fuel to the receiver aircraft. As we previously reported, issues with the original subsystems can cause the operator to scratch stealth aircraft with the boom due to visual acuity and depth perception problems. The Air Force continues to procure more KC-46As that will need to be retrofitted with the redesigned subsystems. As of January 2025, the Air Force procured 158 total aircraft and Boeing delivered 89 of them, according to the program office. The program also said that Boeing and the Air Force are addressing issues found in operational testing with the wing aerial refueling pods. This will inform the revised required assets available date.

Boeing is updating delivered aircraft with an interim software solution to provide operator performance improvements until it can begin retrofitting the aircraft with the redesigned RVS, currently planned by the end of 2026. An official said that operators provided feedback on the software before Boeing fielded the interim solution and the Air Force plans to incorporate the feedback on the redesigned RVS, consistent with leading practices.

In 2023, the Air Force discovered cracked air ducts due to high vibrations from a pump during aerial refueling operations. In July 2024, Boeing conducted flight tests with new operating procedures to mitigate the risk of further damage to the ducts while it conducts a root cause analysis to determine a permanent solution. Officials stated that Boeing is responsible for any costs associated with fixing this issue.

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 Boeing is progressing toward flight tests for the revised RVS and boom starting in 2025; it is engaged with Boeing to address issues with the aerial refueling pods prior to fielding; and it is focused on production quality and mitigating delivery delays. Lastly, the program is working on an air-duct cracking solution while Boeing continues to repair any damaged aircraft to return to the fleet.

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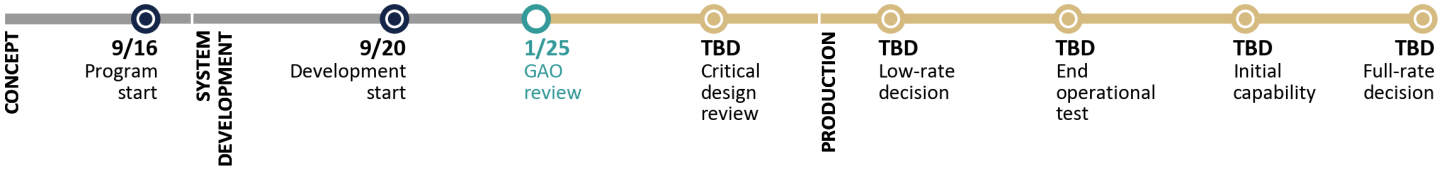
Source: U.S. Air Force. | GAO-25-107569

LGM-35A Sentinel

The Air Force's Sentinel, formerly the Ground Based Strategic Deterrent, is intended to replace the Minuteman III intercontinental ballistic missile system. Sentinel's large program scope includes the development of a new missile and command and control and ground systems, as well as replacing Minuteman III's infrastructure. Sentinel is expected to enhance the capability, security, and reliability of the land-based portion of the nuclear triad. The Air Force is restructuring Sentinel following a critical program acquisition unit cost breach reported to Congress in January 2024.



Program Performance fiscal year 2025 dollars in millions

	Total Acquisition Cost (dollars in millions)			Unit Cost (dollars in millions)	Quantities (number)	Cycle time (in months)
First Full Estimate (9/2020)	$27,805	$57,912	$94,072	$143	659	106
Reported in 2024[a]	Program costs and schedule were under review due to a Nunn-McCurdy breach					
Current Estimate (4/2024)	$35,037	$69,919	$129,038	$196	659	TBD

Total quantities comprise 25 development quantities and 634 procurement quantities. Cost estimates will be revised as the program progresses toward a new development start decision. 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. We examined the identified causes of Sentinel's Nunn-McCurdy breach and the steps DOD is taking to avoid similar problems in our restricted report: *Nuclear Modernization: Sentinel Program Taking Steps to Restructure After Cost Breach*, GAO-25-107615SU.
[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Agile and DevSecOps

Software cost percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$3,270.98 | 2.53%

Percentage of progress to meet current requirements: 1–25%

Program Essentials

Prime contractor: Northrop Grumman Systems Corp.

Contract Type: CPIF

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	◐
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	◔
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	◐

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

Sentinel Program

Program Performance

In January 2024, the Air Force declared a critical breach of a statutory unit cost threshold for the Sentinel program due to a projected cost increase of at least 37 percent over the current baseline, which triggered a required reassessment of the program. In July 2024, for the program to continue, the Undersecretary of Defense for Acquisition and Sustainment certified that the program is essential to national security and that no alternatives exist that would provide an acceptable capability to meet the military requirement at a lower cost. As part of the certification, DOD rescinded Sentinel's approval to start development and its acquisition program baseline from September 2020. DOD directed the Air Force to, among other things, restructure the program to address the root causes of the critical cost breach and to ensure it has an appropriate management structure to prevent future cost growth.

As of September 2024, Sentinel program officials indicated that this restructuring was ongoing and they are reevaluating several parts of the acquisition approach and design of the weapon system, including the launch facilities. As part of the reassessment process, the Office of the Director, Cost Assessment and Program Evaluation determined that a reasonably modified Sentinel program with redesigned launch facilities could cost about 81 percent more than the September 2020 cost estimate, or $170.6 billion (in fiscal year 2025 dollars).

According to the program, two of its 18 critical technologies are mature, while 15 are approaching maturity. One critical technology is undergoing design changes and the program was not able to provide a maturity level. The program plans to mature and demonstrate most of the technologies during its first flight and full system functional tests, currently planned for March 2028 and December 2030, respectively. Given that the program's critical technologies remain immature more than 4 years after starting development, it calls into question the level of work required to mature these technologies and the validity of the cost estimate used to certify the program.

Leading Product Development Practices

The Sentinel program reported that it created initial digital threads for design artifacts, requirements, and architecture, and is working to extend the threads to detailed product design and verification. The program noted that it will develop and refine a minimum viable product as part of its acquisition strategy and systems engineering plan. Additionally, the program reported plans to update system engineering documents and its digital engineering strategy to reflect incorporation of a digital twin. According to the program, it will complete development of the twin by the time of its full operational capability—a date yet to be determined.

Software and Cybersecurity

Sentinel's software development, which began in January 2021, continues to progress more slowly than anticipated, and the program's software metrics remain behind schedule. The certification for software needed for first flight has slipped 4 years. This software increment is planned to be one of the smallest and least complex of Sentinel's software development efforts. The delay has raised concerns from program officials about the prime contractor's ability to complete the program's software in a timely manner. The program is updating the software development plan as part of the larger restructuring process following the critical breach.

Program officials stated that while cybersecurity testing was required, the prime contractor claimed it was unclear as to what type of testing was needed. As a result, program officials plan to clarify this as part of the ongoing restructuring effort. In addition, program officials stated that they are updating the entire cybersecurity strategy to ensure they adequately conduct cyber testing on all necessary components.

Other Program Issues

The program continues to evaluate options to potentially redesign portions of the system for cost reductions. It has identified developing a reliable schedule and designs for the launch facilities and launch centers as necessary items for understanding the program's true cost, but it is unclear when these may be finalized due to the ongoing restructuring effort. Additionally, several portions of the missile design remain immature, which could also affect the program's cost.

Program Office Comments

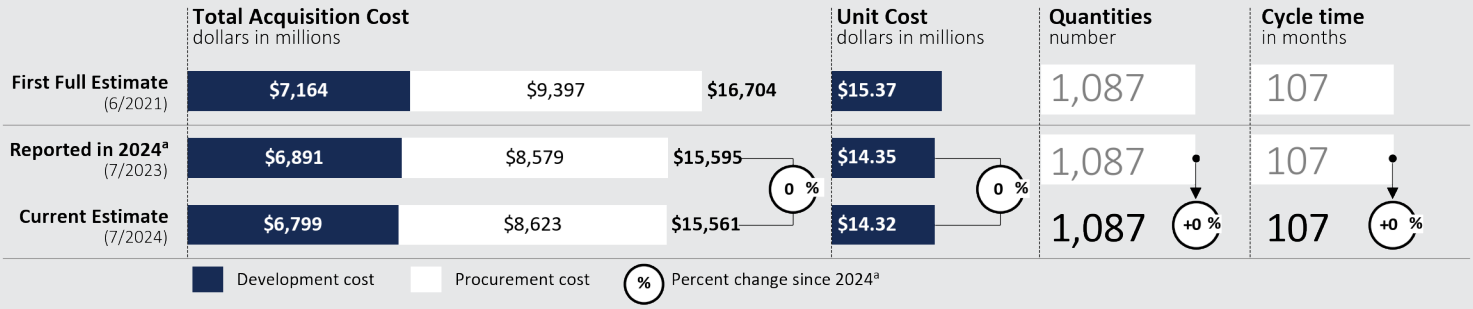
We provided a draft of this assessment to the program office for review and comment. It provided technical comments, which we incorporated where appropriate. According to the program, it made incremental strides in refining and restructuring. It stated that the areas it initially considered key to restructure were: collaboration with external stakeholders to reevaluate and validate program requirements; organizational restructuring; and advancement of mature segments while evaluating changes to the acquisition strategy. The program added that it prioritized understanding and addressing systemic issues impacting performance. It stated that its effort to that end involved several aspects, including: a deep dive into management structures and partnership with the prime contractor; changes to systems engineering processes and infrastructure deployment; prioritizing partnerships and open communication; and integrated processes to deliver critical deterrence capabilities. The program noted that it aimed to establish a more robust and efficient framework for execution, and that its approach underscores the Air Force's commitment to starting development and fostering a collaborative, integrated environment conducive to success.

Source: U.S Air Force. | GAO-25-107569

Long Range Standoff (LRSO)

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

Program Performance fiscal year 2025 dollars in millions



Total quantities comprise 67 development and 1,020 procurement end items. 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 acquisition costs and quantities shown are for the LRSO missile body only.
[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Agile, Waterfall, Incremental, and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$185.42 | 1.19%

Percentage of progress to meet current requirements: 51–75%

Program Essentials

Prime contractor: Raytheon Missiles & Defense

Contract Type: CPFF

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	◐
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	●

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

The status for implementation of leading product development practices reflects only the Air Force's development of the LRSO missile. It does not include DOE's warhead life-extension program efforts.

LRSO Program

Program Performance

LRSO cost and schedule estimates remain unchanged over the past year. The missile's technology maturity showed a slight improvement from our last assessment, but three of the six critical technologies are still approaching maturity. They are expected to be fully mature in fiscal year 2025, about 4 years after development start. DOE also identified critical technologies for the warhead, of which only 35 percent are considered mature. This is lower than what we previously reported, as DOE officials stated that they mistakenly identified several technologies at higher maturity levels last year. DOE does not expect to mature all the warhead technologies until fiscal year 2026. Like the missile's technology status, and consistent with our December 2024 report on DOE's nuclear weapon acquisitions, the warhead falls short of the long-standing best practice to start development with mature technologies and creates risk for future cost increases and schedule delays.

Leading Product Development Practices

The Air Force is not using an iterative approach for development of the missile with no plans to have a minimum viable product. Instead, the Air Force plans to field the full capability in a single increment with no options to iterate and provide additional capability. Program officials stated that they executed some basic elements of a minimum viable product approach, such as refining requirements with users prior to placing them on the development contract.

The Air Force is not currently using a digital twin and is still developing a digital thread. These are data sharing tools that leading companies use to virtually test functionality, uncover design problems, and inform their decision-making. While the Air Force plans to develop a future digital twin for key subsystems, our leading practices found that digital twins at the overall system level provide an enhanced opportunity to understand how fully-integrated systems will perform. Program officials expect to complete development of a digital thread in 2028 for use during production and sustainment.

The program identified potential production constraints and plans to complete an industrial base assessment in April 2025 to assess manufacturing capacity. The program uses a modular open systems approach with system interfaces and architectures that allow for future upgrades to some components such as avionics and sensors. The program is requesting procurement funding in fiscal year 2025 for long-lead items. With developmental testing ongoing until September 2026, the program risks that any deficiencies this testing finds could require design changes to these long-lead items.

Software and Cybersecurity

The program delivered eight of 13 software releases with nuclear certification of the software continuing to be a program watch area. According to program officials, an independent review team found evidence that the software does not meet certain nuclear safety requirements outlined in Air Force policy. The program office and prime contractor are working to resolve this issue, but LRSO risks not using as much of the existing software as planned, which could lead to delays if additional software development is needed.

Program officials reported delays to the remaining cybersecurity assessments. They attributed these delays to prioritizing other test efforts and ensuring system maturity for future cybersecurity tests. The program plans the next assessment for September 2025 with a final, full system assessment now 2 years later, in September 2027. According to program officials, these delays will not affect the start of production or initial operational capability.

Other Program Issues

Since development start, the Office of the Secretary of Defense's (OSD) independent production cost estimate has been $1.9 billion more than the Air Force's estimate. We previously reported that OSD agreed to update its independent estimate as test missile production data became available. Completion of this update is currently scheduled for the summer of 2025. As part of this update, Air Force officials stated that they plan to work with OSD to fully understand LRSO production costs and provide better cost estimation in support of the program's fiscal year 2027 budget request.

DOE officials stated that they are not using a minimum viable product, digital twin, or digital thread for development of the warhead. They are using an existing digital infrastructure characterized by varying levels of fidelity to aid some warhead design and testing efforts during its development.

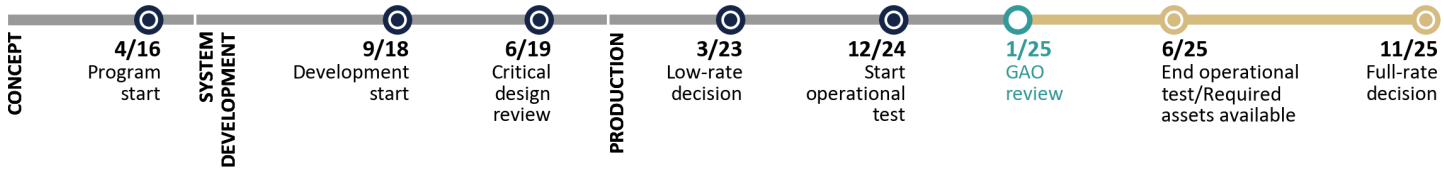
Program Office Comments

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 Air Force, LRSO remains on track to complete development—maturing its technology, software, and cybersecurity at an appropriate pace—to meet planned production and on-time weapon system fielding. Officials added that LRSO successfully completed nine ground and four flight tests, providing them with high confidence in the missile's design and technical maturity. DOE officials stated that the warhead's technology will be more than 80 percent mature by the end of fiscal year 2025 in support of its final design review. They stated that this keeps the warhead on track to meet its first production unit milestone in fiscal year 2027.

Source: U.S. Air Force. | GAO-25-107569

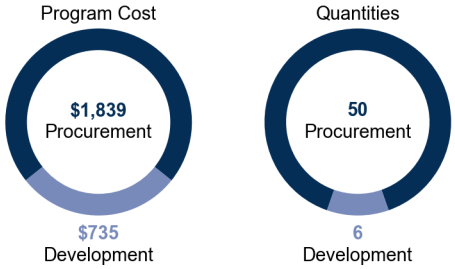
MH-139A Grey Wolf Helicopter (MH-139A)

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. The MH-139A program is acquiring a militarized version of a commercial helicopter that will be integrated with previously developed systems. The Air Force plans to acquire an integration laboratory, training system, and support and test equipment as part of the program.



Program Performance

(fiscal year 2025 dollars in millions)



	Reported in 2024[a] (1/2023)		Current Estimate (6/2024)
Acquisition Cost	$3,337	-12%	$2,923
Unit Cost	$41.71	+25%	$52.20
Cycle Time (in months)	77	+5%	81

(%) Percent change since 2024[a]

[a]GAO-24-106831.

Software Development as of January 2025

Approach: Agile

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions): Information not available

Percentage of progress to meet current requirements: See note

The program reported that software costs are included in the 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)

Current Status

The program office reported that the MH-139A fleet was reduced from 80 to 56 in 2024, a 30 percent decrease, to support higher Air Force priorities. During this period, the program's acquisition cost decreased by 12 percent, while the unit cost increased 25 percent.

The program reported experiencing key delays in 2024 that it attributed to late delivery of contractually required data. Program officials told us that Boeing delivered required training manuals 6 months late, leading to delayed crew training and supplemental certification testing. As a result, the start of initial operational testing slipped from September 2024 to January 2025 but without an adjustment of the testing end date—reducing operational testing by over 4 months. In addition, full-rate production shifted from September 2025 to November 2025. The program reported experiencing late delivery of contractually required data since 2020 and is taking steps to address it, such as streamlining its data request processes and developing contingency plans. However, the program reported that training and maintenance data delivery remains delayed. Officials told us that these particular data are subject to additional scrutiny because some of the information is proprietary.

The program reported that it started testing the aircraft's full flight simulator software in November 2024 and continues to conduct cybersecurity testing, with exercises scheduled through April 2025. As of October 2024, program officials reported that early cybersecurity testing did not identify critical vulnerabilities.

Officials told us that supplemental testing is ongoing and will continue as new capabilities are added to the aircraft. Currently, the program is testing the aircraft's ability to identify friendly forces. The program told us it plans to complete this testing in September 2026 and does not expect that timing to pose further design stability risk.

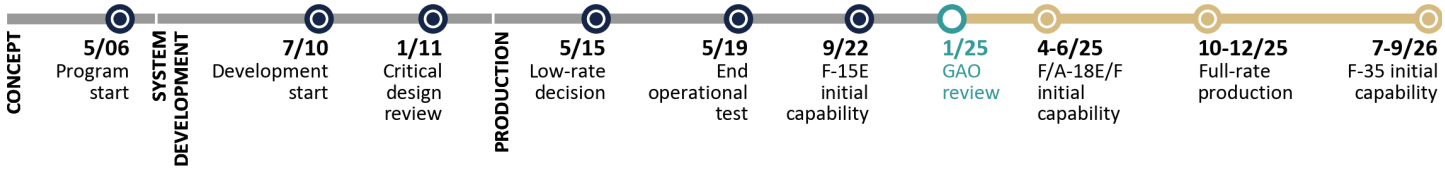
Program Office Comments

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

Source: © 2009 Raytheon Company. | GAO-25-107569

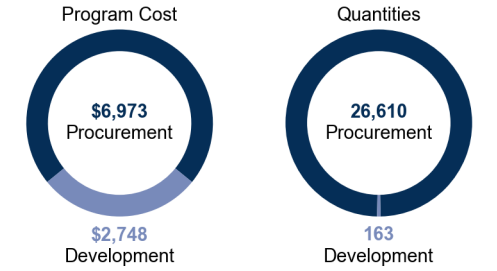
Small Diameter Bomb Increment II (SDB II)

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 2025 dollars in millions)



	Reported in 2024[a] (8/2023)		Current Estimate (8/2024)
Acquisition Cost	$10,098	-4 %	$9,720
Unit Cost	$0.38	-4 %	$0.36
Cycle Time (in months)	N/A	N/A%	194

(%) Percent change since 2024[a]

Cycle time was previously calculated using the F-15E initial capability date. We are now using the F-35 initial capability date since it is the last aircraft to reach initial capability prior to the full-rate decision. The program reported that the decrease in acquisition costs was the result of a reduction of requirements, as a response to budget constraints.

[a]GAO-24-106831.

Software Development as of January 2025

Approach: Agile

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$332.75 | 3.42%

Percentage of progress to meet current requirements: 76-99%

The program reported that the software development approach did not change but indicated Agile is the most accurate response this year. The program also reported that software costs increased due to additional development, and the percentage of software complete decreased from that reported in our prior report due to changes required as a result of development issues.

Program Essentials

Prime contractor: Raytheon Missiles and Defense

Contract type: FPI/FFP (procurement)

Current Status

While the contractor delivered approximately 1,000 of 1,100 lot 7 units in 2024, the program continues to experience production challenges related to obsolescence and part shortages. It conducted an industrial base assessment in 2013 but did not incorporate manufacturer and supplier feedback throughout product design to begin planning for production early. Our leading practices found that this early planning could have reduced the risk that manufacturing issues would delay delivery. The program has taken steps, such as identifying additional suppliers, to make up delivery time and minimize production delays and expects to resolve these challenges by the third quarter of fiscal year 2025.

Initial capability for both the F/A-18E/F and F-35 are delayed since our last assessment. Program officials attributed F/A-18E/F delays to weather, aircraft maintenance, aircraft not having priority on the test range for flight testing, and issues discovered during operational testing, such as problems with the cryptographic keys that improve information security. Officials stated they are trying to determine what additional testing to perform to achieve initial capability, which is now delayed by about a year. While SDB II is ready for testing on the F-35, the F-35 is still working through its own software development issues that continue to delay SDB II integration and testing. SDB II's full-rate production decision is contingent on F-35 initial capability, which is delayed by almost 2 years, but the program is coordinating with DOD leadership to decouple these milestones.

The GPS military code (M-code) receiver—which provides a stronger, encrypted GPS signal intended to help military users overcome signal jamming—is still in development. In March 2024, the program received security approval to integrate a circuit chip into the receiver, a key step for the receiver to become M-code compliant. According to officials, the program subsequently obtained test units for qualification and flight testing. As of October 2024, the M-code receivers were undergoing verification testing. The receivers are expected to incorporate M-code capability for weapon deliveries in 2028.

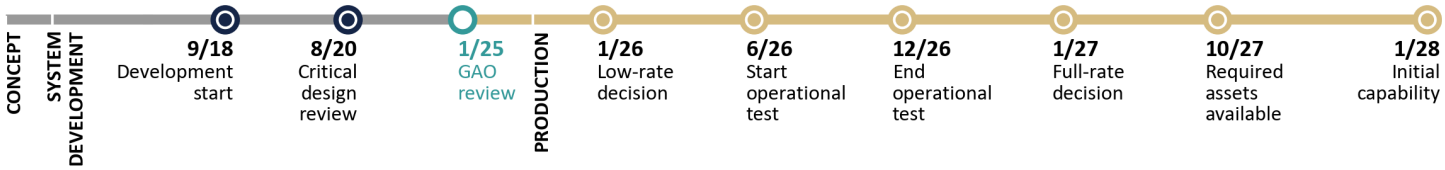
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. It provided technical comments, which we incorporated where appropriate. It stated that it awarded two additional production contracts and accepted new bombs with an updated datalink.

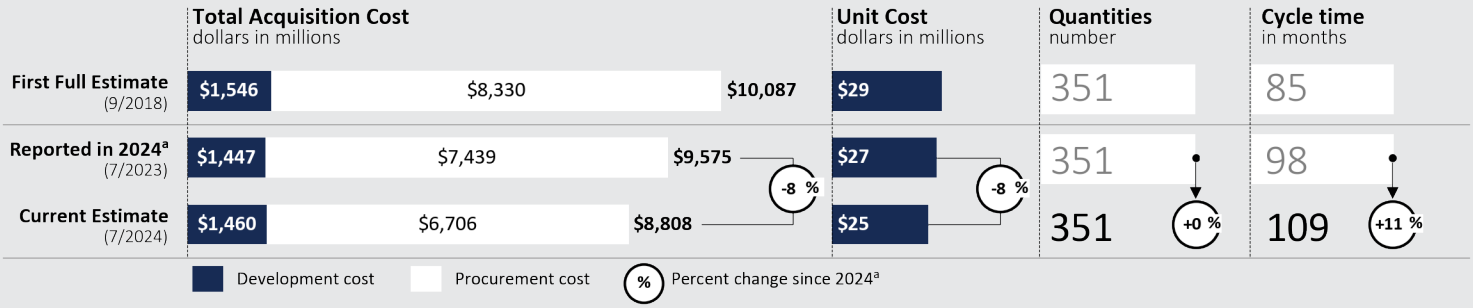
Source: Boeing Corporation. | GAO-25-107569

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 2025 dollars in millions



Total quantities comprise five development quantities and 346 procurement quantities. The program reported an 8 percent decrease in program costs when the contingency costs for inflation were removed—after determining they were no longer necessary. 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 assessments are calculated using required assets available dates.
[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Agile

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

Information not available

Percentage of progress to meet current requirements: 76–99%

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)

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	●

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

T-7A Program

Program Performance

The T-7A program reported that it continues to concurrently develop key aspects of the aircraft, such as the flight software, while testing the aircraft. At the same time, the contractor decided to begin production using its own funding in 2022, even though the Air Force had yet to place a delivery order for production aircraft. As a result, the T-7A is being developed and produced with high concurrency, which is a high-risk programmatic approach as delays in one area could affect other aspects of the program.

In the last year, T-7A development issues, such as engine problems and other unplanned maintenance on test jets, further delayed flight testing by about 6 months, according to program officials. As of October 2024, officials said the program completed approximately 360 of at least 1,100—or 33 percent—test points needed for the Air Force's upcoming January 2026 production decision. If all test points are not completed, the program will likely lack information needed to determine readiness to begin production. Program officials said that testing flight control software under stressing maneuvers may not be completed prior to the planned production decision. They noted that completion of flight test criteria to support the first phased production decision is targeted for October 2025.

While the program progressed in testing the escape system, it does not plan to qualify it until after the January 2026 production decision. Additionally, testing of a system-level integrated prototype, which will include linking the Ground-Based Training System with the aircraft in flight, is not expected until early- to mid-2026—more than 2 years later than the program reported last year. At that point, the Ground-Based Training System may still not employ the final version of the 8K simulator projector—a key component of the system. The program reported that, as of January 2025, it had isolated the cause for persistent projector stability issues and expects to correct the issues by the end of March 2025.

Leading Product Development Practices

The program stated that it does not plan to develop a digital twin or digital thread, or connect its system-level integrated test results to a digital environment, due to not having procured the requisite data as part of the development contract. Our prior work found that digital twins and digital threads provide real-time testing and validation data to inform production decisions and could reduce the program's concurrency risk.

Additionally, the T-7A program did not follow an iterative development approach, which we previously found allows leading companies to refine operational needs into an MVP and deliver essential technologies with speed. Program officials explained that the original acquisition strategy was to pursue a technically mature product that would require minimal development. However, with the delays facing the program, the Air Force approved a phased and highly concurrent approach that allows for low-rate production deliveries in parallel with completion of development to mitigate further delays in providing aircraft to the user. This approach may result in deliveries that require future updates, and program officials said they are working with Air Force Air Education and Training Command stakeholders to reassess program requirements against the minimum user needs for initial production aircraft. Program officials noted that the T-7A design employs a modular open systems approach for interfaces between major systems and components. This approach enables incremental changes to major components throughout the aircraft's life cycle.

Software and Cybersecurity

The program stated that the flight control software version delivered at the end of 2024 brought full functionality and critical fixes for flight control laws, which it expected to enable the aircraft to complete developmental testing. Subsequent versions will address issues that arise during remaining flight testing.

The program identified a range of vulnerabilities by conducting key developmental cybersecurity tests and has addressed several high-risk vulnerabilities through iterative tests. Continued developmental testing is planned to address additional vulnerabilities before operational testing.

Other Program Issues

The T-7A program delayed its initial operational capability date by nearly 1 year, to January 2028. Program officials said that initial operational capability depends on having 14 operational jets that, officials said, the Air Force will not have funding for until a year later than originally planned.

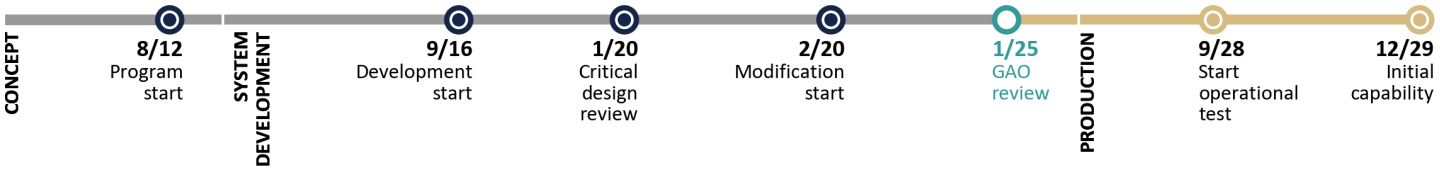
Program Office Comments

We provided a draft of this assessment to the program office for review and incorporated its technical comments where appropriate. It stated that source selection resulted in a very competitive price and schedule and fixed-price contracts constrained cost growth, but the schedule experienced significant delays. The program added that to mitigate further delays, it allowed production to commence before development concludes. It noted that the approach accelerates the program but introduces concurrency risks for both the government and Boeing, and that it implemented management strategies to support production and expedite development completion. In April 2025, the Air Force reported that the program had completed 50 percent of the test points for the production decision and that it is targeting initial operational capability to occur in November 2027.

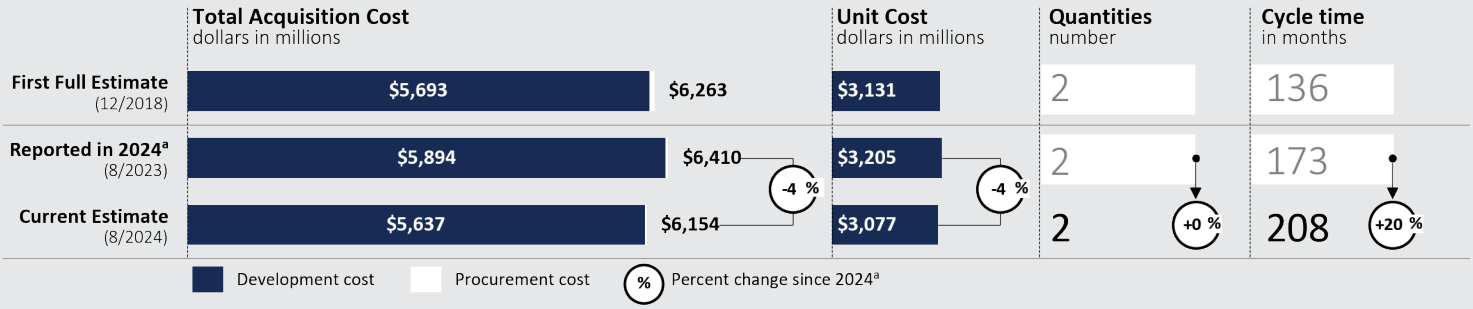
Source: The Boeing Company. | GAO-25-107569

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 2025 dollars in millions



Total quantities comprise two development quantities and zero procurement quantities. The program office reported that the current estimate above represents the program's funding level, not the current estimate for total acquisition cost. The reduction does not reflect a cost savings. 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-24-106831.

Software Development

as of January 2025

Approach: Agile and Waterfall

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions): Information not available

Percentage of progress to meet current requirements: 76-99%

The program previously reported "Iterative (other than Agile)" but is unable to provide an alternative description for this approach. The program reported that it did not track software costs under the firm-fixed-price contract.

Program Essentials

Prime contractor: Boeing

Contract Type: FFP (development)

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	○

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

VC-25B Program

Program Performance

Ongoing design issues, modification rework, and workforce challenges slowed the VC-25B's progress toward modifying two Boeing 747-8 aircraft into presidential aircraft, program officials stated. Boeing shifted its focus from implementing new modifications to clearing the rework backlog and completing existing designs.

Boeing has yet to resolve four schedule risks that we reported on previously:

- Boeing continues to work on design issues related to decompression and the environmental control system that contribute to excess noise in the aircraft cabin, among other things. According to VC-25B officials, Boeing is conducting an aircraft-wide decompression study and anticipates making design changes to mitigate issues.
- Boeing is continuing to work on its wiring design and expects to complete the remaining 10 percent of the baseline design in the second quarter of fiscal year 2025. Program officials said that Boeing started wiring racks, panels, and cabinets, but the wiring has yet to be installed on the aircraft. Program officials previously noted that wiring delays contributed to modification rework and affected timely completion of other work on the aircraft.
- Boeing still faces challenges hiring and retaining qualified mechanics due to ongoing market conditions, according to VC-25B officials. Program officials said that approval rates for mechanics to acquire necessary clearances remain a workforce limitation.
- Boeing continues to deliver test plans. However, according to program officials, a significant amount of test plans remains with Boeing pending completion of certification plans and aircraft design.

Program officials noted that Boeing's proposed schedule does not include time between the end of developmental testing and the start of operational testing, which could provide time to fix unexpected discoveries and avoid additional test delays. They said that unexpected discoveries during testing could affect Boeing's ability to meet future milestones.

Leading Product Development Practices

The VC-25B program has not implemented leading product development practices, which we have found help companies deliver complex products with speed. Program officials said that the program has specific performance parameters that cannot be modified so iterative development was not possible. In addition, they said that VC-25B had no requirement for digital engineering for virtualization or creation of a digital twin at development start. They also said it is not cost effective to test a system-level prototype because the program is integrating mature technology into two commercial aircraft. However, even though the program is well into development, the adoption of modern tools and methods could help ensure the system works as intended throughout operations and increase future agility so that the system remains relevant and effective.

Software and Cybersecurity

As we previously reported, VC-25B officials said that commercial derivative aircraft are required to meet Federal Aviation Administration software and cybersecurity standards to obtain certification. Officials also stated that cybersecurity requirements were excluded from the contract due to the risk of modifying commercial systems to address them. The program office plans to conduct cybersecurity assessments in the future.

Other Program Issues

In February 2024, Boeing provided a revised schedule to the program office that projected a delay of 2.5 years in aircraft delivery, from May 2027 to December 2029. Program officials said that the revised schedule incorporated risk related to finishing design and aircraft modification and provides detail up to first flight. They expect Boeing to provide the remaining schedule in early 2025 and will then conduct a schedule risk assessment and update the program's baseline schedule.

Program officials stated that unplanned aircraft maintenance could negatively affect aircraft materiel availability. They said that some maintenance tasks were not included in the original contract and will have to be completed before first flight of the first aircraft. Officials also said that they plan to establish contracts for these tasks to avoid delays.

Boeing discovered stress-corrosion cracks on the 747-8 commercial fleet in 2019. Repairs of VC-25B cracks on certain aircraft support structures were expected to be completed by summer 2023 but are still ongoing, according to program officials. The officials stated that inspections will continue for the life of the aircraft and that the program is still evaluating the effect of additional inspections required by 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 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.

ARMY

Program Assessments

▲ Future Long Range Assault Aircraft (FLRAA)

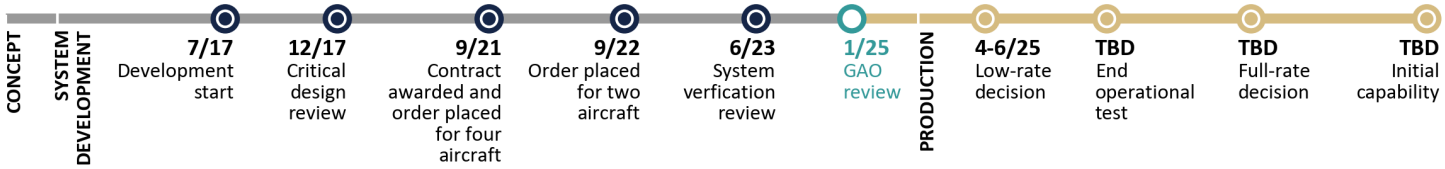
Program name	Assessment type
CH-47F Block II Modernized Cargo Helicopter (CH-47F Block II)	MDAP
Future Long Range Assault Aircraft (FLRAA)	MDAP
High Accuracy Detection and Exploitation System (HADES)	MTA
Indirect Fire Protection Capability Increment 2 (IFPC Inc 2)	MTA
Improved Turbine Engine Program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

Source (previous page image): Bell Textron, Inc. | GAO-25-107569

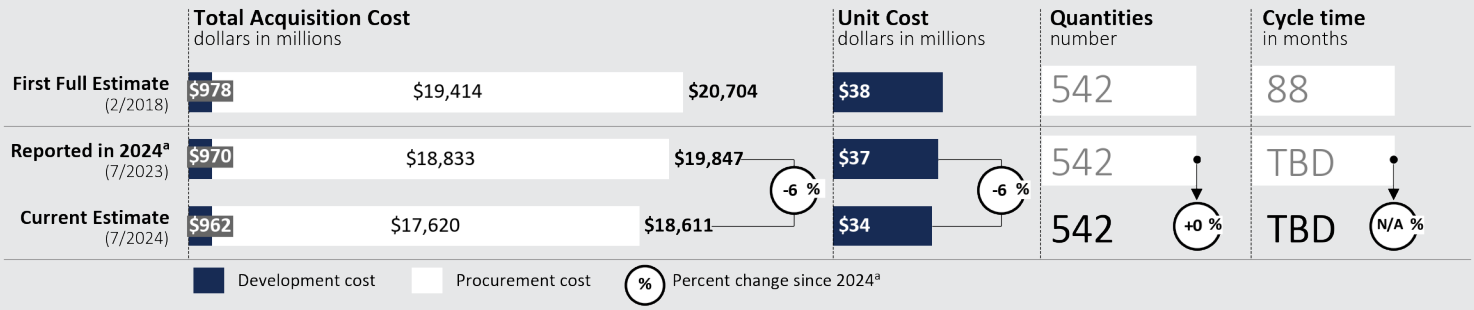
Source: U.S. Army. | GAO-25-107569

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 2025 dollars in millions



Total quantities comprise three development quantities and 539 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-24-106831.

Software Development

as of January 2025

Approach: Agile and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$12 | 0.07%

Percentage of progress to meet current requirements: 76–99%

The program reported that, in addition to using Agile and DevSecOps, it follows additional processes to ensure the system meets requirements for aircraft software. Software costs are for the current-year effort only.

Program Essentials

Prime contractor: Boeing

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

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	●

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

CH-47F Block II Program

Program Performance

In February 2024, the Army aviation rebalance decision authorized the program to proceed to a low-rate production decision by no later than the end of fiscal year 2025. According to the Army, to maintain the production line in the interim, the Army procured four Block II aircraft with fiscal year 2021 funding, two Block II aircraft with fiscal year 2022 funding, and three Block II aircraft with fiscal year 2023 funding. Additionally, the Army is currently negotiating with Boeing for three Block II aircraft using fiscal year 2024 funding. The Army is updating cost and schedule estimates for the production decision with a new program baseline expected prior to the end of fiscal year 2025. Further, according to the Army, technical requirements are stable, and initial capability date is to be determined.

Leading Product Development Practices

The program reported that it is not using an iterative approach—including developing a minimum viable product or digital twin for development—due to the CH-47 Chinook system operating in the fleet for more than 60 years and the approaching end of the system development phase. However, the program incorporated user and stakeholder feedback through various activities. It established a working group of stakeholders that meets every 2 weeks to discuss computer resources, invited industry stakeholders to join a software review board, and held quarterly design reviews to obtain user feedback on software capabilities. Our prior work has shown that leading companies collaborate closely with a wide range of stakeholders—such as users, engineers, and manufacturers—to identify potential problems early and provide feedback on desired product improvements to inform subsequent iterations.

Although the program reported that it did not develop a digital thread, officials said that benefits of a digital thread methodology include streamlined requirements analysis, design evaluation and optimization, and developmental and operational tests, among others. Many of these have been in place for approximately 20 years. The program plans to explore the lessons learned from other Army programs implementing their own digital threads, as well as opportunities to develop a digital thread as the system changes to align with modular open system architecture implementation.

Software and Cybersecurity

The program considers its development of software to be low risk. Remaining risk factors include completion of software needed to support Block II operational tests, upcoming hardware changes requiring software changes, and the availability of software integration facilities for developmental hardware. According to the program, mitigation plans are in place to address these concerns.

According to the program, cybersecurity continues to pose a moderate risk to the program because of the vulnerabilities identified during a key cybersecurity assessment. Additionally, according to the program, after completion of a classified report, a contract was awarded in June 2024 to address vulnerabilities identified during testing.

Other Program Issues

The Army reported that current funding may not be adequate to address known obsolescence issues. These include the need to qualify new material for the rotor blades, and to design and integrate replacement items, including the cockpit voice and data recorder. Army officials stated that they are working with the manufacturer to ensure the materials are available to support production needs.

Inadequate funding could negatively affect the industrial base and degrade supplier predictability, according to the Army. For example, the program encountered obsolescence issues related to the industrial base during the 7-year gap between development start and the Army decision to rebalance its aviation investments in 2024. As a result, the industrial base is a moderate risk. According to the Army, mitigation plans include supporting foreign military sales to provide stability and predictability to suppliers. According to the program, an industrial base assessment has been completed and is in the approval process.

Program Office Comments

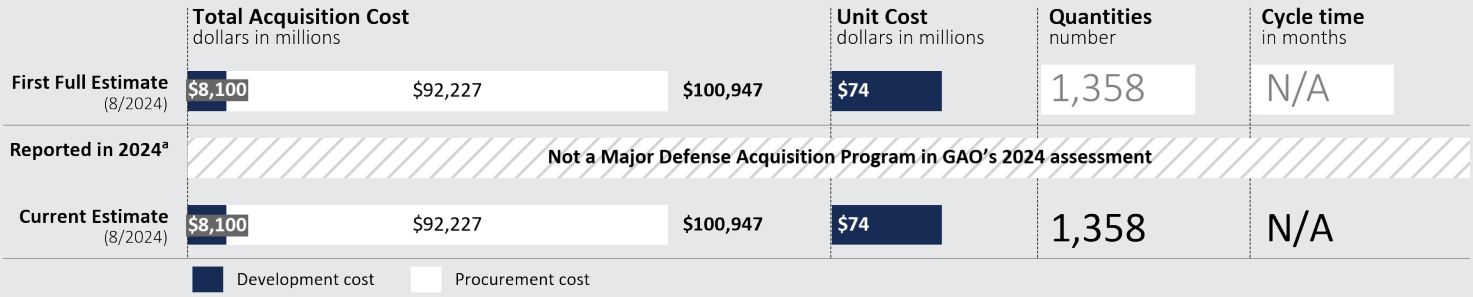
We provided a draft of this assessment to the Army for review and comment. It provided technical comments, which were incorporated as appropriate. After our January 31, 2025, cutoff date for new information, the Army stated that the Army Requirements Oversight Council reduced the total program quantity to 432 CH-47F Block II aircraft, with an additional 69 MH-47G aircraft. According to the Army, in support of the February 2024 aviation investment rebalance decision, the CH-47 program office continues to work with stakeholders to develop production documentation to support a fiscal year 2025 low-rate production decision. In addition, according to the Army, the program office began delivering production representative Block II aircraft. Finally, the Army stated that Block II is adequately funded to qualify the system.

Source: Bell Textron, Inc. | GAO-25-107569

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 with current Black Hawk helicopters. The Army also expects the program to provide combatant commanders with tactical capabilities at operational and strategic distances. The Army completed FLRAA's MTA rapid prototyping effort and transitioned the program to the MCA pathway in July 2024.

Program Performance fiscal year 2025 dollars in millions



Total quantities comprise eight development quantities and 1,350 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-24-106831.

Software Development

as of January 2025

Approach: Agile, Incremental, and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$457| 0.45%

Percentage of progress to meet current requirements: 1–25%

The program reported that the software cost reported above includes both the MTA and MCA efforts.

Program Essentials

Prime contractor: Bell Textron, Inc.

Contract Type: CPIF/FPI (development)

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	●
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	◐
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	◐
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	◔
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	◔
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	●

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

FLRAA Program

Program Performance

FLRAA transitioned to the MCA pathway in July 2024 and started system development. However, officials reported that the program's critical technologies were not fully mature at that time. The program plans for the technologies to be fully mature at production start—a date that program documentation targets for the first quarter of fiscal year 2029 but also indicates could be as late as the third quarter of fiscal year 2030. According to our best practices for technology readiness, programs should fully mature all critical technologies in an operational environment by the start of system development. We previously found that MTA programs transitioning with immature technologies may risk costly and time-intensive redesign work for the overall effort.

DOD's Office of the Under Secretary of Research and Engineering conducted a system-level preliminary design review and a schedule risk assessment for FLRAA in March 2024. The review stated that the program is at high risk to meet its planned milestone dates due to various delays but allowed the program to progress into detailed design. Schedule risk analysis showed that delays for the program's start of production and initial operating capability could be approximately 18 and 11 months, respectively.

In addition, the preliminary design review also stated that the aircraft's weight growth is putting certain planned mission capabilities, particularly regarding payload, at moderate risk. While the review noted that FLRAA has a plan to reduce approximately 270 pounds of weight, this falls short of the 2,000-pound reduction needed to reduce the payload risk from medium to low. Program officials stated that they are planning to conduct a system-level critical design review in late fiscal year 2025.

FLRAA officials reported that they plan to take delivery of two virtual prototypes by the second quarter of fiscal year 2025. These virtual prototypes consist of a crew station simulator and a digital engineering model of the FLRAA aircraft and mission equipment. The program expects these prototypes to lend insight into system design, integration, and developmental testing.

Leading Product Development Practices

The FLRAA program, an Army-designated "pathfinder" program for pioneering the department's digital engineering efforts, reported that it incorporated multiple leading practices for product development. Our prior work shows that these practices allow for design, validation, and delivery of complex products with speed.

Among these practices, the program reported that it completed an iterative process to establish a minimum viable product, documented plans for a digital twin, and initiated development of a digital thread. It also expects to complete testing of system-level integrated physical prototypes in an operational environment in fiscal year 2028, and to connect the data from the testing to a digital twin or thread.

FLRAA officials stated that the digital twin will allow for continuous analysis on the system without using physical assets and that the twin will be developed iteratively. According to these officials, they made progress over the last year in addressing challenges related to access and use of the digital twin. For example, they said that they successfully resolved initial challenges with stakeholder access to the twin as well as identified potential solutions to the challenges as part of an aviation digital engineering roadmap.

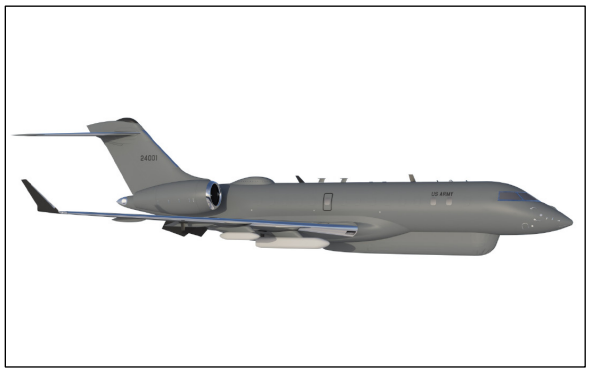
The program also reported that it implemented a modular open systems approach. As part of this approach, the program established technical performance measures and maturity targets. The program anticipates that a modular approach will help to minimize future technology integration efforts and lower costs during sustainment.

Software and Cybersecurity

The independent technical risk assessment for FLRAA rated the software risk for the program as medium. It also noted that the program office still needs to determine some portions of the design. The program's cybersecurity strategy was approved in June 2024.

Program Office Comments

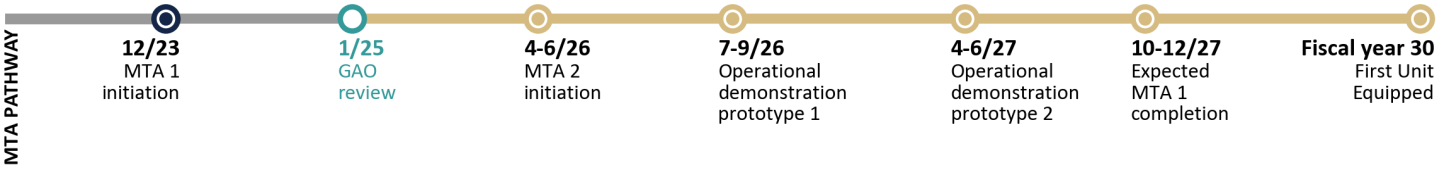
We provided a draft of this assessment to the Army for review and comment. The Army provided technical comments, which we incorporated where appropriate. The Army stated that the program's current phase allows it to exercise options 1 and 2 in the development contract. It added that option 1 authorizes the contractor to conduct detailed design, procure materials, and build prototype aircraft. It also stated that option 2 secures materials needed to support the limited user test aircraft builds. The Army stated that the program is focused on activities to support its critical design review and has planned at least 12 special user evaluations during this phase. Additionally, it noted that it remains committed to providing the best aviation capabilities to its soldiers, the joint force, and allies, and will continue to work with industry partners to build a strong and resilient aviation industrial base. According to the Army, FLRAA remains on track to initiate fielding in fiscal year 2030.



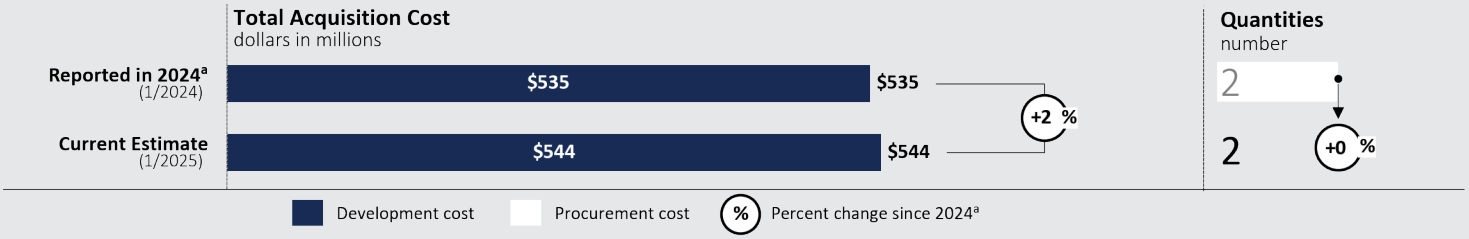
High Accuracy Detection and Exploitation System (HADES)

The Army's 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 through early indications and warnings, providing commanders with enhanced reaction time. As part of the Multi-Domain Sensing System concept, HADES's capabilities aim to help the Army and Joint Forces achieve wartime objectives against peer adversaries. We assessed MTA 1, the first of several expected HADES MTA efforts.

Source: PEO-Avn, FWPO(SEMA) HADES. | GAO-25-107569



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2025 dollars in millions



[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Information not available

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

Information not available

Percentage of progress to meet current requirements:

Information not available

The program reported that no software development is expected under the MTA effort.

Program Essentials

Prime contractor: Learjet (aircraft); Sierra Nevada Corporation (lead system integrator)

Contract Type: FFP (using other transaction authority); fixed price and cost reimbursement types

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	◐
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	●

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

HADES Program

Program Performance

The Army initiated HADES as an MTA rapid prototyping effort (MTA 1) in December 2023. The Assistant Secretary of the Army for Acquisition, Logistics, and Technology approved MTA 1 to develop the first two prototype aircraft to include finalizing the design of the aircraft, ensuring adequate power distribution, and integrating both legacy and newly developed sensors. HADES expects to initiate a second MTA effort (MTA 2) in fiscal year 2026 for the development and production of a third prototype aircraft.

The Army reported awarding a contract to the lead system integrator in August 2024. Another offeror filed a bid protest on this award in September 2024. GAO denied in part and dismissed in part the bid protest in December 2024 and work resumed in January 2025. According to Army officials, the bid protest minimally affected the HADES schedule, and the delivery dates for the first two prototypes remain the same.

HADES plans to integrate four fully mature critical technologies for sensors and other military equipment in the first prototype aircraft. Officials stated that these technologies are derived from other Army programs. For the second prototype, the Army plans to integrate four additional mature critical technologies, including a new radar and sensors used for advanced signals intelligence.

Another critical technology identified by HADES is a digital backbone. According to Army officials, the digital backbone is a mature commercially available technology that implements a fully integrated modular open systems architecture and will allow sensors to transmit data across the system on future prototypes. This technology is not a requirement for the first prototype. Army officials told us that the first HADES prototype was never intended to contain the digital backbone and it will be integrated starting with the second prototype.

Leading Product Development Practices

HADES officials reported plans to use elements of leading product development practices, including refining high-level operational needs into a minimum viable product and incorporating user feedback into decisions to prioritize capabilities. We previously found that direct and continuous feedback from potential users on product development efforts assists in delivering the most essential capabilities quickly and ensuring that the insertion of capabilities in the future meets the warfighters' needs. HADES officials also said that they intend to develop a digital twin but noted that work on the digital twin will not occur until future iterations. The Army stated that because HADES integrates predominately existing capabilities into an existing civil aircraft, it plans for digital representation to occur post-production. It added that it will utilize variations of digital twinning, such as a virtual cockpit to create training materials for soldiers' use. We previously found that a digital twin enables real-time collaboration and allows for informed decision-making with stakeholders and users.

HADES reported leveraging a modular open systems approach with its digital backbone, which officials stated will allow the system to be rapidly updated to meet new requirements. Officials also said that they are leveraging a modular approach with a piece of fully mature hardware, called the canoe—a reconfigurable external housing for mission hardware and software. The canoe is detachable from the aircraft so updates can occur on the ground. According to Army officials, this configuration will allow HADES to make changes to the system in a matter of months rather than years.

Cybersecurity

HADES has yet to conduct any cyber exercises or assessments, but officials reported that they determined what cybersecurity assessments will be performed for the first two prototypes. We previously found that early and regular discovery of system vulnerabilities makes it easier to fix them and reduces risk to schedule.

Other Program Issues

The Army stated that HADES uses model-based systems engineering to supplement activities and that it plans to more fully integrate such efforts in the future. However, Army officials also continue to identify the lack of a digital environment that HADES can use for system design and development as a challenge. HADES has a model that the program intends to use, but Army officials said that they have yet to use it and are working with Army digital environment officials to publish it. This issue slows development timelines by limiting the amount of model-based systems engineering HADES can perform.

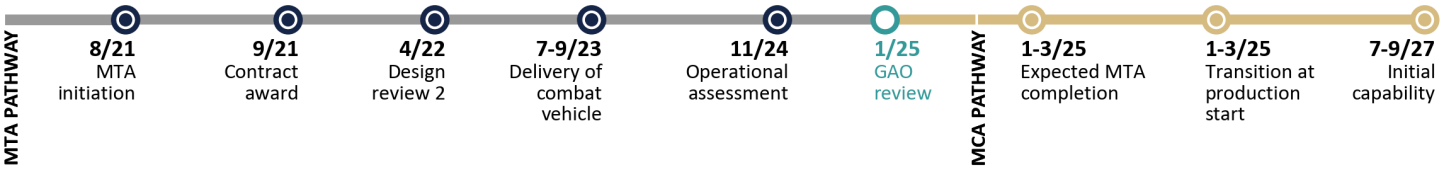
Program Office Comments

We provided a draft of this assessment for the Army's review and comment. It provided technical comments, which we incorporated where appropriate. The Army stated that the government team is forming a HADES modeling strategy with the lead systems integrator, Sierra Nevada Corporation. According to the Army, the integrator's HADES predecessor, ATHENA-S, will provide lessons learned and risk reduction efforts for the HADES Prototype 1 design. The Army noted that the HADES program intends to continually evolve its modular open systems approach and plans to use Army Program Executive Office Aviation's enterprise architecture to the extent possible. It added that, if any planned MOSA effort lacks maturity for the current system integration, the effort will be considered for a later system integration once mature. According to the Army, the key enabler for this approach is the digital backbone that will be first integrated into Prototype 2 and then into follow-on efforts.

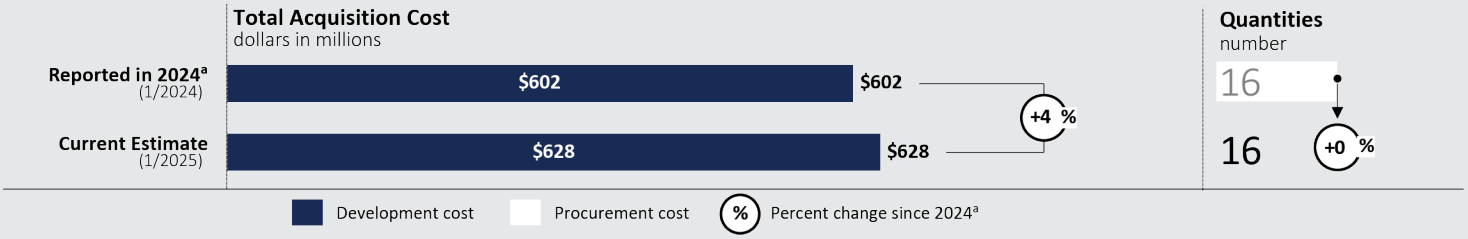
Source: U.S. Army. | GAO-25-107569

Indirect Fire Protection Capability Increment 2 (IFPC Inc 2)

The Army's IFPC Inc 2 is a mobile, ground-based weapon system designed to defeat subsonic cruise missiles, uncrewed aircraft systems, and other aerial threats. IFPC Inc 2 consists of the Army's Sentinel A4 radar, the Army's Integrated Air and Missile Defense Battle Command System, the Navy's AIM-9X interceptor, and a new air defense launcher.



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2025 dollars in millions



According to the program, the cost model is updated with inflation indices each year, resulting in the current 4 percent increase in total acquisition cost.

[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Agile

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$33 | 5.21%

Percentage of progress to meet current requirements: 76–99%

Program Essentials

Prime contractor: Dynetics, Inc.
Contract Type: FFP (using other transaction authority)

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	○

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

IPFC Inc 2 Program

Program Performance

The IFPC Inc 2 system started developmental testing in January 2024 and, according to program officials, completed Phase 3 of that testing in August 2024. Program officials stated that Phase 4, which will be completed in early calendar year 2025, will be the final phase of developmental testing. This will help inform the program's planned transition to the major capability acquisition (MCA) pathway at production start in the second quarter of fiscal year 2025. Program officials stated that developmental testing is focused on launcher capability and missile datalink integration within a system of systems.

We previously reported that the technical issues with one subsystem were resolved but that the program would be unable to fully verify this until developmental testing. Although program officials reported no significant deficiencies identified with this subsystem in testing, there are questions regarding whether the model used in testing is appropriate. While program officials indicated that they are confident the modified model they are using is sufficient, an Office of the Director, Operational Test and Evaluation (DOT&E) official stated that the model the Army used to test this subsystem has not been accredited for the way in which the Army used it. In addition, this DOT&E official stated that changes to how the Army planned to conduct elements of IFPC's operational assessment raise the possibility that the testing was not truly representative of real-world conditions. Given program officials' acknowledgement that IFPC's testing schedule has little margin for error before transitioning to the MCA pathway, any deficiencies or limitations identified during testing could result in a delay to the program transitioning or require these issues to be resolved prior to production. Either option risks a delay to delivering capability to the warfighter.

Leading Product Development Practices

We previously reported that IFPC is implementing limited aspects of leading practices for product development, such as taking steps to obtain user feedback as IFPC undergoes development. IFPC previously reported that program requirements identified a specific materiel solution. This is counter to our leading practices because development is focused on compliance with fixed requirements rather than demonstrated performance and user feedback.

Additionally, the program is not developing a minimum viable product that is consistent with an iterative approach to development. Instead, it is developing a minimum capability based on an incremental approach. Future increments will focus on providing additional capabilities. For example, the Army plans to develop a second interceptor to counter additional threats. Program officials stated that this second interceptor would work with the IFPC system, minimizing the need for additional development.

Although program officials reported that the program has a digital twin of the IFPC system, we instead found that IFPC is utilizing a hardware-in-the-loop system to conduct pre- and post-test analyses. This system is not a true digital twin because it is not a full digital representation of the physical system that feeds data into a digital thread. However, program officials describe it as coming as close to representing the launcher and interceptor as physically possible while also modeling the sensor and mission control systems. We previously found that digital twins can assist development teams in iterating on a system's design to meet the most important user needs.

The program reported that it is implementing one of the three elements that leading practices call for in a modular open systems approach—using modular system interfaces between major systems, major system components, and modular systems. However, the program also reported that it is not incorporating two other elements of modularity that leading practices advocate. Program officials told us that only one of the three elements is included based on the findings of their technology assessment.

Other Program Issues

Program officials stated that several significant risks remain as the program transitions to the MCA pathway. They noted potential issues with the supply chain and the lead times needed to acquire parts for production. The officials stated that they are confident these risks can be addressed but did not provide specific information on planned mitigations.

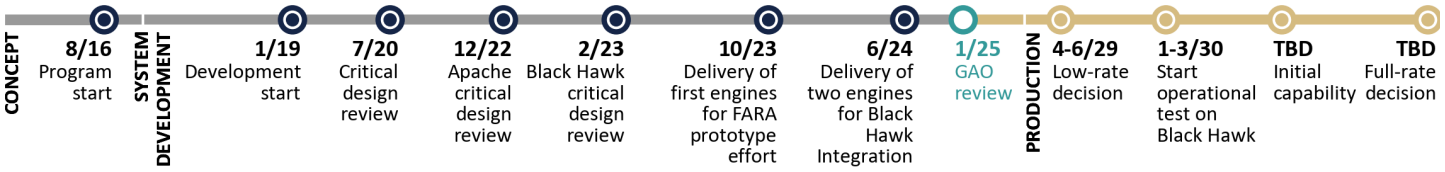
Program Office Comments

We provided a draft of this assessment to the Army for review and comment. It provided technical comments, which we incorporated as appropriate. The Army stated that it submitted an updated requirements document in November 2024 that did not identify specific materiel solutions. It also stated that the IFPC Inc 2 program is on track to complete the MTA rapid prototyping effort and rapidly developed and tested prototype weapon systems, which will inform fielding a combat capability and proceeding to the MCA pathway at production start.

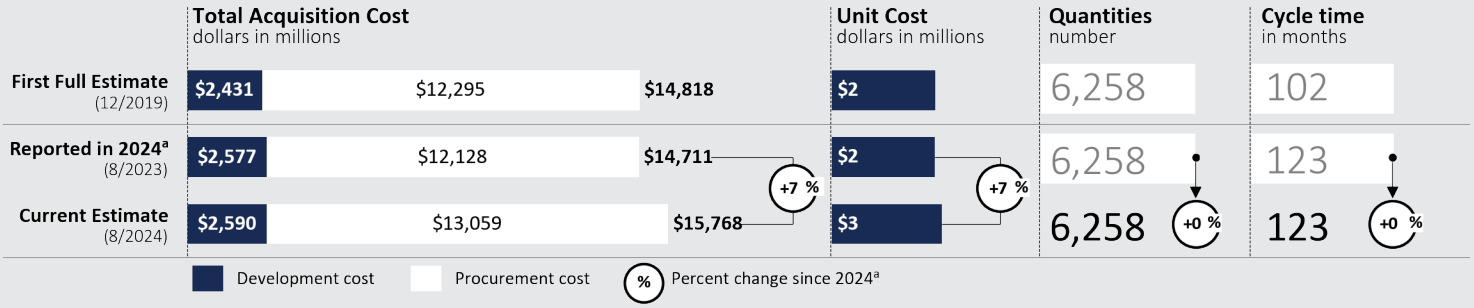
Improved Turbine Engine Program (ITEP)

The Army's ITEP is developing a next generation turbo-shaft engine for the Black Hawk and Apache helicopter fleets. The program includes engine development, manufacturing, platform integration, and qualification. The Army intends for the ITEP to fit inside the existing engine compartments of the Black Hawk and Apache helicopters and expects that the ITEP will provide power, fuel efficiency, reliability, and sustainment improvements.

Source: U.S. Army. | GAO-25-107569



Program Performance fiscal year 2025 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-24-106831.

Software Development

as of January 2025

Approach: Agile and Incremental

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$166| 1.05%

Percentage of progress to meet current requirements: 51-75%

Program Essentials

Prime contractor: GE Aerospace

Contract Type: CPIF

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	◐

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

ITEP Program

Program Performance

In February 2024, the Army announced a rebalance of its aviation modernization investments to better reflect future needs. As part of this, the Army delayed production start for ITEP to allow more time for integration with the Black Hawk and Apache platforms and discontinued development of the Future Attack and Reconnaissance Aircraft (FARA). According to program officials, production start for ITEP, previously planned for the third quarter of fiscal year 2026, is now delayed until the third quarter of fiscal year 2029.

As a result of the aviation investment rebalancing, the program reported that a stop work order was issued for Apache platform integration efforts. According to program officials, the reduction in fiscal year 2025 funding associated with the rebalance required the program to change from a parallel to a sequential approach to integrating ITEP onto the two platforms. The program plans to complete integration, testing, and qualification of the Black Hawk prior to production start, and the Apache after production start. The program plans to request funding to resume Apache integration efforts in fiscal year 2030.

According to the Army, it made progress toward ITEP engine qualification. It delivered engines to test facilities and initiated ground testing for Black Hawk platforms as of the second quarter of fiscal year 2025 and expects flight testing on the Black Hawk to begin in 2025.

Leading Product Development Practices

Program officials reported that they are not using an iterative development approach and will deliver the full required capability upon delivery of the first engines to the warfighter. However, we previously found that using an iterative approach could help the Army develop a system that delivers the most critical capabilities needed in the near term and inform innovations for the next system.

The program currently employs some digital engineering tools but not a digital twin or digital thread. The Army plans to develop an enterprise-level digital thread, officials reported. We found that leading companies create virtual representations of their physical products and a common source for storing information to enable efficiencies during development, production, and sustainment. Program officials stated that, while the Army did not request model-based systems engineering artifacts or digital engineering products at the time of contract award, the program heavily employs digital engineering and analysis tools as well as modeling and simulation in engine development.

The Army is implementing a digital strategy that will enable an enterprise-level digital thread for aviation programs, noted officials. The Army stated that the program's digital engineering tools assist with design, manufacturing, and cost reduction. However, as we previously reported, digital twins and digital threads allow leading companies to take full advantage of digital engineering efficiencies in those areas.

ITEP is collecting end-user feedback during development from pilots, aircraft maintainers, and supply personnel. This feedback influenced the critical design review when soldier feedback identified difficulty performing a maintenance task and influenced the design of the virtual interactive training engine, program officials noted. They reported that they are incorporating a modular open systems approach (MOSA) for interfaces between the Black Hawk and Apache platforms and ITEP. They cited some challenges with incorporating and adjusting to new MOSA guidance midway through the verification phase, such as the insertion of new requirements to demonstrate conformance. The program plans to complete incorporation of a MOSA prior to production start.

Software and Cybersecurity

The program completed one developmental cybersecurity test in 2024, and one previously scheduled for 2024 is now planned for 2026. Two operational cybersecurity tests originally planned for 2026 are now planned for 2027 and 2028. 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

The program reported that total acquisition costs increased by 7 percent in the past year. Program officials noted that these increases were caused in part by GE Aerospace failing to develop manufacturing and quality processes within originally planned cost targets. Higher than expected turnover rates of contractor personnel and rework of engine hardware also contributed to cost increases and hardware delays. The program reported that it is working on implementing cost saving measures with GE.

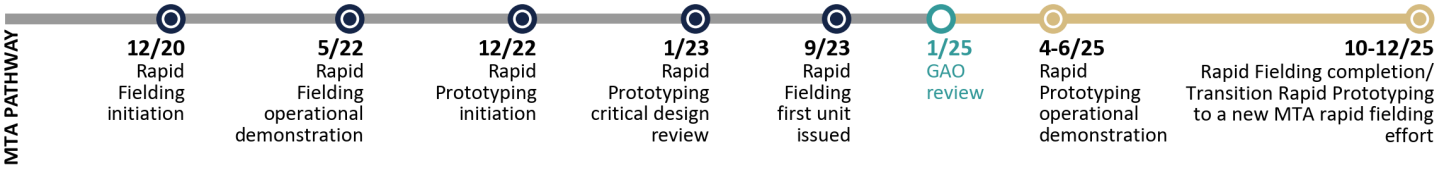
Program Office Comments

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 continued progress toward preliminary flight rating testing, Black Hawk platform integration, and ground testing. It also stated that the ITEP office is working with GE Aerospace to conduct formal schedule replanning in alignment with the Army's aviation rebalancing. According to the Army, the President's Budget 2025 funding position presents funding and scheduling challenges. The Army noted that it submitted a program deviation report outlining schedule impacts. It also stated that it is requesting development funding to enable a production start decision in fiscal year 2029.

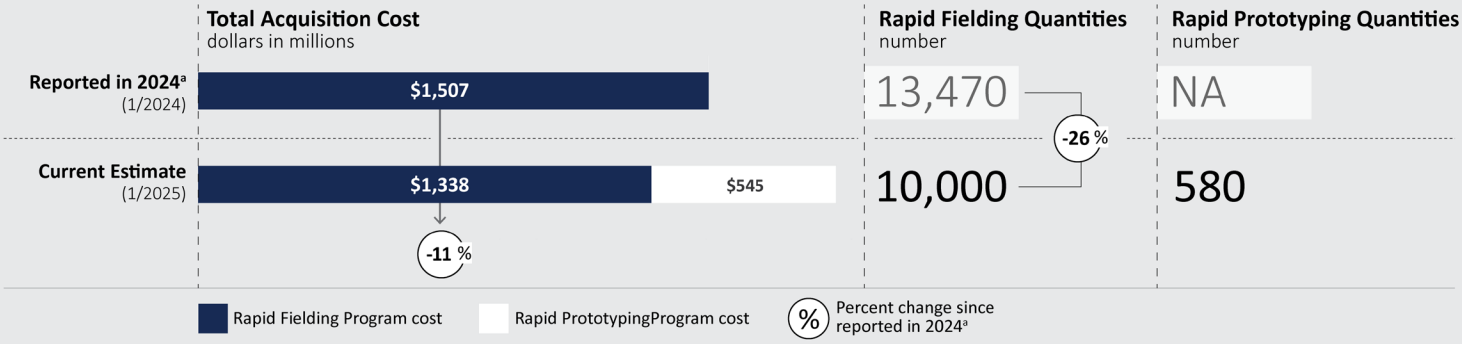
Source: U.S. Army. | GAO-25-107569

Integrated Visual Augmentation System (IVAS)

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. In 2018, the Army initiated IVAS as a rapid prototyping effort that led to the development of versions 1.0 and 1.1 and ended in 2023, with a subsequent rapid fielding effort planned to continue through 2025. In parallel with this fielding effort, a second rapid prototyping effort for version 1.2 was initiated in 2022. This assessment reviews both the version 1.0/1.1 rapid fielding and 1.2 rapid prototyping efforts.



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2025 dollars in millions



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-24-106831.

Software Development

as of January 2025

	MTA rapid prototyping	MTA rapid fielding
Approach	Agile, DevOps, and DevSecOps	Agile, DevOps, and DevSecOps
Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions)	$67 12.27%	Information not available
Percentage of progress to meet current requirements	See Notes	See Notes

The program reported that the firm-fixed-price agreement for the rapid fielding effort does not separate out software costs. The minimum viable product software is complete for both efforts and the program expects it to have annual software updates.

Program Essentials

Prime contractor: Microsoft (for both efforts)
Contract Type: FFP (production) (using other transaction authority)

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status: Rapid fielding versions 1.0/1.1	Current Status: Rapid prototyping version 1.2
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	●	◐
Use Digital Engineering to Connect Stakeholders and End Users to System Data		
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○	○
Validate Integrated Hardware and Software Functionality in the Operating Environment		
Test a system-level integrated fully digital prototype in a digital operational environment	○	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○	○
Prepare for Modularity to Support Production and Updates to the MVP		
Incorporate a modular open systems approach (MOSA)	○	○

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

IVAS Program

Program Performance

Over the last year, the program continued rapid fielding of 5,000 version 1.0 systems to the Army's Training and Doctrine units to inform improvements for version 1.2 in operational units. According to officials, the Army began production of 5,000 version 1.1 units in March 2024, incorporating a new low-light sensor to improve image quality. It planned to field the first 1.1 systems in the third quarter of fiscal year 2024. However, the program reported a delay to this fielding to December 2024 after an explanatory statement moved the requested funds from procurement to research, test, and evaluation. Both systems are expected to transition to sustainment upon completion of their deliveries.

The program also continued a rapid prototyping effort for version 1.2 as the full-rate production model. As previously reported, version 1.2 is expected to increase reliability and have an improved physical design. The program struggled with soldier acceptance of initial versions due to reliability and wearability issues. It anticipates that version 1.2 will improve acceptance.

After several delays, the program received a version 1.2 rapid prototyping budget review from the Deputy Assistant Secretary of the Army-Cost and Economics (DASA-CE) in December 2023. The budget review indicated that program office estimates were suitable to inform budget programming decisions. But, since the program largely based estimates on subject matter expert input and not actual data, a full review could not be completed. The budget review recommended that the program coordinate with the DASA-CE office to develop a better estimate for an expected version 1.2 rapid fielding effort. The program expects to complete this estimate by the second quarter of fiscal year 2025.

Leading Product Development Practices

As we previously reported, the program used elements of iterative development in its initial rapid prototyping effort as well as in version 1.2 rapid prototyping. For example, the program conducts risk reviews and user assessments every 1 to 3 months. Officials said that the program conducted user assessments on the first two version 1.2 prototypes to ensure the design will fix version 1.0 and 1.1 deficiencies. Participants noted improvements but stated, "it's not there yet." Three additional prototype builds and test events are scheduled, including a full operational demonstration in the third quarter of fiscal year 2025, after which the program anticipates a minimum viable product validation. Additionally, versions 1.0 and 1.1 will be fielded to training units to leverage lessons learned in the design and fielding of version 1.2.

The program does not plan to use either digital twins or digital threads, stating that developing them would not provide future cost savings until a full-rate production baseline hardware design is approved. The program will revisit this after the full-rate production decision for version 1.2 is made in third quarter of fiscal year 2025. We previously found that digital twins allow companies to create virtual representations of physical products to enable efficiencies during the design-build-test phase of development. For example, digital twins enable rapid iterative design cycles and facilitate stakeholder and user feedback earlier.

The program stated that it used elements of a modular open systems approach in the rapid fielding effort, including modular design interfaces that comply with common standards. However, the program did not use a system architecture allowing major system components and modular systems to be incrementally added, removed, or replaced over the platform's life cycle. According to the program, the state of technology at the start of version 1.2 prototyping did not facilitate a modular design for major components within size, weight, and power constraints. The program plans to use additional modular open systems approach elements in version 1.2 production. For example, it will include technical insertions as requirements in future versions. We previously found that leading companies design systems so components can be added, removed, or replaced to update and improve products post delivery.

Software and Cybersecurity

The program received a cybersecurity certification for version 1.0 in October 2022. The Army stated that the IVAS program completed a cybersecurity strategy (CSS) but is not required to have it approved as an MTA program. According to the Army, IVAS will achieve CSS approval when transitioning to a new acquisition pathway, planned for the first quarter of fiscal year 2026. The program plans to obtain a CSS for future versions of IVAS. DOD's policy for acquiring digital capabilities requires MTA programs to develop a CSS customized to the unique characteristics and risks of the program.

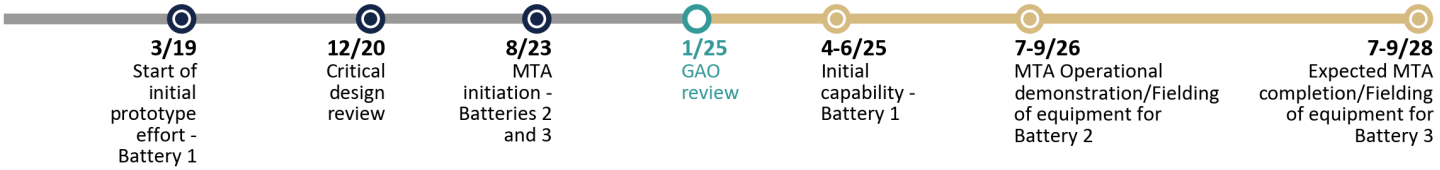
Program Office Comments

We provided a draft of this assessment to the Army for review and comment. It provided technical comments, which we incorporated where appropriate. According to the Army, the prototype builds of IVAS 1.2 had four successful user assessments and tests. It stated that positive soldier feedback and test results indicated that the program is on track to meet IVAS 1.2 design objectives—including but not limited to improved reliability, low light sensor performance, and form factor. The Army stated that final delivery of IVAS 1.2 production representative hardware will occur no later than the third quarter of fiscal year 2025.

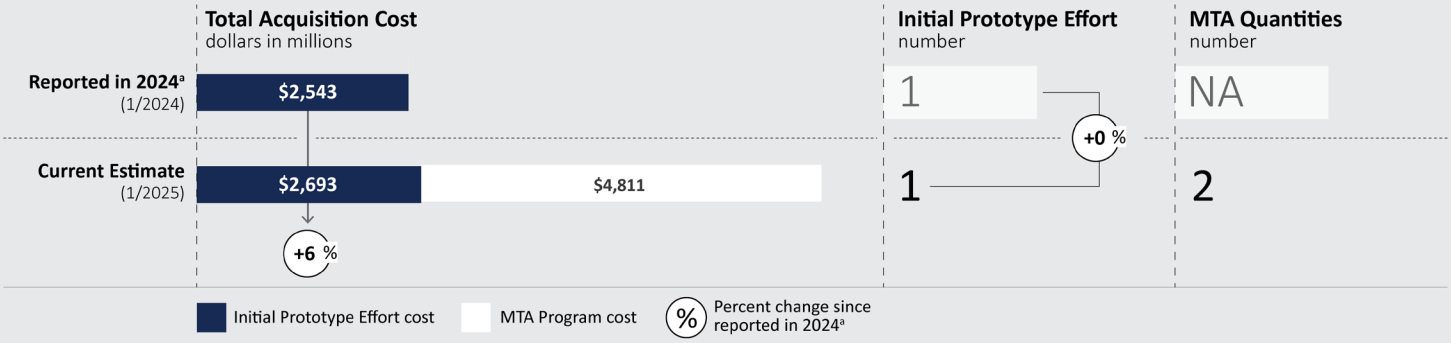
Source: U.S. Army. | GAO-25-107569

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 Army has two ongoing LRHW efforts. The first is a research and development effort—managed by the Army's Rapid Capabilities and Critical Technologies Office—with the goal of fielding an initial prototype battery, consisting of four launchers, related equipment, and eight missiles. The missile is common with the Navy's Conventional Prompt Strike (CPS) 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. We assessed both efforts.



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2025 dollars in millions



We include the launchers and related equipment for batteries 2 and 3, as well as the missiles for these batteries, in the MTA program cost. The Army procures the missiles from the Navy and does not include the missiles in its MTA cost estimates. We include the same items in the battery 1 cost. Quantities are the number of batteries.
[a]GAO-24-106831.

Software Development

as of January 2025

	Initial Prototype Effort	MTA
Approach	Agile and DevSecOps	Agile and DevSecOps
Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions)	Information not available	Information not available
Percentage of progress to meet current requirements	76–99%	76–99%

The program reported that it is currently in the process of implementing software cost reporting.

Program Essentials

Prime contractor: Lockheed Martin; Dynetics, Inc.; Dynetics Technical Solutions

Contract Type: CPIF/CPFF/FFP (includes use of other transaction authority)

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	●
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	●

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

The LRHW program stated that its leading product development practices reflect both the initial prototype and MTA efforts.

LRHW Program

Program Performance

The Army will not field its first LRHW battery—including missiles—until the third quarter of fiscal year 2025, which is at least 18 months later than its initial goal. The Army missed its fielding goal due to integration and production quality issues discovered during testing that it has since resolved. The Army conducted four tests in 2023 and 2024 that were not completed due to launcher, launch sequence, and missile production quality issues. These issues affected missile deliveries as well. The Army reported putting a hold on the completion of the missiles for the first battery until a successful end-to-end flight test verified the design worked.

The Navy's CPS program, which uses the same missile as the LRHW program and develops it for both programs, conducted a successful end-to-end flight test in the third quarter of fiscal year 2024. Our report includes a separate assessment of the CPS program. The Army reported lifting its hold on missile production after the successful Navy test and expects the delivery of the eight missiles for the first battery to be complete within 11 months. In the first quarter of fiscal year 2025, the Army also conducted a successful end-to-end missile flight test—the first using its launch system.

The estimated cost of fielding the first LRHW battery also increased by $150 million since last year. According to the Army, the cost growth was attributed to increases in the cost of the missiles and testing issues that resulted in investigations and retests.

Program officials stated that the second battery, which is part of the rapid fielding MTA effort, is on schedule to be fielded in the fourth quarter of fiscal year 2026. This effort includes a missile with minor modifications, which the Army plans to flight test for the first time in the fourth quarter of fiscal year 2025. The Army also stated that the planned award date for battery 3 ground support equipment slipped from the first quarter of fiscal year 2024 to the third quarter of fiscal year 2025 due to funding delays.

Leading Product Development Practices

The LRHW program is implementing some aspects of leading practices for product development. For example, program officials stated that they developed the capabilities in the first battery as the minimum viable product for the MTA effort and validated them in their recent flight test. Program officials also said that they solicited extensive feedback from operators and maintainers during the design phase, including some operators participating in LRHW flight tests, and that the battery will accommodate successive updates.

However, the LRHW program has only made limited use of digital engineering tools. In July 2024, we reported that the program used some digital engineering tools to create a virtual reality model of the launcher that users could interact with to identify potential design flaws and challenges. However, it was not a high-fidelity, dynamic digital model necessary for achieving the efficiencies associated with digital twins. We recommended that the LRHW program assess implementing digital engineering, including digital twins, and whether to incorporate these tools. The Army stated that LRHW officials completed the assessment in December 2024 and provided it to the Army for review. Program officials told us that they do not see LRHW as a viable program for digital twinning because the Army does not have plans to produce more than three batteries. We previously reported that digital twins are also useful for sustainment.

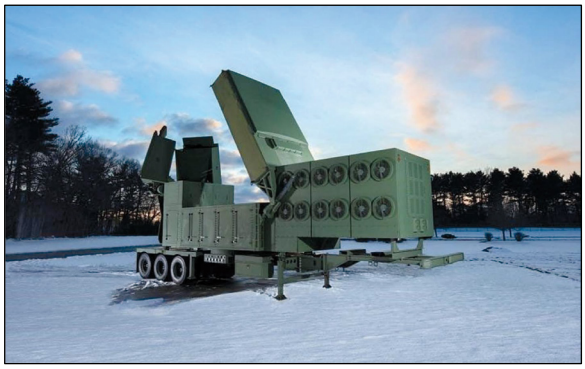
Software and Cybersecurity

The LRHW program reported that software development is a medium risk. Challenges, such as having adequate development hardware to support software integration efforts, contributed to this risk. The program also made fewer software deliveries than planned. Program officials stated that this is due, in part, to completing fewer tests than expected to gather software feedback and identify software issues. They expect software deliveries to increase now that a successful flight test has occurred.

The program completed its first cybersecurity exercise in fiscal year 2020 and plans for an additional exercise in fiscal year 2025. The program reported that it expects to have an approved cybersecurity strategy in fiscal year 2025.

Program Office Comments

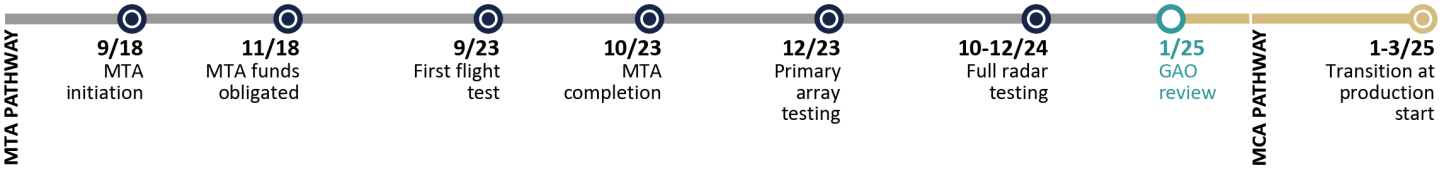
We provided a draft of this assessment to the Army for review and comment. The Army provided technical comments, which we incorporated where appropriate. The Army stated that the LRHW program, in coordination with the Navy's CPS program, is committed to delivering this critical capability. It also stated that following the completion of two successful flight tests, the LRHW program resumed production of missiles and is on track to field batteries 2 and 3 on schedule.



Source: © 2020 Raytheon Company. | GAO-25-107569

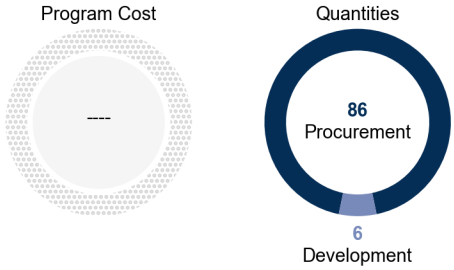
Lower-Tier Air and Missile Defense Sensor (LTAMDS)

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 completed a full-system operational assessment in the first quarter of fiscal year 2025 and plans to enter the major capability acquisition pathway at production start in the second quarter of fiscal year 2025.



Estimated Cost and Quantities

(fiscal year 2025 dollars in millions)



The Army determined that cost information was not suitable for public release.

Software Development as of January 2025

Approach: Agile and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$125 | --

Percentage of progress to meet current requirements: 76–99%

Program Essentials

Prime contractor: Raytheon

Contract type: FPIF/CPFF (production); FFP (build and test prototypes) (using other transaction authority); CPFF/FFP (incorporate improvements) (using other transaction authority)

Current Status

The LTAMDS program reported that it completed a full system operational assessment against cyber threats and low altitude cruise missiles in the first quarter of fiscal year 2025.

The program reported implementing some leading practices for product development. For example, the program stated that it incorporated modular open systems architecture, including modularity to interface with major systems, system components, and modular systems. We have identified modular design as a leading practice that enables leading companies to more easily produce systems at scale. The Army tested a full system physical prototype in a realistic environment in December 2023. Previously, we reported that conducting such testing prior to production allows users to verify performance and can uncover problems that were not apparent in earlier subsystem testing. Program officials stated that they are using data from this test to develop a digital twin, which can quickly determine the optimal design of a product that meets users' specifications. The Army told us that it has a minimum viable product in place. However, it is not fielding LTAMDS with iterations of the array but rather waiting to field the system after achieving fixed requirements for the full array. This is counter to leading product development practices, which recommend a minimum viable product with an initial set of capabilities that meet end user needs, can be fielded quickly, and can be successively updated.

Officials stated the Army approved LTAMDS's new cybersecurity strategy in September 2024, but the program faced challenges with completing initial hardware and software integration. This resulted in cost growth. Officials said these challenges stem from having limited testing opportunities for a fully integrated LTAMDS and needing additional time to solve problems associated with interfacing LTAMDS with the Integrated Fire Control Network.

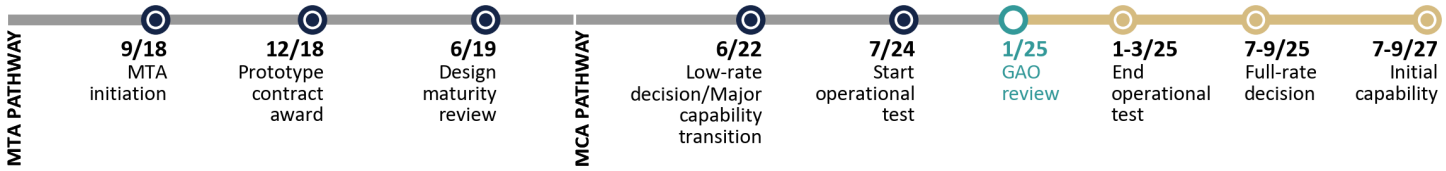
Program Office Comments

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 two flight tests in fiscal year 2024 demonstrated 360-degree capability against multiple surrogate threat classes. It added that LTAMDS will move into low-rate initial production in fiscal year 2026.

Source: U.S. Army. | GAO-25-107569

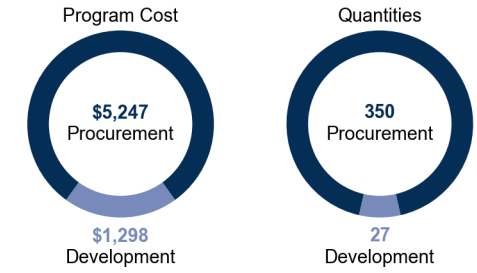
M10 Booker

The Army's M10 Booker, formerly the Mobile Protected Firepower, provides a new direct fire capability for support of infantry units across a range of military operations. The program requires the M10 Booker to 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 (MCA) pathway for production. The Army developed 24 prototype vehicles with two vendors during the MTA effort. Under the major capability acquisition pathway, the program has begun low-rate production and operational testing with one vendor.



Program Performance

(fiscal year 2025 dollars in millions)



	Reported in 2024[a] (9/2023)		Current Estimate (9/2024)
Acquisition Cost	$7,397	-1 %	$7,357
Unit Cost	$19.6	-1 %	$19.5
Cycle Time (in months)	108	+0 %	108

(%) Percent change since 2024[a]

The program reported that acquisition costs decreased due to reductions in contractor testing and software maintenance. 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.

[a]GAO-24-106831.

Software Development as of January 2025

Approach: Incremental

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions): $57 | 0.77%

Percentage of progress to meet current requirements: 76-99%

The program reported that Incremental development best describes the software development approach and software costs decreased due to revised lower labor hours.

Program Essentials

Prime contractor: General Dynamics Land Systems

Contract type: FFP; FPIF; CPFF

Current Status

As of the fourth quarter of fiscal year 2024, the Army reported ordering the production or retrofitting of up to 96 vehicles. General Dynamics delivered 13 low-rate production vehicles, as well as six prototype vehicles retrofitted to the low-rate production configuration. In September 2024, program officials identified delivery delays of up to 2 months due to material backlogs and supply-chain issues. However, in January 2025 the Army indicated there is up to a 5 ½-month delay due to quality challenges impacting production. The program plans to award the full-rate production contract in the fourth quarter of fiscal year 2025 and place an initial order of 38 additional vehicles.

We previously reported that the program completed developmental testing in 2022 and identified two key technical issues. The program stated that one issue was resolved, and it plans to complete testing on the second in the fourth quarter of fiscal year 2025. Officials stated that they identified the root cause for a third technical issue and expect the contractor to retrofit the relevant parts in the first or second quarter of fiscal year 2025. The program started operational testing in the fourth quarter of fiscal year 2024, which it said has helped reveal multiple pre-production issues currently under assessment.

The program plans to receive delivery of its final software drop in the second quarter of fiscal year 2025 and to upgrade all prior vehicles with that configuration. This delivery will also address several cybersecurity vulnerabilities discovered during required cyber assessments.

According to program officials, the program used stakeholder and user feedback throughout the development and test process—including from operational and maintenance crews—to provide technical support and system integration expertise. Our leading practices recommend continuous engagement with stakeholders and users to ensure delivered products meet users' needs.

Program Office Comments

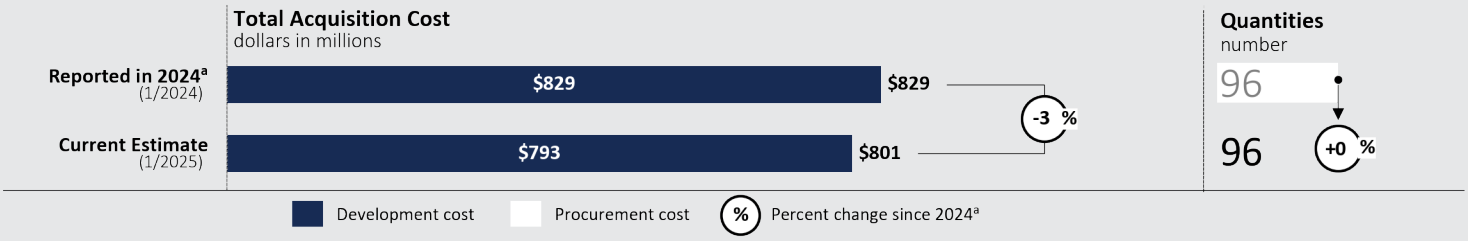
We provided a draft of this assessment to the Army for review and comment. It provided technical comments, which we incorporated where appropriate. It stated that test agencies will begin preparing reports to support the M10 Booker full-rate production decision in the fourth quarter of fiscal year 2025.

Source: U.S. Army. | GAO-25-107569

Maneuver Short Range Air Defense Increment 3 (M-SHORAD Inc 3)

M-SHORAD Inc 3 is an 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 improve 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. The program intends to transition to the major capability acquisition pathway and make its low-rate production decision in fiscal year 2028.

Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2025 dollars in millions



[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Agile, Incremental, and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$89 | 11.18%

Percentage of progress to meet current requirements: 1–25%

Program Essentials

Prime contractors: Raytheon; Lockheed Martin

Contract type: CPFF (using other transaction authority)

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	◐

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

M-SHORAD Inc 3 Program

Program Performance

Since our last assessment, M-SHORAD Inc 3 reported maturing one of its eight critical technologies. Its remaining seven critical technologies are still immature. Program officials said that contractors previously reported several technologies as approaching full maturity, but the program has since reassessed them as less mature after two reviews. A third design maturity review is expected in the second quarter of fiscal year 2025. Program officials said that they expect all critical technologies to be approaching full maturity by the first quarter of fiscal year 2026. Program officials stated that the program is on track to meet its goal of fully maturing all critical technologies by the fourth quarter of fiscal year 2028. Our prior work has shown that increasing even one maturity level can take multiple years and becomes more challenging as the technology approaches maturity.

The Army selected two vendors to design, develop, and test a prototype NGSRI during the rapid prototyping effort. It plans to select one vendor to proceed with the effort after completing the operational assessment in fiscal year 2027.

The program completed an initial schedule risk assessment and associated mitigation plans in fiscal year 2024.

Leading Product Development Practices

M-SHORAD Inc 3 officials stated that the program initiated work to incorporate a modular open systems approach (MOSA) into key interfaces and major system components, with expected completion by the end of the MTA in late fiscal year 2028. The program noted that the MOSA will allow for five of the program's subsystems to be upgraded in the future. We previously found that leading companies use modularity—designing systems so components can be added, removed, or replaced—to update and improve products after delivery. By implementing the MOSA, the program may be able to upgrade its subsystems while minimizing disruption to its overall development.

The program stated that it is assembling technical data into a system architecture model to create a repository of engineering information accessible to stakeholders throughout the program's life cycle. However, the program also stated that engineering data are transferred into the repository via analysis and reporting. That aspect of the program's approach differs from a key characteristic of a digital thread—that is, data feeds into a digital thread in real-time. Our prior work on leading product development practices shows that real-time data connect stakeholders and users with information as soon as they become available and that this better informs product decisions.

M-SHORAD Inc 3 will develop a digital twin for several discrete components of the NGSRI, but officials stated that they will not develop a full system-level digital twin that operates in real time due to funding constraints. Officials also said that the launcher is mechanically stable, and its embedded software will be tested as part of a missile simulation evaluation. Our leading practices found that digital twins at the system level provide an enhanced opportunity to understand how fully integrated systems will perform. Due to the lack of a complete digital thread and system-level digital twin, the program may miss opportunities to take advantage of the efficiencies they can provide, such as anticipating potential design flaws, optimizing manufacturing, and reducing costs.

Software and Cybersecurity

The program's contractors are developing software for the NGSRI's guidance, navigation, and control system, and for the command and launch assembly. As a part of the competitive effort, each contractor is to deliver a complete prototype, including hardware and software. The program reported that its contracts did not require vendors to deliver software metrics to the government. As a result, the program may not have insight into the prototypes' software development before delivery of the complete prototypes. The program does not have an approved cybersecurity strategy, but it plans to have one by the fourth quarter of fiscal year 2026.

Other Program Issues

Officials noted that the program faces a potential reduction in funding in fiscal year 2025. If that occurs, the program stated that it will assess what needs to be delayed in this fiscal year.

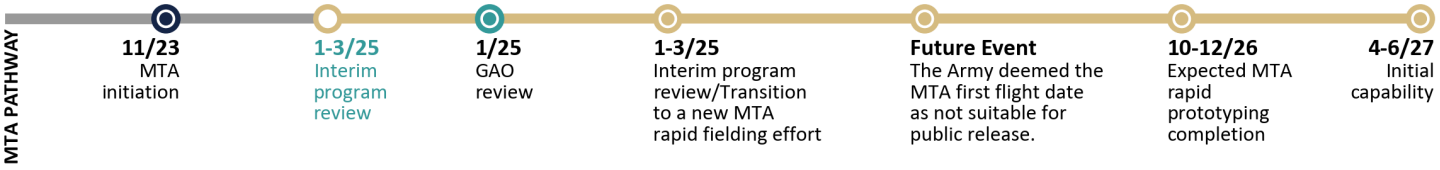
Program Office Comments

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 the program completed subsystem technology demonstrations in the second quarter of fiscal year 2025 and that it witnessed maturity in several critical technologies. The Army stated that the program is on track to mature all critical technologies by the fourth quarter of fiscal year 2028. It further stated that the program will continue to assess maturity through its next design maturity review and during flight tests throughout fiscal year 2025.

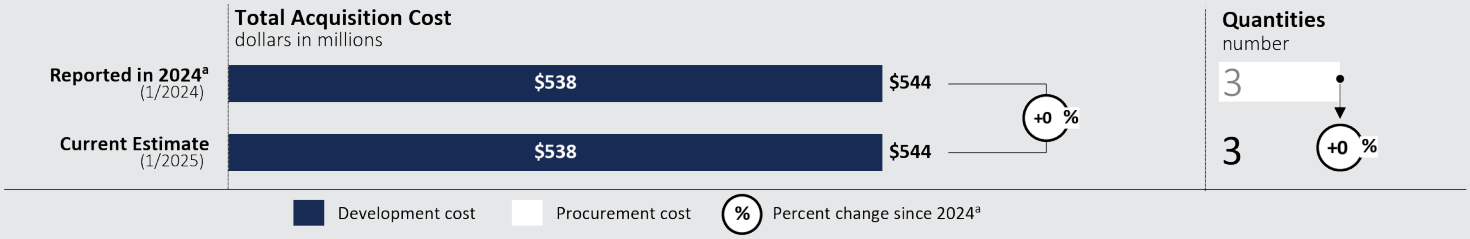
Source: Lockheed Martin with edits from U.S. Army RCCTO. | GAO-25-107569

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 - 6 and Tomahawk cruise missile technology and modifying the Navy's ship-based vertical launching system for containerized use with existing Army vehicles. The Army's Rapid Capabilities and Critical Technologies Office (RCCTO) delivered the first MRC battery in September 2023 through a prototype development effort. The Army, through Program Executive Office Missiles and Space, intends to deliver batteries 2 through 4 during the current MTA rapid prototyping effort, and battery 5 during a follow-on MTA rapid fielding effort.



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2025 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-24-106831.

Software Development

as of January 2025

Approach: Agile, Waterfall, DevOps, and DevSecOps

Software cost percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$92 | 17%

Percentage of progress to meet current requirements: 1–25%

The program reported that the percentage of software development completed is less than previously reported because, although development for the initial prototype battery is complete, further development is ongoing to enhance and increase capabilities and mitigate software issues.

Program Essentials

Prime contractor: Lockheed Martin

Contract Type: CPFF (using other transaction authority and FAR-based contracts)

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	●
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	○

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

MRC Program

Program Performance

Since our last assessment, the MRC program completed new equipment training and accepted delivery of battery 2 in September 2024. According to the program office, production of battery 3 and battery 4 is scheduled to be completed in 2025 and 2026, respectively.

The program plans to conduct an operational demonstration in 2026 with flight test events for the Standard Missile-6 Block IA and Tomahawk Block V missiles. This testing will support the fielding of battery 4 and provide the program with a better understanding of the system's capabilities and limitations. According to the program, each test event will use tactically representative hardware, and soldiers will operate the equipment.

In April 2024, the Army successfully deployed the MRC system for the first time. Battery 1—developed by the Army's RCCTO prior to the current MTA effort—was sent to the Philippines as part of a bilateral exercise in support of U.S. Indo-Pacific Command and U.S. Army Pacific. The program office expects to complete the lessons learned process for this exercise in the second quarter of fiscal year 2025.

Leading Product Development Practices

The MRC program reported that it refined high-level operational needs into a minimum viable product, with stakeholder and end user feedback incorporated during this process. According to the program office, it implemented multiple design changes to the minimum viable product based on input provided during new equipment training and other exercises. These changes include updates to the reloader to reduce stress and breakage of components, as well as changes to reduce the reloading time. According to the program, stakeholders were also involved in monthly management reviews and warfighter-focused design reviews and feedback sessions. The program expects to enhance future batteries through technology insertion points, which are driven, in part, by requirement changes, soldier feedback, and mission needs.

The program, however, has neither documented nor initiated any of the remaining leading practices that our prior work found could help deliver capability more quickly, such as developing a full system-level digital twin or digital thread. We previously found that digital engineering—specifically, digital twins—allows leading companies to create virtual representations of their physical products to enable efficiencies during the design-build-test phase of development. The MRC program stated that it is developing a full system integration lab at Redstone Arsenal and expects to assess the feasibility of implementing a digital twin and digital thread by the end of fiscal year 2025. The program expects the Navy to play a role in these decisions given the Army's use of Navy hardware and software for the MRC system.

Software and Cybersecurity

The program previously reported that software development was complete but has since clarified that it was referring to the initial prototype battery developed prior to the current MTA effort. The program office stated that software development is ongoing to enhance capabilities, as well as to mitigate software issues found in the field for both MRC and the Navy's software baseline used by the Army for MRC.

Since our last assessment, the program scheduled a full cybersecurity assessment, which it expects to conduct during the second half of fiscal year 2025. The Army expects the operational demonstration in 2026 to include a tabletop exercise with electronic warfare, cyber, and other threats, as well as cyber survivability testing with adversarial and cooperative vulnerability and penetration assessments.

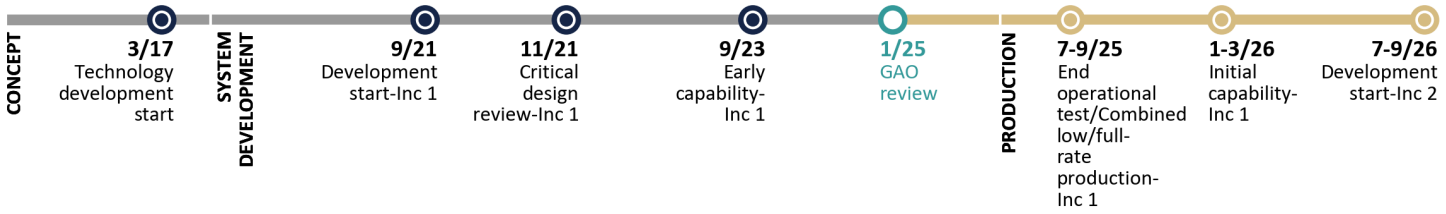
Program Office Comments

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 its prototype MRC system was developed and delivered in record time to meet Army and DOD mandates. According to the Army, the program incorporated operational user feedback from initiation resulting in technology insertions to enhance performance and address operational findings. It further stated that the program is pursuing upgrades to the Aegis Weapon System virtual twin, which is part of the system's command and control architecture. While the program noted that it acknowledges the benefits of our leading practices, the Army also stated that those benefits would not be fully realized prior to the completion of deliveries in fiscal year 2027 due to the rapid nature of development. The Army added that the program will continue to explore further implementation of these practices during the operations and sustainment phase of the program.

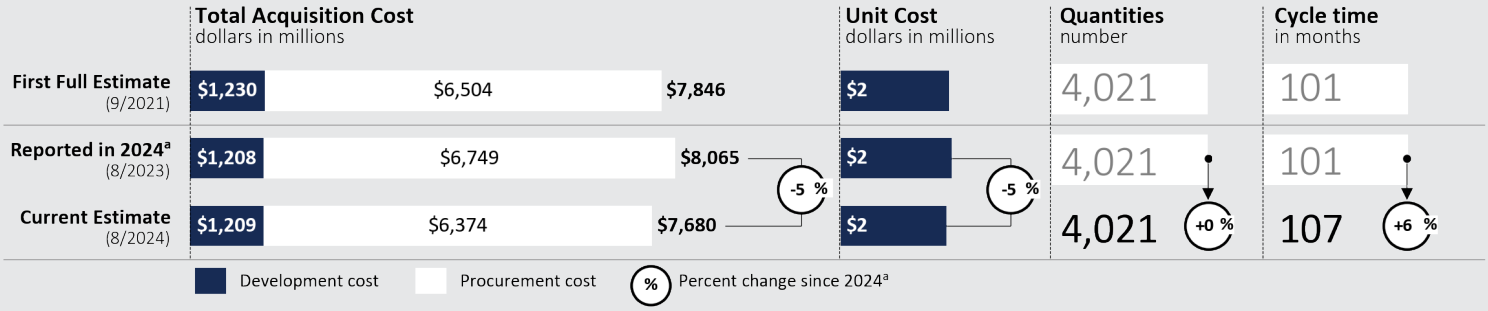
Source: Lockheed Martin. | GAO-25-107569

Precision Strike Missile (PrSM)

The Army's PrSM is a surface-to-surface ballistic missile designed to attack point and area targets at distances ranging from 70 to over 400 kilometers. Each PrSM container will hold two missiles, twice the current missile container's capacity, and will remain compatible with existing rocket launcher systems. The Army is developing PrSM across four increments. The first increment will replace the Army Tactical Missile System and aims to achieve initial operational capability in fiscal year 2026. Subsequent increments will provide seeker capability, extend missile range, and add more lethal payloads. PrSM is designed to comply with statutory requirements for insensitive munitions to reduce vulnerability to accidental stimuli, as well as DOD's policy on cluster munitions to minimize unintended harm from unexploded ordinance. We assessed the first two of the expected increments.



Program Performance fiscal year 2025 dollars in millions



Total quantities comprise 35 development quantities and 3,986 procurement quantities. Program officials stated that the reduction in the total acquisition cost was due to the transfer of certain software maintenance expenses to the operation and sustainment budget lines. 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-24-106831.

Software Development

as of January 2025

Approach: Agile and Waterfall

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$135| 1.76%

Percentage of progress to meet current requirements: 76–99%

Program Essentials

Prime contractor: Lockheed Martin

Contract Type: FFP

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	◐
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	◐
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	◐
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	◐
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	●

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

PrSM Program

Program Performance

The PrSM program conducted a design completion review in April 2024 that established an initial product baseline for Increment 1. It also began production qualification testing in the first quarter of fiscal year 2024. The program plans to continue testing through the third quarter of fiscal year 2025 to support a production start decision that fiscal year.

The Army reported delays to several milestones, including initial operational testing, combined low-rate and full-rate production, and initial operational capability. Officials attributed these delays to manufacturing challenges related to defects with multiple missile hardware components, and the associated root cause investigations and corrective actions. These revised dates place each of these four PrSM planned milestones within 1 month of the milestones' baseline threshold dates. We previously reported that programs with concurrent design and production phases, like PrSM, are at higher risk of cost growth and schedule delays.

The Army reported that it demonstrated the maturity of each of PrSM's seven critical technologies in an operational environment upon completion of its limited user test in the fourth quarter of fiscal year 2024. The next technology maturation event—that of the actual rather than prototype system—is planned for the third quarter of fiscal year 2025 upon completion of production qualification testing.

Parallel to testing and technology maturation, the Army is producing early operational quantities of PrSM Increment 1. Officials said that they pursued this strategy to rapidly field an urgently required capability. Officials also stated that the program has delivered 26 early operational missiles to the warfighter as of January 2025.

The PrSM program is also continuing development of its Increment 2 design, which will incorporate seeker technology into the PrSM baseline missile. The Army has been cooperatively developing Increment 2 alongside Australia since 2021 and intends to deliver early capability missiles in fiscal year 2028. In fiscal year 2025, the Army intends to continue progress on Increment 2 by maturing the seeker, preparing for prototype test flights against maritime targets, and holding a preliminary design review.

Leading Product Development Practices

The PrSM program reported that it is using some leading practices for product development, including input from stakeholders and a modular open systems approach. However, it is not fully implementing iterative efforts or digital twinning in ways that we found lead to efficiencies.

- The Army told us that it incorporated soldier feedback from a user touchpoint event early in the design phase and had plans to obtain soldier input for limited user testing. The Army also told us it plans to incorporate manufacturer or supplier feedback.
- The Army stated that PrSM incorporates all elements of a modular open system approach that allow components and modular systems to be incrementally added, removed, or replaced. Program officials said that it was challenging to implement a modular open system approach while delivering an early capability to meet Army requirements. To overcome this concurrency, PrSM officials reported that they urged contractors to complete challenging elements of the design early, during the technology maturation phase of the program.
- The program reported that it has an MVP for the first increment. However, the Army set fixed requirements for all increments. Based on our ongoing work on Army long-range fires, it is unclear to what extent the program will use demonstrated achievements in Increment 1 to inform subsequent increments. We previously found that demonstrating an MVP—or capability—before starting the next iteration allows companies to incorporate feedback and ensure that delivered capability meets user needs.
- According to the Army, PrSM developed two digital models, including the program's simulation of record, to predict and assess flight testing performance. While PrSM's high-fidelity models incorporate elements of a digital twin (virtual representations of physical products), they do not integrate data automatically to mirror real-time performance, which our prior work found is key for achieving efficiencies.

Software and Cybersecurity

As we previously reported, the PrSM program office finalized its cybersecurity requirements after initial system design, requiring updates that will cost about $200 million and take 5 years. The Army told us that the program is implementing software changes to meet the new requirements for Increment 1 and plans to incorporate hardware changes for Increment 2. According to the program, this approach preserves timelines for early fielding while providing full cybersecurity capabilities during full-rate production.

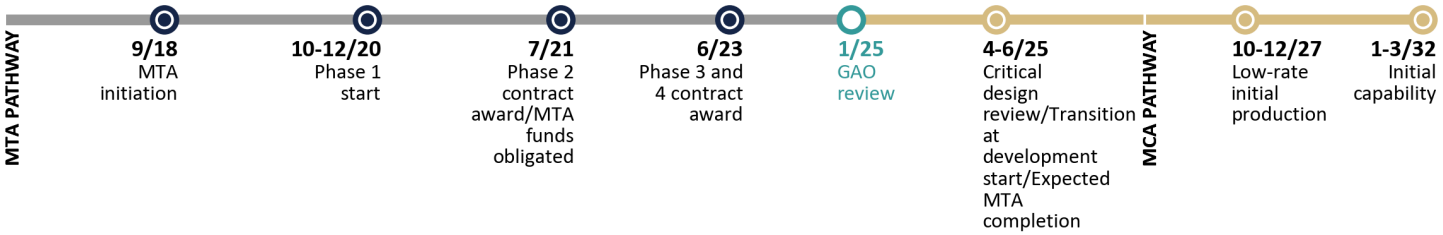
Program Office Comments

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 continues to procure the missile to meet requirements through early operational capability and plans to conduct a production start decision review in the third quarter of fiscal year 2025, following initial operational test and evaluation. It stated that the results of this testing will be used to support a full-rate production decision review.

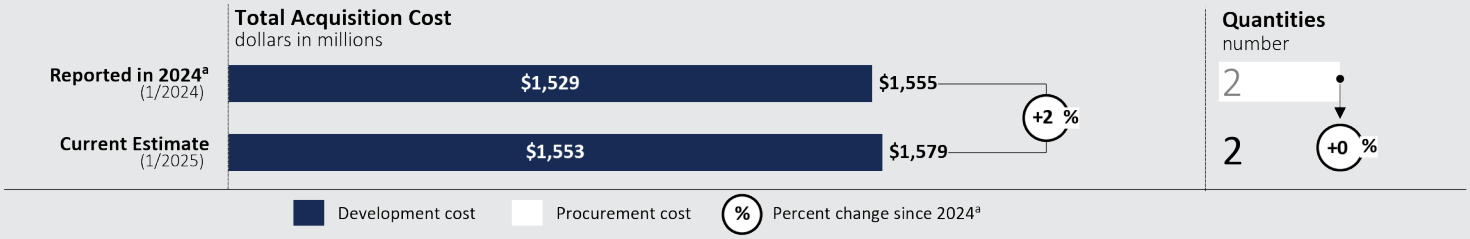
Source: U.S. Army. | GAO-25-107569

XM30 Mechanized Infantry Combat Vehicle (XM30)

The XM30 is the Army's planned solution to maneuver warfighters on the battlefield to advantageous positions for close combat. The Army expects XM30 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 has a five-phase plan: market research and requirements refinement (Phase 1), concept design (Phase 2), detailed design phase (Phase 3), prototype build and test (Phase 4), and transition to 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). XM30 is currently in Phases 3 and 4. The MTA rapid prototyping effort will develop two physical prototypes, one from each vendor. The program is developing additive software separately on the software acquisition pathway.



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2025 dollars in millions



[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Agile, Incremental, and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$47| 2.95%

Percentage of progress to meet current requirements: 1–25%

The program reports that the software costs are estimates representing fiscal years 2024–2028.

Program Essentials

Prime contractors: General Dynamics Land Systems; American Rheinmetall Vehicles

Contract Type: FFP

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	◐
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	◔
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	◔
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	●

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

XM30 Program

Program Performance

Since our prior assessment, XM30 delayed its critical design review and planned transition to the MCA pathway from the first and second quarters to the third quarter of fiscal year 2025. Program officials said the delay resulted from both contractors failing to develop MOSA-compliant software and hardware. Program officials stated that they assumed the contractors had some degree of proficiency in using a models-based engineering approach. Officials ultimately found that the contractors lacked that experience. Building and maturing the system architecture model resulted in significantly more growth in data and specifications than program officials anticipated. Program officials stated, however, that this approach has yielded a greater understanding of the vehicle than they anticipated for a development contract.

The Army expects to identify XM30's critical technologies in the third quarter of fiscal year 2025. Identifying critical technologies this late in development risks XM30 not reaching maturity before it transitions to the MCA pathway. Using immature technologies further increases the risk of redesign.

Leading Product Development Practices

The XM30 program—an Army-designated "pathfinder" program for pioneering the service's digital engineering efforts—reported that it is incorporating some elements of leading product development practices. For example, program officials reported plans to develop a digital twin and a digital thread. Officials said that while the program has a link between the model and the physical design, they are still developing the full requirements for the digital twin and will include them in the contract for Phase 5. Program officials stated that they want a digital twin to also address manufacturing and sustainment, including the supply chain, with a digital version of every vehicle to get real-time visibility on sustainment. We previously found that leading companies use digital twins to refine designs and optimize manufacturing.

Additionally, as we reported last year, XM30 continues to incorporate stakeholder and end user feedback into the prototypes. The program held a soldier touchpoint with each vendor prototype in August 2024, focusing on maintenance and users' interaction with physical models overlaid with augmented reality. According to the officials, users provided feedback that resulted in the realignment of certain equipment to ease access for the maintainers.

According to program officials, the program identified an MVP as part of concept design during Phase 2. The officials stated that the Phase 3 and 4 contract award would lead to a fielded MVP, and that they plan to add more capabilities to the system in the future, such as the ability to detect uncrewed aerial systems.

However, the program also identified the refined XM30 requirements as highly detailed to complete the capability development document and likely to be met by a specific materiel solution—in which development is focused on compliance with fixed requirements instead of on user feedback and mission effect. In contrast, we previously found that leading companies allow for requirements to evolve, and that doing so helps ensure that the requirements are defined in concert with demonstrated achievement.

Software and Cybersecurity

XM30 is continuing software development in two parallel efforts—basic vehicle software and additive software using the software acquisition pathway. The two prototype contractors have been slow to use a government-provided DevSecOps environment to develop the basic software for the vehicle. As a result, the program identified risk to completing software in time for developmental and operational testing.

The Army approved the execution phase of XM30's software pathway in the first quarter of fiscal year 2025. During this phase, XM30 will analyze user needs to identify additive capabilities, focusing on higher risk technical capabilities in parallel with development of the base XM30 platform.

Other Program Issues

XM30 is not conducting a full industrial base assessment. Instead, the program will conduct a production readiness review during low-rate initial production with criteria that includes identification of manufacturing sources and material shortages, following a standard process. Program officials concede that there is some risk in conducting this assessment after selecting a prototype for low-rate initial production.

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. According to the Army, its iterative approach refined capabilities over time—starting with an initial capabilities document that identified high-level capabilities; then an abbreviated capabilities document that enabled the Army and industry to iterate requirements based on soldier feedback and early engineering analysis. It stated that, during Phase 2 requirements refinement, it followed those efforts with a more-defined capabilities document and draft technical performance specifications, which it said helped identify technically-achievable attributes and specifications. The Army noted that continued soldier feedback and analysis were used to finalize the capabilities document. It stated that this iterative, collaborative approach provided the ability to balance risk for the Phases 3 and 4 contract award and ensure that it did not direct high-risk requirements on an unachievable schedule.

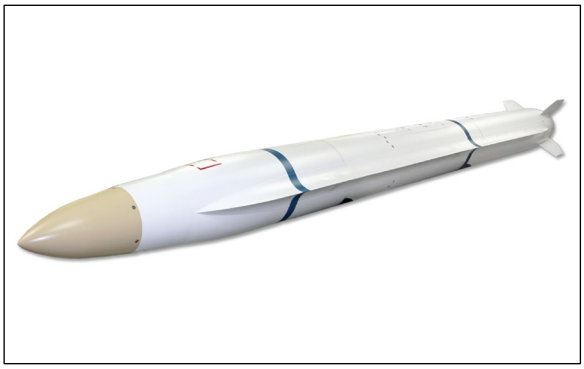
NAVY

Program Assessments

▲ Air and Missile Defense Radar (AMDR)

Program name	Assessment type
Advanced Anti-Radiation Guided Missile - Extended Range (AARGM-ER)	MDAP
Air and Missile Defense Radar (AMDR)	MDAP
Conventional Prompt Strike (CPS)	MTA
CVN 78 Gerald R. Ford Nuclear Aircraft Carrier (CVN 78)	MDAP
DDG 1000 Zumwalt Class Destroyer (DDG 1000)	MDAP
DDG 51 Arleigh Burke Class Destroyer, Flight III (DDG 51 Flight III)	MDAP Increment
DDG(X) Guided Missile Destroyer (DDG(X))	Future Major Weapon Acquisition
E-6B Recapitalization (E-130J)	MDAP
F/A-18E/F Infrared Search and Track (IRST)	MDAP
FFG 62 Constellation Class Frigate (FFG 62)	MDAP
Hypersonic Air-Launched Offensive Anti-Surface Warfare Weapon System (HALO)	MTA
Large Unmanned Surface Vessel (LUSV)	Future Major Weapon Acquisition
Medium Landing Ship (LSM)	Future Major Weapon Acquisition
MK 54 MOD 2 Advanced Lightweight Torpedo (MK 54 MOD 2 ALWT)	Future Major Weapon Acquisition
MQ-25 Unmanned Aircraft System (MQ-25 Stingray)	MDAP
MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)	MDAP
Next Generation Jammer Low-Band (NGJ LB)	MDAP
Next Generation Jammer Mid-Band (NGJ MB)	MDAP
Orca Extra Large Unmanned Undersea Vehicle (XLUUV)	Future Major Weapon Acquisition
Ship to Shore Connector Amphibious Craft (SSC)	MDAP
SSBN 826 Columbia Class Ballistic Missile Submarine (SSBN 826)	MDAP
SSN 774 Virginia Class Submarine (VCS) Block V (VCS Block V)	MDAP Increment
T-AGOS 25 Explorer Class Ocean Surveillance Ship (T-AGOS 25)	MDAP
T-AO 205 John Lewis Class Fleet Replenishment Oiler (T-AO 205)	MDAP

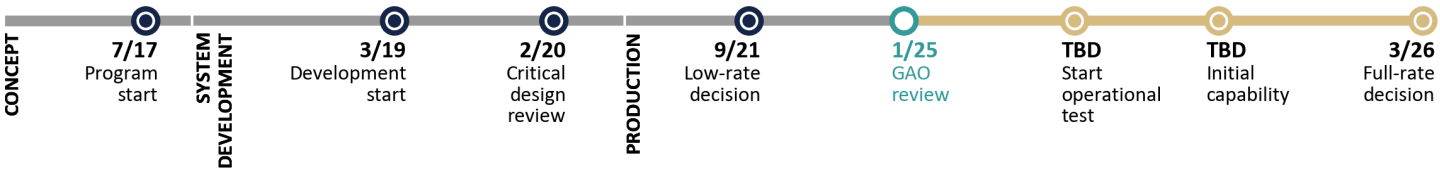
Source (previous page image): Huntington Ingalls Industries. | GAO-25-107569



Advanced Anti-Radiation Guided Missile—Extended Range (AARGM-ER)

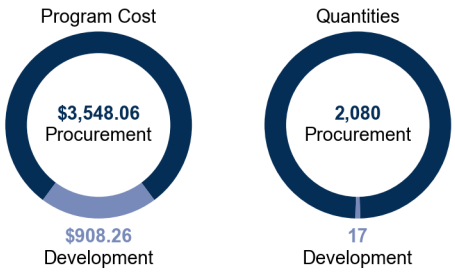
The Navy's AARGM-ER program is an upgrade to the AGM-88E AARGM. The AARGM-ER is an air-launched missile that is intended to provide increased range, higher speed, and more survivability to counter enemy air defense threats. It will incorporate upgrades to the AARGM missile's guidance and control sections, 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.

Source: Northrop Grumman Innovation System (NGIS). | GAO-25-107569



Program Performance

(fiscal year 2025 dollars in millions)



	Reported in 2024[a] (8/2023)	%	Current Estimate (9/2024)
Acquisition Cost	$4,063	+10%	$4,456
Unit Cost	$1.9	+10%	$2.1
Cycle Time (in months)	66	N/A%	TBD

(%) Percent change since 2024[a]

We could not calculate the current cycle time estimate since the program has yet to develop a new estimate for reaching initial operational capability.

[a]GAO-24-106831.

Software Development as of January 2025

Approach: Spiral

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$26.52 | 0.6%

Percentage of progress to meet current requirements: 76-99%

Program Essentials

Prime contractor: Alliant Techsystems Operations, LLC

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

Current Status

The AARGM-ER experienced significant delays as a result of rocket motor, structural, and software problems discovered during testing. The program delayed its full-rate production decision by 10 months and has yet to develop a new estimate for reaching initial operational capability. The program had expected to reach initial operational capability in July 2024. Contracting officials noted that the program worked with the prime contractor to investigate the root causes of the identified deficiencies and implement corrective actions, including changes in the production process. According to the program, it returned to flight testing in late 2024 and successfully completed a flight test during which the missile acquired, tracked, and scored a direct hit on the target.

Program costs also increased for several reasons, according to program officials. For example, the program extended development, conducted root cause investigations, and implemented corrective actions due to the problems discovered in testing. Further, production costs have been higher than originally estimated. Also, program officials stated that the amount the program pays to use testing ranges increased.

The program is still experiencing production delays as well. Since our last assessment, program officials stated that testing issues, supply chain challenges, and construction delays for a new production facility slowed completion of the first two production contracts by 1 year. We have found that starting production before demonstrating a system will work as intended—which the Navy did—increases the risk of discovering deficiencies that require costly, time-intensive rework.

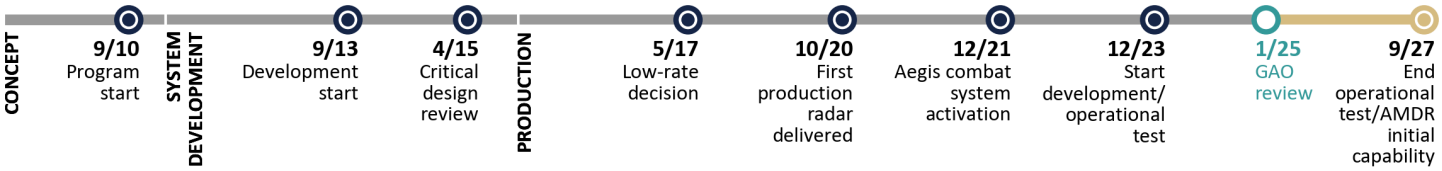
Program Office Comments

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 fielding was delayed due to several hardware issues discovered during qualification tests. It expects to complete qualification in 2025, and upon concurrence from a Navy safety board, enter operational testing. The program office noted that it would not accept production missiles until qualification is complete.

Air and Missile Defense Radar (AMDR)

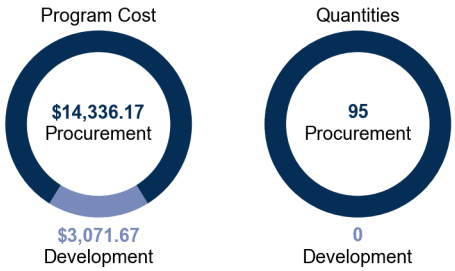
The Navy's AMDR is a radar program supporting surface warfare and integrated air and missile defense. The Navy expects AMDR's family of radars to provide increased sensitivity for long-range detection to improve ballistic missile defense against advanced threats. The Navy is also developing a radar suite controller to provide integrated air and missile defense for DDG 51 Flight III destroyers. In January 2023, the Navy added two Enterprise Air Surveillance Radar variants to the program, and in February 2024, the Navy added a fourth radar variant. This family of variants will provide radars for other ship classes.

Source: Huntington Ingalls Industries. | GAO-25-107569



Program Performance

(fiscal year 2025 dollars in millions)



	Reported in 2024[a] (7/2023)		Current Estimate (8/2024)
Acquisition Cost	$10,791	+62%	$17,446
Unit Cost	$168.6	+9%	$183.6
Cycle Time (in months)	167	+22%	204

(%) Percent change since 2024[a]

The program reported that acquisition costs increased due to the procurement of the fourth radar variant.

[a]GAO-24-106831.

Software Development as of January 2025

Approach: Agile and Incremental

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$2,038.83 | 11.69%

Percentage of progress to meet current requirements: 26–50%

According to the program, the percentage of software completed is less than that reported in our prior report due to the addition of new increments.

Program Essentials

Prime contractor: Raytheon

Contract type: FFP (procurement); CPFF (engineering)

Current Status

Due to shipbuilding delays, radar production continues to outpace ship production of DDG 51 Flight III and other ships. This production mismatch has required the Navy to store some delivered radars as the AMDR program waits for ships to become available for installation. To mitigate the costs of storage, AMDR officials stated, the program is establishing a government secure storage facility. Additionally, AMDR program officials told us that it remains cost effective and efficient to maintain continuous production of the AMDR family of radars to complete and deliver equipment at a predictable pace.

Program officials reported that the first radar variant is currently in development testing and that deficiencies found under certain testing conditions for the inverter modules have been addressed and modules in production are being delivered with the updates. However, program officials told us that they conducted a root cause analysis and software fixes and are addressing integration issues with the radar to support upcoming test events. The program received its first software to address this risk in spring 2024.

Last year the program reported the initial capability date as August 2024. However, program officials explained that the AMDR program adjusted this date to September 2027 to align with the DDG 51 Flight III initial operational testing plan and fleet needs. The Navy does not plan to certify radars until fiscal year 2026. We previously reported on the potential for discovery of additional deficiencies during ongoing testing that could result in costly, time-intensive revisions, particularly if rework is required for installed radars. Program officials acknowledged this risk, and the Navy continues to try to mitigate these issues.

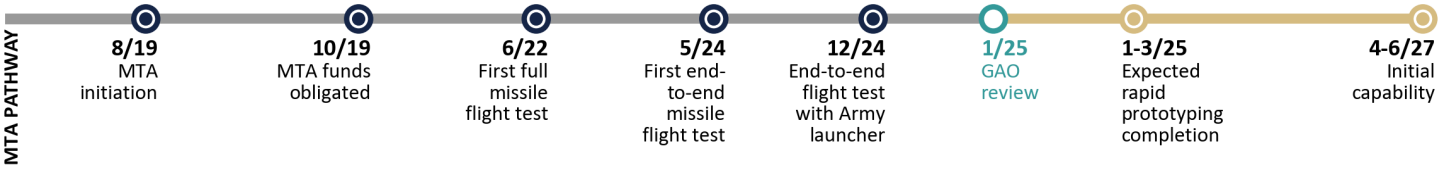
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. It stated that it is on track to support combat systems for all variants, and that the secure storage facility's first intake is scheduled for April 2025. It noted that new builds of radar and combat system software for continuing DDG 125 at-sea testing match those planned for operational testing. In April 2025, the office of DOD's Director, Operational Test and Evaluation provided comments stating that AMDR's operational testing date should be reflected as the fourth quarter of fiscal year 2029. The Navy's comments did not provide a revision to this date.

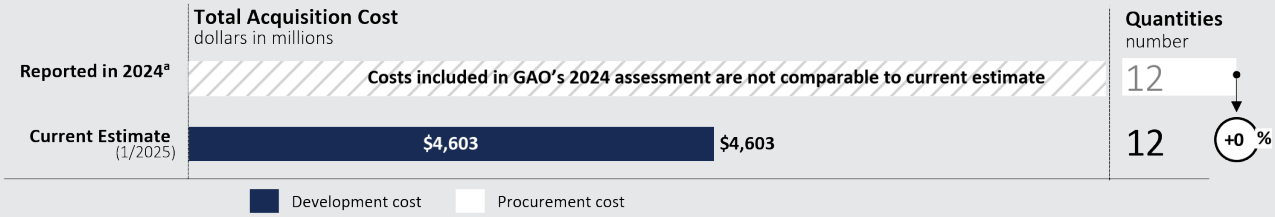
Source: U.S. Navy. | GAO-25-107569

Conventional Prompt Strike (CPS)

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—in spring 2025. The second phase, a planned MTA rapid fielding effort, aims to field the missile on a surface ship by 2027. The third phase, a planned major defense acquisition program, aims to field the missile on *Virginia* class submarines by the early 2030s. The CPS program partners with the Army's Long Range Hypersonic Weapon program, which we assessed separately.



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2025 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-24-106831. The costs reported in 2024 are not comparable due to changes in the program's cost estimating methodology.

Software Development

as of January 2025

Approach: Agile, Waterfall, Incremental, and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$103.19 | 2.24%

Percentage of progress to meet current requirements: 51–75%

Program Essentials

Prime contractor: Lockheed Martin

Contract Type: CPIF

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	●
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	◐
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	◔
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	◐

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

CPS Program

Program Performance

DOD extended the CPS MTA rapid prototyping effort by 1 year due to testing issues, but recent results have been more positive. In 2023 and 2024, the Army and Navy conducted four tests that were not completed due to Army launcher and missile production issues. After a series of technical reviews, the Army and Navy conducted a successful end-to-end flight test from a launch pad in mid-2024, followed by a successful test using the Army's launcher in December 2024. Program officials stated they plan to conduct another flight test during the second quarter of fiscal year 2025 from a Navy launcher that mimics the launch method that will be used when the system is fielded on *Zumwalt* class destroyers. If successful, this test will complete the MTA rapid prototyping effort.

The Army's and Navy's testing issues also caused the cost of the MTA rapid prototyping effort to grow and delayed the follow-on MTA rapid fielding effort. We could not determine the total year-to-year cost growth due to changes in the CPS program's cost estimating methodology. But, since our last assessment, the program added at least $284 million (fiscal year 2025 constant dollars) in estimated costs to extend design and development and complete flight testing associated with the MTA rapid prototyping effort. Since our last assessment, the program also delayed the estimated completion of the MTA rapid fielding effort to put CPS on the *Zumwalt* class destroyers by 2 years, to 2027.

Leading Product Development Practices

The CPS program is implementing some aspects of leading practices for product development. For example, the program reported that it iteratively developed a minimum viable product. According to the program, it prioritizes capabilities based on a technology insertion process informed by factors like technology maturity, affordability, and evolving user needs. For example, to reduce schedule risk, the program removed some features from the first technology insertion that were not essential to the Navy's capability needs.

The CPS program also developed a digital engineering strategy that included a digital twin and digital thread. But, program officials stated that neither will be fully implemented due to time and budget constraints and program complexity. Instead, the program is in the process of implementing a digital twin at the subsystem level, including a digital prototype of missile components and subsystems by 2027, but will not establish a full digital twin of the system. Program officials also stated they will not have a full digital thread, although the program does plan to improve digital integration of systems and link organizations supporting the program. We previously found that these digital design tools are useful in the design and validation process as they can enable more rapid iterative design cycles and facilitate stakeholder and user feedback at earlier stages. Without them, the CPS program may take a longer time to make needed changes to future iterations of the weapon system.

Program officials noted that compressed time frames and a constrained budget for the program led them to scale back implementation of digital engineering practices, despite their recognition of the potential benefits. They also stated that the complexity of the program and the difficulty in integrating around 30 activities at different levels of classification have been challenges.

Software

In the past year, software development costs increased due to testing issues. Program officials stated that the increases occurred due to needing additional software builds to conduct additional, previously unplanned tests.

Other Program Issues

The Army and Navy faced challenges in missile production quality and capacity that they are working to mitigate. After missile production issues resulted in aborted Army tests, the CPS and Long Range Hypersonic Weapon System programs stated that they increased oversight of the prime contractor and the contractor was working to improve its work instructions and quality assurance processes. CPS officials also stated that the Army and Navy had difficult conversations about production prioritization as they try to balance Navy testing needs and Army fielding goals. These officials stated that the prime contractor plans to add equipment by March 2025 to address a chokepoint in the production process related to the missile's thermal protection system, which will increase capacity.

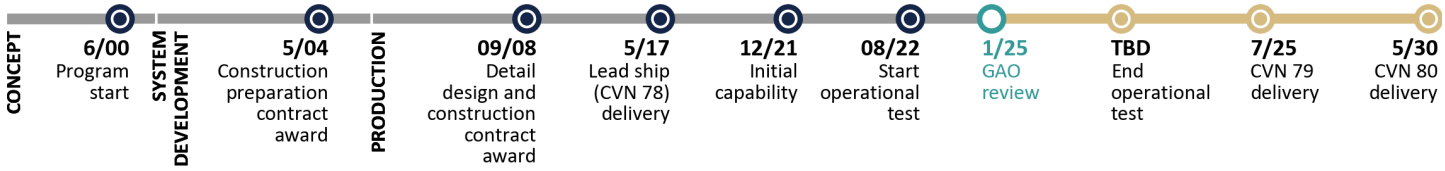
Program Office Comments

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 CPS program office, following flight test challenges in fiscal years 2023 and 2024, the Navy and Army program offices, with their industry partners, initiated a series of design and production quality reviews and additional testing opportunities to achieve critical knowledge points and reduce risk. The program office stated that the programs returned to the range in 2024 and completed two successful end-to-end flight tests. It stated that it also completed CPS cold-gas eject demonstrations. In fiscal year 2025, the program plans to conduct the first cold-gas launch of the hypersonic missile and install the CPS Weapons System onboard the USS *Zumwalt*. The program stated that it continues to coordinate with the *Zumwalt* class and *Virginia* class programs to support design, development, and testing in preparation for fielding CPS.

Source: U.S. Navy. | GAO-25-107569

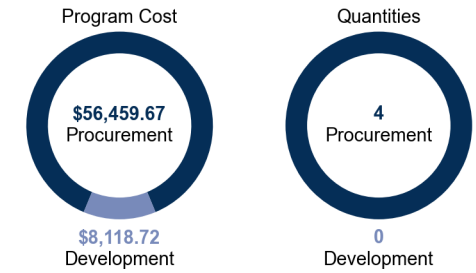
CVN 78 *Gerald R. Ford* Nuclear Aircraft Carrier (CVN 78)

The Navy developed the CVN 78 (or *Ford* class) nuclear-powered aircraft carrier to create operational efficiencies and increase the rate of sustained flight operations compared with legacy aircraft carriers. The *Ford* class introduced new propulsion, aircraft launch and recovery, and survivability capabilities to the carrier fleet. It is the successor to the *Nimitz* class aircraft 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 2025 dollars in millions)



	Reported in 2024[a] (10/2023)		Current Estimate (7/2024)
Acquisition Cost	$63,275	+3%	$65,200
Unit Cost	$15,819	+3%	$16,300
Cycle Time (in months)	212	+0%	212

(%) Percent change since 2024[a]

The graphic bars depict only research and development and procurement costs.

[a]GAO-24-106831.

Software Development as of January 2025

Approach: Information not available

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions): Information not available

Percentage of progress to meet current requirements: Information not available

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)

Current Status

The program's unit costs increased by 3 percent, or about $480 million, since last year. Changes to CVN 79's delivery schedule that we previously reported account for about half of this increase but the Navy is using funds it previously planned and budgeted for post-delivery activities, so these are not new program costs. CVN 80 delays and cost increases for CVNs 81, 82, and 83, among other costs, account for the rest, according to program officials.

Construction challenges affected CVN 79 and CVN 80 delivery schedules. Continuing delays to Advanced Weapons Elevators construction put CVN 79's July 2025 delivery at risk, according to program officials. They said that, while this construction improved since CVN 78, they may postpone noncritical work like painting until after delivery to avoid delay. Further, the Navy now plans for CVN 80 delivery in May 2030, a 26-month delay since last year. Program officials attributed this delay to construction material availability and persistent shipyard workforce issues that the program is working to mitigate with revised schedules and worker incentives. The program reported it has not assessed the carrier industrial base for potential manufacturing risks but officials said that they plan to leverage other industrial base initiatives. This includes those related to submarines and within the Navy's new Maritime Industrial Base program office.

The program is assessing how to complete initial operational test and evaluation. The Navy began CVN 78's operational testing in August 2022 but had to deploy CVN 78 earlier, extending the test period to March 2025. Testing may not be complete until fiscal year 2027 due to coordination of test events with CVN 78's next deployment. Program officials said they may move events into the ship's follow-on operational test phase. Moving test events would help the program report initial test results sooner but would delay the Navy's ability to determine whether the program meets all key performance goals.

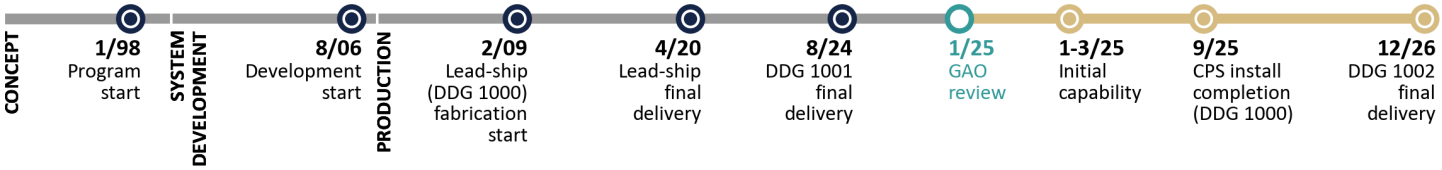
Program Office Comments

We provided a draft of this assessment to the program office for comment and incorporated its technical comments where appropriate. The program stated that CVN 78 was recognized as the best all-around ship in the Atlantic Fleet in 2024. It also stated that, since inaugural deployment, CVN 78 completed a maintenance period and is conducting training and other readiness activities for future operations. The program stated that it also completed CVN 78's final live fire test and evaluation event in January 2025.

Source: BAE Systems San Diego. | GAO-25-107569

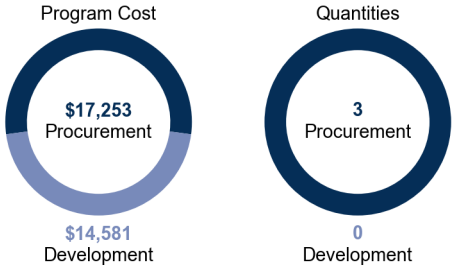
DDG 1000 *Zumwalt* Class Destroyer (DDG 1000)

The DDG 1000 was conceived as primarily a land-attack ship, but the Navy is 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 plans to add Conventional Prompt Strike (CPS) hypersonic missile capability. This capability is scheduled to be demonstrated on the lead ship in 2027. We evaluate the CPS program in a separate assessment in this report.



Program Performance

(fiscal year 2025 dollars in millions)



	Reported in 2024[a] (9/2023)		Current Estimate (7/2024)
Acquisition Cost	$31,786	+0%	$31,834
Unit Cost	$10,595	+0%	$10,611
Cycle Time (in months)	316	+3%	325

(%) Percent change since 2024[a]

The cycle time of 316 months above reflects the corrected value reported for 2023 in our 2024 report, The estimated initial operational capability date provided for our 2024 report was insufficient to calculate the cycle time.

[a]GAO-24-106831.

Software Development as of January 2025

Approach: Agile and DevOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions): Information not available

Percentage of progress to meet current requirements: 76-99%

The program reported that it does not track software cost elements.

Program Essentials

Prime contractor: General Dynamics Bath Iron Works; Huntington Ingalls Industries; Raytheon

Contract type: FPI/FFP/CPFF (ship construction); CPFF/CPAF (mission systems equipment)

Current Status

Since last year's assessment, the DDG 1000 program made progress with its installation of the CPS hypersonic weapon system on the lead ship and accepted final delivery of DDG 1001. The Navy also continued DDG 1002 combat systems testing in the lead up to CPS installation, builder's trials, and acceptance trials, intended to support ship delivery in late 2026.

After years of delays, program officials stated that they plan to complete initial operational test and evaluation in fiscal year 2025. Following live fire testing of the Tomahawk missile systems on the DDG 1001 in January 2025, the Navy deployed DDG 1001 before the ship enters a planned modernization period for CPS installation in mid-2026.

According to DDG 1000 officials, CPS program challenges resulted in a roughly 24-month delay to the DDG 1000 live fire demonstration of the weapon system, which was previously scheduled for 2025. DDG 1000 program officials stated that these developmental challenges do not affect their current installation of the Large Missile Vertical Launch System for CPS on the lead ship. This is because the CPS program is responsible for ensuring that the hypersonic missile launches from the shipboard system. Still, key CPS technologies—including the missile canister and system to eject the missile—remain immature. Such immaturity poses design, cost, and schedule risks to achieving the DDG 1000 program's hypersonic strike capability as planned.

DDG 1000 officials noted that risk remains for CPS software and integration. They said that the DDG 1000 program will use testing to assess integration risk involving software interfaces once the CPS program delivers a developmental version of the advanced payload module that will hold the hypersonic missile and cannister. Delivery of this module is scheduled for spring 2025.

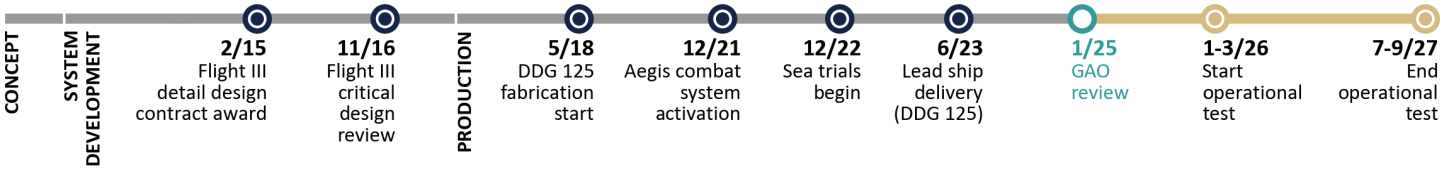
Program Office Comments

We provided a draft of this assessment for program office review and comment. It provided technical comments, which we incorporated where appropriate. The program office stated that it has made significant progress in the testing and modernization of *Zumwalt* class ships and noted that CPS installation efforts are in various stages on DDG 1000 and DDG 1002. It also stated that the *Zumwalt* class is on track to field CPS' capability. In May 2025, after our cutoff date for new information, program officials told us that they have yet to achieve initial operational capability as planned, but they expect to do so in fiscal year 2025.

Source: U.S. Navy. | GAO-25-107569

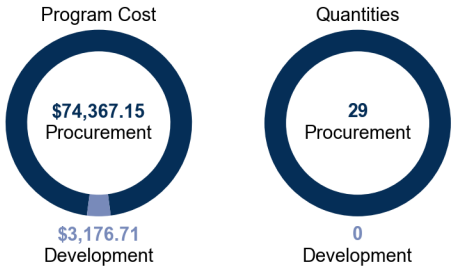
DDG 51 *Arleigh Burke* Class Destroyer, Flight III (DDG 51 Flight III)

The Navy's DDG 51 Flight III destroyers are multimission ships designed to operate against air, surface, and underwater threats. 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 2025 dollars in millions)



Cost reflects the procurement of 29 ships bought or planned from fiscal years 2017–2029. The President's budget for fiscal year 2025 indicates plans to procure at least five additional Flight III ships after fiscal year 2029.

Software Development as of January 2025

Approach: Agile, Incremental, and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions): Information not available

Percentage of progress to meet current requirements: 76-99%

According to the program, software development and procurement costs are not tracked specifically for Flight III. The relevant data collected by the program are for the entire DDG 51 program.

Program Essentials

Prime contractors: General Dynamics-Bath Iron Works; Huntington Ingalls Industries

Contract type: FPI (construction)

Current Status

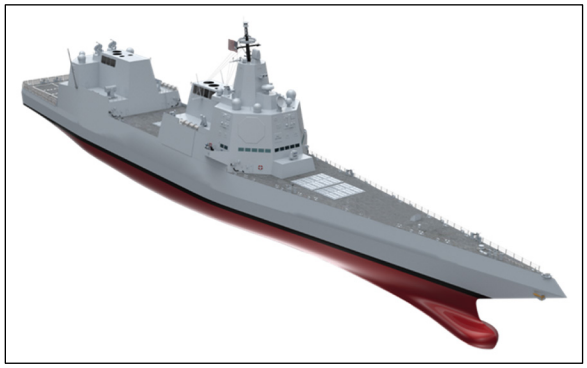
Since last year's assessment, persistent shipyard performance issues contributed to additional schedule growth. The DDG 51 program office stated that both shipbuilders have made progress but continue to struggle to meet hiring, training, and retention targets needed to stabilize construction schedules. The schedule instability led to additional delivery delays since our last assessment for each of the first 13 follow-on ships. The delivery delays for these ships now range from 8 to 41 months compared with the contract dates provided by the program. These delays undermine Navy efforts to provide timely new capability to counter current and future air and surface threats.

The program office said that it assessed shipyard capacity and workload prior to its 2023 construction contract awards and conducted studies to understand the shipyards' challenges. To address the challenges, the program office said that it is using funding received above the program's request to support shipbuilder infrastructure projects and the supplier base for the program. Further, the program office stated that it is using workforce development contract incentives to help DDG 51 shipbuilders improve their facilities, employee training, and retention and recruitment.

Since our last assessment, the program also delayed the planned start of initial operational test and evaluation by at least 18 months. The program office stated that it added two developmental test periods—one completed in 2024—to reduce overall risk to the initial capability. The revised schedule maintains the program's plan to complete testing in 2027. However, the changes to the operational testing approach delay the Navy's achievement of initial operational capability by roughly 3 years as compared to previous plans. The program office deemed the initial operational capability date as not suitable for public release.

Program Office Comments

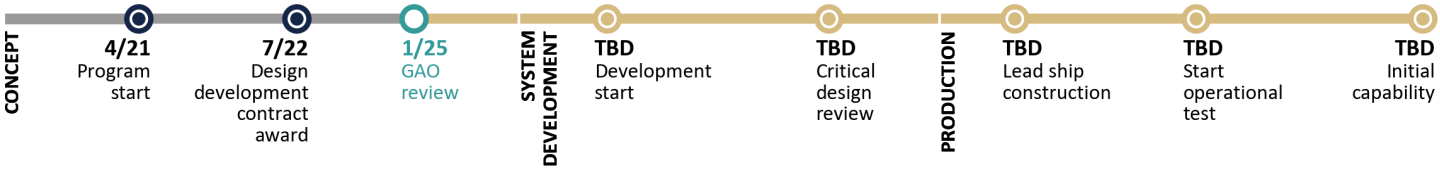
We provided a draft of this assessment for program office review. The DDG 51 program office provided technical comments, which we incorporated where appropriate. The program office stated that it has delivered 74 ships as one of the Navy's longest-running production lines, with 25 new ships under contract and in various stages of production or pre-construction. The program office added that the first Flight III ship, DDG 125, continues to make progress in achieving the Navy's objective to deliver a fully tested and certified integrated air and missile defense-capable ship in fiscal year 2027.



DDG(X) Guided Missile Destroyer

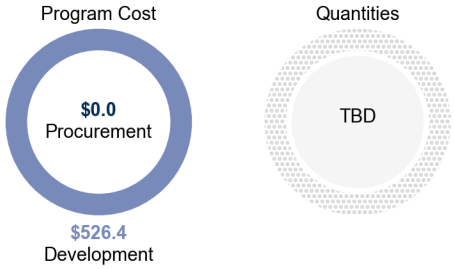
The Navy's DDG(X) program is developing a new integrated air and missile defense large surface combatant to follow the DDG 51 class destroyers, which the Navy plans to be more fuel-efficient and to accommodate future capability growth. The Navy expects DDG(X) to incorporate existing weapons, such as 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.

Source: Herren Associates. | GAO-25-107569



Estimated Cost and Quantities

(fiscal year 2025 dollars in millions)



According to program officials, the increase in the program's cost was due to funding that the program did not include in the prior assessment funding it provided.

Software Development as of January 2025

Approach: Information not available

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions): Information not available

Percentage of progress to meet current requirements: Information not available

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) is in the concept development phase. The Navy approved changes to the operational requirements for the program in August 2024. The program is assessing how the changes affect its schedule and cost estimates and officials did not provide a time frame for when they will update these estimates. The changes were based on additional input from the fleet and Navy leadership to increase speed and power. The program plans to have an integrated power system (IPS)—one of the ship's two critical technologies—that allows the ship's power to be directed based on mission need. For example, the IPS could direct the ship's power for speed and then quickly divert the power to fire a weapon. The Navy plans to model the IPS at a land-based test site, but the results may not be available to fully inform the ship's design prior to detailed design. The second critical technology is the ship's hull form. The program continues to conduct risk reduction activities for both critical technologies.

Program officials stated that the Navy's planned acquisition strategy and close collaboration with industry is in line with leading commercial practices for ship design. The Navy plans to complete the ship's functional design prior to transferring the design efforts to the shipbuilders. This is a departure from previous Navy practices, which were to list design specifications to then have the shipbuilders design the ship. The program is researching a design tool that it can use concurrently at both shipyards to better collaborate on the ship's design. Officials stated that one challenge is how to protect each shipbuilder's proprietary information. The program continues to evaluate costs and benefits to develop a digital twin, which could prove valuable for a program with a potential 60 to 100 year life cycle. A digital twin would enable real-time data to inform design changes and technology upgrades.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. It provided technical comments, which we included where appropriate. According to the program, the DDG(X) is designed to be the next enduring large surface combatant following DDG 51. It stated that the Navy developed a collaborative team with industry and has awarded design contracts. According to the program, the DDG(X) will utilize existing systems and is designed to accommodate future capabilities. It also stated that the program will conduct land-based testing prior to detail design.

Source: U.S. Navy. | GAO-25-107569

E-6B Recapitalization (E-130J)

The Navy's E-130J 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-130J is planned to augment and eventually replace the TACAMO capabilities currently performed by aging E-6B aircraft. The Navy plans to integrate the E-130J mission systems, which include communications through multiple radio frequency bands, onto C-130J-30 aircraft.

Program Performance fiscal year 2025 dollars in millions

	Total Acquisition Cost (dollars in millions)			Unit Cost (dollars in millions)	Quantities (number)	Cycle time (in months)
First Full Estimate (12/2024)	$10,931	$9,269	$23,491	$758	31	N/A
Reported in 2024[a]	Program not a Major Defense Acquisition Program in GAO's 2024 assessment					
Current Estimate (12/2024)	$10,931	$9,269	$23,491	$758	31	N/A

Development cost | Procurement cost

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-24-106831.

Software Development

as of January 2025

Approach: Agile and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$688.69 | 2.93%

Percentage of progress to meet current requirements: See notes

The program reported that software development has not started.

Program Essentials

Prime contractor: Northrop Grumman Systems Corporation

Contract Type: CPIF

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	◔
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	◔

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

E-130J Program

Program Performance

The Navy approved the E-130J program to enter system development in December 2024 despite significant technical risks to systems integration; manufacturing; and reliability, availability, and maintainability. Shortly thereafter in December 2024, the program awarded a cost-plus-incentive-fee contract for system development, test, and delivery of three engineering development model aircraft, and options for up to three system demonstration test articles and up to six aircraft in the first production lot. The technical risks could negatively affect the program's cost and schedule and will challenge the program to meet its mission if unresolved, according to a September 2024 independent technical risk assessment.

Leading Product Development Practices

In tandem with its goals to expedite development, testing, and deployment of capability, the E-130J program reported it plans to implement some leading product development practices. These practices include use of a modular open systems approach and a digital thread that will include data from the system model. Yet, the program's acquisition strategy centers on a traditional linear development approach, which our work has shown greatly impedes application of leading practices needed to develop and deliver innovative capabilities faster. Further, the lack of an iterative approach will inherently impede rapid updates to the E-130J design should the program determine that changes are needed to meet evolving user needs or to accommodate new technologies—undermining its modular open systems approach that allows for faster upgrades.

Nonetheless, the Navy continues to move forward using an antiquated development approach for E-130J, one of its newest acquisition programs. The Navy's premise is that it can design a system that will operate effectively for decades using legacy technologies—even though history is littered with examples of weapon systems retired prior to the end of their planned service lives due to obsolescence. In support of this aim, the Navy established highly detailed system capabilities and performance measures prior to E-130J development start, curbing the program's ability to refine capabilities during design to ensure that it continues to meet user needs as development progresses.

Further fueling the development uncertainty, the program made key decisions that constrain the system's design and introduce known technical risks. For example, the C-130J aircraft—selected 4 years before E-130J's development start—may not meet operational availability requirements. The E-130J's technical risk assessment highlighted the complexity associated with integrating E-130J systems onto this aircraft. The Navy's technical risk assessment team expects the integration risks to translate to manufacturing issues given the potential deviation from standard components and the security environment required.

Software and Cybersecurity

The E-130J program identified software development as a medium risk, driven in part by changes to meet cybersecurity needs. The program reported that the contractor will lead the Agile and DevSecOps approach to software development, expected to start in April 2025. It stated that the goal is to have constant communication with end users—pilots and back-end communication systems operators—throughout the software development effort. According to the program office, software development is following the major capability acquisition pathway as part of the E-130J platform and aligns with software acquisition pathway concepts. Our prior work found that requirements processes used by weapon programs developing software outside of the software pathway generally do not incorporate Agile principles, risking developing capabilities that may not reflect changing user needs or threats.

The E-130J cybersecurity strategy was first approved in September 2023, before development start. The program will be among the Navy's first to implement a Zero Trust strategy, which will require changes to existing avionics and mission systems. E-130J reported that key performance parameters address cybersecurity, and it plans to conduct a cybersecurity exercise and a cooperative vulnerability and penetration assessment.

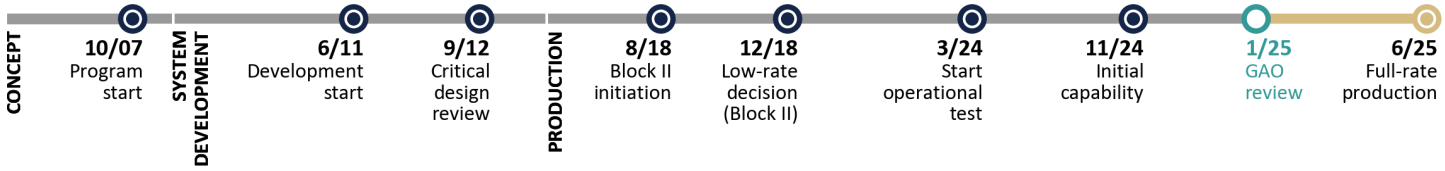
Program Office Comments

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 E-130J is an executable, accelerated program that integrates technology it considers mature into a proven aircraft, which it stated was chosen through an assessment of all available aircraft in production that considered many mission-related factors. The program office stated that it acknowledges technical risk but that, before it awarded the development contract, it executed risk reduction contracts with subcontractors to address obsolescence and size, weight, and power-cooling risks. According to the program office, it has a robust risk management plan to mitigate risk to acceptable levels.

Source: U.S. Navy. | GAO-25-107569

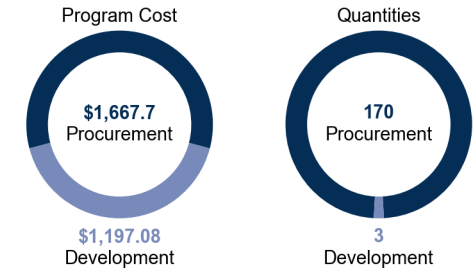
F/A-18E/F Infrared Search and Track (IRST)

The Navy is integrating new and existing infrared search and track sensors onto the F/A-18 external fuel tank. The sensor is 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, developed an improved sensor, upgraded processor, and additional software.



Program Performance

(fiscal year 2025 dollars in millions)



	Reported in 2024[a] (10/2023)		Current Estimate (7/2024)
Acquisition Cost	$2,867	-0 %	$2,865
Unit Cost	$16.6	-0 %	$16.6
Cycle Time (in months)	----	N/A %	159

(%) Percent change since 2024[a]

The program's cycle times were removed from our 2024 report, since the Navy determined that the program's expected initial operational capability date was not suitable for public release.

[a]GAO-24-106831.

Software Development as of January 2025

Approach: Agile

Software cost percentage of total acquisition cost (fiscal year 2025 dollars in millions): $364.31 | 12.72%

Percentage of progress to meet current requirements: 76–99%

Program Essentials

Prime contractor: Boeing (through Lot 4 procurement); Boeing, Lockheed Martin, and Meggitt

Contract type: FPI (Lots 3, 4); FFP (Lots 5, 6, 7)

Current Status

In November 2024, the IRST program achieved initial capability on schedule by completing initial operational testing and accepting delivery of the first lot of low-rate initial production IRST pods. However, the program reported that it would not reach a full-rate production decision by its baseline schedule threshold in January 2025 due to delays incurred during flight testing. IRST officials told us that operational tests were delayed by 2 months due to software defects that caused IRST pods to falsely report overheating. Director, Operational Test and Evaluation (DOT&E) officials told us that the defect was relatively easy to fix and would likely have been addressed during developmental testing had the program allocated more time for that testing. DOT&E officials told us that, due to the operational testing delays, they would provide their report that informs the IRST full-rate decision in March 2025. The program now expects a full-rate decision in June 2025. This is the second time the program breached its baseline schedule in the past 3 years.

DOT&E officials told us that, while the IRST pods demonstrated capability at tactically significant ranges during operational testing, the pods were extremely unreliable. These officials said that the program improved pod reliability as it made software updates but only managed to achieve 14 hours mean time between operational mission failures—short of the 40 hours required. As such, DOT&E officials said that deploying the IRST pods without improving their reliability would transfer risk to the Navy's fleet. Program officials noted that IRST initial capability was achieved without any noted limitations.

According to the program, it considered a modular open systems approach in Block I and early Block II development phases, but acknowledged that Block II does not meet modular open systems approach definitions implemented on other programs. It said that some Block II components have potential reuse but cannot currently fit on other platforms.

Program Office Comments

We provided a draft of this assessment to the program office for comment and incorporated its technical comments as appropriate. The program stated that it expects that development pods will not meet operational thresholds but that new production hardware, tactical mitigations, and software updates will increase reliability and effectiveness and lower the sustainment burden.

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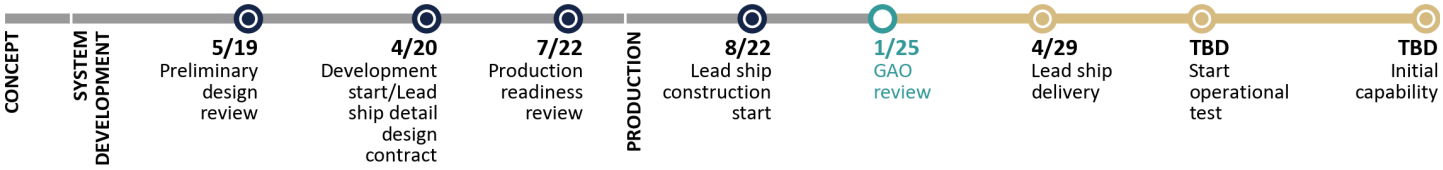
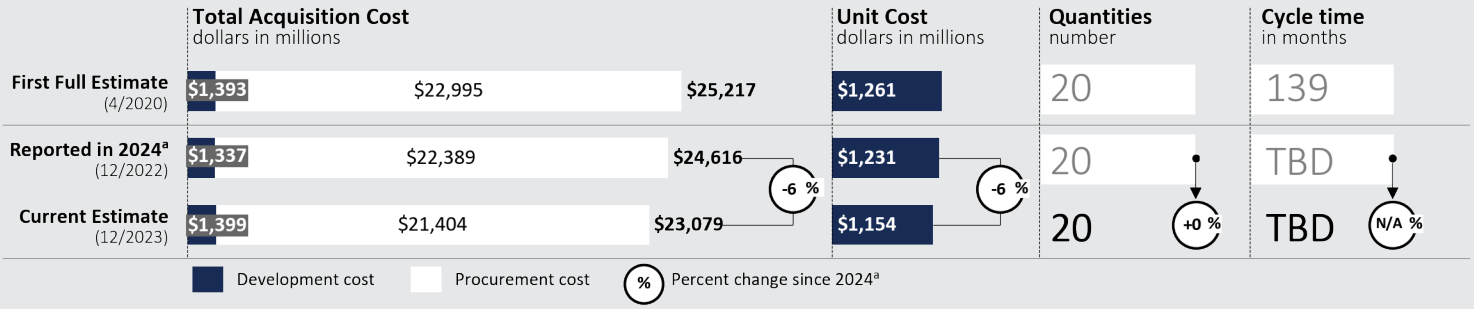
Source: Fincantieri Marinette Marine. | GAO-25-107569

FFG 62 *Constellation* Class Frigate (FFG 62)

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. In April 2020, the Navy awarded a detail design and construction contract for the lead ship (FFG 62) with options for up to nine additional ships. Since then, the Navy exercised contract options for construction of five follow-on ships (FFG 63 through FFG 67).



Program Performance fiscal year 2025 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. Program officials noted that the cost reduction was primarily due to a reduction in military construction costs due to updated estimates, as well as from Navy leadership's revised guidance on adjusting costs. They reported that revised guidance deflated funding to base year dollars differently than how prior year funding was adjusted for inflation. The program office stated it has consistently reported cost increases driven by ongoing cost negotiations between the Navy and the contractor and cost increases related to government furnished equipment and land base testing. However, the graphic does not reflect these costs.
[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Agile, DevOps, and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

Information not available

Percentage of progress to meet current requirements:

Information not available

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)

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a digital twin of key subsystems *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test an integrated physical prototype of key subsystems in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	○

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

FFG 62 Program

Program Performance

Since our last assessment, the program continued to face challenges completing its functional design, which is needed to demonstrate design stability. More than 2 years after beginning lead ship construction, this persistent lack of design stability stalled construction of the lead ship and poses the same risk to initial follow-on ships. The Navy currently plans to deliver the lead frigate in April 2029—3 years later than the original contracted delivery date. The Navy and shipbuilder continue to revise basic design documents, including the ship's general arrangement drawings—the design drawings that all other design aspects are based on—and structural components of the ship. This approach is inconsistent with shipbuilding leading practices, which call for completion of basic and functional design activities prior to construction start.

Further, in response to a recommendation we made in our May 2024 report, the program restructured its functional design metrics to more closely align with actual design progress. As a result, the program concluded that its functional design progress is significantly less than the 92 percent complete it reported in August 2023. As of December 2024, the program reported that the functional design was 70 percent complete, as measured with the restructured design metrics. Although program officials expect to achieve a stable basic and functional design by late spring 2025, the program has yet to achieve its planned rate of design progress to meet this goal.

The frigate design is further complicated by unanticipated weight growth. In October 2024, the Navy reported 759 metric tons of weight growth from initial estimates—nearly a 13 percent increase—due in part to the underestimation of applying Navy technical requirements to a foreign ship design. Navy personnel are working with the shipbuilder to reduce the ship's weight, but weight growth has only become more pronounced over the last year as the program further developed the frigate design. We previously reported that unplanned weight growth during ship construction can compromise ship capabilities, as the fleet seeks to alter and improve initial capabilities over the planned decades-long service life of the ship. Such alterations may leave frigates less combat capable, limit the ability to add capabilities to address evolving threats, and reduce planned service lives.

Leading Product Development Practices

In May 2024, we reported that the frigate program employed a traditional, linear development approach to acquisition, in contrast to leading companies' use of iterative design approaches centered on identifying a minimum viable product to quickly meet users' needs. We recommended that the Navy evaluate ways to incorporate these leading practices into the frigate acquisition strategy prior to the acquisition of an 11th ship. The Navy stated that it is taking steps to implement this recommendation.

Program officials stated that plans for a digital twin and digital thread will not be incorporated into program documentation until 2025. Officials stated that they have encountered challenges with the availability of data, cost of data environments, and finding skilled personnel. Additionally, as we reported in January 2025, the program's documents contain general language about MOSA principles but do not address planning elements for modularity.

Other Program Issues

As of November 2024, frigate program officials reported that the shipbuilder had submitted a total of five requests for equitable adjustment, raising the potential of unbudgeted program cost growth, depending on the outcome. Requests for equitable adjustment provide a remedy payable only when unforeseen or unintended circumstances, such as government modification of the contract, cause an increase in contract performance costs. The Navy deemed the total costs of the five requests as not suitable for public release. According to program officials these requests relate to government change orders and significant design changes from the frigate's parent ship design.

Despite the unresolved issues identified above, the Navy has proceeded full steam ahead with the frigate program, exercising options for the fifth and six ships in May 2024. Further, in November 2024, the Navy requested information seeking shipbuilders to serve as a second shipyard for constructing future frigates. In January 2025, the Navy began assessing industry responses to inform future acquisition strategies.

Program Office Comments

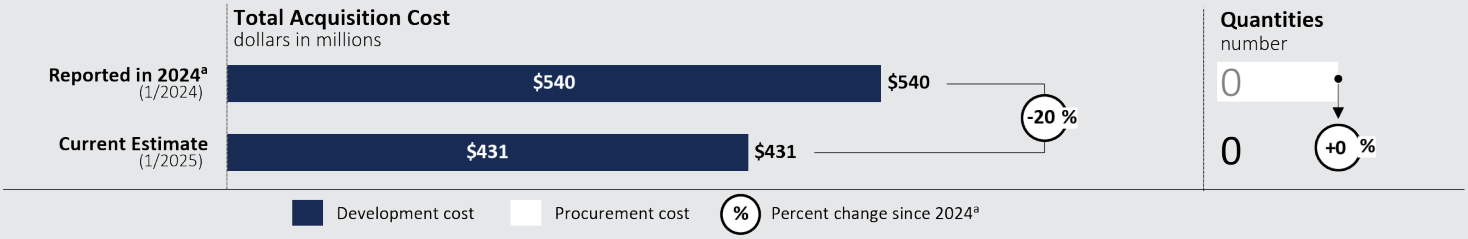
We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office stated that in early spring 2025, it anticipates completing design products needed to support production. According to the program office, the Navy increased its leadership and technical presence at the shipyard, including contracted engineering support personnel. The program office further noted that it continues to work with the shipbuilder on frigate weight reduction and identified potential weight savings to regain service life allowance through a phased implementation across the first three ships. According to the program office, the requests for equitable adjustment are currently under Navy review. In April 2025, the office of DOD's Director, Operational Testing and Evaluation provided comments stating that the start date for the program's operational test should be reflected as the first quarter of fiscal year 2032.

Hypersonic Air-Launched Offensive Anti-Surface Warfare Weapon System (HALO)

The Navy's HALO program began as an MTA rapid prototyping effort to develop 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. In August 2023, the Navy updated the HALO acquisition strategy to account for ending the MTA effort and transitioning to the major capability acquisition pathway earlier than originally planned. The Navy is reassessing this strategy.

Source: U.S. Navy. | GAO-25-107569

Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2025 dollars in millions



According to program officials, the MTA cost estimate decreased because the program was going to transition to the major capability acquisition pathway earlier than originally planned. It does not reflect a decrease in the expected costs for the entire HALO acquisition effort. The Navy is reassessing this strategy.
[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Information not available

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

Information not available

Percentage of progress to meet current requirements:

Information not available

The program reported that software development has not started.

Program Essentials

Prime contractor: Lockheed Martin; Raytheon

Contract Type: FFP

Contract information is for the MTA rapid prototyping effort.

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	◐
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	◐
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	◐

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

HALO Program

Program Performance

The HALO program's accelerated plan to transition to the major capability acquisition pathway has been put on hold due to budget concerns, according to program officials. Last year, we reported that the HALO program revised its acquisition strategy to accelerate its transition to the major capability acquisition pathway by 2 years to early fiscal year 2025. The program eliminated its planned prototype flight tests—which can help reduce technical risks, among other benefits—from the MTA as part of the strategy change. According to HALO officials, the program is now restructuring. The Navy determined that offers it received for the system development contract were too costly given the program's budget. The program stated that it is reconsidering its planned acquisition pathway as part of the restructuring.

Before the HALO program's plans were put on hold, it completed its preliminary design review in August 2024 as planned. The preliminary design review included both MTA contractors. According to program officials, both contractors' designs were at the expected level of maturity and consistent with the Navy's performance requirements for the system. The officials stated that there were no major design changes as a result of the review. The HALO program plans to select a single contractor to continue the effort.

Prior to the transition to the major capability acquisition pathway, the program also planned to complete an independent cost estimate. The MTA cost estimate decreased by 20 percent since last year. This does not reflect a decrease in the expected costs for the entire HALO acquisition effort. According to program officials, the MTA cost decrease is due to the program transitioning to the major capability acquisition pathway in 2025 rather than 2027, as outlined in its original acquisition strategy.

Leading Product Development Practices

The HALO program did not use an iterative approach for development for the MTA effort. We previously found that leading companies use iterative processes to design, validate, and deliver products with speed. Even though the HALO program stated that it was not using an iterative development approach, the program does use certain modern design tools. These digital design tools are useful in the design and validation process as they can enable more rapid iterative design cycles and facilitate stakeholder and user feedback at earlier stages. Specifically, the program is establishing a single, integrated, secure computing environment where vendors can upload digital models of the components they plan to include in their design. These can then be assembled and tested as a digital prototype—also known as a digital twin. Program officials said that the digital twin is a work in progress and some of the models have been useful for exploratory design work. They also stated that securing software licenses for the secure computing environment is a challenge that they are still working to address.

Software and Cybersecurity

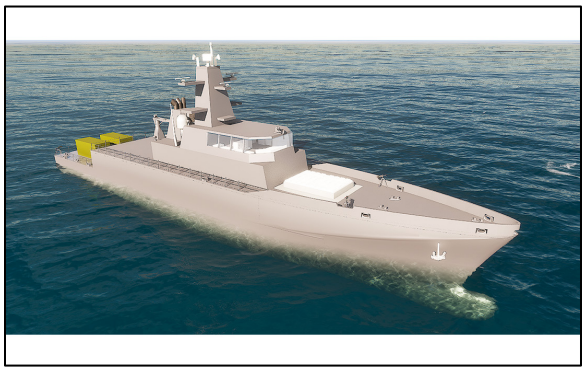
The HALO program did not develop software as part of the rapid prototyping effort. The program plans to have an approved cybersecurity strategy before transitioning to the major capability acquisition pathway.

Other Program Issues

The HALO program is working to better understand potential industrial base risks before transitioning to the major capability acquisition pathway. We previously reported on industrial base risks for hypersonic programs, such as the limited number of suppliers for critical components and long production times for components due to the processes used to manufacture them. The HALO program has yet to conduct an industrial base assessment, which can help identify potential manufacturing capacity and capability risks. According to program officials, the program engaged the two prime contractors to review and brief on the state of the industrial base as part of the transition to the major capability acquisition pathway. These reviews identified issues similar to what other hypersonic programs have faced. Left unaddressed, these issues can limit production rates and make systems more costly to produce.

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 HALO program stated that it has made significant advances in hypersonic technologies and manufacturing capabilities under the MTA. According to the program, it reduced risks associated with Navy-specific implementation of key propulsion technologies, specialty materials, and sensors while achieving important maturation milestones on air vehicle design. Further, the program added that an early manufacturing assessment provided a key opportunity to address and retire risks associated with production transition. It noted that, although HALO has not proceeded to the MCA pathway as planned, the lessons learned through preliminary design and manufacturing assessment activities will prove invaluable in guiding the revised acquisition strategy and eventual transition to production. The program stated that it will revalidate that its requirements, available resources, and acquisition strategy are aligned and will update its engagement with the industrial base, with the intent for HALO to enter an acquisition pathway in fiscal year 2026.



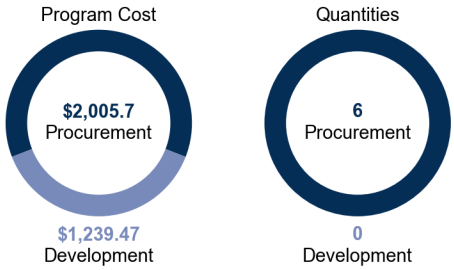
Source: U.S. Navy. | GAO-25-107569

Large Unmanned Surface Vessel (LUSV)

The Navy plans for the LUSV to be a long-endurance ship intended to conduct warfare operations with varying levels of robotic system autonomy and in conjunction with crewed ships. The Navy also expects the LUSVs to be low-cost ships with capacity for carrying various modular payloads. For example, the Navy plans to use the LUSV to augment the fleet's missile capacity. The LUSV builds on earlier prototyping efforts funded by the Office of Naval Research and the Office of the Secretary of Defense Strategic Capabilities Office. The LUSV program started concept development in September 2020.

Estimated Cost and Quantities

(fiscal year 2025 dollars in millions)



Cost and quantity represent fiscal years 2020–2029. The program stated that the procurement quantity of nine reported last year represented procurements through fiscal year 2030.

Software Development as of January 2025

Approach: Agile and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

Information not available

Percentage of progress to meet current requirements: 26-50%

The program reported that because it transitioned from a contractor furnished equipment approach to a government furnished equipment software approach, it does not have estimated software development costs at this time.

Program Essentials

Prime contractor: TBD

Contract type: TBD

Current Status

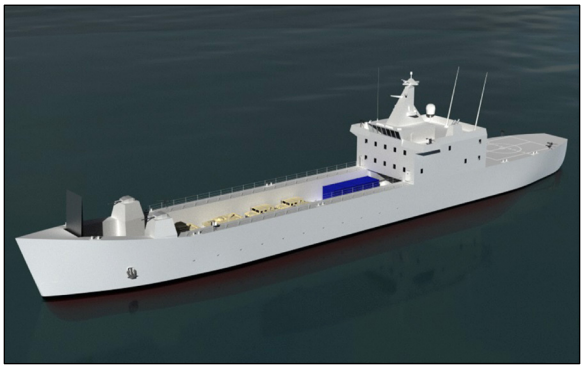
The LUSV program reported a delay in awarding a lead ship detailed design contract in fiscal year 2025 and now plans to award the contract in fiscal year 2027—a more realistic date for the program to achieve, according to program officials. In terms of cost, the program reported that it is developing a new estimate using stakeholders outside of the program office because the Navy often uses assumptions in its initial cost estimates that may not apply to the LUSV. For example, officials told us that the Navy traditionally bases cost estimates on a ship's weight, but the LUSV's automated systems will have different weights than manual systems due to the need for mechanized controls.

In 2024, the Navy reported that it successfully demonstrated the employment of robotic autonomous system prototypes during an exercise that ran from August 2023 to mid-January 2024. During this exercise, the prototypes traveled over a combined 46,000 nautical miles and navigated primarily using autonomy software. The prototypes also integrated with a Carrier Strike Group and Marine Expeditionary Force, helping the Navy understand how to integrate the LUSV into future fleet operations.

According to the program, the Navy is developing a repository of autonomous capabilities provided by a mix of government and industry partners. Under this approach, the program stated, industry will act as the system integrator for the LUSV and other robotic autonomous systems. The program also noted that this approach is designed to reduce software acquisition and sustainment costs across multiple robotic autonomous systems. The Navy plans to leverage and integrate the repository to fulfill its mission requirements for the LUSV.

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 2025, officials indicated that the LUSV program will merge with the program for medium unmanned surface vessels into a single program for autonomous surface craft. The consolidated program intends to start development under the major capability acquisition pathway by fiscal year 2027.



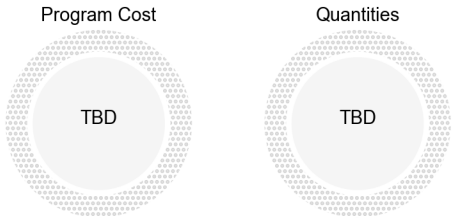
Source: U.S. Navy. | GAO-25-107569

Medium Landing Ship (LSM)

The Navy's LSM program is developing a medium-sized landing ship intended to transport 50 to 75 Marines and their associated supplies and fuel from shore to shore in contested environments. The Navy expects LSM to support the operations of the Marine Corps' Marine Littoral Regiments (MLR) and to provide distributed maneuverability, mobility, and logistics for near-shore operations. The Navy initially plans to procure 18 LSMs and up to 35 ships as operational plans are refined. MLRs became operational in 2023, so LSM is late to need.

Estimated Cost and Quantities

(fiscal year 2025 dollars in millions)



Total cost and quantity are to be determined.

Software Development as of January 2025

Approach: Information not available

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

Information not available

Percentage of progress to meet current requirements: Information not available

The program reported that it is not developing software and is instead using software that has been fielded on other platforms.

Program Essentials

Prime contractor: TBD

Contract type: TBD

Current Status

The Navy planned to award an LSM detail design and construction contract in 2025 but canceled the solicitation in December 2024. Program officials said the offers they received were hundreds of millions of dollars higher than budgeted. Additionally, Congress required by law that the Secretary of the Navy certify that LSM's basic and functional design were complete before entering a construction contract. We previously identified this as a ship design leading practice, but LSM's acquisition strategy did not require it. The program determined that this legislation precluded it from negotiating about the cost drivers in the offers and from making the planned award, which combined design and construction.

Design and cost are recurring risks for LSM. The program intended to use existing designs to accelerate its schedule but determined through industry engagement that the designs would require significant changes to meet requirements, particularly for beaching. A Navy cost analysis also indicated that initial per hull cost estimates could vary by more than $115 million depending on design changes added to meet survivability requirements.

Going forward, officials said the Navy plans to reevaluate requirements with the Marine Corps, revise cost and schedule estimates, and develop an acquisition strategy that separates design from construction. In support of this effort, the program asked industry in January 2025 to provide new information on existing landing ship designs. As the Navy reevaluates LSM, our product development leading practices suggest that iteratively working with key stakeholders—like industry, warfighters, and engineers—could help the program identify a design that meets essential user needs within realistic cost and schedule estimates.

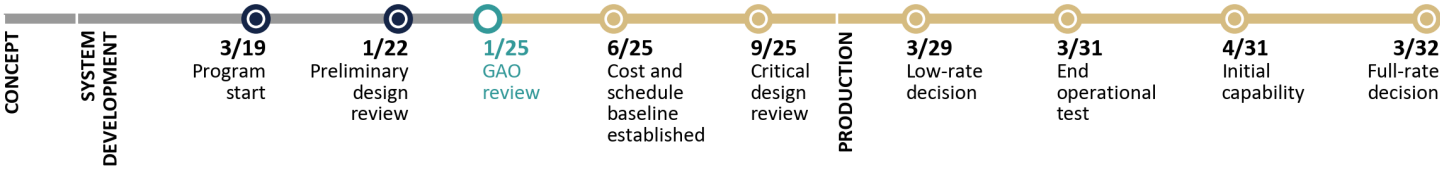
Program Office Comments

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 LSM remains a key littoral maneuver enabler that the Navy and Marine Corps are focused on delivering. It stated that per congressional direction, it is pursuing a non-developmental vessel as a Block 1 and plans to award a lead ship contract by the end of fiscal year 2025, subject to appropriations. It added that, concurrently, the Navy and Marine Corps will refine LSM requirements and deliver full capability in a future block.

Source: Alion Science and Technology. | GAO-25-107569

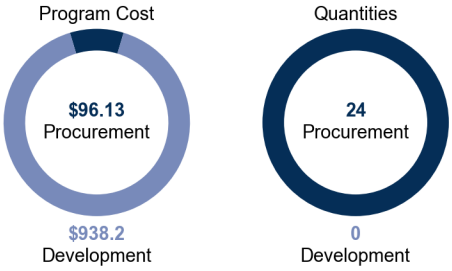
MK 54 MOD 2 Advanced Lightweight Torpedo (MK 54 MOD 2 ALWT)

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 and warhead to increase 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 in fiscal year 2025.



Estimated Cost and Quantities

(fiscal year 2025 dollars in millions)



Cost and quantity represent fiscal years 2019–2029.

Software Development as of January 2025

Approach: Agile and Other

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions): $33.10 | 3.2%

Percentage of progress to meet current requirements: 26-50%

The program reported that it is using an iterative development approach where the government tests incremental builds and then incorporates capabilities to address issues found during testing.

Program Essentials

Prime contractors: Progeny Systems Corporation; Northrup Grumman Corporation; Aerojet Rocketdyne; Raytheon Technologies

Contract type: CPFF (using other transaction authority)

Current Status

The MK 54 MOD 2 torpedo program is revising its acquisition strategy to defer certain capabilities due to cost and funding issues. Program officials stated that contractors' estimated costs to complete system development and testing were significantly higher than expected. The program received less development funding than planned for in fiscal years 2023 and 2024 and the Navy included less development funding in its 5-year budget for the program. The program now plans to focus on lethality improvements, while delaying more costly improvements to the propulsion system. The program also plans to extend its schedule by 5 years and deliver initial capability improvements in 2031 or later. In 2023, we reported that the program's acquisition strategy had significant risks, in part due to a compressed schedule.

The program also continues to have development delays. According to program officials, the contractors' deliveries of the hardware needed for testing is delayed until mid fiscal year 2025 because of the length of time it takes for contractors to acquire parts and components. The program also moved the start of in-water tests, which are critical to discovering issues on torpedo programs, from fiscal year 2024 to mid fiscal year 2026.

The MK 54 MOD 2 program still plans to use an iterative approach for development, but with fewer of the practices that leading companies employ. The Navy uses a modular open systems approach for its torpedo programs, which makes it easier to add to capabilities and keep systems relevant longer. However, according to program officials, budget constraints have forced them to scale back plans for using digital engineering tools. We have found that efforts that do not fully utilize these tools may miss opportunities to anticipate potential design flaws, optimize manufacturing, and reduce costs.

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 the MK 54 MOD 2 addresses a critical gap in the Navy's weapon inventory related to challenging adversary submarines. It added that parts and component delays across multiple weapon programs are a key schedule driver. It stated that, to meet the operational need, it continues to optimize its development schedule and approach to supply challenges to field lethality upgrades as quickly as possible within funding constraints.

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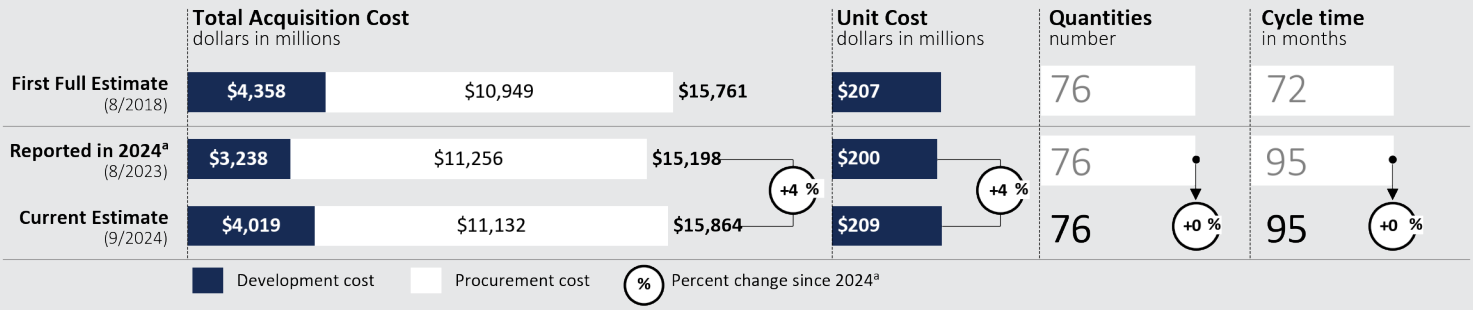
Source: U.S. Navy. | GAO-25-107569

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 2025 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-24-106831.

Software Development

as of January 2025

Approach: Agile, Waterfall, and Incremental

Software cost percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$193.60 | 1.22%

Percentage of progress to meet current requirements: 51-75%

Program Essentials

Prime contractor: Boeing

Contract Type: FPI (development)

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	●
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	●
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	●
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	◐
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	◐
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	◔

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

MQ-25 Stingray Program

Program Performance

The MQ-25 Stingray program continues to report cost and schedule challenges that have led to a funding shortfall of $291 million. The program's decision to delay the low-rate initial production (LRIP) contract to September 2025, and its efforts to accelerate testing replacements for at least seven components with obsolescence and other issues, contributed to a significant increase in development costs since our last report.

The program plans to award the LRIP contract before it receives all of its production representative aircraft. Doing so risks concurrency between developmental testing and the start of production, as well as cost increases and further delays if changes are needed based on testing. The Navy requested $502 million in its fiscal year 2025 budget request to acquire the first lot of LRIP aircraft—without receiving all the developmental aircraft to inform the decision. We previously found that procuring units before developmental testing is complete could result in future changes and costly delays.

Leading Product Development Practices

The program reported implementing multiple leading practices for product development, such as creating a digital thread that sustains authoritative data throughout the life of the program. Our prior work found that digital twins and threads provide real-time data to inform production decisions and could reduce the program's concurrency risk.

The program reported having a documented plan to incorporate a modular open systems approach as part of its imaging and surveillance systems, which we found could help address technology obsolescence issues to update products after delivery. However, the program has yet to initiate the plan. Program officials told us that they mitigated all known obsolescence issues through low-rate initial production.

The program stated that it tested a system-level integrated prototype of the MQ-25. According to the program, it connected test data and operational learning from this prototype to a digital environment in order to test and validate the MQ-25's design in the carrier operational environment. It also stated that a systems integration test lab includes a ground control station interacting with MQ-25 representative hardware and software in a digital environment.

Additionally, the program noted several other integration activities that it said fed MQ-25 hardware and software design—for example, the prototype demonstrated aerial refueling with aircraft, test results fed updates to flight control designs, and performance data were incorporated into MQ-25 development models. Our prior work on leading product development practices found that, by using rapid digital design and test cycles, a leading company can model and simulate many more possibilities than with physical prototypes alone.

Software and Cybersecurity

Program officials told us that system-level testing is underway for the Block 5 software package, designed to support the aircraft's first flight and flight testing in the third quarter of fiscal year 2025. However, the program's software costs increased substantially since last year. Program officials attributed this increase to their 2021 decision to switch from a government-furnished ground control station to one provided by another contractor, which resulted in more complex integration with the Boeing aircraft than anticipated.

Program officials stated that they completed two cybersecurity assessments. The program does not plan to complete cyber testing until March 2026, 6 months after awarding the LRIP contract. By waiting to complete this testing until after the start of production, the program risks increased costs or delays to fix vulnerabilities.

Other Program Issues

The program is assessing the strength of its industrial base after identifying at least 12 critical components—such as wing structure composites and other parts—that rely on a single supplier. Reliance on a single supplier creates the risk of potential delays if the supplier experiences problems with production.

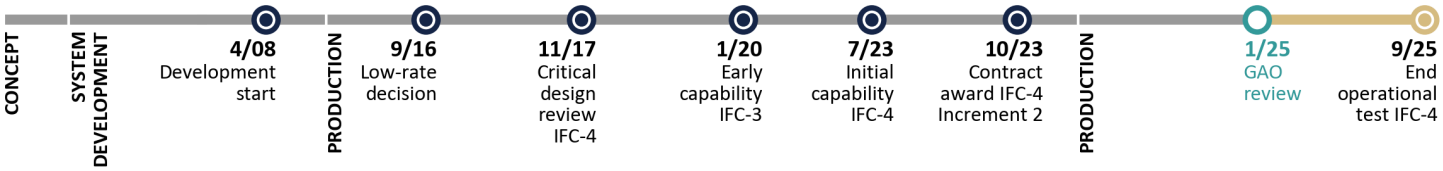
Program Office Comments

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 the MQ-25 program is on track for production and first flight in 2025—backed by significant progress in software, digital integration, and delivery of three vehicles. According to the program, testing verified aircraft design stability with no structural findings for production maturity. Additionally, the program stated that Block 5 software is in testing within an integrated digital environment and that digitally-connected capabilities enabled six successful integrated tests, carrier network testing to simulated MQ-25 aircraft, and numerous carrier landing simulations. The program noted that it is ready to deliver critical fleet capability with carrier-based refueling. It also stated that it is addressing challenges in converting the MQ-25 prototype to production through efforts to make two development models production-ready and by mitigating industrial base risks through supplier production reviews concluding in spring 2025.

Source: U.S Navy. | GAO-25-107569

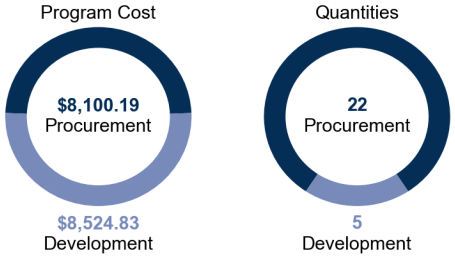
MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)

The Navy plans for MQ-4C Triton to provide intelligence, surveillance, reconnaissance, and data collection and dissemination. Each system includes an air vehicle, communications suites, and mission payload, among other components. Two aircraft configurations—Integrated Functional Capabilities (IFC)-3 and IFC-4—make up Increment 1. The Navy is retrofitting the IFC-3 aircraft into the IFC-4 configuration, which adds signals intelligence. It plans to add multiple subsystems to the aircraft in a second increment to enhance effectiveness and survivability. We assessed both increments.



Program Performance

(fiscal year 2025 dollars in millions)



	Reported in 2024[a] (9/2023)		Current Estimate (7/2024)
Acquisition Cost	$17,083	-0 %	$17,043
Unit Cost	$632.7	-0 %	$631.2
Cycle Time (in months)	183	+0 %	183

(%) Percent change since 2024[a]

Quantities reflect the number of aircraft that make up Increment 1, while program costs include Increment 1 and Increment 2.
[a]GAO-24-106831.

Software Development as of January 2025

Approach: Agile and Incremental

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$1,004.39 | 5.89%

Percentage of progress to meet current requirements: See note

The program reported that baseline IFC-4 software development is complete and that Increment 2 software development is in progress. It noted that it is updating IFC-4 software with corrections and added capability.

Program Essentials

Prime contractor: Northrop Grumman

Contract type: Cost-sharing (development); FPI (procurement)

Current Status

The Navy had deployed nine IFC-4 aircraft deployed as of early 2025. Aircraft delivered to the fleet did not have a full radar suite and were not fully mission capable. The program has mitigations in place to address radar availability and expects to field all radar improvement initiatives by 2027.

The program extended operational testing by about a year since we reported in 2024. According to the program, the added time is necessary to correct signals intelligence deficiencies. A DOD Operational Test and Evaluation official stated that the program made progress in addressing significant deficiencies, but remaining deficiencies preclude operational testing. The official further stated that MQ-4C's operational effectiveness, suitability, and survivability for primary missions remain undemonstrated.

The Defense Contract Management Agency estimates that the next two retrofits of IFC-3 to IFC-4 aircraft, in 2025 and 2026, will cost a total of about $15 million more than planned. This is due to the potential for part failures resulting from the length of time that the IFC-3 aircraft were in storage.

The program reported no plans or budget for a digital twin or digital thread. It stated that it is assessing the viability of developing a digital twin to support integration and retrofit of future capabilities. Given the anticipated content and cost of the second increment—a total cost of about $3 billion in fiscal year 2025 dollars—these digital engineering tools could save time, money, or both. We previously found that not using such tools could mean missed opportunities to identify potential design flaws, optimize manufacturing, and reduce costs.

Program Office Comments

We provided a draft of this assessment to the program office for comment and incorporated its technical comments as appropriate. It stated that one aircraft without a full radar suite is now fully mission capable and that the scope of work impacts the IFC-3 retrofit cost. The program added that it does not have a requirement to develop a digital twin or thread; would assess their viability; and had not determined if such tools would benefit design, manufacturing, or costs. In April 2025, after our January 31, 2025 cut-off date for new information, the program stated that an updated Increment 2 acquisition program baseline was approved.

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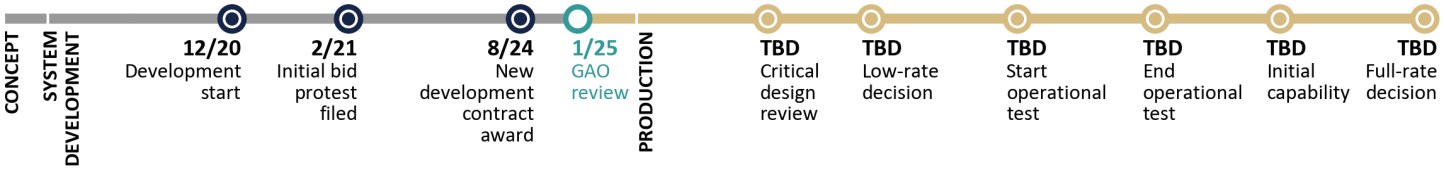
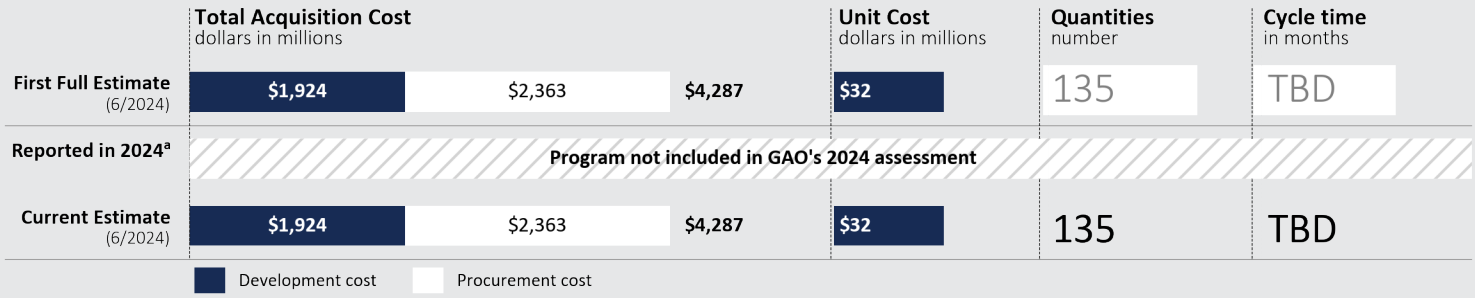
Next Generation Jammer Low-Band (NGJ LB)

The Navy's NGJ LB is an external jamming pod system that will be integrated on EA-18G Growler aircraft. It is expected to replace the ALQ-99 jamming system in the low-band frequency range. The Navy expects the system to provide enhanced airborne electronic attack capabilities to disrupt adversaries' use of the electromagnetic spectrum for radar detection, among other purposes. The Navy also has a mid-band frequency program—assessed separately in this report—and a documented, but unfunded, need for a high-band capability. We assessed the low-band program.

Source: AVIAN CSS. | GAO-25-107569



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2025 dollars in millions



Total quantities comprise zero development quantities and 135 procurement quantities. The Navy's first full estimate in 2020 was overcome by bid protests and re-opening of competition. As a result, we use the Navy's current cost information as the first full estimate.
[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Agile and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

Information not available

Percentage of progress to meet current requirements:
Information not available

The program reported that it does not break out software costs. Additionally, percentage of software completed is unavailable until the initial software submission.

Program Essentials

Prime contractor: L3Harris

Contract Type: CPIF

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	◐
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	◔

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

NGJ LB Program

Program Performance

The NGJ LB program entered the major capability acquisition pathway at development start in August 2024, after a 4-year delay. The Navy initially awarded a development contract in December 2020. Following multiple bid protests at GAO and the United States Court of Federal Claims, the Navy terminated the original contract and reopened discussions with the two companies that made offers for the original contract. In August 2024, the Navy awarded a new development contract for the development of eight operational prototypes that will provide an initial capability. The program plans to deliver these prototypes in fiscal year 2029. The program reported that it is updating its schedule estimates to reflect the new development contract and will establish a new program baseline by mid-2025.

Leading Product Development Practices

The NGJ LB program is incorporating some practices that we found companies employ to deliver innovative products rapidly, and it is considering whether to incorporate others. For example, the program reported that it is in the process of identifying a minimum viable product. However, it also reported that development is focused on meeting highly detailed system requirements, which could limit its ability to refine capabilities as user needs evolve. According to the program, it plans to complete this minimum viable product by the end of 2028. We previously found that leading companies use iterative design and testing to identify a minimum viable product, in turn ensuring that they deliver essential product capabilities to users with speed.

The program also stated that it incorporated requirements for a modular open systems approach into the NGJ LB development contract. We found that leading companies employ modular design and manufacturing to combine and reuse common elements. This enables them to produce systems at scale and keep systems relevant for longer.

The program is in the process of evaluating whether it will develop a digital twin. However, it is evaluating only whether to develop a digital twin for the subsystem that directly controls the jammer, rather than for the whole system. Our prior work found that leading companies build fully-integrated prototypes—incorporating data from both physical models and digital twins—to test with users in the expected operating environment. Testing of a fully-integrated system can uncover problems that were not apparent when subsystems were tested.

According to the program office, it is also creating, in effect, a digital thread with model-based system engineering for end-to-end system views that will evolve over the life cycle of the system to incorporate real-time system data. However, the program also reported that it had yet to document whether it will develop a digital thread adhering to leading product development practices. But, it has the opportunity to do so given the work that it stated is underway on model-based system engineering. We previously found that leading companies capture data from iterative cycles in a digital thread, then use this information to inform decision-making, such as how to refine requirements or change the product's design.

Software and Cybersecurity

The NGJ LB program is employing several modern software development practices, such as Agile and DevSecOps approaches, and also plans to employ several modern processes that the Defense Science Board previously recommended. For example, the program reported plans to include the delivery of a minimum viable product for software, continuous iterative software development, iterative development training for program management and staff, and software documentation provided to DOD at each production milestone. We will continue to monitor these efforts. The program stated that because it recently awarded the development contract, it has yet to establish software metrics or tools, such as sprint plans or product backlogs, to help determine the status of its software development.

The NGJ LB cybersecurity strategy was approved in July 2019, and the program plans to complete further cybersecurity assessments in the future.

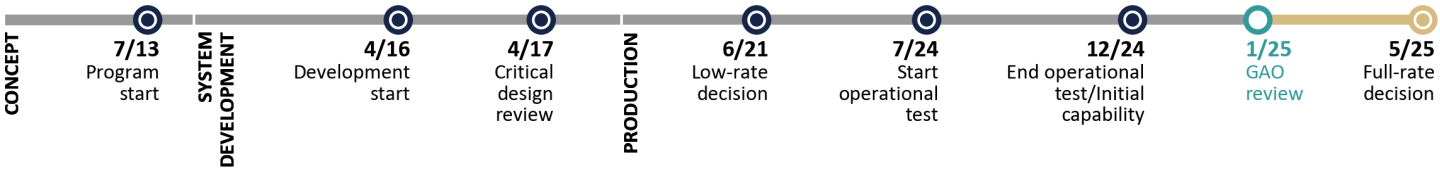
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. It stated that NGJ LB is utilizing monthly agile software sprints and a modular open systems approach design. The program office also stated that it is exploring the use of a digital twin to accelerate future development and sustainment, with potential to integrate multiple programs into a common government-owned software support activity.

Source: U.S. Navy. | GAO-25-107569

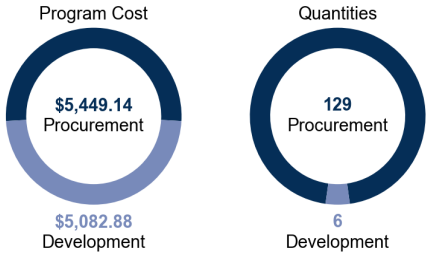
Next Generation Jammer Mid-Band (NGJ MB)

The Navy's NGJ MB is an external jamming pod system that will be integrated on the EA-18G Growler aircraft. It is expected to augment, then replace, the ALQ-99 jamming system in the mid-band frequency range. The Navy expects the system to provide enhanced airborne electronic attack capabilities to disrupt adversaries' use of the electromagnetic spectrum for radar detection, among other purposes. The Navy also has a low-band frequency program—assessed separately in this report—and a documented, but unfunded, need for a high-band capability. This assessment is of the mid-band program.



Program Performance

(fiscal year 2025 dollars in millions)



	Reported in 2024[a] (9/2023)		Current Estimate (7/2024)
Acquisition Cost	$10,099	+4 %	$10,541
Unit Cost	$74.8	+4 %	$78.1
Cycle Time (in months)	128	+7 %	137

(%) Percent change since 2024[a]

The program reported cost increases due to new development work added to the program. In our 2024 assessment, units were erroneously reported as pods, instead of shipsets.
aGAO-24-106831.

Software Development as of January 2025

Approach: Agile

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

Information not available

Percentage of progress to meet current requirements: 100%

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 (development); Boeing (integration)

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

Current Status

The Navy completed initial operational testing and declared that the NGJ MB reached initial operational capability in December 2024—9 months later than the planned date that was reported in last year's assessment. According to the Navy, the delay in declaring an initial capability was due to not completing all operational test events. In July 2024, DOD's Director of Operational Test and Evaluation required the program to conduct additional tests of the program's revised pod software with the relevant EA-18G aircraft software in the most stressing operational environment. According to program officials, operational testing was completed in December 2024.

NGJ MB officials said that the program also moved its full-rate production decision to May 2025 due to the testing delays. To avoid a gap in production, the Navy increased its approved low-rate production quantity over the past 2 years from up to 19 to up to 49 shipsets; each shipset consists of two pods. The Navy awarded a contract for 13 additional shipsets in November 2024 to bring the total under contract to 36.

The NGJ MB program identified several risks that could delay pod production. A June 2024 Navy Production Readiness Review also assessed NGJ MB production as a medium risk, but it still recommended that the program proceed with its full-rate production decision review. Some of the production risks include whether the prime contractor can build enough of certain key subcomponents to meet the production schedule. According to program officials, the contractor is working to hire additional engineers and create efficiencies to increase subcomponent production rates, but the program still expects these issues to present a long-term risk.

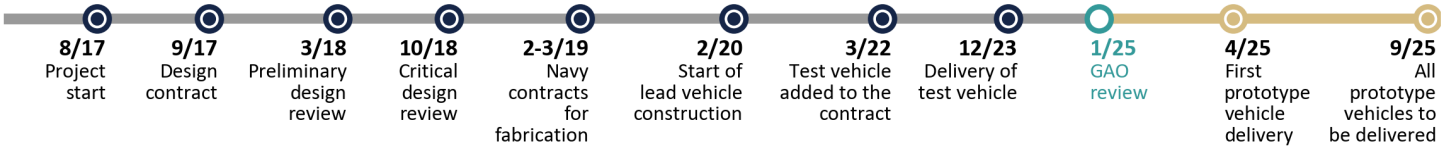
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office stated that it completed shipset deliveries through the second production contract and continues to mature the production line. It added that government subject matter experts are working with contractors to increase overall product quality and reduce program risk. The program office stated that Raytheon's production capacity is adequate to meet the proposed build schedule through program completion.

Source: Boeing. | GAO-25-107569

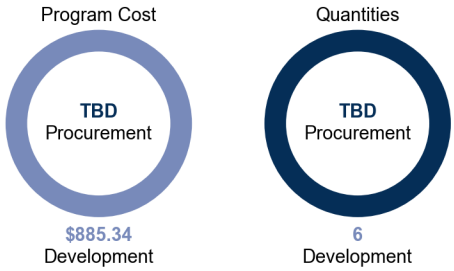
Orca Extra Large Unmanned Undersea Vehicle (XLUUV)

The XLUUV is a robotic autonomous system that the Navy intends to meet an emerging operational need for laying undersea mines. With future development, the Navy may also use the XLUUV to carry and deploy various payload types. The Navy began developing the XLUUV in fiscal year 2017. Its strategic plans state that the technologies developed as part of the XLUUV effort will likely serve a key role in the future fleet by helping the Navy field additional robotic autonomous systems. The XLUUV is currently a research and development effort.



Estimated Cost and Quantities

(fiscal year 2025 dollars in millions)



The Navy received the XLUUV test asset in December 2023. In addition, the Navy expects to receive five prototypes before the end of calendar year 2025. The Navy will test the received prototypes and, if successful, may elect to procure additional XLUUVs as part of a program of record. The Navy continues to evaluate potential procurement costs and quantities should it elect to transition XLUUV to a program of record. Estimated procurement costs and quantities are yet to be determined.

Software Development as of January 2025

Approach: Agile and Incremental

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

Information not available

Percentage of progress to meet current requirements: 76–99%

The program reported software costs are not known as software is developed through the contractor's own research and development funding.

Program Essentials

Prime contractors: Lockheed Martin (design); Boeing (design and fabrication)

Contract type: CPFF, FPIF, FFP, CPIF

Current Status

The XLUUV effort continues to experiment with and evaluate the test asset received in 2023 to gain knowledge on vehicle performance, and support manufacturing and software development for the remaining prototypes.

As of January 2025, the Navy reported obligating over $400 million for the test asset and five prototype vehicles, which it expects to receive before the end of 2025. This is at least a 3-month delay from last year's assessment and several years later than initially planned due to fabrication delays and ongoing battery development challenges. In January 2024, the Navy identified critical technologies for the XLUUV—such as autonomy, battery endurance, and navigation—that have ongoing technical challenges requiring development and mitigation if the XLUUV is to meet performance requirements. The Navy plans to use less-capable battery technology for testing as it awaits Boeing's development of the intended XLUUV battery. It also plans to begin operational testing —needed to understand if the XLUUV meets mission requirements—concurrently with acceptance of the five prototypes through fiscal year 2025.

It is now unclear whether the Navy will transition the XLUUV to a program of record because there are no clear requirements that the XLUUV can meet within current budget constraints, according to officials. Changes to XLUUV payloads to meet other requirements or capability gaps would require the Navy to pay the contractor to modify the XLUUV's proprietary software, according to officials. However, officials said that the modular design of XLUUV software and payload modules provides hardware flexibility and supports the potential for adopting an iterative approach. Should the Navy decide to transition to a program of record, an iterative approach could accelerate the Navy's deliveries.

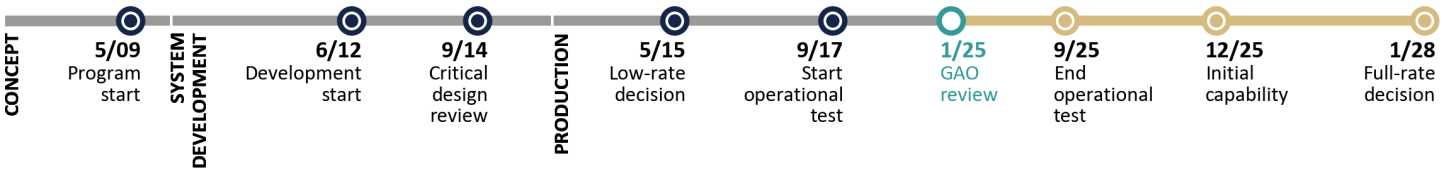
Program Office Comments

We provided a draft of this assessment to the program office for comment and incorporated its technical comments as appropriate. It stated that the Navy is focused on incorporating lessons learned into remaining vehicles; that in-water testing helped identify and address technical risks to production; that the program continues to provide training, logistics, and replacement parts to the fleet; and that XLUUV will be ready for operations in fiscal year 2026. In April 2025, the office of DOD's Director, Operational Test and Evaluation noted that the program is experiencing testing delays.

Source: U.S. Navy. | GAO-25-107569

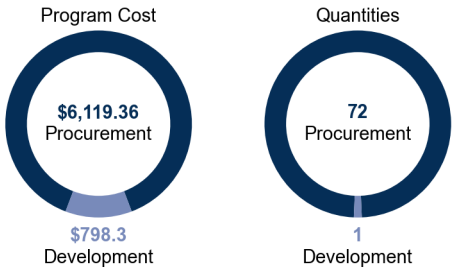
Ship to Shore Connector Amphibious Craft (SSC)

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 2025 dollars in millions)



	Reported in 2024[a] (9/2023)		Current Estimate (8/2024)
Acquisition Cost	$6,691	+4 %	$6,937
Unit Cost	$91.7	+4 %	$95.0
Cycle Time (in months)	184	+8 %	199

(%) Percent change since 2024[a]

[a]GAO-24-106831.

Software Development as of January 2025

Approach: Modified Agile, Iterative, and Waterfall

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions): Information not available

Percentage of progress to meet current requirements: 100%

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)

Current Status

Since our last assessment, the program further delayed the completion of initial testing and initial operational capability (IOC) by 15 months due to reliability issues associated with the power inverter units. These units are the technology that converts electrical power for use on the craft's electrical systems. According to program officials, the contractor could not produce spare parts at the pace needed to repair the installed units. The cause of the reliability issues is unknown. These officials stated that a simplified part—the Electrical Power Generation System (EPGS)—could replace the power inverter units, provide lower technical risk, and be developed more quickly and at lower cost. The SSC program installed and tested EPGS on LCAC 100 in November 2024. SSC program officials stated that they began installing EPGS on the remaining craft and conducting reliability testing in January 2025.

In general, SSC has suffered from some of the same issues as the Navy's larger, more complex ship programs, such as issues with supplier quality. The most recent schedule slips are consistent with delays we have reported on for several years. Specifically, the program delayed its IOC date in each of our annual assessments since its originally scheduled IOC in August 2020—a total delay of more than 5 years. These delays also exceeded the schedule thresholds for both initial operational test and evaluation (IOT&E) and IOC outlined in the program baseline, which the program is updating. As the program continues to delay key events in its schedule, it continues to construct and deliver craft—with 25 craft either under construction or delivered to date. As construction continues, any additional problems or issues identified during testing, such as the power inverter challenges identified above, could require costly rework.

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. It stated that the contractor began delivering four craft per year in 2024, has streamlined the production line, and is working to shorten the testing schedule. It added that EPGS testing demonstrated initial success and that it is targeting EPGS installation, required for IOT&E, by the end of August 2025. The program also noted that it partially achieved IOC in 2023 when six craft were delivered to the fleet, and that full IOC will occur upon IOT&E completion.

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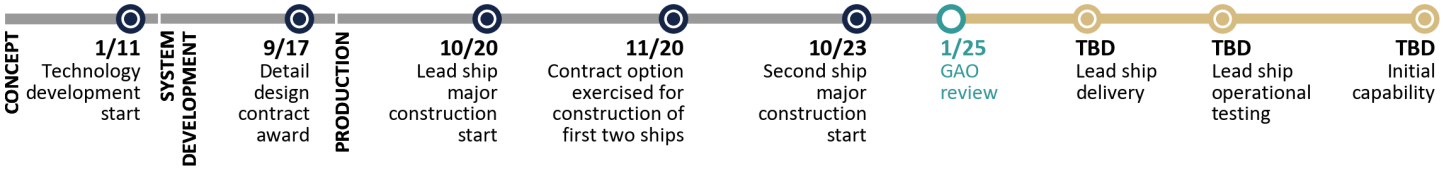
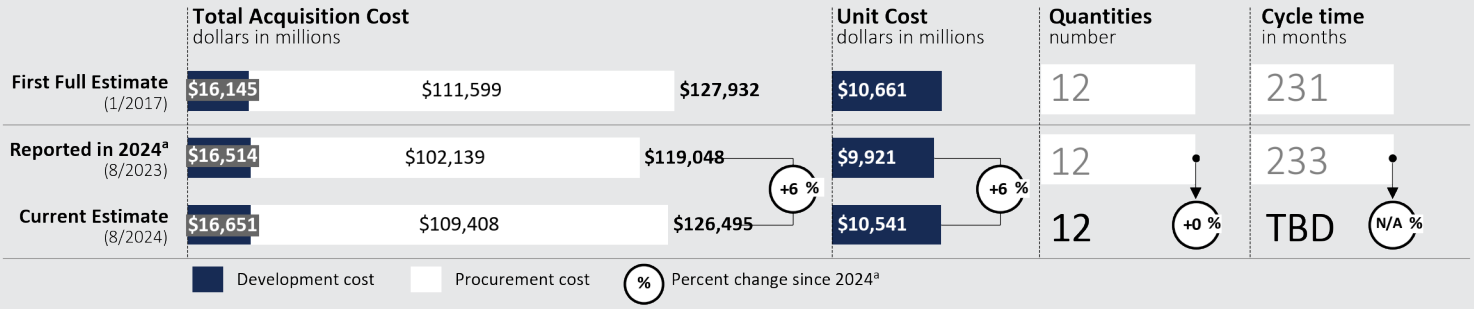
Source: General Dynamics Electric Boat. | GAO-25-107569

SSBN 826 *Columbia* Class Ballistic Missile Submarine (SSBN 826)

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 2025 dollars in millions



Total quantities comprise zero development quantities and 12 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. According to the program, a revised cost estimate expected to be completed in 2025 will include increased total acquisition costs. The program reported a baseline schedule breach, and the cycle time may change if initial capability is delayed.
[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Incremental

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

Information not available

Percentage of progress to meet current requirements: 76–99%

The program reported that software was based on software developed for previous Navy programs.

Program Essentials

Prime contractor: General Dynamics Electric Boat

Contract Type: CPIF (development and construction)

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a digital twin of key subsystems *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test an integrated physical prototype of key subsystems in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	●

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

SSBN 826 Program

Program Performance

In November 2024, the Navy declared a schedule breach for SSBN 826. As a result, the Navy is planning to update the acquisition program baseline by September 2025. The Navy is also developing plans to meet a delivery date of October 2028 for SSBN 826—a 12-month delay from the program's contract delivery date. However, the Navy estimated that delivery may be delayed to as late as March 2029 if planned construction improvements do not materialize. Moreover, we previously reported that the Navy lacked schedule insight that would better position the program to mitigate risks to achieving key dates, including independent analysis and data to easily validate the schedule's quality.

Program officials stated that, while construction performance was stable during much of 2024, it was not good enough to recover from existing delays. The program attributed particularly slow periods of construction to out-of-sequence work that significantly disrupted planned construction events and led to large amounts of rework. According to program officials, the out-of-sequence work resulted from missing instructions in some design products that detail how to build the submarine. For example, some areas of the submarine were missing electrical work and holes for pipe installation. Officials added that while the shipbuilders are taking steps to correct these design products, there remains a backlog of design changes that the shipbuilders need to address. This could further affect the program's schedule.

In an attempt to improve schedule performance, the program resequenced some work to optimize the order of construction events. For example, delivery of the turbine generators—a major propulsion system component—is delayed over 2 years due to design challenges. According to program officials, these delays forced modifications to the order of work on the engine room, one of the submarine's six large hull modules. Other resequencing involved moving selected work among shipyards to ensure the shipbuilders deliver modules as planned. However, we previously reported that resequencing can introduce additional schedule risks. Moreover, program officials stated that the volume of work yet to be completed is substantial, and their ability to further optimize the schedule by resequencing it is limited.

According to program officials, costs for SSBN 826 and the second submarine, SSBN 827, each significantly exceed their respective cost to complete due to poor construction performance, inflation, and higher material costs. Program officials stated that increases in the total acquisition cost estimate from last year reflect inflation and higher labor and material costs. Increases do not yet reflect recent construction trends. Officials stated that a future estimate will reflect higher costs due to further inflation and poor construction performance through July 2024.

Leading Product Development Practices

The program reported implementing some elements of leading product development practices. For example, it provided high-level operational needs to stakeholders that were subsequently refined prior to beginning detail design, and officials said that they incorporated end user feedback throughout the design process. The program also reported implementing a modular approach for certain architecture and software components. However, it reported no plans for a digital twin of key subsystems or a digital thread. Our prior work found that these tools are key to anticipating potential design flaws and incorporating changes. Program officials stated that a 3D model was developed for some of the submarine for use by the shipbuilders and maintainers.

Other Program Issues

The program continues to face challenges across the submarine industrial base such as a lack of workers trained in the necessary trades like welding and metal fabrication. There is also limited workforce and industrial capacity at suppliers that manufacture *Columbia* class components. According to program officials, while the Navy is working to identify additional suppliers to help increase capacity, it can take years for potential suppliers to complete the qualification process.

After more than a year of formal construction, SSBN 827 is about 12 percent behind schedule. According to program officials, material availability issues, among others, hindered construction progress. SSBN 827's planned construction schedule is 4 months shorter than the lead submarine's now-unachievable contract schedule, and the program will need to significantly accelerate construction to meet planned delivery.

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, the *Columbia* class 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.

According to the program, the Navy continues to address industrial base challenges with oversight, workforce development pipelines, and supplier development funding. The program added that the Navy is pursuing additive manufacturing, robotics, automation, and digital technologies to increase efficiency, capacity, and quality. It also stated that the Navy is working to minimize SSBN 826 delays, mitigate the effect of late delivery on planned initial capability, and incorporate lessons learned for SSBN 827 and future submarine construction.

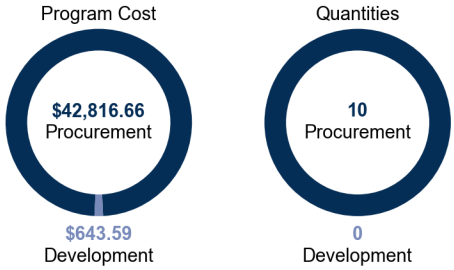
Source: U.S. Navy photo courtesy of Huntington Ingalls Industries. | GAO-25-107569

SSN 774 *Virginia* Class Submarine (VCS) Block V

The Navy's VCS is a class of multirole nuclear-powered submarines. 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 Block V 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. The Navy plans to begin buying the next increment—Block VI—in fiscal year 2025. The Navy plans Block VI to include the VPM and minimal design changes from Block V, such as safety enhancements.

Estimated Cost and Quantities

(fiscal year 2025 dollars in millions)



The program is in the process of negotiating a modification to the Block V contract to add two additional Block V submarines, for a total of 12. Funding for these submarines was appropriated in fiscal year 2024.

Software Development as of January 2025

Approach: Waterfall

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

Information not available

Percentage of progress to meet current requirements: Information not available

The program reported that all software has been developed and tested and costs are not tracked separately.

Program Essentials

Prime contractor: General Dynamics Electric Boat

Contract type: FPI (procurement)

Current Status

The program's 2024 construction rate fell to 1.15 submarines per year from 1.2 per year in 2023, short of the Navy's goal of 1.5, according to program officials. Congress appropriated funds for two VCSs per year from 2011 through 2024, although the Navy only requested one VCS for fiscal year 2025. The Navy has a goal to deliver 2.3 submarines per year by the early 2030s. According to officials, this increase is needed to meet the Australia-United Kingdom-United States initiative under which Australia plans to acquire up to five conventionally armed VCSs. The shipbuilder's work progress data show potential for further deterioration of the construction rate due to inefficient shipyard work, slow growth in supplier production capacity, and prioritization of *Columbia* class submarine work, putting at risk the Navy's ability to preserve its fleet size.

Construction continues to cost more than planned. Navy officials estimate Block V will require additional appropriations from Congress to pay for the government's share of estimated total cost growth as each submarine approaches delivery. They told us that cost increases influenced award of two planned fiscal year 2024 VCSs. Construction costs are estimated to exceed the funds Congress already appropriated, prompting the Navy to request a budget anomaly for an additional $5.7 billion, which Congress appropriated funds for in December 2024. Navy officials stated that $0.5 billion in wage increases included in the Navy's budget anomaly request are one key to hiring and retaining skilled workers, which slowed construction progress.

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, 24 VCSs have been delivered with an additional 14 under contract. The program also stated that VCS construction performance is not meeting goals, and the program is not recovering as quickly as projected or needed. It added that actions are ongoing for hiring, reduction of attrition, workforce development, supplier base, production improvements, and continued investment to support achieving a generational workload increase that would allow for construction of one *Columbia* class and two *Virginia* class submarines per year.

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Source: U.S. Navy. | GAO-25-107569

T-AGOS 25 *Explorer* Class Ocean Surveillance Ship (T-AGOS 25)

T-AGOS 25 will replace the Navy's existing five ocean surveillance ships that are approaching the end of their service lives. The T-AGOS 25 ships will be larger and faster than the current in-service *Victorious* and *Impeccable* class ships. Like the in-service ships, the new class will use the Surveillance Towed-Array Sensor System equipment to gather undersea acoustic data.

Program Performance fiscal year 2025 dollars in millions

	Total Acquisition Cost (dollars in millions)			Unit Cost (dollars in millions)	Quantities (number)	Cycle time (in months)
First Full Estimate (12/2023)	$72	$4,136	$4,208	$601	7	64
Reported in 2024[a]	Program not included in GAO's 2024 assessment					
Current Estimate (7/2024)	$74	$3,470	$3,544	$506	7	97

Development cost | Procurement cost

Total quantities comprise zero development quantities and seven 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-24-106831.

Software Development

as of January 2025

Approach: Information not available

Software Cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

Information not available

Percentage of progress to meet current requirements:
Information not available

The program reported that it will rely on commercial technologies. It is not developing software or tracking specific software costs.

Program Essentials

Prime contractor: Austal USA, LLC

Contract Type: FFP; FPI (detail design and construction)

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a digital twin of key subsystems *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test an integrated physical prototype of key subsystems in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	◔

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

T-AGOS 25 Program

Program Performance

The Navy estimates that a purchase of seven T-AGOS 25 ships will have a total program cost of $3.5 billion. The Navy plans for an average cost per ship of $506 million with $790 million planned for the lead ship. This estimate from the Navy's fiscal year 2025 budget submission represents an over 80 percent increase in lead ship cost from its initial estimate.

The Navy planned to begin replacing the legacy ocean surveillance ships in 2027, as they reach the end of their service lives. Since the program exercised the lead ship construction option in May 2024, shortages in ship design resources and lags in receiving vendor furnished information delayed contractor progress on the design. The shipbuilder is working to develop a new schedule, which the program estimated would be available in mid-2025. The program has yet to set a date for the start of lead ship construction. Officials stated that, as of October 2024, the functional design was only 12 percent complete, far below the contract requirement that it be 100 percent complete to start construction. Due to these delays, the program will likely miss its goal for fielding T-AGOS 25 in 2027 by several years.

T-AGOS 25 ships will employ a Small Waterplane Area Twin Hull (SWATH) design, where the ship's upper portion sits on struts above two submerged hulls. A SWATH ship that meets the program's requirements for speed, seakeeping, and endurance has never been built, making the design a significant risk for the program. Program officials told us that SWATH is an unusual design for Navy ships and is complex because it is weight sensitive; small changes in weight or displacement affect how the ship sits in the water. They noted that keeping the weight in an acceptable margin imposes risk to schedule and cost, which would be exacerbated by beginning construction work prior to completing the functional design.

We previously found that leading commercial shipbuilders limit risk from unusual designs by setting and upholding expectations that basic and functional design—including the ship structure; routing of major distributive systems such as electricity or water; and positioning of piping, ventilation, equipment, and other ship outfitting—be fully 3D modeled to achieve design stability before construction begins. In line with leading ship design practices, the program currently requires the contractor to complete functional design before the start of construction and plans to complete the detail design of each design zone of the ship before beginning construction on that zone. However, the 3D model requirements fall short of these leading practices. Specifically, the Navy requires a minimum of 70 percent 3D-model completion and 3 months of production work packages prior to starting construction. Our previous work has shown that setting design expectations that are below leading practices contributes significant risk to cost and schedule.

Leading Product Development Practices

Program officials told us that Military Sealift Command, which operates the ships, is involved in developing user requirements, will be involved in design review, and will serve as an owner's representative at the shipyard during construction. They also said that the program receives input from Military Sealift Command and the testing community and has regular meetings with the shipyard to incorporate potential improvements, consistent with leading practices to incorporate stakeholder feedback in product development. The program also reported plans to incorporate a modular open systems approach for its integrated bridge and the ship's navigation and maneuvering control systems. According to the program, its use of a 3D product model is consistent with modern commercial and naval shipbuilding standards and best practices. However, it is not using a digital twin or digital thread, which could ensure different systems and subsystems work together to maximize modularity and the efficiency of design and construction of follow-on ships.

Software and Cybersecurity

The T-AGOS 25 program is procuring, rather than developing, software for the ship class. The program approved a cybersecurity strategy in May 2023.

Other Program Issues

Austal USA is currently executing work for 12 new construction programs for Navy and Coast Guard ships, up from two programs in 2021. Resource and workforce demand from these other programs could impose cost and schedule risks for the T-AGOS 25 program.

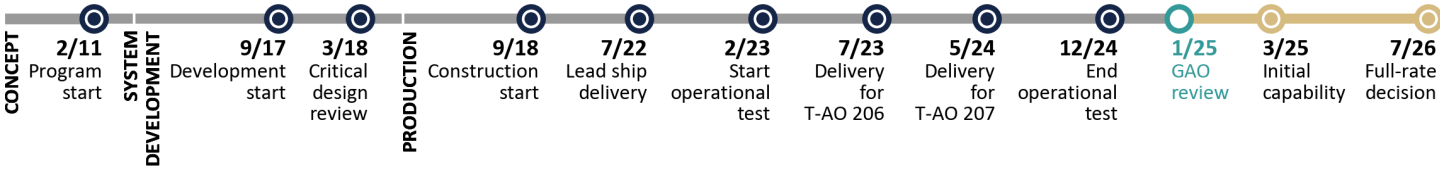
Program Office Comments

We provided a draft of this assessment to the program office for review and incorporated its technical comments where appropriate. It stated that inflation increased initial cost estimates developed prior to 2020, and that the fiscal year 2025 budget submission and acquisition program baseline cost estimates reflect contract award pricing. It also stated that functional design is about 20 percent complete as of February 2025 and that it continues work with the shipbuilder to resolve issues that delayed design efforts and to identify problems early. It added that, upon the required 100 percent completion of the functional design and before authorizing the start of construction, the Navy will conduct a review to demonstrate that: (1) the design is sufficiently mature, (2) the flow of production information will support production, and (3) the status of material ordering and delivery will support the proposed build schedule. In April 2025, DOD test officials stated that the program lengthened the time between design reviews and scheduled an early operational assessment and an internal business review during that time.

Source: U.S. Navy. | GAO-25-107569

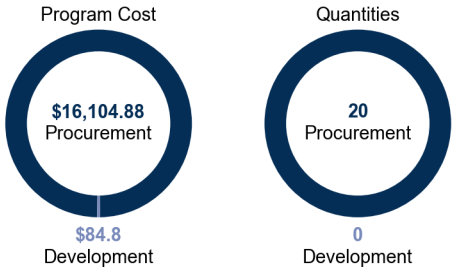
T-AO 205 *John Lewis* Class Fleet Replenishment Oiler (T-AO 205)

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 2025 dollars in millions)



	Reported in 2024[a] (8/2023)		Current Estimate (9/2024)
Acquisition Cost	$15,248	+6%	$16,190
Unit Cost	$762.4	+6%	$809.5
Cycle Time (in months)	77	+17%	90

(%) Percent change since 2024[a]

[a]GAO-24-106831.

Software Development as of January 2025

Approach: Information not available

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

Information not available

Percentage of progress to meet current requirements: Information not available

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)

Current Status

Since our last assessment, the program delivered the third ship (T-AO 207). The next seven ships are all tracking to deliver to the rebaselined schedule that we previously reported.

In September 2024, the program awarded a contract for eight ships using specific authority granted by Congress. The Navy expects this contracting approach to save money over contracting for each ship individually. However, there is still an increased average cost per ship because, per program officials, the program is experiencing higher material pricing following the COVID-19 pandemic and is allowing for a fair profit for the shipbuilder and suppliers.

Some key events, such as Initial Operational Test and Evaluation, were delayed since our last report. Program officials stated that these delays are affected by the availability of other fleet ships to participate in testing. The program office stated that T-AO completed its final significant test event in December 2024, a 16-month delay from the previous estimate. The program expects this delay to push planned initial operational capability from February 2024 to March 2025 and the full-rate production decision from March 2024 to July 2026. However, program officials noted that they expect the lead ship to be available to support the fleet in 2025. This availability includes overseas deployment, even if initial operational capability is further delayed due to more testing delays.

Program officials noted that user feedback from the lead ship drove improvements, such as modification of the ship's water purification system to one that worked better.

Program Office Comments

We provided a draft of this assessment to the program office for comment and incorporated the program's technical comments as appropriate. The program stated that T-AO 208 was delivered in December 2024, 3 months before the Navy's planned delivery. It said that T-AO 209-214 delivery dates remain stable and that T-AO 206 successfully completed the final test demonstration with a carrier and destroyer in December 2024, putting the program on track to declare initial operational capability. The program noted that despite continued material cost growth above projected market indices, overall cost performance is stabilizing as the program moves into serial production.

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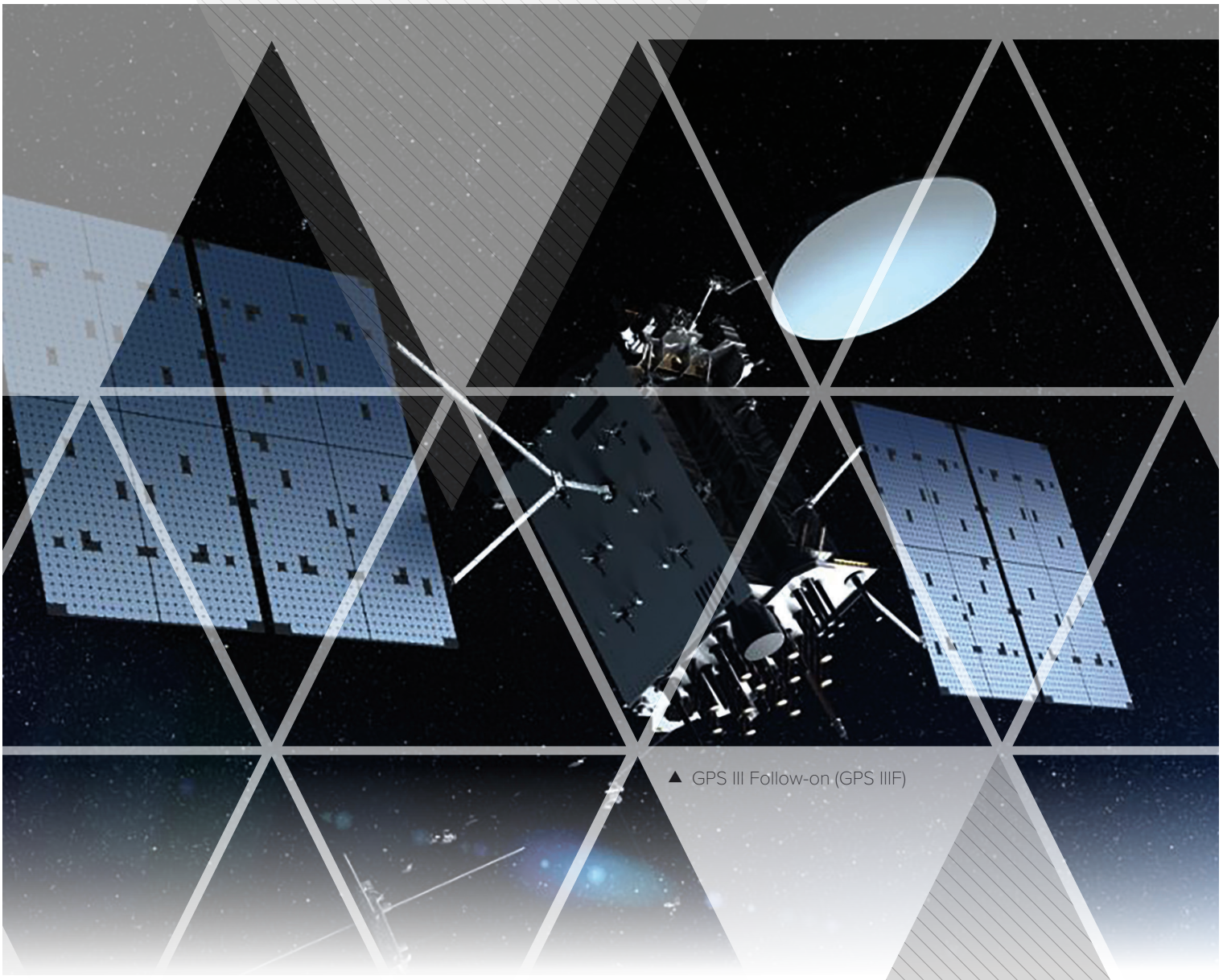
SPACE FORCE

Program Assessments



▲ GPS III Follow-on (GPS IIIF)

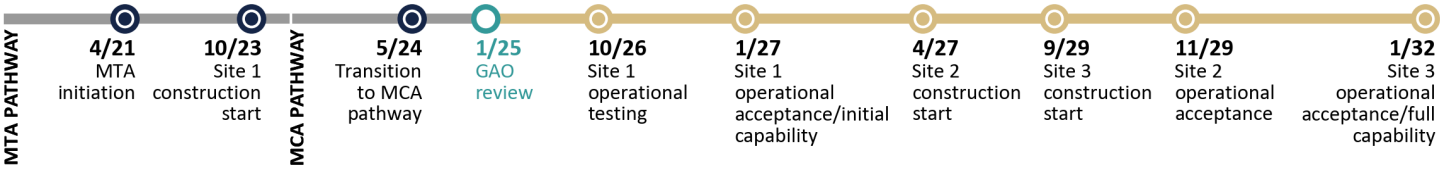
Program name	Assessment type
Deep Space Advanced Radar Capability (DARC)	MDAP
Future Operationally Resilient Ground Evolution (FORGE)	MTA
GPS III Follow-On (GPS IIIF)	MDAP
Military GPS User Equipment (MGUE) Increment 1 (MGUE Increment 1)	MDAP
Military GPS User Equipment (MGUE) Increment 2 (MGUE Increment 2)	MTA
National Security Space Launch (NSSL)	MDAP Increment
Next Generation Operational Control Systems (OCX)	MDAP
Next Generation Overhead Persistent Infrared Geosynchronous Earth Orbit Satellites (Next Gen OPIR GEO)	MDAP
Next Generation Overhead Persistent Infrared Space Polar (Next Gen OPIR Polar)	MDAP
Protected Tactical SATCOM - Resilient (PTS-R)	MDAP
Resilient Missile Warning/Missile Tracking Medium Earth Orbit (Resilient MW/MT MEO) – Epoch 1	MTA
Tranche 1 and 2 Tracking Layer (T1 TRK and T2 TRK)	MTA
Tranche 1 and 2 Transport Layers (T1TL and T2TL)	MTA
Weather System Follow-On (WSF)	MDAP

Source (previous page image): Lockheed Martin Corporation. | GAO-25-107569

Source: Northrop Grumman on behalf of USSF/SSC/SZGGD/DARC PMO. | GAO-25-107569

Deep Space Advanced Radar Capability (DARC)

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. The Air Force initiated the DARC MTA effort to develop an initial site (Site 1) and a command and control center. The program office restructured all three sites into one program that transitioned to the major capability acquisition (MCA) pathway.



Program Performance fiscal year 2025 dollars in millions

	Total Acquisition Cost (dollars in millions)	Unit Cost (dollars in millions)	Quantities (number)	Cycle time (in months)
First Full Estimate (1/2025)	Program has not developed formal cost or schedule estimates			
Reported in 2024[a]	Not a Major Defense Acquisition Program in GAO's 2024 assessment			
Current Estimate (1/2025)	Program has not developed formal cost or schedule estimates			

In our prior assessment, the DARC MTA rapid prototyping effort for Site 1 was $864.59 million (in fiscal year 2025 dollars).

[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Agile and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$87.23 | Information not available

Percentage of progress to meet current requirements: 51–75%

Program Essentials

Prime contractor: Northrop Grumman Systems Corporation

Contract Type: CPIF (using other transaction authority) (Site 1); CPIF, FFP (Site 2)

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	◐
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	●
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	●

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

DARC Program

Program Performance

In May 2024, the DARC program office restructured its planned acquisition of three DARC radar sites into one program that entered the MCA pathway at the technology maturation and risk reduction phase. The Site 2 contract, which the program awarded in August 2024, was limited by Air Force leadership to only working on preliminary design and software development until the Space Force approves the program to enter the MCA pathway production phase. This is tentatively scheduled for May 2025.

For Site 1, the program reported challenges in development of the systems integration lab—a simulation, testing, and diagnostics facility—due to the contractor's lack of expertise in building such a lab. In January 2025, the program stated that the lab was complete and functional after external vendors provided additional on-site support. However, according to the program, challenges with the lab caused a 7-month schedule delay.

Program officials acknowledged that Site 1 delays have caused cascading delays to the construction of Sites 2 and 3. For instance, the program delayed Site 2 construction start by 9 months to April 2027 and deferred operational acceptance by 13 months to November 2029. Similarly, for Site 3, the program postponed both construction start and operational acceptance by 26 months, to September 2029 and January 2032, respectively. According to these officials, the Site 2 and Site 3 delays are further compounded by anticipated future decreases in program funding and cost growth on Site 1.

Leading Product Development Practices

The DARC program reported taking several approaches in line with leading practices for product development, but it is not fully implementing the elements of iterative development that we found lead to efficiencies. For example, the program reported using an iterative approach to develop a minimum viable product (Site 1). However, it is not taking the important step of fully demonstrating the minimum viable product for the first iteration before moving forward with the next. The program stated that while Site 3 may incorporate changes based on the results of testing from Site 1, the requirements for Site 2 are currently closed for changes. The program said it could use an engineering change proposal for Site 2 if needed.

The program also reported that it completed development of a digital thread and started developing what it described as a digital twin. However, while this twin will include some components, the program does not plan to digitally twin the system as a whole. We previously found that leading companies use system-level digital twins to identify significant differences between expected and actual performance as well as gain insight into a system's design that cannot be obtained physically. We also found that digital twinning allows for faster design iterations and can facilitate quick delivery of successive minimum viable products. A system-level digital twin could assist the program to more quickly design Sites 2 and 3, as well as future iterations of the system.

The program office stated that DARC incorporated a modular open systems approach to allow for easy upgrades and third-party development. According to the program office, a modular open systems approach was incorporated into all major system components and associated interfaces. Officials said that antennas can be added to the array to increase capability. Officials also stated that as Sites 2 and 3 incorporate new functionalities, Site 1 could be upgraded to the same level of capability.

Cybersecurity

The program reported that it will conduct a cooperative vulnerability identification assessment in May 2025, 7 months later than planned, after it deems the system integration lab mature enough for the cybersecurity inspection.

Other Program Issues

We reported last year that the Space Force identified a high risk between how the DARC system operates with a space situational awareness data repository and a missile defense system program. Program officials reported that efforts to resolve system interoperability remain on track for planned completion in June 2025.

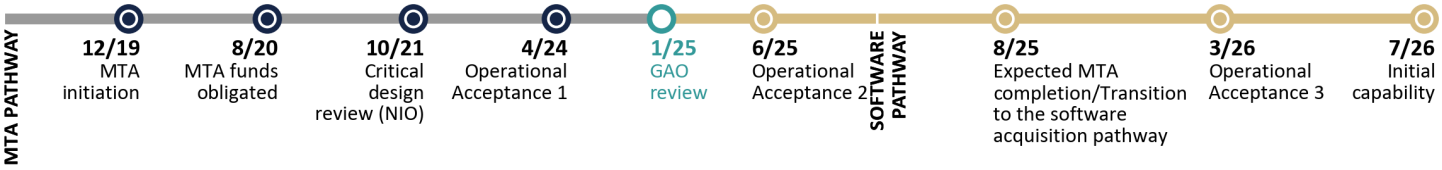
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office had no comments.

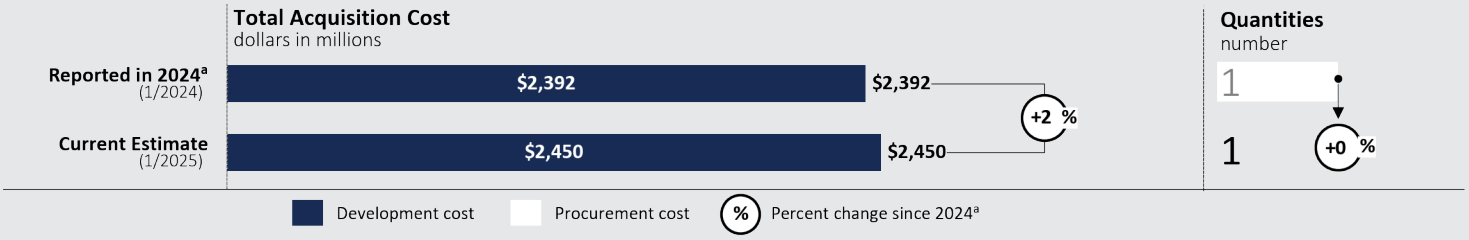
Source: U.S Space Force. | GAO-25-107569

Future Operationally Resilient Ground Evolution (FORGE)

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 both 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 ground stations. In addition, the program developed Next Gen Interim Operations (NIO) that serves as the baseline command and control for the earliest Next Gen OPIR space vehicles. The Next Gen OPIR efforts are assessed separately in this report.



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2025 dollars in millions



[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Agile and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions): Information not available

Percentage of progress to meet current requirements: 51–75%

The program reported that it is unable to separate out software costs between the MTA effort and the upcoming software acquisition pathway effort.

Program Essentials

Prime contractors: Raytheon; SciTech; Lockheed Martin; Northrop Grumman

Contract Type: Cost reimbursement with various fee structures (using other transaction authority)

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	◐
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	◐
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	●
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	NA
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	●

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

We did not assess the test of a system-level integrated physical prototype because FORGE is primarily a software program.

FORGE Program

Program Performance

The Space Force intends for FORGE to support legacy satellites and provide enhanced ground processing capabilities for Next Gen OPIR satellites. The program is currently using NIO to support the first launch of Next Gen OPIR satellites, scheduled for March 2026. It is using a multi-vendor approach for developing the prototype software systems that comprise FORGE. The program stated that one of these vendors was awarded the contract for the second phase of development of FORGE Command and Control (FORGE C2) in February 2025. Program officials expect to transition remaining development efforts to the software acquisition pathway at the end of the MTA effort in August 2025.

The first operational acceptance demonstration of the FORGE framework was to initiate hosting of software applications within FORGE. The applications convey SBIRS data to users for battlespace awareness and technical intelligence. After several months of delay, program officials reported the FORGE Operational Acceptance was completed in April 2024. The FORGE framework demonstrated new capabilities and backward compatibility with legacy SBIRS as well as delivered some of its planned increased resilience and enhanced mission support. According to program officials, when the FORGE C2 capability is mature, it will replace NIO's support of Next Gen OPIR GEO space vehicles. According to the program, Next Gen OPIR Polar vehicles, scheduled for first launch late 2028, will also be supported by FORGE C2.

Leading Product Development Practices

The FORGE program reported that it implemented some leading product development practices. The program reported that it delivered the minimum viable product at the first Operational Acceptance and that it continues to develop subsequent releases as it plans its transition to the software pathway. According to program officials, FORGE initiated development of a digital twin with a full software suite deployed on representative hardware. They stated that activities on this suite rely on a mixture of automated and manual processes, and that they have plans to add more automation over the next year. Additionally, the program stated that it conducted testing of an integrated, fully digital prototype in a digital environment during 2024. Program officials noted that testing is conducted at a facility that replicates the operational hardware, infrastructure, and platforms. We previously found that high-fidelity digital twins, coupled with high-resolution simulations of the operating environment, can be used for testing a system to validate that it meets requirements.

Program officials reported that FORGE is colocated with the operator, and that the program works with this operations team at least weekly to discuss software capabilities. When needed, the program also works with this operations team during test events to maintain close coordination between developers and operators. We previously found that leading companies repeatedly obtain feedback from users to ensure the product specifications meet user needs.

Software and Cybersecurity

Program officials report continued plans to have contractors provide major software deliveries three times per year, or similar frequency, utilizing Agile and DevSecOps principles. Officials stated that a cybersecurity system vulnerability and penetration assessment was completed in September 2024 and the program received feedback from agencies and stakeholders on the completed cyber assessment report. The program held a cyber stand down event to work collaboratively with cyber and FORGE subject matter experts to advance cyber configurations and implement changes to elevate FORGE's cyber resilience, according to officials.

Other Program Issues

Program officials stated that funding was realigned from the Endurable-FORGE (E-FORGE) effort—a conceptual mobile ground capability—due to pending results from the Space Warfighting Analysis Center Force Design study. According to officials, the study was completed in December 2024 and provided options to inform future improvements to missile warning capabilities. Program officials indicated that no decisions on an E-FORGE solution have been made at this time.

Due to delays in hardware deliveries, officials indicated that the second Operational Acceptance of FORGE within the OPIR Battlespace Awareness Center is delayed by approximately 6 months to June 2025. During this delay, program officials conducted a configuration change to newer server hardware and notified the Service Acquisition Executive of the change. The broader FORGE program schedule will not be affected by this delay, according to officials.

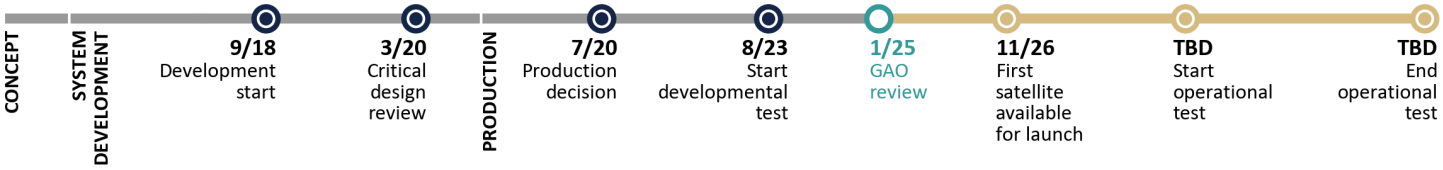
Program Office Comments

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.

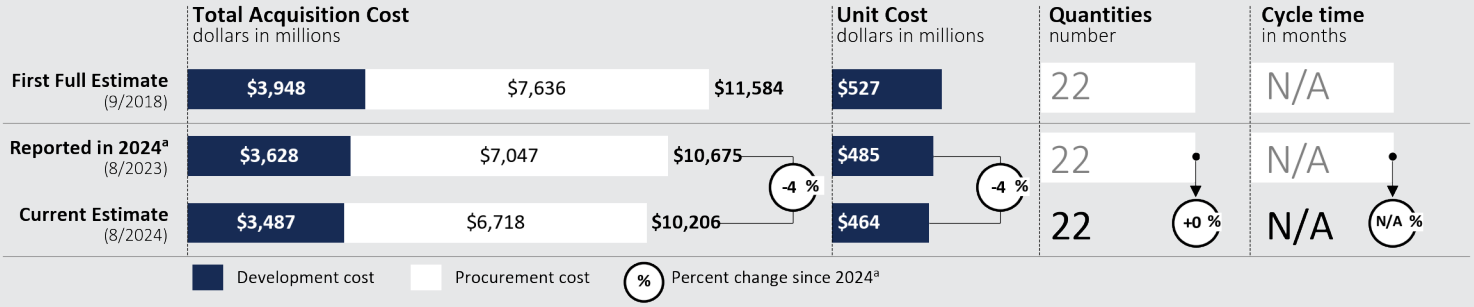
Source: Lockheed Martin Corporation. | GAO-25-107569

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 2025 dollars in millions



Total quantities comprise two 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. We could not calculate cycle time because the initial capability depends on the availability of complementary systems.
[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Waterfall and Incremental

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

Information not available

Percentage of progress to meet current requirements: 76–99%

According to the program, it is not tracking total acquisition cost for software development and procurement as not all space vehicle contract options have been exercised.

Program Essentials

Prime contractor: Lockheed Martin

Contract Type: FPI; FPAF

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	NA
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	○

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

We did not assess the test of a system-level integrated physical prototype in an operational environment due to the difficulty of conducting tests in the operational environment—space.

GPS IIIF Program

Program Performance

In 2024, the program continued efforts toward maturing the satellite's mission data unit (MDU)—the brain of the satellite's navigation mission. The program reported that it successfully concluded investigations on the technical challenges with the MDU's timekeeping system and digital waveform generator that we reported on last year. However, program officials reported that the projected delivery of the MDUs for the first two GPS IIIF satellites had been delayed to August 2025 and November 2025, respectively. The delays stemmed from issues discovered in acceptance testing of the MDU for the first GPS IIIF satellite. Space Force officials stated that the program has mitigations to prevent these shifts from causing delays to projected satellite deliveries.

The program reported continued risk reduction with the linearized traveling wave tube amplifier (LTWTA) in 2024. The program reported that it had reduced risk, in part, through testing LTWTAs for qualification purposes, beginning this year. To maintain the satellite build schedule, the program will install flight LTWTAs onto GPS IIIF satellites prior to test completion for the qualification LTWTAs, officials noted. Consequently, if failures occur in the qualification testing, the program risks deinstallation and rework of the flight LTWTAs, according to program officials.

The program also continued testing of its non-flight, system-level testbed, which includes all key GPS IIIF subsystems and components. The program reported that it completed planned risk reduction testing with the testbed, resulting in validation of the Regional Military Protection deployment mechanism's design and performance.

Space Force officials stated the program is working to mitigate delays to projected GPS IIIF satellite deliveries. For example, for flight components with delivery delays, non-flight components may be substituted for portions of testing. They also stated that some subcontracted LTWTA deliveries could precede the prime contractor-built LTWTAs, enabling earlier delivery for some satellites.

Leading Product Development Practices

The program reported that it is not implementing leading product development practices, such as incorporating user feedback to prioritize capabilities or using digital twins and digital threads to verify design performance. Officials said that this is because development is focused on compliance with the program's defined baseline, which does not allow for an iterative development approach. We previously found that using an iterative approach could help the Space Force develop a system that delivers the most critical capabilities in the near term. It could also inform innovations for the next system to address less urgent needs.

Software and Cybersecurity

In 2024, the program progressed with development of an MDU software update that will deliver some functionalities that are required for the GPS IIIF satellites' Regional Military Protection capability. The program reported that a software acceptance review for the new MDU software version is planned for January 2025.

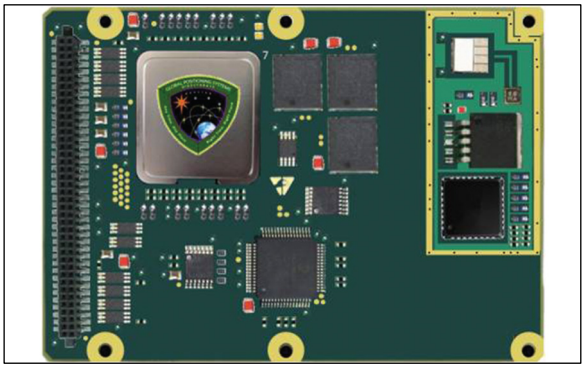
Program officials stated that in May 2024, the program successfully completed an initial phase of its cyber vulnerability assessment of the GPS IIIF satellite using a GPS IIIF satellite simulator. In November 2024, program officials reported that the program completed a test readiness review for an upcoming cyber vulnerability and penetration assessment, which will be carried out using the same satellite simulator.

Other Program Issues

Launch and operation of GPS IIIF satellites depends on the delivery of Next Generation Operational Control System (OCX) Block 3F. As of December 2024, the OCX Block 3F program reported that it is undergoing a schedule rebaseline due to contractor Raytheon's projected delays to the program's final acquisition milestone—the predelivery integrated testing. The OCX Block 3F program reported experiencing delays due to the extended diversion of Raytheon personnel to the delayed OCX Blocks 1 and 2 program—which we assessed separately in this report. The OCX Block 3F program reported that the first of the program's planned capability deliveries—the launch and check-out capability for GPS IIIF satellites—is projected to be delivered in January 2025. Delays to the OCX Block 3F program could have corresponding effects on the Space Force's ability to launch and operate GPS IIIF satellites.

Program Office Comments

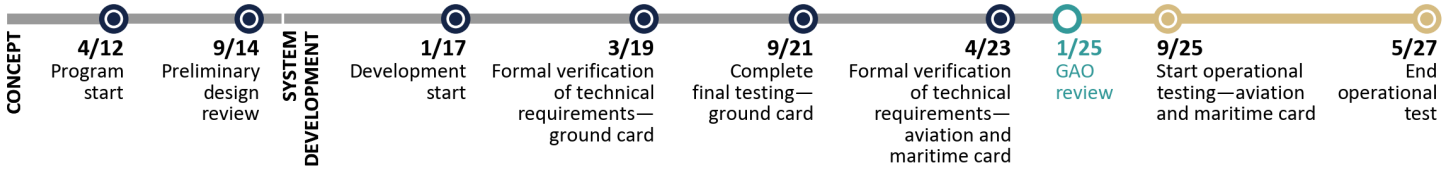
We provided a draft of this assessment to the program office for review and comment. The program stated that GPS IIIF's estimated total acquisition cost declined by 4 percent due to a combination of reasons that included the impact of congressional marks and a decrease in estimated values for engineering change orders, other government costs, and launch and on orbit support.



Source: U.S. Air Force. | GAO-25-107569

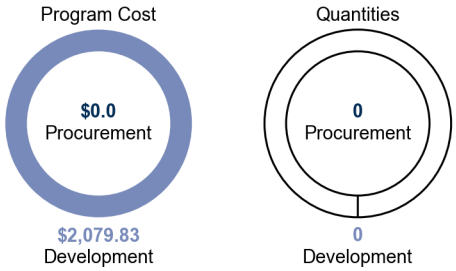
Military GPS User Equipment (MGUE) Increment 1

The Space Force's MGUE Increment 1 program is developing the first-generation 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 robust threat-resistant positioning, navigation, and timing capabilities. The program is developing one card for ground and one card for aviation and maritime applications. The MGUE program is integrating and testing cards on four lead platforms across the military departments. The cards will then be available for procurement.



Program Performance

(fiscal year 2025 dollars in millions)



	Reported in 2024[a] (8/2023)		Current Estimate (8/2023)
Acquisition Cost	$2,080	+0 %	$2,080
Unit Cost	N/A	N/A%	N/A
Cycle Time (in months)	N/A	N/A%	N/A

(%) Percent change since 2024[a]

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-24-106831.

Software Development as of January 2025

Approach: Agile, DevOps, and Incremental

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

Information not available

Percentage of progress to meet current requirements: 76–99%

The program reported that it does not track software costs.

Program Essentials

Prime contractor: L3Harris; Raytheon Technologies; BAE Systems

Contract type: CPIF/CPFF/FFP (development)

Current Status

In September 2024, the MGUE Increment 1 aviation/maritime circuit card achieved card-level certification for the Navy's lead platform—the *Arleigh Burke*-class destroyer. This marked the accomplishment of one of the remaining two program milestones and cleared the card for operational testing. While the card is ready for operational testing, according to program officials, a deficiency discovered during integration testing required the Navy to make improvements to its receiver. According to program officials, the Navy identified a solution that it expects to fully address this issue. In addition, these officials indicated that they have a funding source to cover a funding short fall discovered during the card-level certification process. Operational testing is now scheduled to end in May 2027, pending ship and test site availability.

In October 2024, the milestone decision authority approved revisions to the aviation platform card-level certification milestones, changed the Air Force's lead platform from the B-2 Spirit to the Army's Gray Eagle, and cleared use of this new platform's receiver for integration with the aviation/maritime card. Schedule delays in the Air Force's receiver program associated with the B-2 resulted in the MGUE Increment 1 program acknowledging that it could not meet the original card-level certification deadline in January 2025. Currently, card-level certification on the Army's Gray Eagle is now projected for July 2025; operational testing is expected to start in September 2025.

As of November 2024, DOD is restructuring MGUE Increment 1 aviation/maritime card's software updates and other programs into an enterprise effort for GPS receivers under the M-Code Aviation Receiver Enterprise program after completion of initial operational testing on the lead platforms. DOD intends for the new major defense acquisition program to better manage cost, schedule, and performance while promoting efficient integration of aviation GPS receiver programs across the military departments. We will continue to monitor these efforts in our future assessments.

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, it is on track to complete the remaining card-level certification on the Army's Gray Eagle within the existing schedule and budget.

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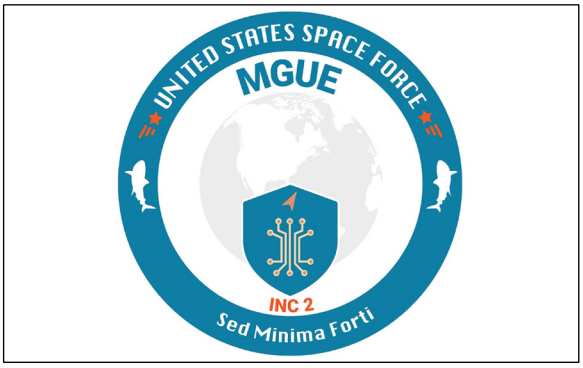
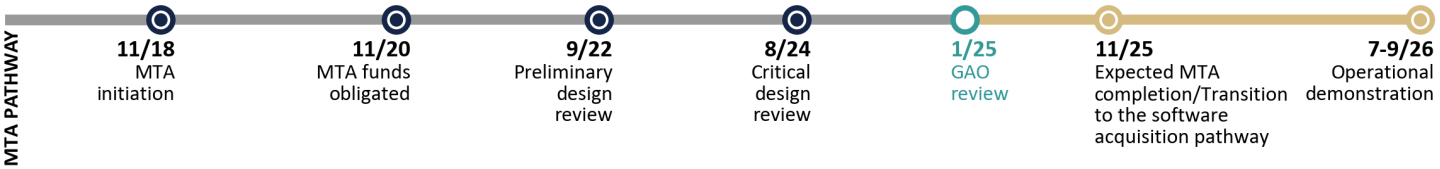


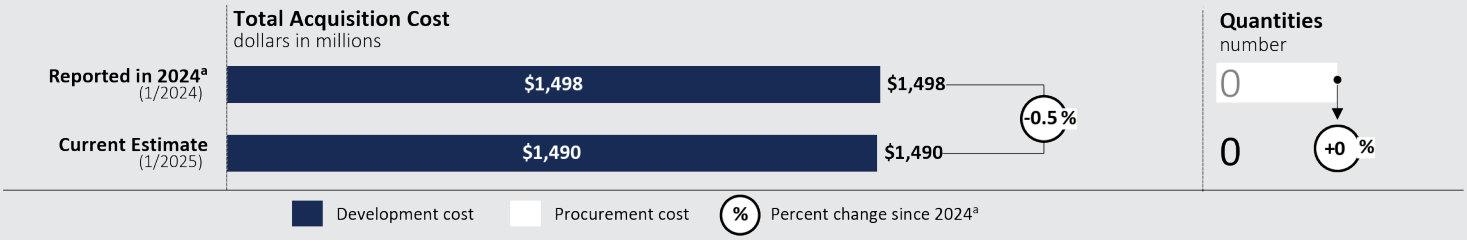
Source: U.S. Air Force. | GAO-25-107569

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. Two vendors are developing the MSI card and application-specific integrated circuit (ASIC), a key component of the MSI on which the vendors will encode M-code receiver functions. The program will transition to the execution phase of the software acquisition pathway in November 2025 to develop and deliver prototypes that meet requirements beyond the 5-year MTA effort. After the execution phase concludes, military departments can procure the production-ready receiver card capability through separate efforts. 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.



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2025 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-24-106831.

Software Development

as of January 2025

Approach: Agile, Waterfall, Incremental, DevOps, and Spiral

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$182.72 | 12.26%

Percentage of progress to meet current requirements: 51–75%

Program Essentials

Prime contractors: BAE; L3Harris Interstate Electronics Corporation

Contract Type: CPIF/CPAF, CPFF, FFP

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	NA

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

We assessed the MGUE Increment 2 MTA rapid prototyping effort. The receiver card is not a system, but a component designed according to a government-defined standard for use with multiple weapon systems.

MGUE Increment 2 Program

Program Performance

The MGUE Increment 2 program changed its acquisition strategy in January 2025 to transition to the software acquisition pathway at the end of the 5-year MTA rapid prototyping time frame. According to the program, vendors need more than the 5-year timeline to deliver a prototype that meets requirements. The program plans to carry two vendors through fiscal year 2025 and proceed with at least one vendor to completion of the software acquisition pathway. The program stated that moving to the software acquisition pathway offered several advantages, including requirements latitude and user/stakeholder involvement.

According to the program, its ASIC technology is immature due to factors that include the vendors' underestimation of the complexity of the development effort and late acquisition of key equipment and personnel. The program stated that multiple technical solutions are in progress to address the ASIC's issues, and that these solutions have cost, schedule, and security risks associated with them. However, the program could not quantify the impacts, officials said, given the ongoing trades among these three risk areas.

Program costs remain uncertain. The program noted that its Increment 2 requirements are unchanged; however, it also stated that it is planning to modify the existing contracts' scope and deliveries for the fifth year of the MTA effort and add contract options for the software acquisition pathway effort. The program estimates that it will execute these contract modifications in the second and third quarters of fiscal year 2025. Program officials stated that the program continues to prioritize schedule over cost to address the risk of MGUE Increment 1 ASIC obsolescence. They also stated that future funding needs have yet to be approved.

The program office continues to track schedule as a risk. Several factors could impact schedule, including security certification and the ASIC's ability to meet performance measures. Current models indicate ASIC conformance with power and temperature requirements, the program said, but full verification will not occur until formal qualification testing in 2027.

Leading Product Development Practices

The program reported that it is not using an iterative development approach for the MTA rapid prototyping effort and that its acquisition strategy for the effort does not call for user feedback during design, verification, or validation. Program officials noted that the vendors use a digital twin to evaluate basic ASIC functionality for the prototyping effort, but that the program office does not have access to it and has no option on the contracts for obtaining it. Officials explained that should the military departments—the ultimate users of the MSI card—want access to the twin they would have to separately contract for it. Officials also reported that a modular open systems approach is not applicable to the prototyping effort because the receiver card is not a system. Instead, they stated that it is a component designed according to a government-defined standard for use with multiple weapon systems.

According to the program, moving to the software acquisition pathway will allow it to iteratively develop the receiver over 2 years. During that time, the program plans to develop a minimum viable product, include multiple users and stakeholders in testing, and establish user agreements. The adjusted strategy aligns more closely with leading product development practices, which are focused on delivering meaningful capability to the warfighter more quickly. We will continue to monitor these efforts.

Cybersecurity

The program previously reported that it expected to test its cybersecurity objectives during the operational demonstration—which is planned for after the 5-year MTA time frame. However, the program is now updating its cybersecurity strategy due to its planned transition to the software acquisition pathway.

Program Office Comments

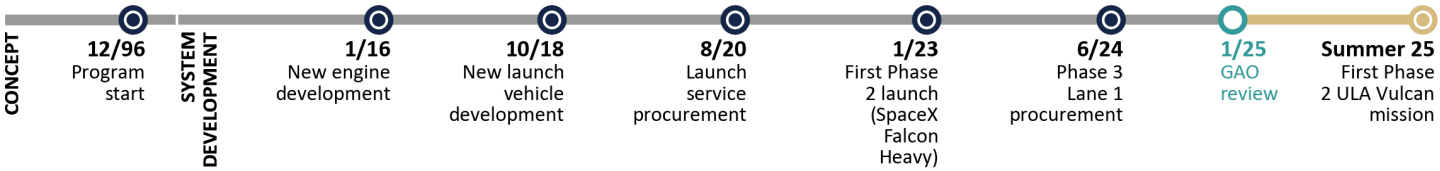
We provided a draft of this assessment to the program office for review and comment. The program stated that, in calendar year 2024, it mitigated ASIC risk that would have cost the program approximately $100 million more and caused a 2-year delay. It added that, as a resolution to address ongoing schedule and cost challenges, it received Air Force approval to move from MTA rapid prototyping to the software acquisition pathway after the MTA effort completes.

According to the program office, the handheld MTA effort will use early integration opportunities from the MGUE Increment 2 software acquisition pathway effort to achieve production readiness by the end of the handheld's MTA effort in 2028. The MGUE Increment 2 program stated that the handheld MTA effort will achieve this readiness by maturing the design through MSI card integration, requirements verification, and operational testing.

Source: Blue Origin, SpaceX and United Launch Alliance. | GAO-25-107569

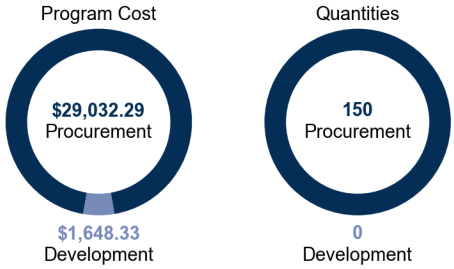
National Security Space Launch (NSSL)

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), Space Exploration Technologies Corporation (SpaceX), and Blue Origin. These procurements are intended to ensure that 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.



Estimated Cost and Quantities

(fiscal year 2025 dollars in millions)



Procurement amounts represent all funding for Phase 2 and Phase 3 contracts for fiscal years 2020–2030.

Software Development as of January 2025

Approach: Information not available

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

Information not available

Percentage of progress to meet current requirements:

Information not available

The program reported that it only procures the launch services and does not take any ownership of hardware or software.

Program Essentials

Prime contractor: Blue Origin, Space Exploration Technologies Corporation, United Launch Alliance (Phase 3 Lane 1); TBD (Phase 3 Lane 2)

Contract types: IDIQ (Phase 3 Lane 1); Indefinite Delivery Requirements (Phase 3 Lane 2)

Current Status

After nearly 3 years of delays due to engine development taking longer than expected, ULA completed development of its new launch vehicle, Vulcan. ULA conducted the first Vulcan certification test flight in January 2024 followed by the second certification flight in October 2024. ULA and NSSL program certification requires two successful test flights. The first Phase 2 Vulcan mission is scheduled for summer 2025, nearly 3 years later than originally planned.

Phase 3 of the program's acquisition strategy uses a "dual lane" approach with two contract types to assure DOD access to space. In Lane 1, providers compete for approximately 30 less-demanding launches over a 5-year period to encourage competition and on-ramp new launch providers. In June 2024, the Space Force reported awarding Phase 3 Lane 1 indefinite delivery/indefinite quantity contracts to SpaceX, ULA, and a new provider—Blue Origin. Blue Origin's launch vehicle conducted its first launch in January 2025. In Lane 2, the Space Force will award contracts for launch services for approximately 54 launches to up to three certified providers able to meet the most demanding requirements. Currently, only SpaceX's Falcon launch vehicles are certified for DOD launches. The program expects Vulcan to be certified in early 2025 and is currently working with Blue Origin to certify its New Glenn launch vehicle. The Space Force plans to award Phase 3 Lane 2 contracts in early 2025.

The program plans to acquire services for approximately 85 launches during Phase 3—a significant increase from the prior phase. This is due in part to DOD's plans for constellations of large numbers of satellites in low-Earth orbit. To address the increase, the program plans to invest $80 million to create additional infrastructure for payload processing—the critical stage in which satellites are encapsulated in the protective nosecone before transport to the launch pad.

Program Office Comments

We provided a draft of this assessment to the program office for comment and incorporated its technical comments as appropriate. The program stated that NSSL provides resilient, responsive launch services that secure the nation's access to space; launches of the last Delta IV and Atlas V in 2024 ended reliance on Russian engines; it increased launch providers by adding the New Glenn vehicle; and it launched a GPS satellite only 7 months from contract award.

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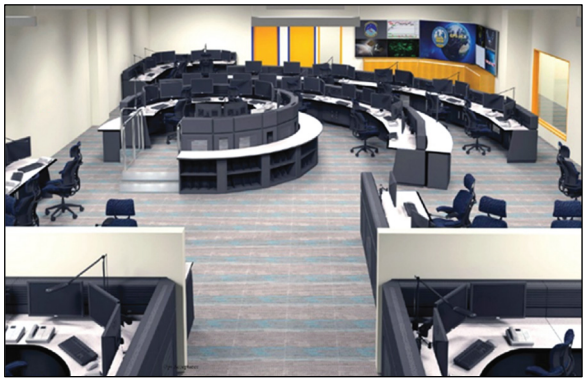
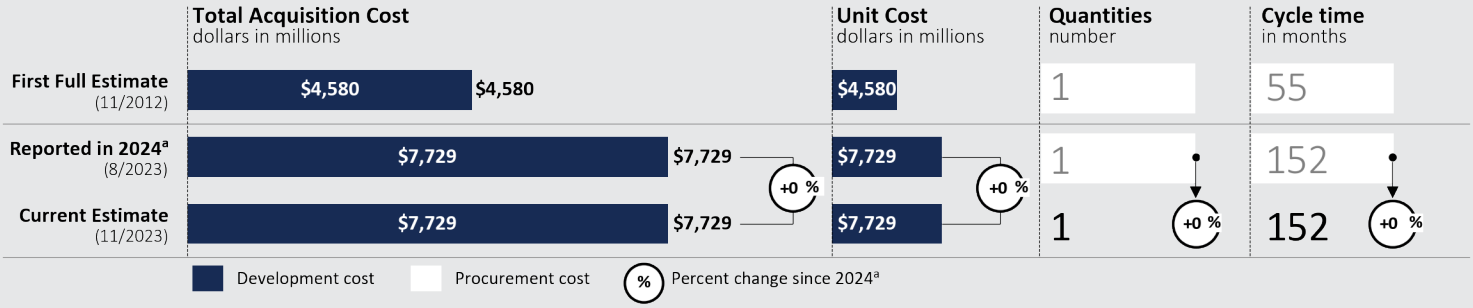


Source: U.S. Air Force. | GAO-25-107569

Next Generation Operational Control Systems (OCX)

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 and 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 series, called Blocks 1 and 2, includes satellite control, among other functions. OCX Block 3F is a separate follow-on program for the GPS III satellites. We assessed Blocks 1 and 2.

Program Performance fiscal year 2025 dollars in millions



Total quantities comprise one development quantity and zero 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 reported that the Space Force is in the process of revising OCX's schedule. As a result, cycle time may change if initial capability is delayed.
[a]GAO-24-106831.

Software Development

as of January 2025

Approach: DevSecOps and Waterfall

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions): $3,180.62 | 41.15%

Percentage of progress to meet current requirements: 76–99%

Program Essentials

Prime contractor: Raytheon

Contract Type: CPIF/CPAF (development)

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	NA
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	●

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated … Information not available NA - Not applicable

We did not assess the test of a system-level integrated physical prototype because OCX is primarily a software program.

OCX Program

Program Performance

The OCX program continues to face delays for Blocks 1 and 2 development and testing. The delays resulted in pushing the expected delivery of the program to June 2025, an additional 9-month delay since last year's reported estimate.

The program expects to complete a series of required testing and development milestones prior to the delivery of OCX Blocks 1 and 2. One of these milestones is site acceptance testing, which DOD development test officials expect to be completed in March 2025—a 6-month delay since last year's estimate. DOD test officials cited air conditioning failure at one of the site acceptance test sites and funding gaps as reasons for recent program delays. According to program officials, the contractor completed technical orders and certifications necessary to support operator training in September 2024—another milestone required before delivery.

The program is continuing to address a backlog of critical deficiencies throughout testing. Test officials noted that, as of December 2024, the OCX program has 102 open deficiencies related to site acceptance testing requirements, 39 related to simulators and testing systems, and 129 directly related to developmental testing. According to defense development test officials, the program reported a decrease in reported deficiencies that will allow it to reduce the backlog, though new deficiencies will continue to be identified when new testing starts.

Leading Product Development Practices

The OCX program reported some implementation of leading product development practices. It is implementing a modular open systems approach with hardware that uses modular commercial-off-the-shelf components, according to the program office.

According to the program, it has been incorporating feedback from stakeholders and end users—including DOD's military departments, civilian agencies such as the Federal Aviation Administration, and the broader GPS-user base of commercial airline pilots—during design, verification, and validation. However, according to the program, OCX is not developing a minimal viable product that incorporates user feedback and prioritizes capabilities because the program was given specific performance parameters identified in previously established requirements.

The program reported that it does not plan to develop a digital twin or digital thread for OCX. According to program officials, implementing these digital tools at this point would be cost prohibitive. The officials stated that the program developed a partial twin of the GPS constellation through a system simulator, which they noted allows the program to test requirements and resolve anomalies.

The program reported that it changed from a linear to an iterative approach in 2017 due to poor performance and design failures that led to rework. By not fully adopting the leading practices that facilitate an iterative solution—such as refining requirements and prioritizing capabilities to ensure they meet user needs—the program is at risk of similar outcomes.

Cybersecurity

Program documents indicated that the program plans to conduct a series of cybersecurity tests in 2025, but like other milestone dates, they have been delayed. For example, the program's adversarial assessment is now scheduled for December 2025, 12 months later than reported last year. DOD developmental testing officials noted that deferring cybersecurity testing represents a risk to the program achieving initial operational capability.

Other Program Issues

In November 2024, DOD announced a $196.7 million modification to Raytheon's OCX development contract. According to program officials, the modification will support testing of OCX Blocks 1 and 2 after delivery to operations, as well as address remaining deficiencies.

Defense testing officials noted that the prioritization of resources to support OCX Blocks 1 and 2 is continuing to affect development of the next iteration of the system, OCX 3F, which is necessary to launch and support the GPS IIIF satellites currently in development. Officials reported that OCX 3F is now undergoing a rebaseline due to delays. We discuss the effect of these delays to GPS IIIF satellites in a separate assessment.

Program Office Comments

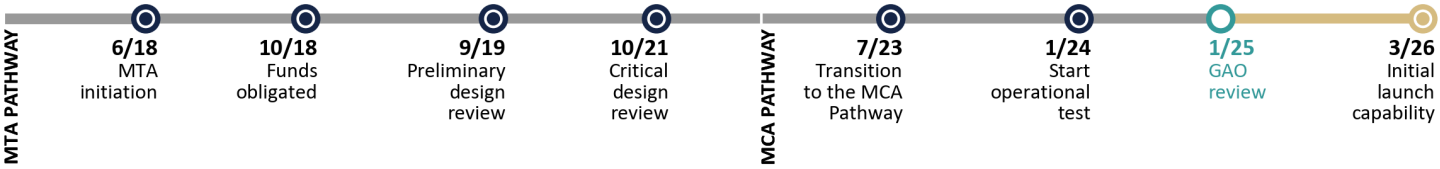
We provided a draft of this assessment to the program office for review and comment.

The program office stated that OCX is progressing through testing and transition events and uniformed operators successfully commanded GPS satellites with the OCX system. The program stated that this resulted in the first broadcast of an OCX-generated navigation signal from a GPS satellite. The program office also stated that it is continuing to test daily and is working with Raytheon to address any lingering deficiencies and outstanding requirements. According to the program office, it expects OCX Blocks 1 and 2 to achieve initial capability in the third quarter of fiscal year 2025 and operational acceptance in the second quarter of fiscal year 2026.

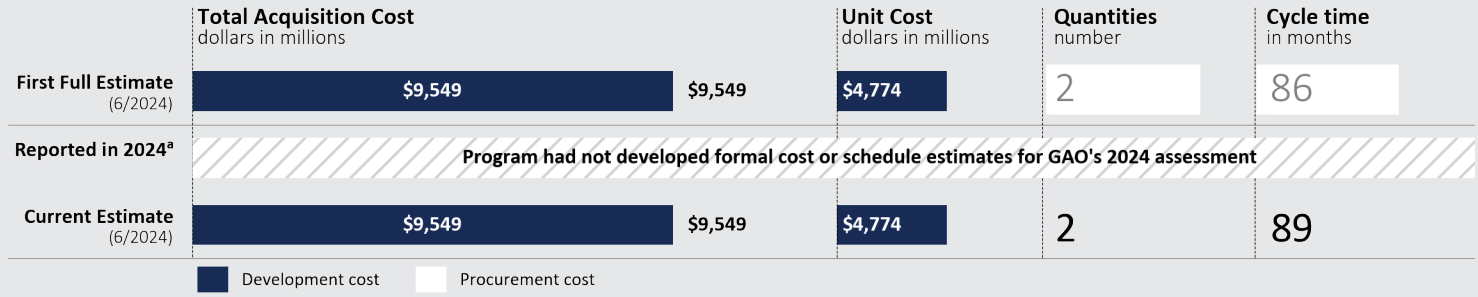
Source: U.S. Space Force. | GAO-25-107569

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) and will consist of two geosynchronous Earth orbit satellites. These satellites are intended to provide initial missile warning of a ballistic missile attack on the U.S., deployed forces, and allies. The program, which transitioned to the major capability acquisition pathway in 2023, expects initial launch capability in 2026. Two additional ongoing efforts are expected to deliver two polar coverage satellites and modernize the ground segment.



Program Performance fiscal year 2025 dollars in millions



We measured cycle time from the MTA funds obligated date to the date the program plans to achieve initial launch capability. The cycle time for the current estimate is based on a revised initial launch capability date provided by the program office in February 2025.
[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Agile, Incremental, DevOps, and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$318.01 | 3.33%

Percentage of progress to meet current requirements: 51–75%

Program Essentials

Prime contractor: Lockheed Martin

Contract Type: CPIF

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	●
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	NA
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	○

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated … Information not available NA - Not applicable

We did not assess the test of a system-level integrated physical prototype in an operational environment due to the difficulty of conducting tests in the operational environment—space.

Next Gen OPIR GEO Program

Program Performance

In June 2024, the Assistant Secretary of the Air Force, Space Acquisition and Integration office approved the Next Gen OPIR GEO acquisition program baseline. The approval followed a decision to reduce the constellation from three satellites to two satellites. Program officials told us that continued positive performance of the SBIRS constellation and the strategic pivot to conduct missile tracking from other orbits drove the decision. Officials reported that this decision would not result in a coverage gap due to the first GEO satellite's planned delivery in 2025.

In September 2024, program officials reported successful completion of the thermal vacuum testing on the mission payload, a critical milestone for the program. Thermal vacuum testing simulates the space environment to determine if the article under test will perform in its intended environment. The program office reported that the payload was installed on the space vehicle in September 2024 and scheduled complete end-to-end testing in December 2024.

Despite recent successes, the program continues to face schedule challenges, driven largely by the mission payload. Program officials reported the mission payload was delivered in August 2024, after a 13-month delay. As a result, the program has no buffer in its schedule to first launch; any payload and space vehicle integration delays will likely result in launch delays and program cost increases. Additionally, the recently approved acquisition program baseline asserts that the program contract schedule is aggressive, and that it has overall high risk in meeting all program objectives for an initial launch capability in fiscal year 2025 due to mission capability and system development and integration risks. A launch delay of at least a year is likely for the first GEO satellite, as we reported in 2024.

In February 2025, after our cutoff date for new information, the program reported that the satellite will be delivered as planned in September 2025, but due to a crowded 2025 launch manifest, Next Gen OPIR GEO will be launched no earlier than March 2026. This launch determination was made by the Space Force's launch program office.

Leading Product Development Practices

Contrary to what the program reported last year, we determined that the program is not following iterative development. Instead, it is using a more traditional acquisition approach, wherein it identifies highly detailed system requirements likely to be met by a specific materiel solution. Additionally, while the program stated that it identified a minimum viable product as part of its approach, that product incorporates only three of the four elements that leading practices define as necessary to establish a minimum viable product. It does not include the fourth element—prioritize capabilities that can be fielded to meet user needs. Without this element, we do not consider the product that the program identified to be a minimum viable product.

The program stated that it completed development of a digital thread, which will support several activities, including requirements analysis, design evaluation, integration, testing, and support and sustainment. The program added that it encountered challenges in developing the thread, such as identifying the necessary components to validate, implement, and execute system integration.

Software and Cybersecurity

The program office reported that it is using a contractor-led approach for software development, since the prime contractor has the subject matter expertise to leverage the heritage SBIRS software baseline. The program also noted that a subcontractor—with robust software development experience and experience developing the complete mission payload systems—is developing the payload software.

The program plans to conduct a key cybersecurity task, cooperative vulnerability identification, in 2025—after the start of operational testing. This may result in late discovery of system vulnerabilities that require more difficult remediation, which could have a negative effect on cost, schedule, and performance.

Program Office Comments

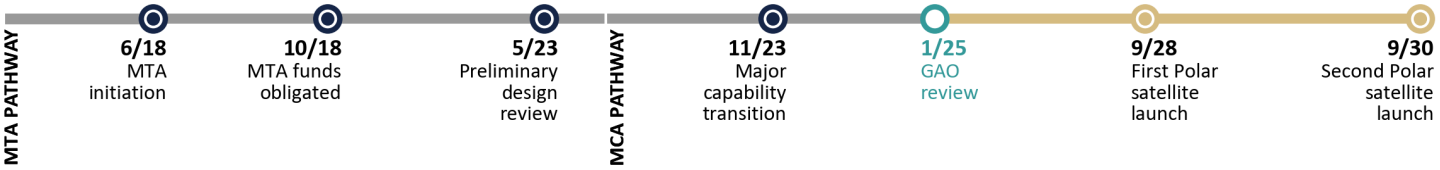
We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

It stated that it is demonstrating execution in speed of acquisitions and is primed to deliver two satellites capable of detecting advanced adversary missiles to ensure sustained operations in contested environments. The program also noted that it continues to mitigate technical and cost risks. It also stated that it frequently engages with the operational community to understand their priorities for minimally viable capabilities that can be fielded most quickly. According to the program, this understanding ensures the right capability is delivered when needed and at the right value. The program added that it is on track to deliver in half the time it took to deliver its predecessor SBIRS program, which it considers a testament to its proactive approach, collaborative partnerships, and adaptability.

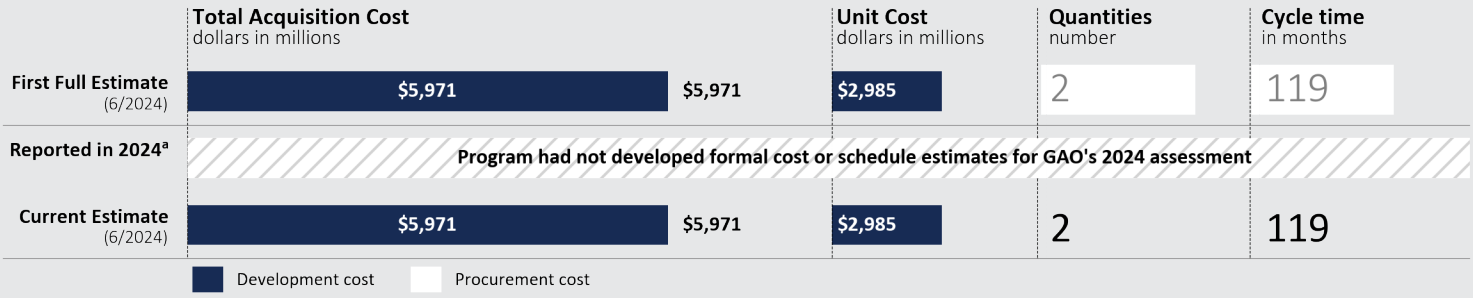
Source: LAAFB Arts and Graphics Department, USG. | GAO-25-107569

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 as well as 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. We assess two related efforts 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 2025 dollars in millions



[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Agile, Incremental, DevOps, and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$237.1 | 3.97%

Percentage of progress to meet current requirements: 51–75%

The program reported that the software costs represent only cost and percentage of total acquisition cost associated with Phase 1.

Program Essentials

Prime contractor: Northrop Grumman

Contract Type: CPIF

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	◐
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	NA
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	○

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

We did not assess the test of a system-level integrated physical prototype in an operational environment due to the difficulty of conducting tests in the operational environment—space.

Next Gen OPIR Polar Program

Program Performance

Program reports indicate that the program is progressing according to plan and that the program is on track for launch in 2028. Since our last assessment, the NG OPIR Polar program successfully completed several significant design reviews and entered Phase 2 of its acquisition. Specifically, in April 2024, the program finalized its space vehicle critical design review, a traditional marker of design stability. Successful completion of these reviews signal that the program is ready for fabrication, assembly, and integration. In addition, the program completed ground and system integration critical reviews in August 2024.

Program officials indicated that Phase 2 of the Next Gen OPIR Polar acquisition will encompass integration, testing and launch, and transition to operations.

Leading Product Development Practices

The Next Gen OPIR Polar program reported that it was not using an iterative development approach for product development. For example, the program stated that for a satellite system, a minimum viable product is not suitable to be fielded to an operational environment, and that these satellites are launched with hardware and software that deliver planned capability. However, we previously found that implementing an iterative structure could result in better program outcomes and efficiencies for satellite programs by using digital tools to prioritize the most essential capabilities with users and adding iterative functionality, such as through software updates.

Program officials told us the program is engaging with users and stakeholders regularly during design, development, integration, and test to solicit feedback. They added that these forums include working groups, technical exchange meetings, and user engagement discussions. Officials also indicated that design modifications have been approved and documented based on these engagement forums. We previously found that direct and continuous feedback from potential users on product development efforts assists developers in prioritizing and delivering the most essential capabilities quickly.

We also found that leading companies use modern tools such as digital twins and digital threads to simulate potential operating scenarios and build confidence that the products will work when produced. According to the program, it initiated development of portions of a digital thread and plans to further develop the thread in the future. The program, however, stated that additional modeling and digital twins would add unnecessary cost, as the program's foundation is built on successfully integrating heritage technology and engineering design units.

Cybersecurity

In July 2024, the Space Force finalized the program's cybersecurity strategy. The program expects to conduct at least two more tests during 2025, followed by a full system assessment in 2027.

The program reported that it intends to use "continuous authorization to operate" for the space vehicles and ground segments. This is a modernized authorization approach that helps organizations maintain security and compliance for their information systems. A system with a continuous authorization to operate has demonstrated sufficient maturity in its ability to maintain a resilient cybersecurity posture so that traditional risk assessments and authorizations become redundant.

Other Program Issues

Next Gen OPIR Polar will rely on a related MTA ground system called FORGE, which we assess separately in this report. Specifically, command and control and mission data processing functions will reside in the FORGE program for Next Gen OPIR Polar. FORGE must successfully complete multiple development, integration, and test steps before it will be ready for system-level testing. Additionally, the Next Gen OPIR Polar program is leveraging the main mission payload from a separate MTA effort called Next Gen OPIR GEO, which we also assess in this report. The payload will need to be modified to some extent to operate in the polar orbit. If the modified payload experiences issues integrating onto the Next Gen OPIR Polar space vehicle, or if the FORGE system lacks sufficient maturity by the end of fiscal year 2026, Next Gen OPIR Polar is likely to experience schedule delays and cost growth.

Program Office Comments

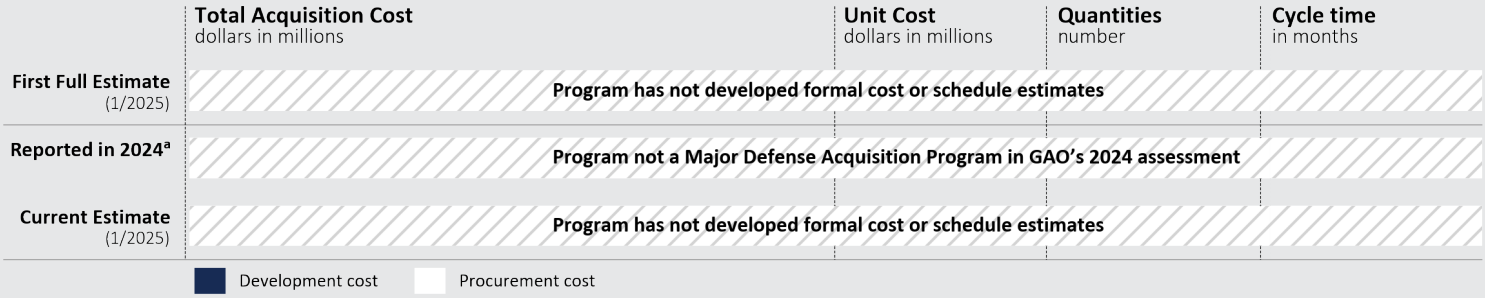
We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office stated that it is primed to deliver two Next Gen OPIR Polar missile warning and tracking satellites capable of detecting advanced adversary missiles over the northern hemisphere and of ensuring operations in contested environments. The program added that it continues to mitigate technical and cost risks and frequently engages with the operational community to understand its priorities for minimally viable capabilities that can be fielded most quickly. This understanding, it stated, ensures the right capability is delivered when needed and at the right value. The program added that it is on track to deliver its first satellite in 2028.

Source: U.S. Air Force. | GAO-25-107569

Protected Tactical SATCOM-Resilient (PTS-R)

The Space Force's PTS-R is a space-based system that processes the protected tactical waveform to provide users resilient, antijamming satellite communications in contested environments. In June 2024, the program's prior MTA rapid prototyping effort, now referred to as PTS-Prototype (PTS-P), transitioned to the major capability acquisition (MCA) pathway. PTS-P is intended to prototype modular, scalable, hostable payloads. These prototypes are to be launched in late 2025 and early 2026 to demonstrate on-orbit performance, provide early use capability, and reduce risk. PTS-R is part of the Space Force's broader Protected Anti-Jam Tactical SATCOM (satellite communications) mission area.

Program Performance fiscal year 2025 dollars in millions



[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Agile and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions): Information not available

Percentage of progress to meet current requirements: 76–99%

The program reported that software costs are to be determined at contract award.

Program Essentials

Prime contractor: Boeing, Northrop Grumman (PTS-P); TBD (PTS-R)

Contract Type: FFP (PTS-P); CPIF, CPAF (planned PTS-R)

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	NA
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	◔

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated … Information not available NA - Not applicable

We did not assess the test of a system-level integrated physical prototype in an operational environment due to the difficulty of conducting tests in the operational environment—space.

PTS-R Program

Program Performance

In June 2024, PTS-P transitioned from the MTA pathway to the major capability acquisition pathway as the PTS-R program, with entry in the technology maturation and risk reduction phase. Under the MTA rapid prototyping effort, PTS-P matured all critical technologies and performed risk reduction efforts for PTS-R. According to program officials, they will demonstrate and test the capabilities of the prototypes on orbit to ensure they operate as expected and can communicate with ground terminals. In addition, officials noted that they intend to use the prototypes as test and training assets and to provide residual operational capability.

The program decided to launch and test PTS-P prototypes as stand-alone assets rather than conduct testing in a digital environment. Program officials stated that, if the prototype demonstrations were successful, they could pivot the prototypes into on-orbit capabilities. Officials said that the prototypes have a 5-year design life and will be used to conduct residual operations.

PTS-R officials said that the program completed security verification testing of the program's cryptographic unit, a critical technology. These officials told us that final certification of these units is scheduled for March 2025 and that certification must be achieved by the scheduled November 2025 launch of the first prototype.

PTS-R officials said that on-orbit testing for the PTS-P prototypes has been delayed to 2026. Previously, we reported that the first test flight for the program was scheduled for April 2025 with on-orbit testing and demonstration scheduled for October 2025. PTS-R officials stated that launch and the first test flight of the prototypes are now scheduled for November 2025 and January 2026, respectively. Officials noted that the planned dates slipped due to a delay resulting from the number of planned launches. Both prototypes will be launched on Vulcan rockets, which have experienced certification delays.

Leading Product Development Practices

The program reported that it incorporated some leading product development practices. For example, it said that it obtained user feedback during quarterly test team meetings and during PTS-P prototype demonstrations, preliminary design review, and critical design review. In addition, it expects to collect user feedback during on-orbit testing of the prototypes—intended to provide fielded on-orbit operational capability—and incorporate that feedback into the PTS-R satellites that the program plans to develop on the major capability acquisition pathway. However, the program did not report that the prototypes include a key element—prioritize capabilities that can be fielded most quickly to meet user needs. Without this element, we do not consider the product that the program identified to be a minimum viable product.

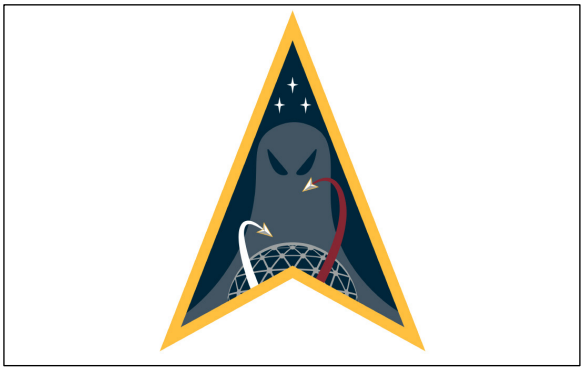
The program reported that requirements for the follow-on satellite will already be set prior to prototype demonstrations, which limits the program's ability to refine requirements as user needs evolve. Rather than fixing requirements before the start of design, leading companies use digital twins—virtual representations of a physical system—to test the performance of different designs and prioritize the most essential capabilities. PTS-R officials said that PTS-P development did not require a digital twin for technology maturation, but that they will evaluate the efficacy of that approach during source selection for the upcoming PTS-R contract. Officials noted that some digital models were used on PTS-P to model the performance aspect of prototype designs. According to the program, the models were not digital twins but gave it assurance that the prototypes could perform on orbit. We previously found that digital design tools, such as digital twins and digital threads, can enable rapid iterative design cycles and inform decision-making, such as how to refine requirements for future cycles.

Other Program Issues

According to program officials, PTS-R is conducting a limited competition between the two prototype vendors and plans to award the contract roughly 9 months later than previously anticipated. According to program officials, the program's acquisition strategy was amended to move PTS-R's transition to the technology maturation and risk reduction phase rather than engineering and manufacturing design. They stated that this allows the program to complete all required documentation, such as an acquisition program baseline.

Program Office Comments

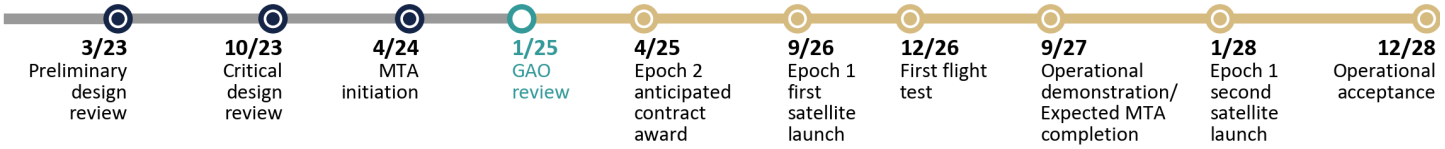
We provided a draft of this assessment to the program office for review and comment. It provided technical comments, which we incorporated where appropriate. The program office stated that both prototypes continue to progress through integration and testing to support launch and the start of on-orbit demonstrations. The program office noted that extensive ground testing and demonstrations conducted during rapid prototyping have shown system requirements are achievable with the technologies developed. Further, it added that on-orbit testing of the prototypes will continue to enable iteration of key elements to be used in operation of the PTS-R system. According to the program office, contract award for the PTS-R program remains on track for an award in the second quarter of 2025.



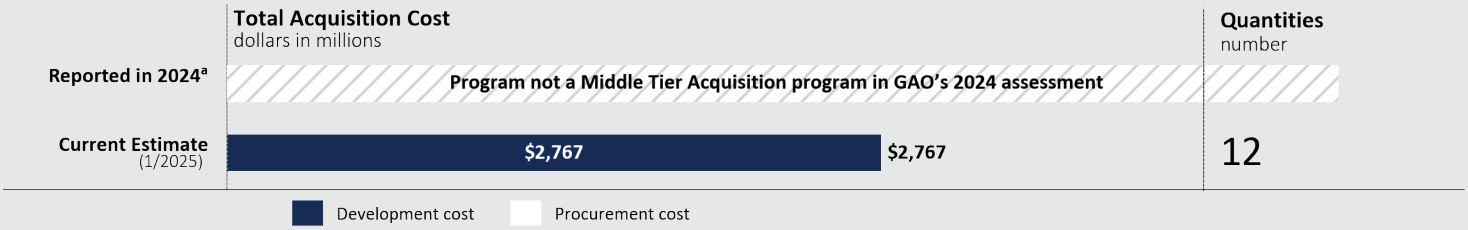
Source: U.S. Space Force. | GAO-25-107569

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

Resilient MW/MT MEO is an effort by the Space Force's Space Systems Command 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 satellite Epochs focused on delivering the latest Overhead Persistent Infrared sensing technology into medium-Earth orbit (MEO). 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. The program intends to initiate Epoch 2 on the major capability acquisition pathway in early 2025 prior to completing the Epoch 1 rapid prototyping effort in 2027.



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2025 dollars in millions



[a]GAO-24-106831.

Software Development

as of January 2025

Approach: Agile, Waterfall, Incremental, and DevSecOps

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$463.46 | 16.75%

Percentage of progress to meet current requirements: 26–50%

According to the program, the total percentage of software complete only reflects new development and not code that is being reused.

Program Essentials

Prime contractor: Millenium Space Systems; L3Harris; Parsons

Contract type: FFP; CPIF; CPFF

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	◐
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	◐
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	◔
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	◔
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	NA
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	◔

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated … Information not available NA - Not applicable

We did not assess the test of a system-level integrated physical prototype in an operational environment due to the difficulty of conducting tests in the operational environment—space.

Resilient MW/MT MEO Program

Program Performance

The Resilient MW/MT MEO program completed its Epoch 1 system design closure review in July 2024 and plans to award Epoch 2 contracts in April 2025 for coverage of two MEO orbital planes. Program officials said that they expect the two critical technologies identified last year—large-format focal plane arrays and optical crosslink terminals—to reach maturity and undergo further representative space environment testing before the Epoch 1 satellite launch, scheduled for September 2026.

The program previously reported plans to develop up to nine satellites. Program officials said that in June 2024, the program terminated its contract with Raytheon, a prime contractor for three satellites, due to cost and schedule growth. However, program officials stated that Epoch 1 increased from six to 12 satellites due to cost savings realized from terminating the Raytheon contract and adding six less-expensive satellites from Millenium Space Systems with a smaller payload. Space Systems Command officials stated that the addition of six satellites will also increase the imagery coverage for missile warning/missile tracking missions. Raytheon's early Epoch 1 development efforts, before cancelation, also provided insight into design complexity needed for future Epoch development, according to Space Systems Command officials. For example, Epochs 3 and 4 may need to have satellites at a higher MEO orbital plane and a wider field of view to provide consistent global coverage.

Leading Product Development Practices

The program reported that it is implementing some elements of leading product development practices, but it is not fully implementing the iterative efforts that we found lead to efficiencies. For example, the program reported that it identified an MVP incorporating both stakeholder and user feedback. However, it is not taking the important step of fully demonstrating the MVP for the first iteration before moving forward with the next. Program officials stated that performance outcomes of the MVP in the first Epoch would not necessarily impact the schedule for the second Epoch. They noted that it is a possibility, but that they do not expect this to occur. The officials added that, if significant setbacks in processing performance or communication issues arise, they may consider solutions before launching Epoch 2 capabilities. They also stated that they expect to award Epoch 2 contracts before they see real-time performance of Epoch 1 vehicles. We previously found that demonstrating an MVP—or capability—before starting the next iteration is an important aspect of iterative development used by leading companies.

According to the program, it is in the process of developing a digital twin that is built over time. Space Systems Command uses Cameo, a model-based systems engineering tool, for digital design, build, and integration of the entire system. Program officials stated that they plan for this tool to enable real-time simulation and feedback but can only conduct functional and performance simulations of the system in a digital environment before the system is launched into MEO. We previously reported that the program experienced challenges in leveraging Cameo due to difficulties with shared access to the Cameo infrastructure and communicating with other stakeholders. Program officials said that this is no longer an issue, as stakeholders have obtained the needed information through other means.

Program officials stated that Epoch 1 has requirements for the system to be modular and use common interfaces and standards. For example, the program uses a published standard tracking data format used by the Overhead Persistent Infrared community.

Software and Cybersecurity

Software development for the Resilient MW/MT MEO program, including the Epoch 1 satellites and ground segment, is part of a missile warning and tracking enterprise effort. The program reported that it began software development in May 2021 and completed up to half of its software requirements. Space Systems Command officials identified software development as a medium risk, driven in part by the lack of alignment in functionality and interface development efforts across the enterprise. Program officials reported that they are still assessing software integration risk between the ground and satellites.

The program completed cyber tabletop exercises, and it plans to conduct cooperative vulnerability identification and adversarial cybersecurity development test and evaluation in September 2025 and November 2025, respectively.

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. After our January 31, 2025, cut-off date for new information, the program office stated that it is prepared to initiate Epoch 2 on either the major capability acquisition pathway or the middle tier of acquisition pathway pending a decision by the Office of the Secretary of Defense for Acquisition and Sustainment.

Source: Qinetiq on contract to Space Development Agency. | GAO-25-107569

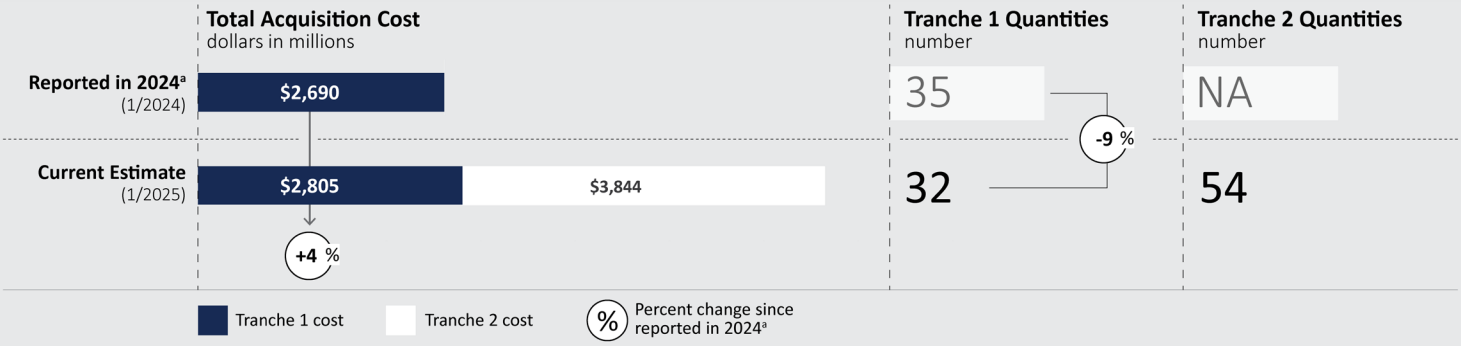
Tranche 1 and 2 Tracking Layer (T1 TRK and T2 TRK)

T1 TRK and T2 TRK are MTA rapid prototyping efforts 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 (PWSA) satellite constellation, to include data communications and missile warning space vehicles (SV). T1 TRK is the first tranche of low-Earth orbit SVs equipped with infrared sensors that will provide initial missile warning and missile tracking capabilities. T2 TRK is the next tranche and will deliver enhanced warfighting capability. T1 TRK and T2 TRK will interoperate with SDA's Tranche 1 and 2 Transport Layer (T1TL and T2TL), which we assessed separately.

MTA PATHWAY

- **4/22** Tranche 1 MTA initiation
- **8/23** Tranche 1 critical design review (vendors 1 and 2)
- **12/23** Tranche 2 MTA initiation
- **1/25** GAO review
- **1/26** Tranche 1 operational demonstration
- **9/26** Tranche 1 initial capability/Tranche 1 expected MTA completion
- **7/27** Tranche 2 operational demonstration
- **1/28** Tranche 2 initial capability
- **3/28** Tranche 2 expected MTA completion

Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2025 dollars in millions



[a]GAO-24-106831.

Software Development

as of January 2025

	T1 Tracking	T2 Tracking
Approach	Agile, DevOps, and DevSecOps	Agile, DevOps, and DevSecOps
Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions)	$92.88 3.31%	Information not available
Percentage of progress to meet current requirements	51-75%	76-99%

The program reported that software costs cannot be accurately reported at this time because space vehicles have not been delivered for Tranche 2 programs.

Program Essentials

Prime contractors: L3Harris; Lockheed Martin; Northrop Grumman; Raytheon; Sierra Space

Contract Type: FFP (using other transaction authority)

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current Status: Tranche 1	Current Status: Tranche 2
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	◐	◐
Use Digital Engineering to Connect Stakeholders and End Users to System Data		
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○	○
Validate Integrated Hardware and Software Functionality in the Operating Environment		
Test a system-level integrated fully digital prototype in a digital operational environment	○	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○	○
Prepare for Modularity to Support Production and Updates to the MVP		
Incorporate a modular open systems approach (MOSA)	●	●

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

T1 TRK and T2 TRK Programs

Program Performance

T1 TRK's quantities decreased by 9 percent since our last assessment. SDA descoped the SVs from the agreement with one of the three T1 TRK SV vendors in early 2024, citing underperformance, and removed those SVs from its T1 TRK launch plans. Program officials said the T1 TRK minimum viable product (MVP) did not include these SVs and the reduction will not impact planned capability.

SDA reported conducting a test readiness review for each of its T1 TRK SV vendors in September and November 2024. Close-out of both reviews, it said, requires availability of flight hardware and software. The program said it plans to launch in June 2025—a 2-month delay from its baseline date. SDA said that to avoid further delays, it is working with the National Security Agency to certify an encryption device and will launch after required certification test steps are completed, but before receiving final certification documentation. According to SDA, the National Security Agency will provide SDA a temporary authority to operate the constellation with conditions until certification is complete.

In January 2024, SDA awarded three other transaction agreements for T2 TRK SVs. These vendors completed preliminary design reviews in late 2024. SDA plans to launch T2 TRK SVs starting in the third quarter of fiscal year 2027 and to conduct an operational assessment in January 2028.

Leading Product Development Practices

SDA reported that it is implementing some elements of leading product development practices, but it is not fully implementing the iterative efforts that we found lead to efficiencies. It stated, for example, that it developed an iterative process and identified an MVP incorporating both stakeholder and user feedback. However, although the program identified the capabilities for an MVP, it is not taking the important step of fully demonstrating the MVP before moving forward with the next iteration. Specifically, SDA officials said that performance outcomes of the MVP in one tranche will not affect the schedule of other tranches. We previously found that demonstrating an MVP—or capability—before starting the next iteration is an important aspect of iterative development used by leading companies.

The program stated that in terms of system-level physical prototype testing, its SV vendors test with their own ground systems. However, it did not indicate that this testing was connected to a digital twin or digital thread. We previously found that such a connection allows stakeholders to collaborate on design strategies and decisions.

Software and Cybersecurity

Software development for T1 TRK and T2 TRK is part of an enterprise effort, including T1TL and T2TL. Last year, program officials said that they expected to complete an MVP for software by May 2024. While only two T1 SV vendors achieved an MVP to start integration and test in July 2024, officials said the schedule impact of this delay is minor due to other delays. SDA plans for end users to begin evaluating and providing feedback on completed software in March 2026.

SDA updated its PWSA cybersecurity strategy in July 2024. As required by DOD, the strategy takes a "zero trust" approach that assumes an attacker is present in the environment. SDA conducted multiple cybersecurity assessments and plans further testing for both T1 TRK and T2 TRK.

Other Program Issues

SDA reported that it does not conduct formal technology or schedule risk assessments, and that the contractors conduct informal assessments. SDA identified three system-level critical technologies and described them as mature based on an informal assessment. However, SDA also identified several technologies within these systems that are key to the mission, including the infrared payloads, optical communications terminals, and encryption. Our best practices for evaluating technology readiness state that programs should select the number of critical technologies to evaluate based on multiple factors, including program documents and consideration for the newness of the operational environment. These best practices also state that programs can conduct a tailored self-assessment in instances of shorter life cycles and streamlined acquisition approaches, which could help inform SDA of additional technology risk areas.

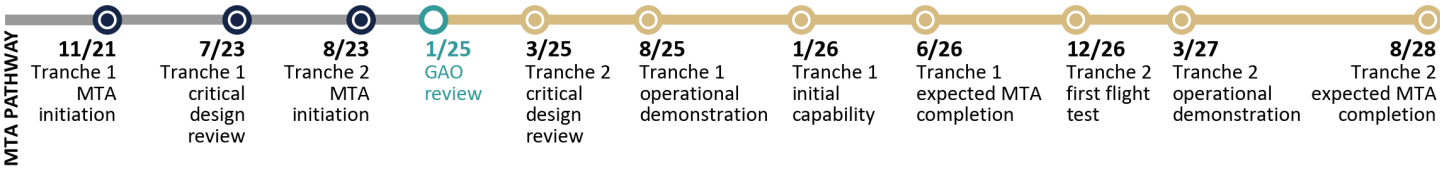
Program Office Comments

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 PWSA's operational utility is based on sensing and communications provided by a constellation of mass-producible SVs. According to the program, Tranche 0 reduced risk for T1 TRK by demonstrating suppression of unwanted signals and shared tracks with the Missile Defense Agency, Space Systems Command, and others. The program also stated that T1 TRK, with T1TL, will support DOD's ability to observe, decide, and act against adversary weapon systems in a timely manner. Additionally, the program stated that T2 TRK will expand on T1 TRK's missile warning, tracking, and defense capabilities via technology enhancements, expanded coverage, and increased integration.

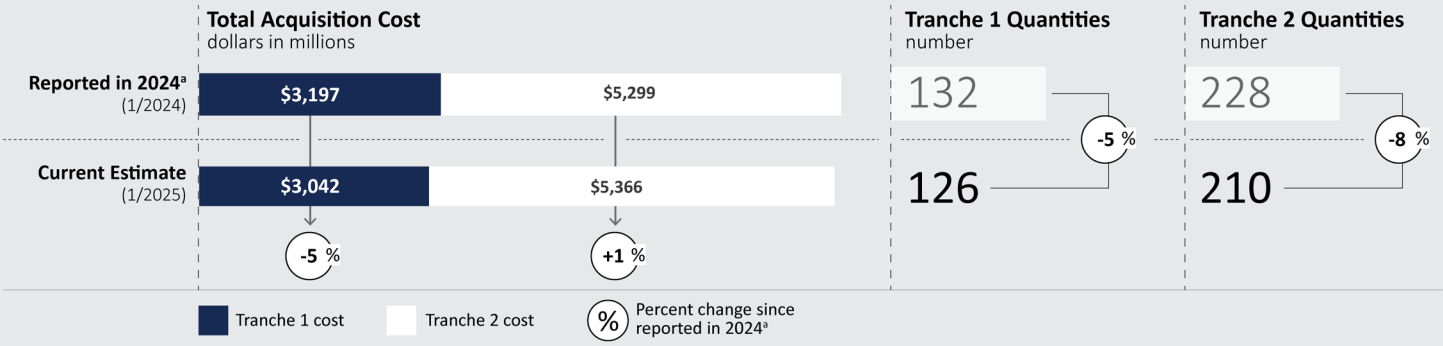
Source: Qinetiq on contract to Space Development Agency. | GAO-25-107569

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 satellite constellation layers in SDA's planned Proliferated Warfighter Space Architecture (PWSA). The transport layer will transmit data throughout the satellite constellation. 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 and will deliver enhanced warfighting capability. We also evaluated PWSA's Tranche 1 and 2 Tracking Layer (T1 TRK and T2 TRK) in a separate assessment.



Estimated Middle Tier of Acquisition Cost and Quantities fiscal year 2025 dollars in millions



[a]GAO-24-106831.

Software Development

as of January 2025

	Tranche 1	Tranche 2
Approach	Agile, DevOps, and DevSecOps	Agile, DevOps, and DevSecOps
Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions)	$125.94 4.14%	Information not available
Percentage of progress to meet current requirements	51-75%	Information not available

The program reported that the Tranche 2 software costs could not be accurately reported until contractor reports are delivered.

Program Essentials

Prime contractors: York Space Systems; Lockheed Martin; Northrop Grumman; Rocket Lab

Contract Type: FFP (using other transaction authority)

Implementation of Leading Product Development Practices as of January 2025

	Current Status	
Iteratively Develop a Minimum Viable Product (MVP)	Tranche 1	Tranche 2
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	◐	◐
Use Digital Engineering to Connect Stakeholders and End Users to System Data		
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○	○
Validate Integrated Hardware and Software Functionality in the Operating Environment		
Test a system-level integrated fully digital prototype in a digital operational environment	○	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○	○
Prepare for Modularity to Support Production and Updates to the MVP		
Incorporate a modular open systems approach (MOSA)	●	●

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated ... Information not available NA - Not applicable

T1TL and T2TL Programs

Program Performance

SDA officials reported that PWSA tranches, including T1TL and T2TL, are being continuously developed every 2 years. They further noted that each current and future tranche will have satellites with 5-year lifespans to allow for rapid technology insertion in response to changing threats, and the MTA efforts will not transition to the major capability acquisition pathway or other acquisition pathway. Rather, SDA refers to these satellites as fieldable prototypes and is planning to launch its first T1TL satellites in summer 2025. This is a delay from the original planned launch date of September 2024, which program officials attribute to unexpected supply chain challenges.

For both T1TL and T2TL, SDA identified three critical technologies. Additionally, it added a fourth for T2TL. SDA also identified several technologies that are central to the success of the constellation, including optical communications terminals that support laser communications. However, SDA reported that it does not conduct formal technology risk assessments and schedule risk assessments, as those assessments are conducted informally by contractors. SDA plans to conduct operational testing in August 2025 for T1TL and in December 2026 for T2TL.

Leading Product Development Practices

SDA reported implementing some elements of leading practices for product development, but it is not fully implementing the iterative efforts that we found lead to efficiencies. For example, the program stated that it developed an iterative process and identified an MVP incorporating both stakeholder and user feedback. However, although the program identified the capabilities for an MVP, it is not taking the important step of fully demonstrating the MVP before moving forward with the next iteration.

Specifically, SDA officials said that performance outcomes of the MVP in one tranche will not affect the schedule of other tranches. SDA officials reported that T0, the demonstration tranche, has demonstrated some communications capability, including radio frequency signals. However, SDA also reported that T0 has only partially demonstrated a key capability—performance of the optical communications terminal—and T0 has not demonstrated its planned minimum viable capability. We previously found that demonstrating an MVP—or capability—before starting the next iteration is an important aspect of iterative development used by leading companies.

We reported last year that by moving forward with two additional iterations, T1TL and T2TL, before testing the initial demonstration tranche, the program is missing an opportunity to validate planned capabilities. This continues to be the case.

Software and Cybersecurity

Software development for T1TL and T2TL is part of an enterprise effort, including the T1 TRK and T2 TRK. Last year, program officials reported that they began software development in September 2022 for T1TL and expected to complete an MVP for software by April 2024. This year, they reported that SDA plans to involve end users in August 2025. They also reported that they do not plan to use the software acquisition pathway since software development is incidental to the primary goal of the T1TL MTA effort.

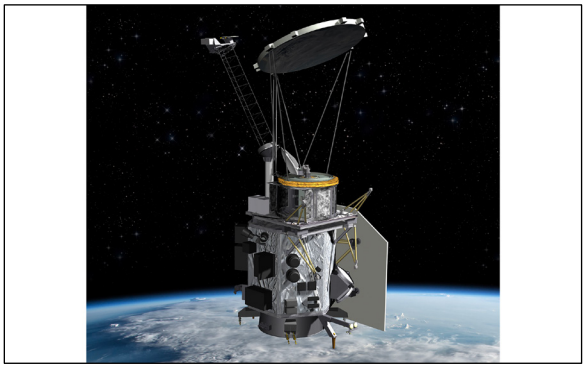
SDA updated its PWSA cybersecurity strategy in July 2024. The strategy takes a “zero trust” approach required by DOD. This approach assumes that an attacker is present in the environment and minimizes access to resources. For T1TL, SDA conducted multiple cybersecurity assessments. This includes an adversarial cybersecurity development test and evaluation, which conducts a cybersecurity event using realistic threat response techniques to identify vulnerabilities. For T2TL, SDA conducted a cyber table top exercise to explore the effects of cyber offensive operations on overall mission capability. SDA plans further cybersecurity testing for both T1TL and T2TL.

Other Program Issues

SDA reported that it conducted supply chain assessments, including market research, but officials reported significant challenges with ensuring access to required components. For example, T1TL requires more than 500 optical communications terminals for the constellation’s 126 satellites. However, officials reported that in January 2025, the program had received 20 terminals. Officials stated that this contributed to the delay of the program’s first planned launch of T1TL satellites. SDA said it provided additional funding to the terminal developers to increase production.

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 PWSA’s operational utility is based on sensing and communications provided by a constellation of mass-producible space vehicles. According to the program, T0 reduced risk for Tranche 1 by demonstrating laser space links as well as demonstrating a radio frequency link from space to land, sea, and air assets for the first time, with no change in mission user equipment. The program stated that T1TL will provide global communications and deliver regional connectivity in support of the warfighters and serve as the backbone for joint command and control. It added that T2TL will expand T1TL capabilities with additional space vehicles for data transport, bring in new communication modes to meet warfighter demands for additional satellite communications, and provide relative navigation around the globe.



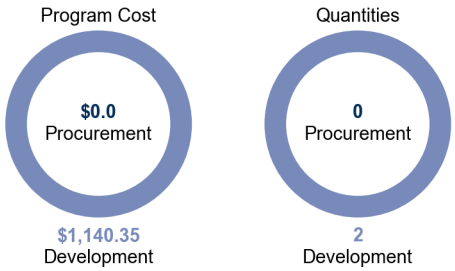
Source: ©2024 by BAE Systems, Inc. All rights reserved. | GAO-25-107569

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 six of 12 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 mission planning and weather forecasting models. The WSF satellites and other capabilities will fulfill the coverage requirements currently supported by the Defense Meteorological Satellite Program, which is part of the greater space-based environmental monitoring family of systems.

Program Performance

(fiscal year 2025 dollars in millions)



	Reported in 2024[a] (8/2023)		Current Estimate (12/2023)
Acquisition Cost	$1,164	-2 %	$1,140
Unit Cost	$581.8	-2 %	$570.2
Cycle Time (in months)	52	+13%	59

(%) Percent change since 2024[a]

[a]GAO-24-106831.

Software Development as of January 2025

Approach: Agile, Waterfall, and Incremental

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$93.04 | 8.16%

Percentage of progress to meet current requirements: 100%

Program Essentials

Prime contractor: BAE Systems, Space and Mission Systems Inc.

Contract type: FFP

Current Status

In April 2024, the Space Force successfully launched the first of two satellites into low-Earth orbit. A lag in a processing system upgrade and subsequent delay to starting the operational utility evaluation delayed the first satellite's initial operational capability by 7 months to April 2025, which, in turn, hindered its operational testing. The program office plans to meet full operational capability for the first satellite by September 2025 and to have the second satellite available for launch by January 2026, according to program officials.

Program officials reported that WSF is not applying iterative development because the program's original performance parameters cannot be refined and a minimum viable product was not needed. In contrast, we found that leading companies employ an iterative development approach that allows them to improve on prior iterations as user needs evolve and technology advances. Officials said that the program incorporated user feedback at the beginning of the acquisition, and that it considered user involvement during development, but did not have user agreements in place. Officials said that they are coordinating an end user agreement for the satellite control authority after fielding the first satellite.

The second satellite is a production carbon copy of the first satellite, and the program does not plan to make changes to the design or manufacturing processes unless the first satellite has on-orbit system issues with a direct mission effect. Currently, officials are proving the design and data quality of the first satellite using on-orbit calibration and validation data, they told us. They said that they identified an on-orbit radio interference issue that the prime vendor will analyze, and the program office will later determine whether any mitigating actions, such as design changes, are warranted.

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 concurred with the contents of this assessment.

Appendix II: Objectives, Scope, and Methodology

This report responds to title 10, section 3072 of the United States Code.[91] Specifically, this report assesses (1) how the Department of Defense's (DOD) portfolio of its costliest weapon programs and selected programs have performed over time; (2) the extent to which opportunities exist to improve program outcomes through the use of leading product development practices; and (3) the extent to which programs are implementing modern software development approaches and recommended cybersecurity practices.

This report also presents assessments of 69 major defense acquisition programs (MDAPs), future major weapon acquisitions, and MTA programs (see appendix I for assessments).

Program Selection

To identify DOD's costliest 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 May 2024 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 between the start of development and the early stages of production. We also identified MDAPs that were well into production but introducing new increments of capability or significant changes expected to exceed the threshold

[91]Title 10, section 3072 of the U.S. Code 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, section 812 of the James M. Inhofe National Defense Authorization Act for Fiscal Year 2023, and section 813 of the Servicemember Quality of Life Improvement and National Defense Authorization Act for Fiscal Year 2025. See Pub. L. No. 116-283, § 813 (2021); Pub. L. No. 117-263, § 812 (2022); and Pub. L. No. 118-159, § 813 (2024). 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 2029. 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. We will issue that report later this year.

for designation as an MDAP. We refer to these as MDAP increments.[92]

- **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 pathway—as of May 2024. Our review included efforts in research and development or programs in pre-system development. In addition, we included one program—Lower Tier Air and Missile Defense Sensor—that completed an MTA effort but has yet to complete a planned transition to the major capability acquisition 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 May 2024. We identified current MTA efforts that have estimated costs above the equivalent threshold cost for designation as an MDAP or were included in our scope last year.[93] 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.

We excluded the Missile Defense Agency's Missile Defense System and its elements from all analyses due to the lack of long-term cost and schedule baselines, which we would use to measure progress.[94] We also excluded classified programs and selected programs for which significant amounts of programmatic information were considered sensitive from our analyses to be able to issue a public report.

[92]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).

[93]We selected 20 MTA efforts for review, of which 15 met the cost threshold for designation as an MDAP.

[94]For recent reporting related to the Missile Defense System, see GAO, *Missile Defense: Annual Goals Unmet for Deliveries and Testing*, GAO-23-106011 (Washington, D.C.: May 18, 2023).

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 on the major capability acquisition pathway.

  A few MDAPs and 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.[95]
- For programs using the MTA pathway, the program start date for programs designated on or after December 30, 2019, is generally the date that an acquisition decision memorandum was signed, initiating the effort as 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.[96] For the purposes of this report, we refer to the initiation date as the

[95]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).

[96]Two MTA programs in our review—Conventional Prompt Strike and XM30 Mechanized Infantry Combat Vehicle—use the funds first obligated date for program start.

date that a program was designated. We used the phrase initial capability to refer to the envisioned initial operational capability, initial warfighting capability, or its equivalent, including any anticipated efforts on other pathways. For MTA efforts that plan to transition to the MCA pathway, this generally refers to the initial operational capability, following any subsequent development or production on the MCA pathway.

- According to DOD policy, programs using the MTA pathway also develop transition plans. Transition refers to the point at which the program begins another effort, using the MTA pathway or another acquisition pathway. For each MTA program that uses the rapid prototyping path, DOD policy directs DOD components to develop a process for transitioning successful prototypes to new or existing acquisition programs for production, fielding, and operations and sustainment.[97] For each MTA program that is using the rapid fielding path, DOD components are required to develop a process for transitioning successful programs to operations and sustainment. These processes will result in a transition plan that programs must provide to the office of the Under Secretary of Defense for Acquisition and Sustainment (USD(A&S)).

For programs we reviewed, we converted all cost information to fiscal year 2025 dollars using conversion factors from DOD's National Defense Budget Estimates for Fiscal Year 2025.[98]

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 the data.

- For MDAPs, we generally obtained and analyzed cost data from each program's September 2024 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 2024 or

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

[98]Department of Defense, Office of the Under Secretary of Defense (Comptroller), *National Defense Budget Estimates for Fiscal Year 2025* (April 2024), 76-77.

a December 2023 Modernized Selected Acquisition Report.[99] For three programs that did not submit a September 2024 DAES—Military GPS User Equipment Increment 1, Next Generation Operational Control System, and LGM-35A Sentinel—we used cost data presented in each of these program's most recent DAES submissions. We compared these cost data with each program's September 2023 DAES, acquisition program baseline issued in 2023, or December 2022 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 assessments.

- For future major weapon acquisitions, MDAPs introducing new increments, and MTA programs, we obtained cost and funding information through a cost and quantity spreadsheet submitted by program offices. 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 2024.

We also distributed a questionnaire to 69 selected program offices:

- 39 MDAPs in development or production;
- three MDAPs that are well into production but introducing new increments of capability or significant changes, which we refer to as MDAP increments;
- seven future weapon acquisitions; and
- 20 MTA programs.

We used the questionnaire to obtain information on programs' schedules and use of leading product development practices, and selected software and cybersecurity practices, among other things.

To help ensure the reliability of the data collected through our questionnaire, we took steps that included:

[99]Modernized Selected Acquisition Report refers to the new acquisition reporting system that replaced the historical Selected Acquisition Report. Section 805 of the NDAA for Fiscal Year 2022 directed USD(A&S) to submit DOD's plan for a new reporting system to report to the congressional defense committees and effectively share information related to covered programs. Section 809 of the NDAA for Fiscal Year 2023 required DOD to institute a defense acquisition reporting system that would replace the requirements of the Selected Acquisition Report statute, which terminated after the final submission covering fiscal year 2023.

- We conducted pretests of new questions prior to distribution to ensure our questions were clear, unbiased, and consistently interpreted.
- We collected and analyzed supplemental program information, such as budget submissions, acquisition decision memorandums, acquisition strategies, transition plans for MTA programs, program cost and schedule estimates, service cost positions or independent cost estimates, risk assessments; and documents related to leading product development practices, 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 2025. Specifically, we asked how DOD monitors and updates DAVE, how the data is updated over time, and what quality assurance steps were taken to ensure data accuracy, among other topics. We sent similar questions to the Army, Navy, and Air Force.

To assess the reliability of MTA cost data, we compared the information received from MTA programs in their supplemental cost and quantity spreadsheets to program identification data submitted to OSD for the fiscal year 2025 President's Budget.

Based on these efforts, we determined that the December 2023 Modernized Selected Acquisition Report data, September 2024 DAES data retrieved from DAVE, and MTA program cost data provided by programs in cost and quantity spreadsheets were sufficiently reliable for the purposes of reporting cost and schedule information.

Assessment of MDAP Cost and Schedule Performance

Our analysis of the MDAP portfolio in this 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. 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 costs from the September 2024 DAES with those individual and combined costs reported in September 2023 DAES. In cases where DAES data were unavailable or incomplete, we used acquisition program baselines or Modernized Selected Acquisition Reports. We also calculated the total cost changes from programs that were included in both our current and last assessment that were both attributable and not attributable to

quantity changes (increases or decreases in the total quantity of units a program plans to order).

We analyzed the factors affecting costs across the 30 MDAPs for which we produced one and two-page assessments in both this report and our most recent report.[100] We examined the programs reporting the largest cost increases and decreases by percentage of total program cost, and analyzed the factors that programs reported drove these cost changes. We identified these factors from program documentation and meetings with program officials. We also analyzed the extent to which changes in planned quantities affected total costs for these programs.

To analyze factors affecting MDAP schedule performance, we also focused on MDAPs for which we produced one and two-page assessments. We identified 30 MDAPs that had yet to declare initial operational capability, as of September 2024. 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.[101] For programs with a cycle time change, we compared the extent of the cycle time change with the program's previous cycle time and identified the driving factors for delays of 12 months or more. 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

To determine the planned costs for current MTA efforts, we generally reviewed the individual and combined procurement; RDT&E; military construction; and operations and maintenance costs from cost and quantity spreadsheets filled out by the program offices. We also used these spreadsheets 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-

[100]GAO, *Weapon Systems Annual Assessment: DOD Is Not Yet Well-Positioned to Field Systems with Speed [Reissued with revisions on July 18, 2024]*, GAO-24-106831 (Washington, D.C.: June 17, 2024). LGM-35A Sentinel program costs were excluded from our June 2024 report, following the program's breach of a statutory critical unit cost growth threshold in January 2024. To calculate 1-year cost change for our macroanalysis, we compared the program's DAES costs effective as of April 2024 to July 2023.

[101]GAO-24-106831.

year MTA cost changes, we compared costs reported for our prior assessment in June 2024 against costs reported for this assessment.[102]

We reviewed schedule data from program identification data and program questionnaires, including program start and planned end dates, operational demonstrations, and planned transitions to another effort. We identified changes to these dates since our last report. We also asked MTA programs to provide the current estimated date for initial operational capability (IOC), initial warfighting capability, or equivalent—which may occur on a subsequent Adaptive Acquisition Framework (AAF) pathway—to calculate the amount of time the program plans to take from MTA program start.

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 identified the lowest current TRL and lowest projected TRL at MTA completion for each MTA effort to understand the amount of expected maturation work that remains before the end of the current effort. Additionally, we reviewed former MTA programs that were included in our previous reports to determine the TRLs of their critical technologies at program start and the subsequent outcome of those MTA efforts. For more information on TRLs, see appendix V.

Leading Practices for Product Development

To assess the extent to which the programs in our review are using approaches aligned with leading practices for product development, we asked questions related to activities associated with an iterative approach identified in our prior work.[103] These questions focused on (1) iterative development of a minimum viable product that refines high-level operational needs into an initial set of capabilities, prioritizes capabilities that can be fielded most quickly to meet user needs, incorporates both

[102]GAO-24-106831.

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

stakeholder and end user feedback, and accommodates successive updates; (2) collaboration with end users during development and after fielding; (3) use of digital engineering to connect stakeholder and end users with system data; (4) validation of integrated hardware and software functionality in the operational environment; (5) preparation for production through industrial base assessments, feedback from manufacturers and suppliers to inform the minimum viable product, and incorporation of a modular open systems approach (MOSA).

For the purposes of this report, we further asked programs whether the MOSA includes three elements based on our prior work in this area: 1) employs a modular design that uses modular system interfaces between major systems, major system components, and modular systems; 2) is subject to verification to ensure that relevant modular system interfaces comply with, if available and suitable, widely supported and consensus-based standards, or the program has obtained government purpose rights to the interface specifications; and 3) uses a system architecture that allows severable major system components and modular systems at the appropriate level to be incrementally added, removed, or replaced throughout the major system platform's life cycle.[104]

We analyzed this information to determine the extent to which the programs plan to implement or have implemented leading product development practices. We also clarified the programs' reported status through meetings with program officials or in program documents in cases where the programs provided information that was unclear. For our individual assessment tables assessing the programs' use of the practices, we determined whether the practice had been implemented; initiated; documented but not initiated; or, neither documented nor initiated.

Implementation of Software Development Approaches and Cybersecurity Practices

To report on MDAPs, future major weapon acquisitions, and MTA programs' software development approaches, we included related questions in our questionnaire. We identified programs that reported the use of a modern software development approach—which we define for this assessment as Agile, DevOps, or DevSecOps approach. We summarized the number of programs that reported using any modern

[104]GAO, *Weapon Systems Acquisition: DOD Needs Better Planning to Attain Benefits of Modular Open Systems*, GAO-25-106931 (Washington, D.C.: Jan. 22, 2025).

approach, those that reported only traditional approaches, and those that did not report a specific approach.

To assess the extent to which selected programs tracked software development performance, we asked programs using a modern software development approach to identify whether they used Agile metrics and tools to help track progress and support decision-making. Specifically, we asked programs whether they used eight Agile metrics and seven Agile tools, which were derived from GAO's *Agile Assessment Guide* and are generally consistent with metrics and tools required in DOD's guidance.[105]

To assess the extent to which selected programs were soliciting regular feedback on software from the intended end users of their systems, we asked programs whether they obtained any end-user feedback, and the frequency with which they solicited and received feedback. We then aggregated program responses on the frequency of this feedback.

To report on modular contracting, we reviewed related DOD policy and guidance and our *Agile Assessment Guide*.[106] We used our questionnaire data to assess the extent selected programs reported that they had implemented this acquisition strategy.

To assess selected programs' progress in implementing software development and acquisitions practices recommended in a 2018 Defense Science Board report, we included a question on the practices used.[107] We compared the portion of our assessed programs that reported they were implementing these practices with the portion of programs that reported implementing them in our 2024 report.[108] We analyzed these

[105]GAO, *GAO Agile Assessment Guide: Best Practices for Adoption and Implementation [Reissued with revisions on Dec. 15, 2023]*, GAO-24-105506 (Washington, D.C.: Nov. 28, 2023). Department of Defense, *Agile Metrics Guide; Strategy Considerations and Sample Metrics for Agile Development Solutions*, Version 1.2 (Nov. 11, 2020); and *DevSecOps Fundamentals Guidebook* (March 2021).

[106]Department of Defense, Office of the Under Secretary of Defense for Acquisition and Sustainment, *Operation of the Software Acquisition Pathway*, DOD Instruction 5000.87 (Oct. 2, 2020); and 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-24-105506.

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

[108]GAO-24-106831.

trends and reported whether the implementation of these practices improved or declined from 2024.

To report on selected programs use of the software acquisition pathway, we asked programs about current and future plans to use the pathway for their software efforts as well as rationales for their plans.[109]

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 in July 2015 and last updated in February 2020.[110] We included a number of cybersecurity-related questions in our questionnaire.

We assessed whether MDAPs had completed specific cybersecurity assessments in time to inform key program events as recommended in the *Cybersecurity Test and Evaluation Guidebook*. We included questions in our 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 that we collected data on as part of the questionnaire's schedule section.[111] We then separated these responses based on whether the relevant key program schedule event had passed or was in the future.

We assessed whether MTA programs completed or planned to complete specific cybersecurity assessments before their planned transition date. We included questions in our questionnaire on the program's transition plan and transition date. We assessed transition plans and determined

[109]Department of Defense, *Operation of the Adaptive Acquisition Framework,* DOD Instruction 5000.02 (Jan. 23, 2020) (incorporating change 1, June 8, 2022); and *Operation of the Software Acquisition Pathway,* DOD Instruction 5000.87 (Oct. 2, 2020).

[110]Department of Defense, *Cybersecurity Test and Evaluation Guidebook 2.0, Change 1* (February 2020). Portions of DOD Instruction 5000.89 relating to operational test and evaluation and live fire test and evaluation were superseded by DOD Instruction 5000.98 in December 2024.

[111]For example, we compared a program's reported completion or planned date for their Cooperative Vulnerability Identification assessment with the program's production start date (Milestone C) to determine if the assessment was completed or planned before the production start date, as recommended by DOD's 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.

the recommended cybersecurity assessments that should be completed before transition. We then compared planned transition dates with the 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.

To determine the extent to which MDAPs and MTA programs have a zero trust strategy, we asked programs whether they currently have a strategy or plan to in the future.

Individual Assessments of Weapon Programs

Appendix I of this report presents 65 assessments of 69 weapon programs.[112] Of the assessments:

- 22 assess MDAPs in development in a two-page format discussing cost and schedule performance, leading product development practices, software and cybersecurity efforts, and other program issues.
- 17 assess MDAPs that achieved milestone C and entered production in a one-page format discussing the program's cost and schedule performance as well as the current status of the program.
- nine assess future major weapon acquisitions or certain MDAPs in a one-page format discussing cost and schedule and the program status. Those assessments include (1) six 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) three MDAPs that are well into production but introducing new increments of capability or significant changes.[113]
- 17 assess MTA programs (three assessments provide combined information on two programs—thus, we assessed a total of 20 MTA programs) in a two-page format that discusses cost and schedule performance, leading product development practices, software and cybersecurity efforts, and other program issues.

[112]We reviewed 69 total programs. The Space Force's Tranche 1 (T1 TRK) and Tranche 2 (T2 TRK) Tracking Layer; Tranche 1 (T1TL) and Tranche 2 (T2TL) Transport Layer; and the Army's Integrated Visual Augmentation System efforts were each reviewed in one assessment. Additionally, the Army's Long Range Hypersonic Weapon System (LRHW) assesses an initial research and development effort and an MTA effort.

[113]One additional future major weapon acquisition program, LRHW, is combined with the MTA effort into one assessment.

For all assessments, we obtained the information from sources such as DOD's DAES reports, program office documents, questionnaires, and cost and quantity spreadsheets. 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 information in each one- and two-page assessment. For the Program Essentials section, we relied on information from various sources, including program documents, contract documents, and information from previous years.

We obtained the information in the Software and Cybersecurity section of the 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, the software cost to the program, and the percentage of progress to meet current requirements. We computed the percentage of software cost to total acquisition cost, using software costs provided by the program and total acquisition cost obtained from the September 2024 DAES.

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 leading product development 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 14 of the 15 MTA programs included in both our current and prior assessment, we determined the change in cost since our June 2024 report.[114]

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, for both one-page and

[114]GAO-24-106831. The Navy's Conventional Prompt Strike was included in our last report, but changes in its cost estimating methodology prevented a cost comparison to last year.

two-page MDAP programs, we present cost, schedule, and quantity data, primarily from the September 2024 DAES reporting, compared with that reported in our 2024 report to show the 1-year cost change.[115]

We took the following steps to present program performance data on 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.[116] Because of rounding and these additional costs, in some situations, the total cost may not match the exact sum of the research and development and procurement costs.
- We deflated cost data for all programs to fiscal year 2025 constant dollars, using conversion factors as described above.
- We calculated program unit costs by dividing the total program cost by the total quantities planned. These costs are often referred to as program acquisition unit costs.
- The quantities listed refer to total quantities, which includes both procurement and development quantities.
- Cycle time 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. For MDAPs that began on the MTA pathway, program start is when the MTA effort began.[117] In some instances, cycle time is not applicable and we annotate this by using the term NA. In some instances, planned initial 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).

[115]GAO-24-106831.

[116]We use the phrase "acquisition operation and maintenance" in assessments to refer to operation and maintenance costs that are part of the acquisition cycle and to exclude operation and maintenance costs budgeted for after production.

[117]The program start date for MTA programs designated on or after December 30, 2019, is generally the date that an acquisition decision memorandum was signed initiating the effort as 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.

Cost and quantity information presented in the MDAP increment and future major weapon acquisitions “Estimated Cost and Quantities” figures is from cost and quantity information provided the program office.

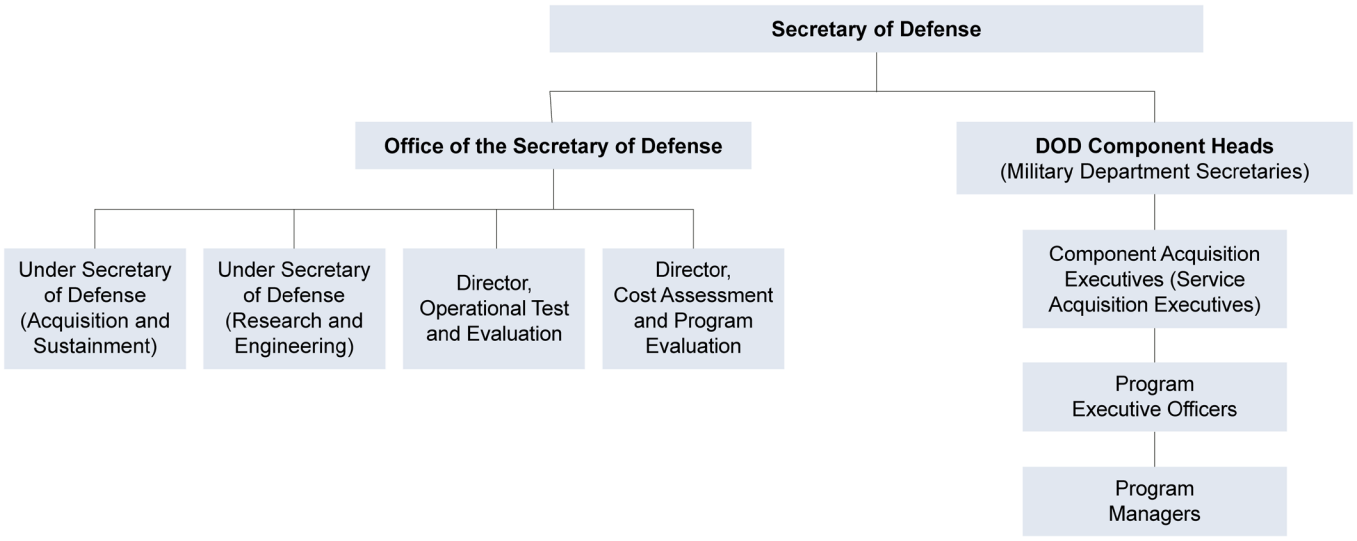
We conducted this performance audit from May 2024 to June 2025, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based 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 (DOD) Responsibilities for Weapon System Acquisitions

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. Entities within OSD are responsible for overarching oversight of weapon systems across the department. This includes developing policies that outline oversight responsibilities; collecting data and metrics; conducting or approving independent cost estimates and cost analyses covering the life cycle of major defense acquisition programs (MDAPs); 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 departments 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 37 depicts the relationship between offices and officials with acquisition oversight responsibilities for the systems we reviewed.

Figure 37: Selected Department of Defense (DOD) Offices and Officials with Acquisition Oversight Roles



Source: GAO analysis of Department of Defense Information. | GAO-25-107569

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, 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.

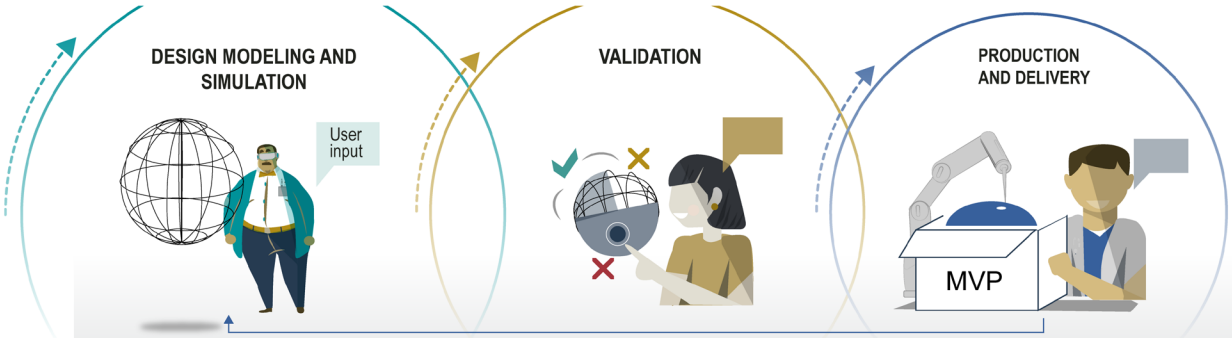
Entity	Responsibilities
Component Acquisition Executives (also referred to as the Service Acquisition Executives)	Implement DOD's acquisition policy within their respective component. In the military departments, the officials designated as Component Acquisition Executives are the Assistant Secretary 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. Space Force acquisition programs are under the authority of the Assistant Secretary of the Air Force for Space Acquisition and Integration. 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) policy documents. I GAO-25-107569

Appendix IV: Leading Practices for Product Development Throughout Iterative Cycles

Leading companies use an iterative development approach to gain early and continuous knowledge about complex systems through iterative cycles of design, validation, and production (fig. 38). These efficiencies are enabled by key principles that, when implemented in product development, position leading companies to satisfy their customers' needs (fig. 39).

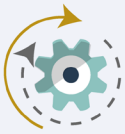
Figure 38: Iterative Cycles of Design, Validation, and Production Used for Product Development



Knowledge gained during iterative cycle	Specifications that ensure the design meets most essential user needs	Integrated prototype that is tested in multiple environments to verify performance and can be manufactured as the minimum viable product (MVP)	Optimized manufacturing tools and processes and insight into efficiencies for future iterations
Principle 1: Attain a Sound Business Case That Is Informed by Research Along with Collaboration with Users	Early user feedback during design provides confidence that the design specifications can be developed to meet schedule and cost parameters identified in the project's business case.	Validation includes integrated tests with users in the expected operating environment. As a part of this process, product teams revisit the business case, assessing whether the MVP remains within cost and schedule parameters and still meets user needs.	Leading companies do not view delivery as the finish line, but a springboard for establishing a new business case for the next iteration of the product. Leading companies will structure this business case around improvements to the already delivered MVP.
Principle 2: Use an Iterative Design Approach That Results in Minimum Viable Products	Product teams use digital engineering and 3D printing, along with augmented and virtual realities to aid in rapid design, modeling and simulation cycles. Stakeholders and users access design information using digital twins that contribute information to real-time digital threads.	Product teams conduct systems-integrated tests on a digital twin, or on a physical prototype connected to the digital twin. Each test data input and design update becomes a part of the digital thread. Validation data is available to outside stakeholders to collaborate on design strategies and decisions.	Throughout production, product teams capture manufacturing data. The digital thread documents all the steps in the process, from the design of the machinery and toolset to the processes for manufacturing and assuring the product meets the company's quality standards.
Principle 3: Prioritize Schedule by Off-ramping Capabilities When Necessary	Product teams refine specifications with user feedback, which may result in starting over with new design solutions. Product teams vigilantly monitor product technologies and will not hesitate to defer any to future design iterations if they prove incompatible with schedule and cost parameters.	Product teams make off-ramping decisions for a given MVP largely based on user needs, with the knowledge that some of the capabilities can be added in subsequent product iterations. Because the iterative process provides such opportunities, leading companies more frequently delay capabilities that are not ready until the next release, rather than decide not to provide them at all.	Product teams include manufacturing and supply team stakeholders throughout product design and validation to ensure the manufacturing process can accommodate the design of the product, and recommend design changes if it cannot.
Principle 4: Collect User Feedback to Inform Improvements to the Minimum Viable Product	Product teams obtain user feedback during design simulation and modeling and make changes to the design based on that feedback.	Product teams incorporate user feedback and results from integrated prototype testing—including decisions about the minimum set of capabilities—into the product's hardware and software design, modifying it as needed to prepare the MVP for production.	After product delivery, product teams collect user feedback to inform the next iteration of the product or the design of a new product. Leading companies obtain feedback from a variety of sources, including surveys, customer clinics, showcases, and social media.

Source: GAO analysis of company information; GAO (icons). | GAO-25-107569

Figure 39: 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 rightsized teams of multidisciplined 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 and illustration of company information. | GAO-25-107569

Appendix V: 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 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-25-107569

Appendix VI: Comments from the Department of Defense

OFFICE OF THE UNDER SECRETARY OF DEFENSE
3000 DEFENSE PENTAGON
WASHINGTON, DC 20301-3000

ACQUISITION
AND SUSTAINMENT

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's (DoD or Department) response to Government Accountability Office (GAO) Draft Report GAO-25-107569, "WEAPONS SYSTEM ANNUAL ASSESSMENT: DOD Leaders Should Ensure that Newer Programs Are Structured for Speed and Innovation," dated March 28, 2025 (GAO Code 107569).

The Department concurs with all four recommendations which recommend that the Under Secretary of Defense for Acquisition and Sustainment, as the Defense Acquisition Executive, and the Secretaries of the Military Departments take steps during the review of relevant acquisition documentation to determine whether future major weapons acquisitions fully incorporate leading product development practices early enough to influence the acquisition approach. Please see our enclosed official written comments that document our concurrence.

The Department is also providing technical comments which are also enclosed.

The Department appreciates the opportunity to comment on the draft report. My point of contact for this effort is Ms. Katherine Edgerton, 571-256-1528.

Sincerely,

TENAGLIA.JOHN.M.1154945926 Digitally signed by TENAGLIA.JOHN.M.1154945926 Date: 2025.05.02 18:31:30 -04'00'

John M. Tenaglia
Principal Director,
Defense Pricing, Contracting, and
Acquisition Policy

Enclosures:
As stated

GAO DRAFT REPORT DATED MARCH 28, 2025
GAO-25-107569 (GAO CODE 107569)

"WEAPONS SYSTEM ANNUAL ASSESSMENT: DOD LEADERS SHOULD ENSURE THAT NEWER PROGRAMS ARE STRUCTURED FOR SPEED AND INNOVATION"

DEPARTMENT OF DEFENSE COMMENTS
TO THE GAO RECOMMENDATION

GAO RECOMMENDATION 1: The Under Secretary of Defense for Acquisition and Sustainment should ensure that it takes steps as the defense acquisition executive during the review of relevant acquisition documentation to determine whether future major weapon acquisitions fully incorporate leading product development practices early enough to influence the acquisition approach.

DoD RESPONSE: Concur.

GAO RECOMMENDATION 2: The Secretary of the Air Force should ensure the decision authorities within the department, including those related to the Space Force, take steps during the review of relevant acquisition documentation to determine whether future major weapon acquisitions fully incorporate leading product development practices early enough to influence the acquisition approach.

DoD RESPONSE: Concur.

GAO RECOMMENDATION 3: The Secretary of the Army should ensure the decision authorities within the department take steps during the review of relevant acquisition documentation to determine whether future major weapon acquisitions fully incorporate leading product development practices early enough to influence the acquisition approach.

DoD RESPONSE: Concur.

GAO RECOMMENDATION 4: The Secretary of the Navy should ensure the decision authorities within the department take steps during the review of relevant acquisition documentation to determine whether future major weapon acquisitions fully incorporate leading product development practices early enough to influence the acquisition approach.

DoD RESPONSE: Concur.

Appendix VII: GAO Contact and Staff Acknowledgments

GAO Contact

Shelby S. Oakley, oakleys@gao.gov

Staff Acknowledgments

Principal contributors to this report were Erin Carson, Assistant Director; Michael H. Moran, Portfolio Analysis Analyst-in-Charge; Jaeyung Kim, Program Assessments Analyst-in-Charge, Vinayak K. Balasubramanian, Brandon Booth, Rose Brister, Daniel Chandler, Gioia Chaouch, Tana Davis, Laura Durbin, Lori Fields, Scott W. Hepler, Matthew L. McKnight, Wendy P. Smythe, and Rachel Steiner-Dillon. Other key contributors included Cheryl K. Andrew, Robert Bullock, Raj Chitikila, Julie Clark, Desiree Cunningham, Jennifer Dougherty, Christopher R. Durbin, Marcus C. Ferguson, Brian Fersch, Laurier R. Fish, Luke Hagemann, Laura Hook, Gina M. Hoover, Justin M. Jaynes, Jessica Karnis, J. Kristopher Keener, Ethan Kennedy, James Madar, Travis J. Masters, Anne McDonough, Heather Barker Miller, Anh Nguyen, John Rastler-Cross, William Reed, Ronald E. Schwenn, Megan Setser, Eli Stiefel, James P. Tallon, Nathan Tranquilli, and Alyssa B. Weir.

Table 11 lists the staff responsible for individual program assessments.

Table 11: GAO Staff Responsible for Individual Program Assessments

Program name	Assistant Directors and Primary Staff
Air Force Programs	
B-52 Commercial Engine Replacement Program (B-52 CERP)	Megan Setser, Andrea Evans, Alexis Olson
B-52 Radar Modernization Program (B-52 RMP)	Megan Setser, Sarah Goubeaux, William Reed, Sandra Mansour
E-7A Rapid Prototyping (E-7A RP)	Brain Fersch, Andrea Evans
F-15 Eagle Passive Active Warning Survivability System (F-15 EPAWSS)	Robert Bullock, Lisa Brown, Matthew Drerup, Chaz Jones
F-15EX	Megan Setser, Jeff Hartnett, Alejandro Coste-Sánchez
F-22 Sensor Enhancements (F-22 SeE)	Laurier R. Fish, Sean Seales
Hypersonic Attack Cruise Missile (HACM)	Ronald E. Schwenn, Matthew Ambrose, Helena Johnson
KC-46A Tanker Modernization Program (KC-46A)	Justin M. Jaynes, Jenny Shinn, Ashley Rawson, Amanda Parker
LGM-35A Sentinel (Sentinel)	James Madar, John W. Crawford, Ryan Stott
Long Range Standoff (LRSO)	Megan Setser, Matthew Drerup, Don Springman, Gary George
MH-139A Helicopter (MH-139A)	Nathan Tranquilli, Gina Flacco, Holly Williams
Small Diameter Bomb Increment II (SDB II)	Justin M. Jaynes, Leigh Ann Haydon, Miranda J. Wickham
T-7A Red Hawk (T-7A)	Laurier R. Fish, Holly Williams, Andrew Redd, Evalin Olson
VC-25B Presidential Aircraft Recapitalization (VC-25B)	Cheryl K. Andrew, LeAnna Parkey, Jenny Shinn, Karen Vasquez-Romero

Program name	Assistant Directors and Primary Staff
Army Programs	
CH-47F Block II Modernized Cargo Helicopter (CH-47F Block II)	Robert Bullock, Wendy Smythe, Margaret C. Fisher
Future Long Range Assault Aircraft (FLRAA)	J. Kristopher Keener, Stephen V. Marchesani, Joseph Shir
High Accuracy Detection and Exploitation System (HADES)	James Madar, Andrew N. Powell, Sean Seales
Indirect Fire Protection Capability Increment 2 (IFPC Inc 2)	J. Kristopher Keener, Brian Smith, Brian Tittle
Improved Turbine Engine Program (ITEP)	J. Kristopher Keener, Julie Kirby, Meghan Kubit, Wendy Smythe
Integrated Visual Augmentation System (IVAS)	Julie Clark, Hans Eggers, Cassidy Cramton
Long Range Hypersonic Weapon System (LRHW)	Ronald E. Schwenn, Jacob Wu, Matthew L. McKnight
Lower Tier Air and Missile Defense Sensor (LTAMDS)	James Madar, John Rastler-Cross, Andrew N. Powell, Megan Ferren
M10 Booker	Julie Clark, Lauren Wright, Sameena Ismailjee, Leila Braun
Maneuver Short Range Air Defense Increment 3 (M-SHORAD Inc 3)	J. Kristopher Keener, Joe E. Hunter, Gioia Chaouch, Jillena Stevens
Mid-Range Capability (MRC)	J. Kristopher Keener, Steven B. Stern, Michael H. Moran
Precision Strike Missile (PrSM)	J. Kristopher Keener, Meghan Kubit, Matthew St. Geme
XM30 Mechanized Infantry Combat Vehicle (XM30)	J. Kristopher Keener, Cale Jones, Jennifer Dougherty
Navy Programs	
Advanced Anti-Radiation Guided Missile - Extended Range (AARGM-ER)	Ronald E. Schwenn, Adriana Aldgate, Joshua Bolanos Cruz
Air and Missile Defense Radar (AMDR)	Laurier R. Fish, Dinah Girma, Eli Stiefel
Conventional Prompt Strike (CPS)	Ronald E. Schwenn, Matthew L. McKnight, Adie Lewis
CVN 78 *Gerald R. Ford* Class Nuclear Aircraft Carrier (CVN 78)	Anne McDonough, Burns C. Eckert, Charlie Shivers
DDG 1000 *Zumwalt Class* Destroyer (DDG 1000)	Laurier R. Fish, Timothy Moss, Sean Merrill
DDG 51 *Arleigh Burke* Class Destroyer, Flight III (DDG 51 Flight III)	Anne McDonough, Sean Merrill, Eli Adler
DDG(X) Guided Missile Destroyer (DDG(X))	Laurier R. Fish, Anh Nguyen, Lindsey Cross
E-6B Recapitalization (E-130J)	Christopher R. Durbin, Brenna Derritt, Andrew Burton
F/A-18E/F Infrared Search and Track (IRST)	Nathan Tranquilli, Zachary Sivo
FFG 62 *Constellation* Class Frigate (FFG 62)	Christopher R. Durbin, Nathan Foster, Riley Knight
Hypersonic Air-Launched Offensive Anti-Surface Warfare Weapon System (HALO)	Ronald E. Schwenn, Ann H. Brooks, Victoria Klepacz
Large Unmanned Surface Vessel (LUSV)	Laurier R. Fish, Jeff Carr, Kieran Pierce, Natalie Logan
Medium Landing Ship (LSM)	Anne McDonough, Jillian Schofield, Sarah Goubeaux, Mazarine-Claire Penzin
MK 54 MOD 2 Advanced Lightweight Torpedo (MK 54 MOD 2 ALWT)	Nicolaus R. Heun, Kyle O'Brien
MQ-25 Unmanned Aircraft System (MQ-25 Stingray)	Cheryl K. Andrew, Gioia Chaouch, Lisa Brown, Jennifer Leone Baker,
MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)	Cheryl K. Andrew, Charlie Shivers, Tana Davis
Next Generation Jammer Low-Band (NGJ LB)	Ronald E. Schwenn, Daniel Glickstein, Carmen Yeung, Leila Braun

Program name	Assistant Directors and Primary Staff
Next Generation Jammer Mid-Band (NGJ MB)	Ronald E. Schwenn, Carmen Yeung, Daniel Glickstein
Orca Extra Large Unmanned Undersea Vehicle (XLUUV)	Nathan Tranquilli, Joseph Neumeier, Tom Twambly
Ship to Shore Connector Amphibious Craft (SSC)	Laurier R. Fish, Laura Durbin, Ethan Kennedy
SSBN 826 *Columbia* Class Ballistic Missile Submarine (SSBN 826)	Anne McDonough, Brendan K. Orino, Ethan Kennedy
SSN 774 *Virginia* Class Submarine (VCS) Block V (VCS Block V)	Anne McDonough, Nathaniel Vaught, Christine Stenglein
T-AGOS 25 *Explorer* Class Ocean Surveillance Ship (T-AGOS 25)	Laurier R. Fish, Kathryn C. Long, Jeff Carr, Celia Sawyerr
T-AO *John Lewis* Class Fleet Replenishment Oiler (T-AO 205)	Anne McDonough, Kya Palomaki, Kathryn C. Long
Space Force Programs	
Deep Space Advanced Radar Capability (DARC)	Christopher R. Durbin, Jaeyung Kim, Heather Barker Miller
Future Operationally Resilient Ground Evolution (FORGE)	Raj Chitikila, Clinton Thurlow, Burns Eckert
GPS III Follow-On (GPS IIIF)	Brian Fersch, Jonathan Mulcare, Matthew Shaffer
Military GPS User Equipment (MGUE) Increment 1 (MGUE Increment 1)	Brian Fersch, Bonita Oden, Matthew Ambrose
Military GPS User Equipment (MGUE) Increment 2 (MGUE Increment 2)	Brian Fersch, Leslie Ashton, Daniel Chandler
National Security Space Launch (NSSL)	Laura Hook, Erin Roosa, Albirio Madrid
Next Generation Operational Control Systems (OCX)	Brian Fersch, Matthew Shaffer, Jonathan Mulcare, Alejandro Gammel-Perera
Next Generation Overhead Persistent Infrared Geosynchronous Earth Orbit Satellites (Next Gen OPIR GEO)	Raj Chitikila, Alexandra Schutz, Claire Buck
Next Generation Overhead Persistent Infrared Space Polar (Next Gen OPIR Polar)	Raj Chitikila, Claire Buck, Alexandra Schutz
Protected Tactical SATCOM - Resilient (PTS-R)	James P. Tallon, Andrew Burton, Desiree Cunningham
Resilient Missile Warning (MW)/Missile Tracking (MT) Medium Earth Orbit (MEO) - Epoch 1 (Resilient MW/MT MEO)	Raj Chitikila, Albirio Madrid, Desiree Cunningham
Tranche 1 and 2 Tracking Layer (T1 TRK and T2 TRK)	Raj Chitikila, Mary Anne S. Sparks, Mary Diop
Tranche 1 and 2 Transport Layers (T1TL and T2TL)	Raj Chitikila, Mary Diop, Mary Anne S. Sparks
Weather System Follow-On (WSF)	Laura Hook, Nicole Warder, Brenna Derritt

Source: GAO. | GAO-25-107569

Appendix VIII: Additional Source Information for Images and Figures

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Front Cover and Highlights Banner:

Future Long Range Assault Aircraft (FLRAA)
Source: Bell Textron, Inc.

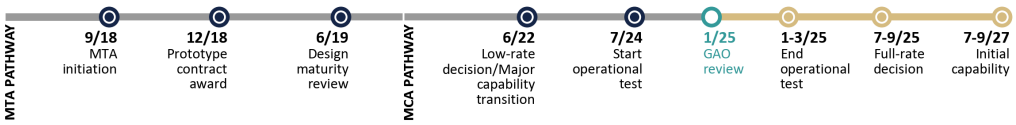
LGM-35A Sentinel
Source: U.S. Air Force

GPS III Follow-On (GPS IIIF)
Source: Lockheed Martin Corporation

Air and Missile Defense Radar (AMDR)
Source: Courtesy Huntington Ingalls Industries (HII)

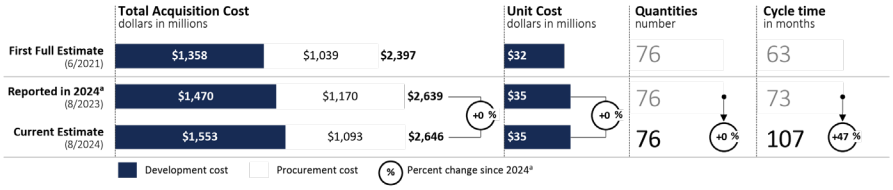
Assessments Graphics:

Timeline:



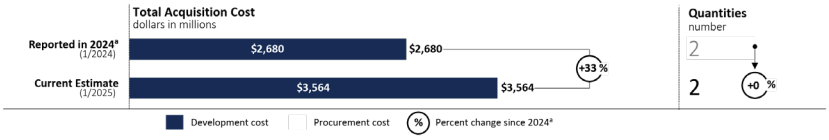
Source: GAO analysis of Department of Defense data

Program Performance (Major Defense Acquisition Programs):



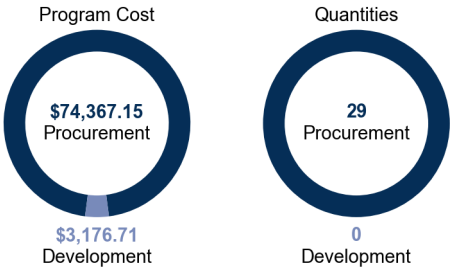
Source: GAO analysis of Department of Defense data.

Estimated Middle Tier of Acquisition Cost and Quantities (Middle Tier of Acquisition Programs):



Source: GAO analysis of Department of Defense data.

Estimated Cost and Quantities (One-Page Assessments):



Source: GAO analysis of Department of Defense data.

Software Development:

Approach: **Incremental**

Software cost and percentage of total acquisition cost (fiscal year 2025 dollars in millions):

$145.86 | 5.51%

Percentage of progress to meet current requirements: 26–50%

Source: GAO analysis of Department of Defense data.

Implementation of Leading Product Development Practices (Two-Page Assessments):

Non-shipbuilding program

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a full system-level digital twin *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test a system-level integrated physical prototype in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	○

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated … Information not available NA- Not applicable

Shipbuilding program

Implementation of Leading Product Development Practices as of January 2025

Iteratively Develop a Minimum Viable Product (MVP)	Current status
Refine high-level operational needs into an MVP *(the initial set of capabilities that meets end user needs, can be fielded most quickly, and can be successively updated)*	○
Use Digital Engineering to Connect Stakeholders and End Users to System Data	
Develop a digital twin of key subsystems *(a dynamic virtual representation of a physical product or system)*	○
Develop a digital thread *(an analytical framework that connects stakeholders and end users with dynamic data across a system's life cycle)*	○
Validate Integrated Hardware and Software Functionality in the Operating Environment	
Test a system-level integrated fully digital prototype in a digital operational environment	○
Test an integrated physical prototype of key subsystems in an operational environment, with data from the testing connected to a digital twin or digital thread	○
Prepare for Modularity to Support Production and Updates to the MVP	
Incorporate a modular open systems approach (MOSA)	○

● Practice implemented ◐ Practice initiated ◔ Practice documented but not initiated
○ Practice neither documented nor initiated … Information not available NA- Not applicable

Source: GAO analysis of DOD data. | GAO-25-107569

Source: GAO analysis of Department of Defense data.

Related GAO Products

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