GAO

United States Government Accountability Office

Report to Congressional Committees

JUNE 2022

Weapon Systems Annual Assessment

Challenges to Fielding Capabilities Faster Persist

AIR FORCE AND SPACE FORCE | ARMY | JOINT DOD | NAVY AND MARINE CORPS

GAO-22-105230

A Report to Congressional Committees June 2022

Weapon Systems Annual Assessment

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GAO Highlights

Highlights of GAO-22-105230

AIR FORCE AND SPACE FORCE | ARMY | JOINT DOD | NAVY AND MARINE CORPS

Precision Strike Missile F-15EX

Armored Multi-purpose Vehicle

Source: Lockheed Martin, U.S. Air Force, and BAE, respectively. | GAO-22-105230

Why GAO Did This Study

Congress included a provision in statute for GAO to review DOD's weapon programs. This report, GAO's 20th annual assessment, assesses the following aspects of DOD's costliest weapon programs: their characteristics and performance, and their implementation of knowledge-based acquisition practices, modern software development approaches, and cybersecurity practices. The report also describes industrial base challenges reported by weapon programs and DOD's efforts to assess these challenges.

GAO identified programs for review based on cost and acquisition status; reviewed relevant legislation and policy; collected program office data; and interviewed DOD officials.

What GAO Recommends

GAO is making two recommendations including that DOD update its industrial base assessment instruction to define the circumstances that would constitute a known or projected problem or substantial risk that a necessary industrial capability may be lost. DOD concurred with the recommendations.

View GAO-22-105230. For more information, contact Shelby S. Oakley at (202) 512-4841 or oakleys@gao.gov.

What GAO Found

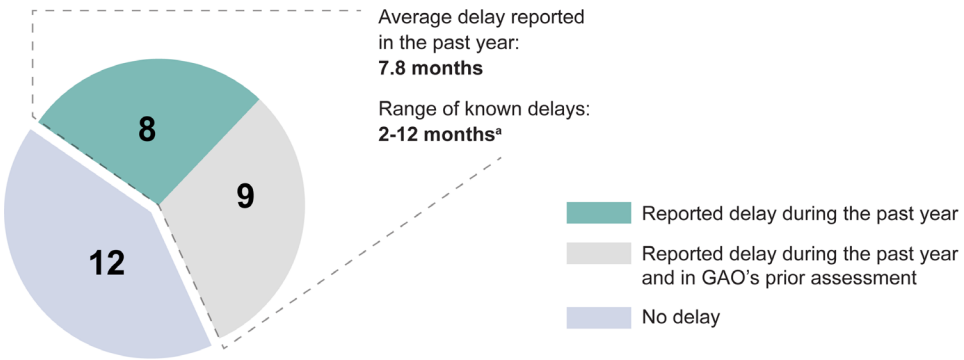
For over 20 years, GAO has assessed the Department of Defense's (DOD) weapon programs and noted significant changes in its acquisition policies and practices. GAO's first assessment in 2003 highlighted challenges, such as committing billions of taxpayer dollars before obtaining key information, including reliable cost estimates and proven designs. Yet these challenges still hinder many programs. And they slow the department's current emphasis on delivering capabilities to the warfighter faster.

This year's report analyzed 63 of DOD's costliest weapon system acquisition programs. These programs include:

- 40 major defense acquisition programs (MDAP);
- four future major weapon acquisitions; and
- 19 programs using the middle tier of acquisition (MTA) pathway, used for rapid prototyping and rapid fielding efforts.

GAO found that MDAPs continue to struggle with schedule delays. Over half of the 29 MDAPs that GAO reviewed that had yet to deliver capability reported delays during the past year (see figure). The lack of future year funding data in the fiscal year 2022 budget request precluded GAO from assessing the MDAP portfolio's cost performance this year.

Over Half of MDAPs Reported a Delay to Capability Delivery since GAO's Prior Assessment



Source: GAO analysis of Department of Defense data. | GAO-22-105230

[a] Five programs reported delays but stated the total delay was unknown at the time of GAO's review.

MDAPs and MTA Programs Continue to Proceed with Limited Knowledge, Signaling Potential Risks

GAO observed a correlation between programs that obtained certain knowledge at key points and better cost and schedule outcomes. Knowledge-based acquisitions attain crucial information about topics such as technology maturity before proceeding beyond key points. But the majority of MDAPs GAO reviewed continue to not fully achieve knowledge that informs key investment decisions. This finding is consistent with GAO's reporting over the last 20 years.

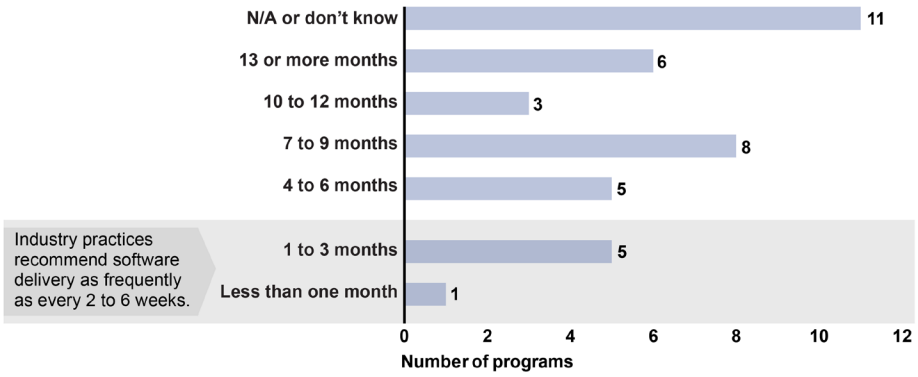
DOD continues to leverage MTA rapid prototyping and rapid fielding efforts, with the aim of delivering capabilities faster. MTA programs do not have comparable milestones to facilitate consistent schedule analysis. However, three MTA programs GAO reviewed reported challenges that may threaten the planned program completion dates. These challenges may also hinder the programs' ability to rapidly deliver capabilities as initially envisioned.

Further, MTA programs' approaches to obtaining knowledge pose potential risks. DOD is increasing its use of the MTA pathway. Yet, GAO observed that these programs generally do not plan to attain sufficient product knowledge before starting follow-on efforts, falling short of leading acquisition practices. This approach increases the risk that these follow-on efforts may encounter cost, schedule, or technical challenges during development or production.

Limited Adoption of Modern Software Practices by Weapon Programs Persists

Additionally, GAO's past work has emphasized the importance of modernizing DOD's software development efforts. The department built on ongoing modernization initiatives over the past year. For example, DOD leadership has emphasized key practices, such as iterative development. However, most of the 39 programs that reported using a modern software development approach deliver working software for user feedback more slowly than recommended by industry's Agile practices, which call for rapid, frequent delivery of software and fast feedback cycles (see figure). As a result, these programs may lose out on some of the benefits of using a modern approach.

Software Delivery Time Frames for Programs That Reported Using Modern Development Approaches (in months)



Source: GAO analysis of programs' questionnaire responses. I GAO-22-105230

GAO's past work has also found that cybersecurity for weapon systems is a critical area that DOD must improve. However, GAO continued to find programs not fully implementing recommended cybersecurity practices, such as testing.

Insight into Industrial Base Challenges May Be Hindered by Limited Risk Assessments

GAO assessed risks that DOD's costliest weapon programs reported related to the defense industrial base. Over half of the 59 programs GAO reviewed reported tracking industrial base risks. However, nearly half of the programs tracking industrial base risks reported that they did not plan for an industrial base assessment—which GAO defined as an assessment of an industry where there is a known problem in certain areas related to DOD products—to be conducted specific to their program. GAO found that DOD instructions do not define certain key phrases associated with the circumstances under which programs should conduct industrial base assessments. DOD intends these assessments to help ensure that needed industrial capabilities meet current and future national security requirements and are available and affordable. As a result, DOD's insight into industrial base risks facing the department may be hindered.

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Abbreviations

AAF	Adaptive Acquisition Framework
C3I	Command, Control, Communications and Intelligence
CDR	critical design review
DAES	Defense Acquisition Executive Summary
DAMIR	Defense Acquisition Management Information Retrieval
DIB	defense industrial base
DOD	Department of Defense
DODI	Department of Defense Instruction
IOC	initial operational capability
MDAP	major defense acquisition program
MRL	manufacturing readiness level
MTA	middle tier of acquisition
NA	not applicable
NDAA	National Defense Authorization Act
OMB	Office of Management and Budget
OSD	Office of the Secretary of Defense
PDR	preliminary design review
RDT&E	research, development, test, and evaluation
TBD	to be determined
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

U.S. GOVERNMENT ACCOUNTABILITY OFFICE
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Comptroller General
of the United States

June 8, 2022

Congressional Committees

I am pleased to present our 20th annual assessment of the Department of Defense's (DOD) acquisition of weapon systems. This year's report offers observations on the performance of 63 of the department's most expensive weapon system acquisition programs, an area on GAO's High-Risk List. These programs include 40 major defense acquisition programs (MDAP), four future major weapon acquisitions, and 19 programs using the middle tier of acquisition (MTA) pathway.

We highlight key aspects of weapon acquisition, including schedule performance, progress in attaining product knowledge, and implementation of recommended software development approaches and cybersecurity practices. We also examine, for the first time in our annual assessment, defense industrial base risks. Due to the lack of future year funding data included in the fiscal year 2022 budget request, we were unable to assess cost performance this year.

In recent years, DOD created and began to implement the Adaptive Acquisition Framework (AAF). The AAF established new pathways for acquisition programs to help deliver solutions to the end user in a timely manner, among other things. The development of the framework was a significant step forward. But DOD's effective implementation of the framework is critical to driving needed changes. For example, programs that obtain sufficient product knowledge before making significant investment decisions better meet their cost, schedule, and performance goals, regardless of the pathway used. Yet most MDAPs reviewed this year passed key knowledge points without obtaining recommended knowledge. In addition, all MTA efforts that plan to transition to production expect to do so before gaining manufacturing maturity information recommended by leading acquisition practices.

The right knowledge at key decision points enables speed, and a lack of knowledge can lead to schedule delays. This year, we continued to see significant numbers of programs reporting delays, even as the department emphasizes the need to deliver capabilities to the warfighter more quickly. For example, 17 of the 29 MDAPs we reviewed that had yet to deliver capability reported a delay to the date that they plan to deliver capability

to the warfighter.[1] In a number of instances, these delays are on top of past postponements.

Each MTA program can use different milestones to create and maintain schedule, which precludes us from completing a consistent schedule analysis across the MTA programs we reviewed. However, we highlight three MTA programs reporting delays to key program events. These delays call into question these programs' ability to rapidly deliver capabilities as planned. If programs continue to proceed through the acquisition process without sufficient knowledge, the department likely will face additional delays in the future.

We also continue to see inconsistent implementation of recommended or required practices in areas like software development and cybersecurity. These areas are critical to DOD's ability to keep pace with evolving threats. For the third year in a row, we reported that many weapon programs are not adopting key practices that could improve the speed and security of software development, such as frequent software deliveries to end users.

This year, we also assessed industrial base challenges. More than half of the programs we reviewed are tracking one or more industrial base risks. However, nearly half of the programs tracking industrial base risks reported that they do not plan for an industrial base assessment—which we defined as an assessment of an industry where there's a known problem in certain areas related to DOD products—to be conducted specific to their program.

DOD policy does not fully define certain key phrases associated with the circumstances under which DOD components should conduct industrial base assessments on a case-by-case basis. DOD intends these assessments to help ensure that industrial capabilities needed to meet current and future national security requirements are available and affordable. Without policies that facilitate a consistent understanding of when these assessments are needed, DOD may be missing opportunities to gain insight to help understand and address critical industrial base risks.

[1]We did not review the schedule performance for 11 MDAPs that are either an MDAP increment, already achieved initial capability, or did not track an initial capability milestone.

Achieving lasting improvements to weapon system acquisition will not be easy or quick. But it is necessary if the U.S. military is to remain well positioned to address the wide range of current and emerging threats. Our assessments of hundreds of weapon programs over the last 20 years underscore certain fundamental practices, such as making investments informed by knowledge about programs' cost, schedule, and technology. These practices remain critical to increasing the likelihood that capabilities will be achieved as promised.

As part of our broader weapon systems acquisition work, we have made hundreds of recommendations to help improve outcomes. However, many of these recommendations have yet to be implemented. We maintain that DOD must address them if the department is to achieve its goal of accelerating the delivery of capabilities.

DOD's ability to build upon its recent acquisition reforms will require sustained efforts by senior DOD leadership. We have consistently observed in our High-Risk List updates that senior DOD leadership has shown such commitment in developing policies that move the department in the right direction.[2] However, going forward, that high level of commitment must carry over to the next steps of taking action to ensure DOD's acquisition workforce has the resources it needs to meet increasingly complex challenges.

GAO also remains committed to ensuring that our approach to assessing weapon programs keeps up with evolving challenges facing DOD and other federal agencies. Toward that goal, we have undertaken a new body of work to assess the practices used by leading companies to develop innovative products. These products satisfy their customers' needs, and leading companies deliver them to market on time and within planned costs.

We issued our first report this winter highlighting four key product development principles leading companies use to drive innovation and

[2]GAO, *High-Risk Series: Dedicated Leadership Needed to Address Limited Progress in Most High-Risk Areas.* GAO-21-119SP (Washington, D.C.: Mar. 2, 2021); *High Risk Series: Substantial Efforts Needed to Achieve Greater Progress on High-Risk Areas*. GAO-19-157SP (Washington, D.C.: Mar. 6, 2019); and *High Risk Series: Progress on Many High-Risk Areas, While Substantial Efforts Needed on Others* GAO-17-317 (Washington, D.C.: Feb. 15, 2017).

speed.[3] DOD's acquisition policies partially addressed each of the key product development principles, such as by emphasizing the application of iterative design approaches in certain policies. However, none of the policies fully addressed these key principles.

We have ongoing work in this area examining the metrics and measures associated with the key principles. We anticipate that our future annual weapon systems assessments will leverage this work to help keep pace with the current acquisition environment.

Gene L. Dodaro
Comptroller General of the United States

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

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Congressional Committees

In response to title 10, section 3072 of the United States Code, this report provides insight into 63 of the Department of Defense's (DOD) most costly weapon programs.[4] Specifically, this report covers the following sets of programs:

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

This report assesses (1) the characteristics of DOD's costliest weapon programs and how these programs have performed according to selected cost and schedule measures; (2) the extent to which programs implemented or planned for knowledge-based acquisition practices; (3) the extent to which programs have implemented modern software development approaches and recommended cybersecurity practices; and (4) how DOD has addressed recent legislative, organization, and policy changes related to the defense industrial base and the extent to which programs reported tracking and assessing defense industrial base challenges. In addition, pursuant to a provision in the William M. (Mac) Thornberry NDAA for Fiscal Year 2021, this report also includes information on DOD's progress in implementing software acquisition

[4]Title 10, section 3072 of the U.S. Code includes a provision for us to submit to the congressional defense committees an annual assessment of selected DOD acquisition programs and initiatives by March 30 of each year from 2020 through 2023. Our assessment of the performance of DOD's IT programs is included in a separate report, which we also prepared in response to title 10, section 3072 of the U.S. Code. That report will issue later this year.

[5]Throughout this report, we refer to programs currently using the MTA pathway as "MTA programs," although some of these programs may also currently use or plan to subsequently use one or more other pathways before fielding an eventual capability. For the purposes of this report, we use the word "effort" to refer specifically to the activities undertaken using a single 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.

reforms for weapon systems, business systems, and other activities that are part of the defense acquisition system.[6]

To conduct our work, we provided a questionnaire to program offices to obtain information on

- the extent to which programs were planning for or following knowledge-based acquisition practices for technology maturity, design stability, and production readiness;
- programs' cost and schedule performance;
- programs' approach to software development and cybersecurity practices;
- the effects of COVID-19 on program performance; and
- the extent to which programs track and assess defense industrial base challenges.

We also analyzed other sources of available data, such as Defense Acquisition Executive Summaries (DAES), MTA program identification data, and cost data provided by program offices. We determined that the September 2020 DAES data and MTA program cost data were sufficiently reliable for the purposes of this report.

To examine the legislative, organizational, and policy changes related to the defense industrial base that have occurred since 2019, we identified and summarized relevant provisions signed into law from fiscal year 2019 to fiscal year 2021. We also identified organizational and policy changes DOD implemented or is in the process of implementing. For all objectives, we also conducted interviews with the Office of Secretary of Defense officials and program officials.

In addition, this report presents individual knowledge-based assessments of 63 programs (see appendix I).

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

We conducted this performance audit from May 2021 to June 2022 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain

[6]See Pub. L. No. 116-283, § 838 (2021).

sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Defense Acquisition Principles and Authorities

DOD generally acquires its weapon systems through a management process known as the Defense Acquisition System, governed by the overarching principles described in DOD Directive 5000.01 and DOD Instruction 5000.02.[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 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 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 being acquired. Programs, with approval from the decision authority or the milestone decision authority, may leverage a combination of acquisition pathways to provide value not otherwise available through

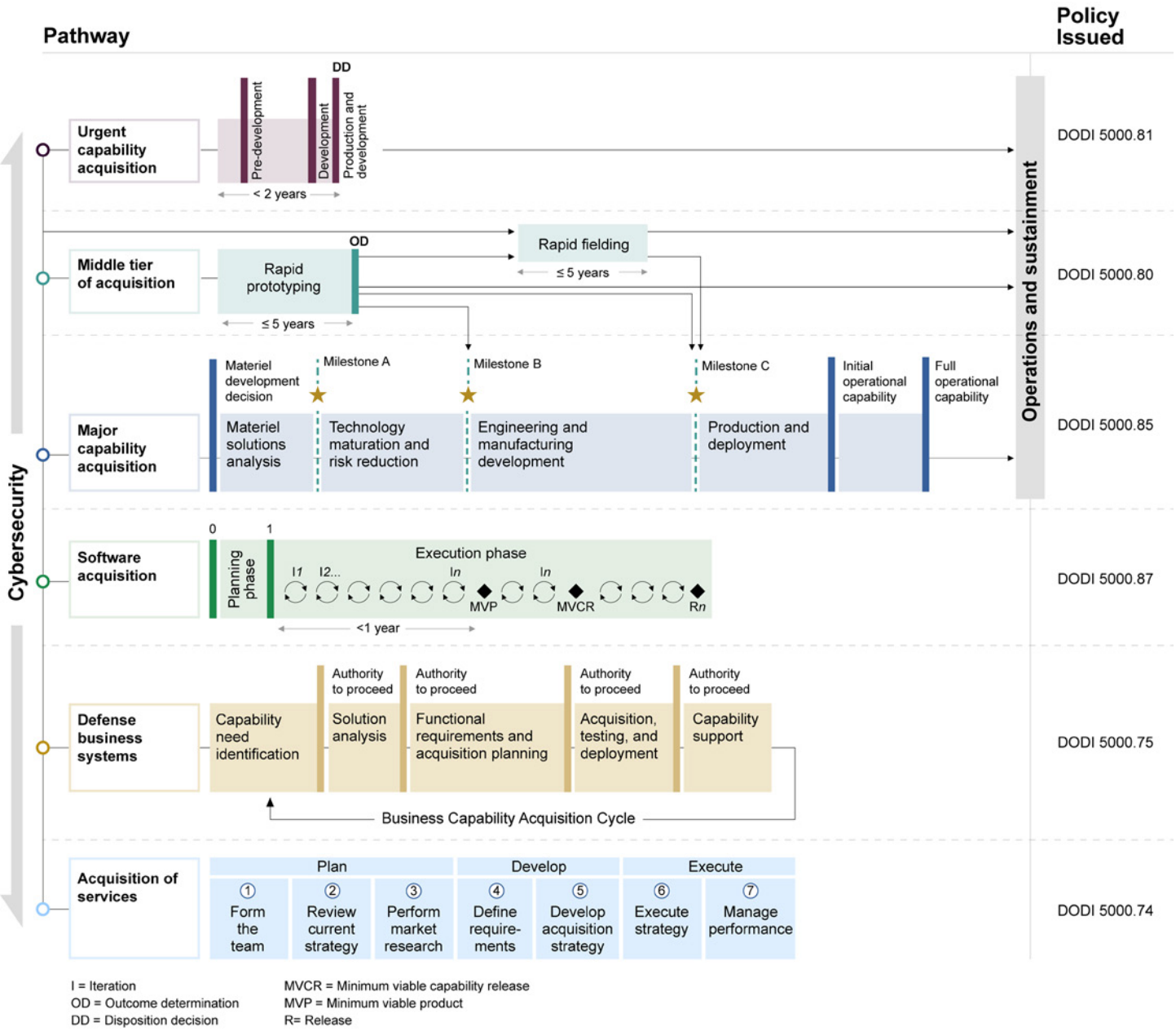
[7]DOD Directive 5000.01, *The Defense Acquisition System* (Sept. 9, 2020); DOD Instruction No. 5000.02, *Operation of the Adaptive Acquisition Framework* (Jan. 23, 2020).

use of a single pathway.[8] DOD issued policy documents to address each of these six acquisition pathways as well as additional functional policy documents in areas such as engineering and test and evaluation.[9] Figure 1 shows the AAF and corresponding guidance specific to each pathway.

[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.

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

Figure 1: Adaptive Acquisition Framework Pathways and Related Department of Defense Instructions (DODI)



Source: GAO analysis of Department of Defense data. I GAO-22-105230

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

MDAPs

Under DOD Instruction 5000.02, DOD's major capability acquisition pathway is designed to support certain complex acquisitions such as MDAPs.[10] 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 major capability acquisition pathway.[11] Within this pathway, programs generally proceed through a number of phases, the following three of which are most relevant to this report:

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

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

Our body of work on MDAPs has shown that attaining high levels of knowledge before programs make significant commitments during

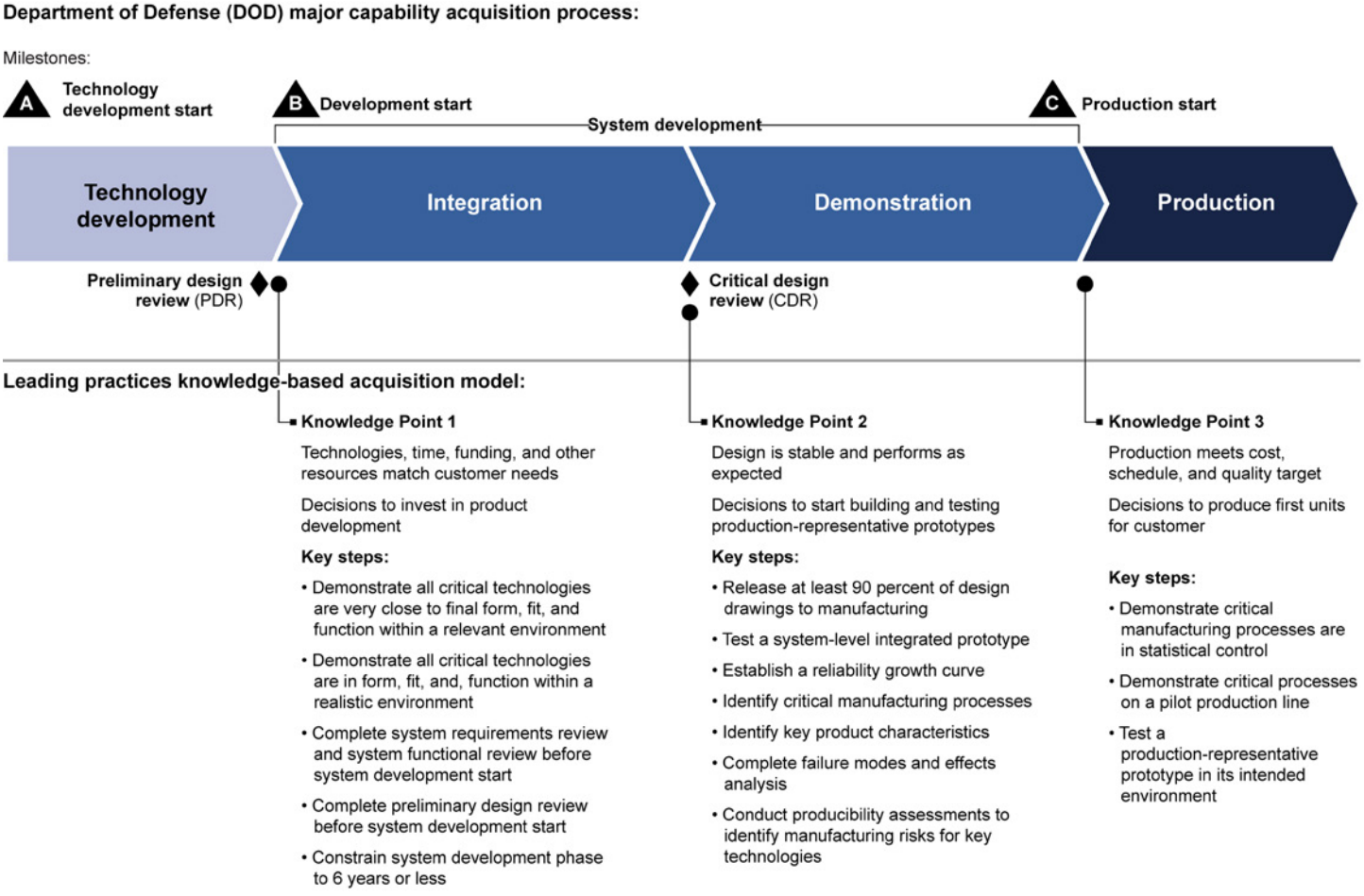
[10]MDAPs generally include those programs that are not a highly sensitive classified program and that are either (1) designated by the Secretary of Defense as a MDAP; or that are (2) estimated to require an eventual total expenditure for research, development, test, and evaluation, including all planned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

[11]DOD Instruction 5000.85.

product development drives positive acquisition outcomes.[12] We have found that to reduce risk, there are three key points at which programs should demonstrate critical levels of knowledge before proceeding to the next acquisition phase: development start, system-level critical design review, and production start. Figure 2 aligns the acquisition milestones associated with the major capability acquisition pathway with these three key decision points.

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

Figure 2: DOD Major Capability Acquisition Pathway and GAO-Identified Knowledge Points



Source: GAO analysis of DOD-provided data, DOD Instruction 5000.85, and leading practices. | GAO-22-105230

Program knowledge builds over time. Our prior work on knowledge-based approaches shows that a knowledge deficit early in a program can cascade through design and production, leaving decision makers with less knowledge to support decisions about when and how to move into subsequent acquisition phases that require more budgetary resources.[13] Under a knowledge-based approach, demonstrating technology maturity

[13]GAO, *Best Practices: Using A Knowledge-Based Approach to Improve Weapon Acquisition*, GAO-04-386SP (Washington, D.C.: Jan. 2004). In addition, a list of related GAO products is included at the end of the report.

is a prerequisite for moving forward into system development, during which time the focus should be on design and integration. Similarly, a stable and mature design is a prerequisite for moving into production, where the focus should be on efficient manufacturing. Appendix III provides additional details about key practices at each of the knowledge points.

MTA Programs

Under DOD Instruction 5000.02, DOD's MTA pathway includes paths for rapid prototyping and rapid fielding efforts. DOD Instruction 5000.80, released in December 2019, established the policy and prescribed procedures that guide these acquisition programs, including the distinctions between the two MTA paths:[14]

- The objective of a program using the rapid prototyping path is to field a prototype meeting defined requirements that can be demonstrated in an operational environment and provide for residual operational capability within 5 years of the MTA program start date.[15] Virtual prototypes can meet this requirement if they result in a residual operational capability that can be fielded.
- The objective of a program using the rapid fielding path is to begin production within 6 months and complete fielding within 5 years of the MTA program start date.[16]

Programs using this pathway are exempt from the guidance in DOD Directive 5000.01 and the Chairman of the Joint Chiefs of Staff Instruction 5123.01I, which outlines processes to implement DOD's traditional requirements process.[17] Instead, according to DOD Instruction 5000.80,

[14]DOD Instruction 5000.80, *Operation of the Middle Tier of Acquisition (MTA)* (Dec. 30, 2019). Prior to the issuance of this instruction, the Office of the Under Secretary of Defense for Acquisition and Sustainment issued interim guidance in April 2018, which it supplemented with additional guidance in October 2018 and March 2019. Some programs in our review are grandfathered under this guidance since they were initiated prior to December 2019.

[15]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.

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

[17]Chairman of the Joint Chiefs of Staff Instruction 5123.01I, *Charter of the Joint Requirements Oversight Council (JROC) and Implementation of the Joint Capabilities Integration and Development System (JCIDS)* (Oct. 30, 2021). This instruction supersedes Chairman of the Joint Chiefs of Staff Instruction 5123.01H, which is currently referenced by DOD Instruction 5000.80.

each DOD component must develop a streamlined process that results in a succinct requirement document within 6 months from the time the operational needs process is initiated. Further, the policy states that approval authority for each capability requirement is delegated to a level that promotes rapid action.[18]

For each MTA program using the rapid prototyping path, DOD Instruction 5000.80 states that DOD components will develop a process for transitioning successful prototypes to new or existing acquisition programs for production, fielding, and operations and sustainment. Programs have numerous options for transition, such as transitioning into the rapid fielding path or another acquisition pathway, including the major capability acquisition pathway.

Additionally, DOD Instruction 5000.80 requires MTA programs that are major systems to submit the following documents at program initiation to the USD (A&S):[19]

- approved requirements;
- a cost estimate;
- a life-cycle sustainment plan for programs using the rapid fielding path; and
- an acquisition strategy that addresses security, schedule, and technical or production risks, and includes a test strategy or an assessment of test results, and a transition plan.

[18]Programs exceeding the dollar thresholds for an MDAP pursuant to Title 10, section 4201 of the United States Code require written approval from the Under Secretary of Defense for Acquisition and Sustainment (USD(A&S)) prior to using the MTA pathway.

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

Our prior work shows that this type of information helps to establish a program's business case and is important to help decision makers make well-informed decisions about MTA program initiation.[20]

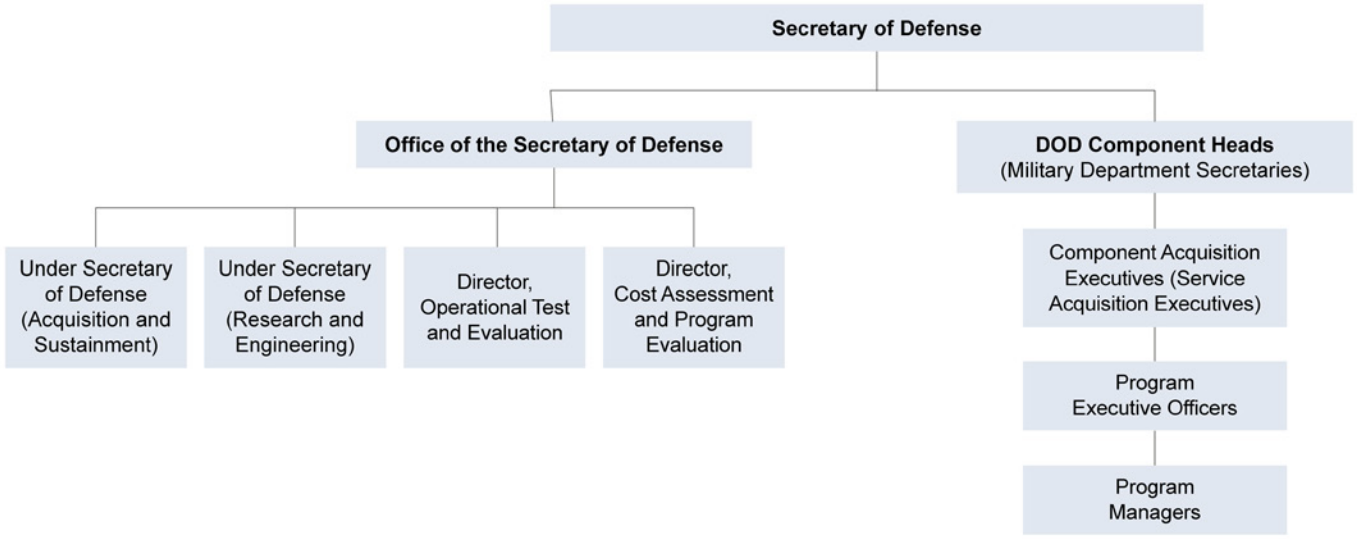
DOD Weapon Acquisition Oversight Roles and Responsibilities

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 MDAPs, and overseeing operational and live fire tests and evaluations, among other roles and responsibilities.

At the military department level, the component acquisition executives, also referred to as the service acquisition executives, are responsible for implementing DOD acquisition policy within their respective department and serves as the milestone decision authority for most MDAPs and many MTA programs, unless delegated by the service acquisition executive. Service acquisition executives at the military department level are also decision authorities for programs using the MTA and software acquisition pathways, with some exceptions. Figure 3 depicts the relationship between offices and officials with acquisition oversight responsibilities for the systems we reviewed.

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

Figure 3: Selected Department of Defense (DOD) Offices and Officials with Acquisition Oversight Roles



Source: GAO analysis of Department of Defense Information. | GAO-22-105230

Additional details about the specific roles and responsibilities for entities at the OSD and military department level are included in appendix V.

Software Development and Acquisition

In January 2020, DOD introduced the software acquisition pathway as part of the AAF. This pathway is governed by DOD Instruction 5000.87 and is intended to facilitate rapid and iterative delivery of software capability, including software-intensive systems, to users.[21] The pathway involves the use of small cross-functional teams that include users, testers, software developers, and cybersecurity experts to deliver software rapidly and iteratively to meet 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.

Software has become one of the most important components of DOD systems. However, we have reported in previous work that the department's software development practices have not kept up with leading industry practices. Our work and the findings of other recent studies show deficiencies in software acquisition and practices within

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

DOD, such as slow software development practices and outdated acquisition processes. 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.[22] The Defense Science Board study identified a number of software development practices that it recommended DOD adopt, which are listed in table 1. In our previous work, we found that DOD was taking steps to address some of these recommendations.[23]

Table 1: Software Practices Recommended by the Defense Science Board in February 2018

Software practice	Description
Software factory	Cloud-based computing used to assemble a set of software tools enabling developers, users, and management to work together on a daily tempo.
Delivery of minimum viable product[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	Written text or illustration that accompanies computer software or is embedded in the source code.

Source: Defense Science Board. I GAO-22-105230

[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.

DOD reported that it is also addressing the numerous recommendations made by a 2019 Defense Innovation Board study that emphasized, among other things, speed and delivery time, hiring and retaining

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

[23]GAO, *DOD Software Acquisition: Status of and Challenges Related to Reform Efforts,* GAO-21-105298 (Washington, D.C.: Sept. 30, 2021).

qualified staff, and focusing on continuous improvement throughout the software life cycle.[24]

According to DOD officials, the department has taken steps to improve its software development approach through the creation of guidebooks, the Software Modernization Strategy, and Software Modernization Senior Steering Group, among other ongoing efforts. For example, in February 2020, DOD issued an Agile Software Acquisition Guidebook that shares Agile and iterative development lessons learned from a congressionally directed Agile software pilot program that included software-intensive warfighting systems.[25] Consistent with our prior work, including our Agile Guide, issued in September 2020, these lessons learned note that Agile is built around frequent, small-batch delivery of working functionality into the hands of end users to gain fast feedback.[26] DOD's lessons learned also note that the biggest risk-reducing factor in an Agile framework is frequent delivery of a product or capability.

Our past work found that DOD acquisition programs employ a wide range of software development models, including Agile frameworks and various incremental models. Table 2 provides descriptions of selected software development models employed by DOD acquisition programs.

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

Software development life-cycle model	Description
Waterfall	This model relies on strict phases, and each phase needs to be completed before going to the next phase. The phases include requirements definition, design, execution, testing, and release. Each phase relies on information from the previous phase. This model is a linear sequential flow in which progress is seen as flowing steadily downwards (like a waterfall) through the phases of software implementation.

[24]Defense Innovation Board, *Software Is Never Done: Refactoring the Acquisition Code for Competitive Advantage* (May 3, 2019).

[25]Office of the Under Secretary of Defense for Acquisition and Sustainment, *Agile Software Acquisition Guidebook-Best Practices & Lessons Learned from the FY18 NDAA Section 873/874 Agile Pilot Program* (Washington, D.C.: Feb. 27, 2020). See National Defense Authorization Act for Fiscal Year 2018, Pub. L. No. 115-91, § 873 (2017) and John S. McCain National Defense Authorization Act of Fiscal Year 2019, Pub. L. No. 115-232, § 869 (2018).

[26]GAO, *Agile Assessment Guide: Best Practices for Agile Adoption and Implementation*, GAO-20-590G (Washington, D.C.: Sept. 28, 2020).

Software development life-cycle model	Description
Incremental	This model sets high-level requirements early in the effort, and functionality is delivered in stages. Multiple increments deliver parts of the overall required program capability. Several builds and deployments are typically necessary to satisfy approved requirements.
Agile	This model breaks a product into components where, in each cycle or iteration, a working model of a component is delivered. The model 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 shippable. The Agile model 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 both software developers and users.
DevSecOps	DevSecOps is an iterative software development methodology that combines development, security, and operations as key elements in delivering useful capability to the user of the software.
Mixed	This approach is a combination of two or more different methodologies to create a new model.

Source: GAO-20-590G and GAO analysis of Department of Defense and software industry documentation. I GAO-22-105230

Cybersecurity in DOD Weapon Programs

As we previously reported, cybersecurity for weapon systems has increasingly been recognized as a critical area in which DOD must improve.[27] We 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.

In November 2020, DOD issued DOD Instruction 5000.89, which establishes policy and procedures for test and evaluation across five of the six AAF pathways—including the major capability acquisition and MTA pathways—that addresses cybersecurity planning and execution.[28] In particular, the instruction requires all DOD acquisition programs and systems, regardless of acquisition pathway, to execute an iterative cybersecurity test and evaluation process detailed in the DOD

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

[28]DOD Instruction 5000.89. The sixth pathway, defense acquisition of services, does not require test and evaluation policy and procedures.

Cybersecurity Test and Evaluation Guidebook throughout the program's life cycle, including new increments of capability.[29] Table 3 outlines the DOD cybersecurity test and evaluation phases from the DOD *Cybersecurity Test and Evaluation Guidebook*.

Table 3: Department of Defense Cybersecurity Test and Evaluation Phases

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

Source: GAO analysis of Department of Defense, *Cybersecurity Test and Evaluation Guidebook*. I GAO-22-105230

Additionally, DOD issued a functional policy on cybersecurity in December 2020, which establishes policy and procedures to manage cybersecurity risk and highlights the need to incorporate cybersecurity into all aspects of the defense acquisition system and operations.[30]

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

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

DOD guidance also generally states that MDAPs are to develop a cybersecurity strategy by milestone A (technology development start) and update the strategy at subsequent milestones.[31] The strategy is expected to detail the cybersecurity practices the program will use to address cybersecurity risks and reduce the likelihood of severe impacts from a cyberattack. DOD guidance for MTA programs requires that components include a test strategy, or assessment of test results, in the acquisition strategy. This test strategy or assessment of test results should document the evaluation of the demonstrated operational performance, to include validation of required cybersecurity.[32]

Defense Industrial Base

The U.S. defense industrial base is the combination of people, technology, institutions, technological know-how, and facilities used to design, develop, manufacture, and maintain the weapons needed to meet U.S. national security objectives. The defense industrial base can be divided into several tiers: prime contractors, major subcontractors, and the lower tiers that include suppliers of parts, electronic components, and raw materials. Industries and companies that comprise the defense industrial base often supply both military and commercial markets. DOD estimates that the defense industrial base consists of more than 200,000 companies.

Building on long-standing concerns about the defense industrial base, recent executive orders and reports have renewed focus on the health of this industrial base.[33] In particular, DOD's September 2018 industrial base report, prepared in response to Executive Order 13806, established a baseline assessment of the defense industrial base and created 10

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

[32]DOD Instruction 5000.80.

[33]See Exec. Order 13806, 82 Fed. Reg. 34,597 (July 21, 2017); Exec. Order 14017, 86 Fed. Reg. 11,849 (Feb. 24, 2021); Department of Defense, *Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States* (September 2018); The White House, *Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth* (June 2021). The DOD and White House reports were issued pursuant to Executive Orders 13806 and 14017, respectively.

archetypes for assessing industrial base risks.[34] Table 4 shows the 10 risk archetypes DOD created.

Table 4: Department of Defense Industrial Base Risk Archetypes and Definitions

Risk archetype	Definition
Sole source	Only one supplier is able to provide the required capability
Single source	Only one supplier is qualified to provide the required capability
Fragile supplier	A specific supplier is financially challenged or distressed
Fragile market	Structurally poor industry economics; potentially approaching domestic extinction
Capacity constrained supply market	Capacity is unavailable in required quantities or time due to competing market demands
Foreign dependency	Domestic industry does not produce the product or does not produce it in sufficient quantities
Diminishing manufacturing sources and material shortages	Product or material obsolescence resulting from a decline in relevant suppliers
Gap in U.S.-based human capital	Industry is unable to hire or retain U.S. workers with the necessary skill sets
Erosion of U.S.-based infrastructure	Loss of specialized capital equipment needed to integrate, manufacture, or maintain capability
Product security	Lack of cyber and physical protection results in eroding integrity, confidence, and competitive advantage

Source: GAO summary of Department of Defense information. I GAO-22-105230

[34]Department of Defense, *Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States* (September 2018).

Examples of Recent Legislative Provisions Related to Defense Industrial Base Issues

Legislative Reporting Requirement Regarding Industrial Base for Large Solid Rocket Motors

Section 1699 of the John S. McCain National Defense Authorization Act for Fiscal Year 2019 requires the Under Secretary of Defense for Acquisition and Sustainment to submit a report to the congressional defense committees on whether, and if so, how, the federal government will sustain more than one supplier for large solid rocket motors.

Source: GAO analysis of Pub. L. No. 115-232. | GAO-22-105230

Initiatives to Leverage Small Businesses in the National Technology and Industrial Base

Section 861 of the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 requires the Department of Defense (DOD) to establish initiatives to increase the effectiveness of the DOD in specifically leveraging small businesses to eliminate gaps and vulnerabilities in the national technology and industrial base as well as expand the number of small businesses in the national technology and industrial base.

Source: GAO analysis of Pub. L. No. 116-283. | GAO-22-105230

DOD and Congress have taken steps to mitigate defense industrial base risks by establishing and modifying policies, implementing organizational changes, and including numerous provisions related to defense industrial base oversight issues in recent NDAAs. These provisions address issues ranging from specific industry sectors, small business matters, and defense industrial base oversight.

According to DOD, one of the first steps to ensure a secure and resilient industrial base is understanding constantly evolving threats and vulnerabilities. DOD conducts assessments of the industrial base to inform the department's policies and to mitigate supply chain problems that have the potential to affect it. DOD Instruction 5000.60 is the overarching instruction that outlines the responsibilities for conducting industrial base assessments.[35] Additionally, DOD Instruction 5000.85 outlines defense industrial base analysis responsibilities for programs following the major capability acquisition pathway.[36] According to DOD Instruction 5000.60, industrial base assessments are an ongoing process that inform a program's acquisition strategy, request for proposals, and the life-cycle management of the program.

The Office of Industrial Base Policy within the Office of the USD(A&S) is DOD's focal point for defense industrial base issues and mitigates industrial base risks and develops related policies. In addition to the Office of Industrial Base Policy, other entities within DOD, such as the Industrial Base Council, jointly oversee the defense industrial base. In addition, some of these entities also coordinate with program offices to identify, mitigate, and monitor risks across the industrial base. Appendix VI provides a description of key entities involved in industrial base oversight.

[35]DOD Instruction 5000.60, *Defense Industrial Base Assessments* (July 18, 2014) (Change 2 Effective Aug. 31, 2018).

[36]DOD Instruction 5000.85.

T-7A Red Hawk

Source: Boeing Corporation. | GAO-22-105230

OVERVIEW

DOD Weapon Portfolio for 2022

Insight into cost performance is hampered by limited data and schedule challenges remain.

The portfolio of DOD's costliest weapon programs tracked by the Office of the Secretary of Defense (OSD) consists of MDAPs, future MDAPs, and MTA programs with costs exceeding the cost threshold for MDAP designation. Table 5 shows the programs that DOD tracked in these categories as of the third quarter of fiscal year 2021. While not reflected in the portfolio, the military departments also track other costly programs, such as classified programs, and programs that have yet to formally designate an AAF pathway but expect to exceed the cost threshold for MDAP designation.

Table 5: Portfolio of Costliest Weapon Programs Tracked by DOD (as of third quarter fiscal year 2021)

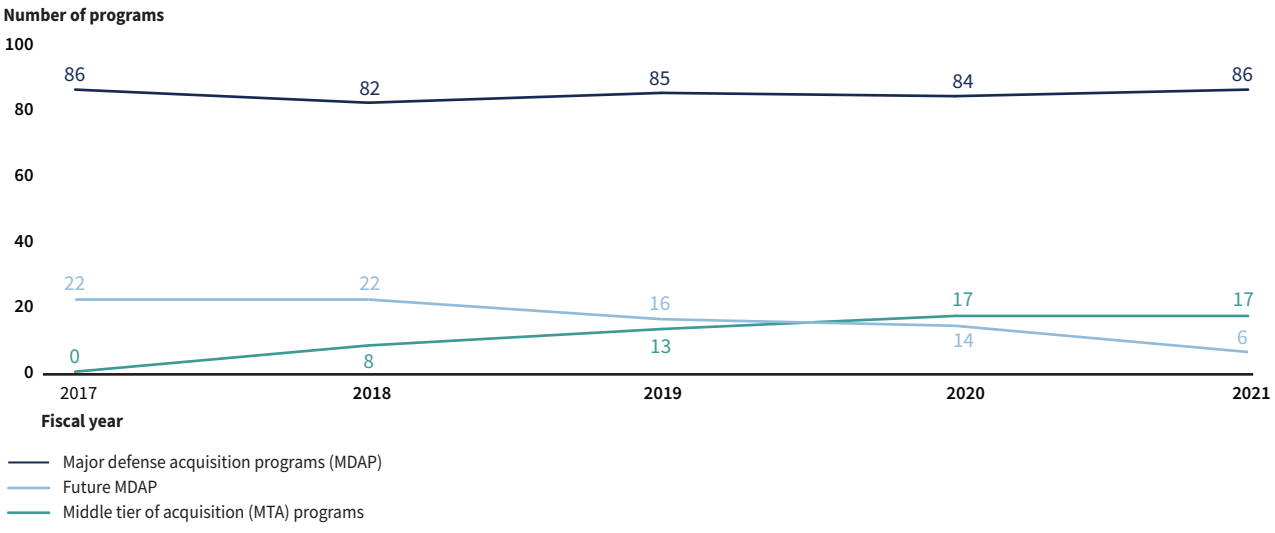
Type of program	Number of programs	Air Force	Navy	Army	DOD
Major defense acquisition program (MDAP)	86	30	39	15	2
Future MDAP	6	3	1	2	0
Middle tier of acquisition program exceeding the cost thresholds for MDAP designation	17	10	1	6	0

Source: GAO analysis of Department of Defense (DOD) information. | GAO-22-105230

Note: The table reflects the count of programs DOD tracks in its Defense Acquisition Visibility Environment and Defense Acquisition Management Information Retrieval systems. Program counts do not match the number of individual programs we assessed in this report due to our criteria for selecting programs.

The composition of DOD's weapon portfolio has evolved over the last 5 fiscal years with the introduction of the MTA pathway in April 2018 and the implementation of the AAF in January 2020. The number of MDAPs that DOD tracks has remained relatively consistent. However, the number of future MDAPs decreased while the use of the MTA pathway generally increased in the last 5 years (see figure 4).

Figure 4: DOD's Use of Future MDAPs Decreased While MTA Programs Increased over the Last 5 Years



Source: GAO analysis of Department of Defense (DOD) information. | GAO-22-105230

Note: This figure reflects programs identified by DOD in each fiscal year. Data for 2021 reflects information obtained from DOD in the third quarter of fiscal year 2021.

SUMMARY OF WEAPON PROGRAMS GAO ASSESSED

Incomplete data in fiscal year 2022 budget request limits analysis of entire portfolio.

Indirect Fire Protection Capability Increment 2

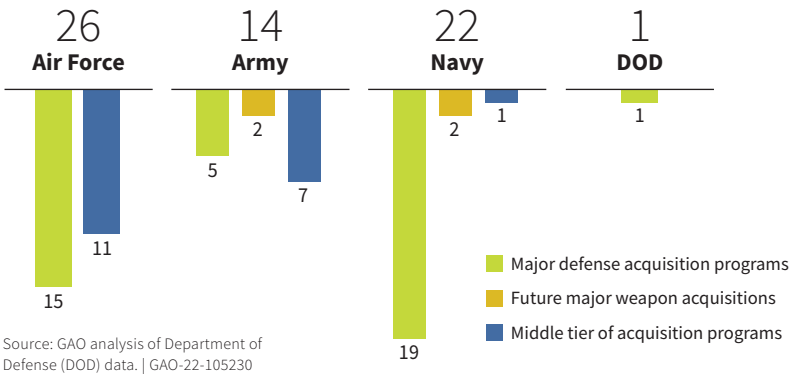
Source: © 2021 Dynetics, Inc. | GAO-22-105230

Figure 5: GAO Assessed 63 Selected DOD Weapon Acquisition Efforts in 2022

Source: GAO analysis of Department of Defense (DOD) data. | GAO-22-105230

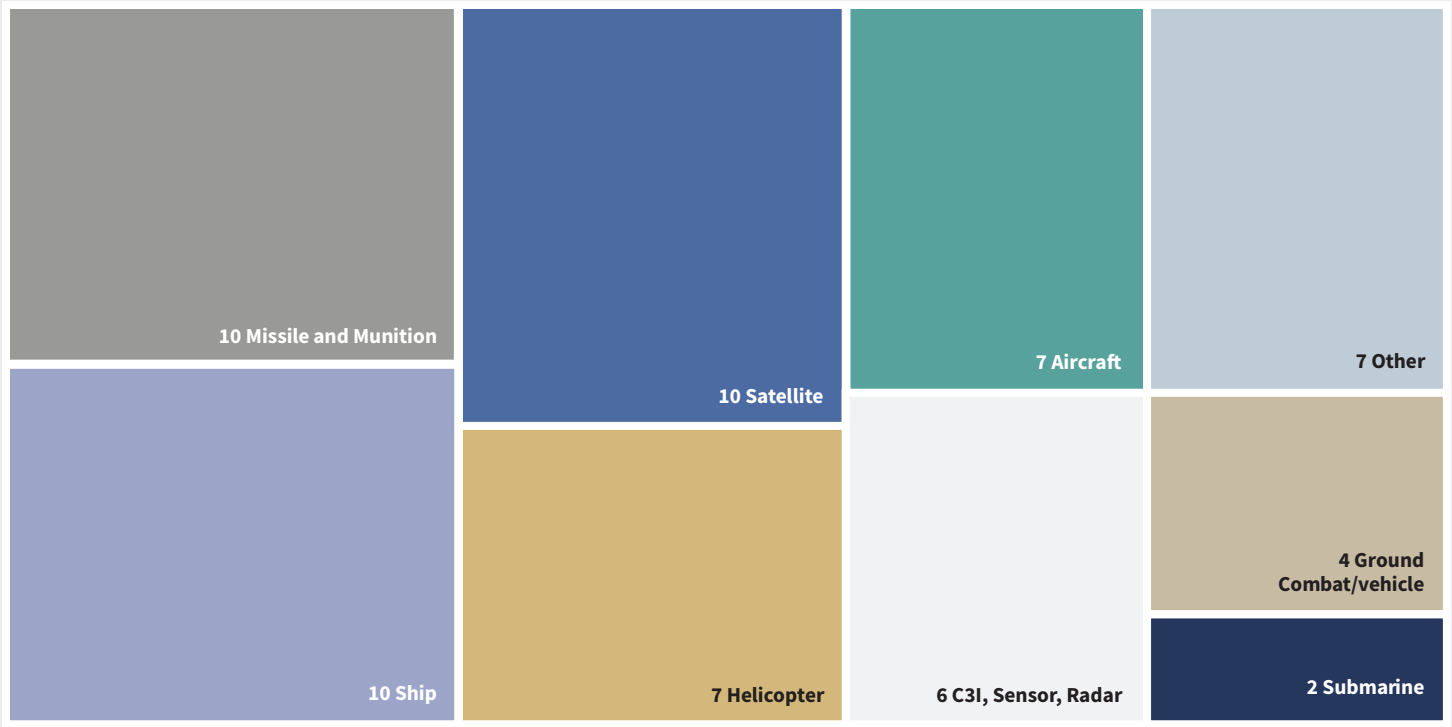
In prior years, we assessed the cost and schedule performance of DOD's portfolio of over 80 MDAPs. Due to the lack of comprehensive Selected Acquisition Reports produced for the fiscal year 2021 reporting period, this year we could not assess the full portfolio of MDAPs. DOD determined it could not develop these reports due to incomplete data in the budget request for fiscal year 2022. As such, this year our analysis is limited to a subset of MDAPs that we individually assessed. Figure 6 shows the type of programs that we reviewed by military department.

Figure 6: Type of Programs GAO Reviewed by Military Department



Source: GAO analysis of Department of Defense (DOD) data. | GAO-22-105230

Figure 7: Number of Programs GAO Reviewed by Commodity



C3I = Command, Control, Communications and Intelligence
Source: GAO analysis of Department of Defense data. | GAO-22-105230

Note: "Other" includes programs that did not list a program type in their Selected Acquisition Report, mission systems, and software systems and components, among other things.

FUTURE MAJOR WEAPON ACQUISITIONS

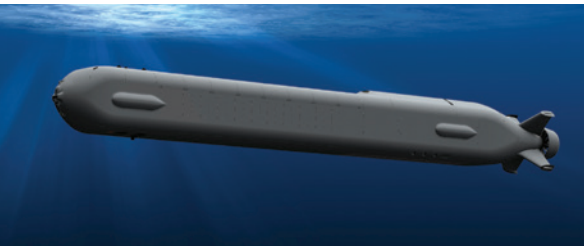
Costly research and development efforts exist that have yet to designate an AAF pathway.

We have previously reported on future MDAPs to highlight large planned investments and assess the extent to which these programs planned to acquire sufficient knowledge by the time they were formally initiated as MDAPs. However, with the introduction of the AAF, many of DOD's costliest future acquisition efforts no longer begin development as a future MDAP.

For example, research and development efforts may begin development before deciding on an AAF pathway. These efforts are not tracked by OSD until they are formally initiated using an AAF pathway.

For the first time, this year we gathered available information about those efforts, which, collectively with future MDAPs, we refer to as "Future Major Weapon Acquisitions." Figure 8 highlights examples of future major weapon acquisitions likely to reach the cost threshold for MDAP designation that have yet to formally initiate an AAF pathway.

Figure 8: Examples of Future Major Weapon Acquisitions Identified by GAO That Have Yet to Designate an Acquisition Pathway



Source: U.S. Navy. | GAO-22-105230

Orca Extra Large Unmanned Undersea Vehicle (XLUUV)

Military department: Navy

Description: The XLUUV is an uncrewed undersea vehicle that is expected to meet various undersea missions by leveraging a modular payload bay that can carry and deploy various payload types.

Approach: Currently being developed as a research and development project in response to an emergent operational need. Design contracts were awarded in September 2017 to develop initial designs and the Navy exercised options in 2019 to acquire five systems. The program reported in June 2021 that delivery of the first system was delayed from December 2020 to September 2022.

Estimated funding: Fiscal year 2022 budget request includes $328 million (excludes costs beyond fiscal year 2022 needed to complete the system).

Quantity for current effort: Five under construction; up to four more under contract.

Planned acquisition pathway: As of March 2022, the Navy plans to transition XLUUV to the major capability acquisition pathway at some point in the future.

Source: U.S. Navy. | GAO-22-105230

Large Unmanned Surface Vehicle (LUSV)

Military department: Navy

Description: The LUSV is a planned long-endurance, uncrewed ship capable of conducting warfare operations with varying levels of autonomy. It is expected to integrate anti-ship and land-attack capabilities.

Approach: Currently being developed as a research and development project. The Navy plans to incrementally deliver capability as technologies mature and qualify representative machinery plants prior to proceeding to production.

Estimated funding: Fiscal year 2022 budget request includes $473.1 million (excludes costs beyond fiscal year 2022 needed to complete the system).

Quantity for current effort: To be determined.

Planned acquisition pathway: As of March 2022, the Navy plans to transition LUSV to the major capability acquisition pathway at some point in the future.

Source: U.S. Army. | GAO-22-105230

Long Range Hypersonic Weapon (LRHW)

Military department: Army

Description: The LRHW effort seeks to develop and field a ground-launched, hypersonic missile as part of the Army's strategic, long-range, precision fires portfolio. LRHW is a joint effort with the Navy's Conventional Prompt Strike program, which is developing the same system to be fired from ships.

Approach: LRHW is using research and development funds to deliver an initial capability.

Estimated funding: $2+ billion in research development, testing, and evaluation costs through fiscal year 2025.

Quantity for current effort: 8 (developmental quantity through fiscal year 2025).

Planned acquisition pathway: To be determined.

As of January 2022, DOD has yet to update its approach to tracking future major weapon acquisitions to reflect the AAF. However, these efforts reflect significant investments to address capability gaps and warfighter needs that are occurring before programs are formally initiated in an AAF pathway. The resulting lack of insight has the potential to undermine DOD's understanding of its full portfolio of weapon programs and ability to allocate resources to programs that best accomplish the department's goals. We will continue our efforts in our future assessments to identify and report on these programs.

DOD MDAP Portfolio

COSTS

Insight into MDAP cost performance is limited by lack of data.

Due to the lack of available data, we could not assess the 1-year cost performance of MDAPs. DOD officials told us they have collected cost data, but those data are inconsistent across the military departments. The inconsistency results from military departments not consistently accounting for future year funding since it was not included in the fiscal year 2022 budget request. Since January 2021, some programs reported new baselines due to updated program costs or milestones. Specifically, we found that seven MDAPs issued new baselines since January 2021, and of those, six show increased costs since our last assessment.

Source: General Dynamics Electric Boat. | GAO-22-105230

Examples of MDAPs that reported cost growth since our last assessment

SSBN 826 *Columbia* Class Ballistic Missile Submarine

The program reported over a $3.4 billion total cost increase since our last assessment. This increase reflects the August 2020 independent cost estimate for the whole class, expenditures on the supplier base and missile tubes that required costly rework, and poor contractor performance during design, among other things.

Integrated Air and Missile Defense (IAMD)

The program reported over a $1 billion total cost increase since our last assessment. A new baseline cost estimate was validated in support of the January 2021 production decision. According to the program office, the updated cost estimate increased funding through fiscal year 2031 in order to provide additional warfighter capability to respond to emerging threats, such as enabling integration with additional weapons and sensors, as well as continuous software development and testing.

Source: Dynetics | GAO-22-105230

Ship to Shore Connector Amphibious Craft (SSC)

The program reported a nearly $510 million cost increase since our last assessment. It breached its cost baseline thresholds in March 2021 due to technical challenges, along with labor and material cost growth. The next 14 craft on the follow-on contract are also expected to have increased unit costs, according to program officials.

Source: Textron Systems. | GAO-22-105230

DOD MDAP Portfolio

SCHEDULE PERFORMANCE

More than half of MDAPs reported schedule delays since last year.

Next Generation Jammer Mid-Band (shown on an EA-18G Growler aircraft)

Source: U.S. Navy. | GAO-22-105230

Despite DOD's efforts over the last several years to accelerate capability delivery, over half of the MDAPs we reviewed reported a delay achieving initial operational capability (IOC) since our last assessment. None of the 29 programs for which we reviewed their schedule reported accelerating a cycle time. Moreover, nine programs that reported schedule delays in our last assessment also reported further delays as of January 2022.

Table 6: More Than Half of Major Defense Acquisition Programs GAO Reviewed Reported a Cycle Time Delay since January 2021

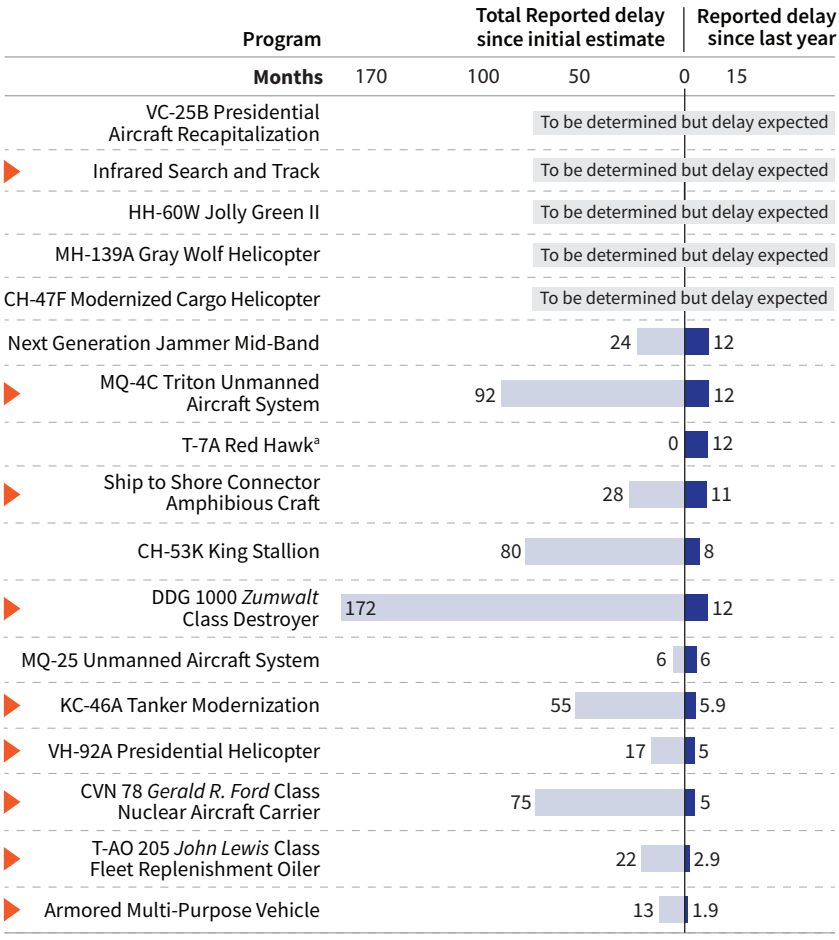
Type of program	Number of MDAPs	Percentage of MDAPs	Range of known delay (in months) reported in the past year
Reported a cycle time delay	17	59	2-12[a]
Did not report a cycle time delay	12	41	—
Total	**29**		

Source: GAO analysis of Department of Defense data. | GAO-22-105230

Note: We analyzed 29 major defense acquisition programs (MDAP) that had yet to declare IOC as of April 2021. We measure IOC change as a cycle time change.

[a]Five programs reported initial operational capability (IOC) delays but the total delay was unknown at the time of our review.

Figure 9: Major Defense Acquisition Programs GAO Reviewed That Reported a Cycle Time Delay since January 2021



Source: GAO analysis of Department of Defense data. | GAO-22-105230

Note: Initial operational capability (IOC) is generally a point in time when a system can meet the minimum operational capabilities for a user's stated need. Five programs that were included in our portfolio analysis and individual program assessments were excluded from this analysis either because they do not track IOC or because they already achieved IOC as of April 2021.

[a]T-7A Red Hawk reported a 12-month delay since last year, but the program is currently ahead of its IOC objective date.

Examples of programs that reported IOC delays since our last assessment

VC-25B Presidential Aircraft Recapitalization

The program projects a delay due to the contractor transitioning to a new supplier and other issues, which requires the program to develop a new baseline, according to program officials. However, the extent of the delay has yet to be determined.

Next Generation Jammer Mid-Band

The program reported a delay due to a design issue with a test pod, which required a redesign to support flight testing. The issue was first discovered in 2019, but the program did not anticipate at the time that it would affect testing.

CVN 78 *Gerald R. Ford* Class Nuclear Aircraft Carrier

The program reported a 21-month delay in its December 2019 Selected Acquisition Report. In September 2021, the program reported an additional delay due to issues with the ship's Advanced Weapons Elevators.

MQ-4C Triton Unmanned Aircraft System

The program reported a 16-month delay in its December 2019 Selected Acquisition Report. Program officials reported an additional delay due to technical problems.

Ship to Shore Connector Amphibious Craft

The program reported a 5-month delay in its December 2019 Selected Acquisition Report. The program has since reported an additional delay due to technical challenges with its propeller and gearbox.

DOD MTA Portfolio

MTA programs face schedule challenges and persistent data quality issues.

Since our last assessment, we expanded our coverage of MTA programs to include 19 programs—17 rapid prototyping and two rapid fielding—15 of which have estimated costs greater than the threshold for MDAP designation.[37] These programs provide critical capabilities that vary from aircraft hardware to satellite communication capabilities. We reviewed four new MTA efforts this year—two of which were previously tracked as pre-MDAPs by DOD—while two other programs from our last assessment exited our portfolio (see figure 10).

Deep Space Advanced Radar Capability

Source: JHU/APL. | GAO-22-105230

Figure 10: Overview of 19 MTA Programs Reviewed by GAO

Middle tier of acquisition (MTA) pathway

Rapid Prototyping: ≤ 5 years

Rapid Fielding: ≤ 5 years

We reviewed 17 rapid prototyping efforts:

Air Force

- Air-launched Rapid Response Weapon (ARRW)
- B-52 Commercial Engine Replacement Program (CERP) Rapid Virtual Prototype (RVP)
- ★ **Deep Space Advanced Radar Capability (DARC)**
- Evolved Strategic SATCOM (ESS)
- F-22 Rapid Prototyping
- Future Operationally Resilient Ground Evolution (FORGE)
- Military Global Positioning System (GPS) User Equipment Increment 2 (MGUE Inc. 2)
- Next Generation Overhead Persistent Infrared Block 0-Geosynchronous Satellites (Next Gen OPIR Block 0 GEO)
- Protected Tactical Enterprise Service (PTES)
- Protected Tactical SATCOM (PTS)

Army

- Extended Range Cannon Artillery (ERCA)
- ★ **Future Long-Range Assault Aircraft (FLRAA)**
- ★ **Indirect Fire Protection Capability Increment 2 (IFPC Inc. 2)**
- Lower Tier Air and Missile Defense Sensor (LTAMDS)
- Mobile Protected Firepower (MPF)
- Optionally Manned Fighting Vehicle (OMFV)

Navy

- Conventional Prompt Strike (CPS)

We reviewed two rapid fielding efforts:

Air Force

- F-15EX

Army

- ★ **Integrated Visual Augmentation System (IVAS)**

Two efforts from our prior report are no longer included:

- The Air Force's Air Operations Center Weapon System Modifications program transitioned to the software acquisition pathway.
- The Army's Integrated Visual Augmentation System (IVAS) rapid prototyping effort is ongoing through fiscal year 2023 but has been funded to over 96 percent of its total estimated cost and transitioned to a rapid fielding effort.

★ **New MTA effort reviewed by GAO this year**

Source: GAO analysis of Department of Defense data. | GAO-22-105230

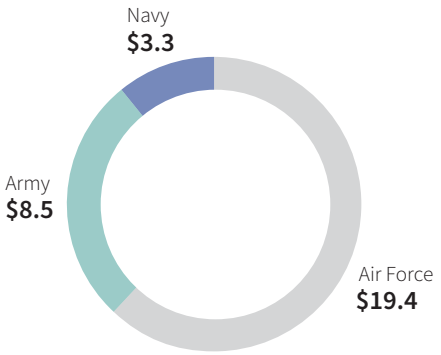
[37]We also assessed four MTA programs that did not meet the cost threshold for MDAP designation. See appendix II for additional details on our selection methodology for these programs.

COST

DOD plans to invest about $31 billion in current MTA programs, but cost reporting continues to be inconsistent.

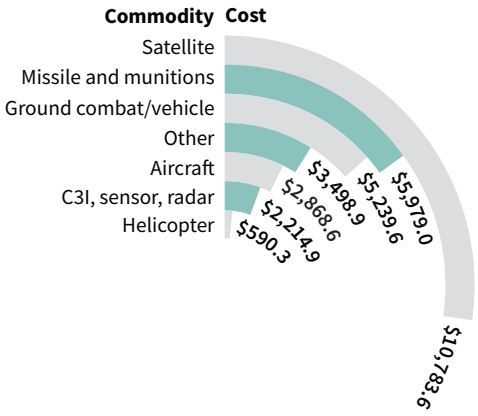
As in past years, we found that MTA programs reported inconsistent cost information to us. We also identified other reliability concerns with MTA program data submitted to OSD and Congress. Combined cost estimates totaled $31.2 billion for the 19 MTA programs we reviewed (see figures 11 and 12).

Figure 11: Planned Cost of Current Middle Tier of Acquisition Efforts (fiscal year 2022 dollars in billions)



Source: GAO analysis of Department of Defense data. | GAO-22-105230

Figure 12: Estimated Costs of Current Middle Tier of Acquisition Efforts by Commodity (fiscal year 2022 dollars in millions)



C3I = Command, Control, Communications and Intelligence
Source: GAO analysis of Department of Defense data. | GAO-22-105230

For the third consecutive year, we found that MTA cost information reported to us was inconsistent across programs. In some cases, reported costs reflected a different scope than the current MTA effort or included funding beyond the current effort. This required follow up with program officials to clarify data and resolve discrepancies.

We also identified other reliability concerns with MTA program data submitted by program offices to OSD. For example, we found discrepancies in MTA planned completion dates and critical technology information reported to OSD compared to what was reported to us. Unreliable data hinders effective DOD and congressional oversight of these programs. We have ongoing work that is further examining these data reliability issues. We expect to issue a report on the results of that review later in 2022.

Examples of MTA programs that reported inconsistent costs as compared with our last assessment

Lower Tier Air and Missile Defense Sensor (LTAMDS)

Source: Copyright 2020 Raytheon Company. | GAO-22-105230

- The Army's LTAMDS program reported a cost estimate this year that was approximately $800 million higher than what the program reported in our prior assessment.
- According to the program, the funding it reported to us in our prior assessment considered only the costs related to developing and fielding urgent material release prototypes and did not include development costs for the entire time frame of the current MTA effort.

Next Generation Overhead Persistent Infrared Block 0-Geosynchronous Earth Orbit Satellites (Next Gen OPIR Block 0 GEO)

- The Air Force's Next Gen OPIR program reported a cost estimate approximately $3.1 billion lower than what the program reported in our prior assessment.
- Program office officials told us the prior costs included both the Next Gen OPIR GEO and Next Gen OPIR Polar satellite portions of the program; however, the latter is no longer part of this MTA effort and, thus, not included in our assessment.

Conventional Prompt Strike (CPS)

- The Navy's CPS program reported a cost estimate approximately $700 million lower than what the program reported in our prior assessment.
- According to officials, the program received approximately 24 percent less funding than requested for fiscal year 2021 and underwent a program restructuring as a result.

DOD MTA Portfolio

SCHEDULE

Delayed interim milestones put planned completion dates and outcomes at risk.

Source: U.S. Air Force. | GAO-22-105230

Some MTA programs have experienced challenges that have delayed interim milestones and depleted schedule margin towards planned completion dates, suggesting that initial plans may have been overly optimistic.

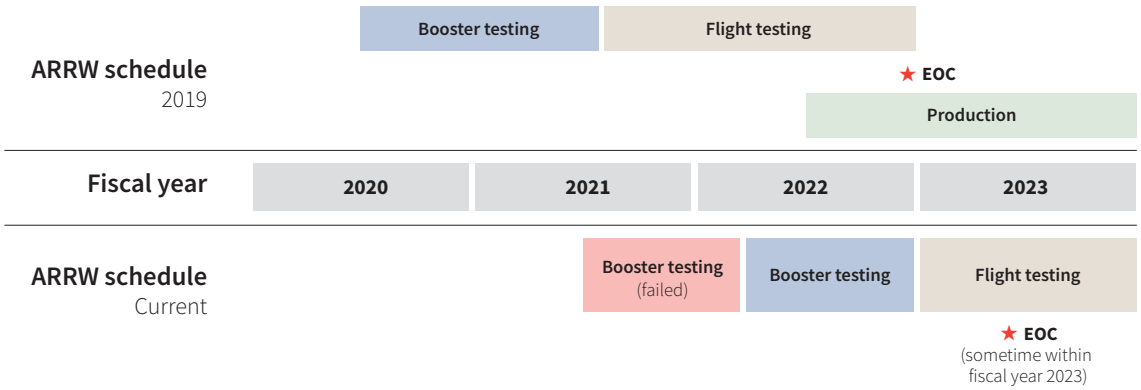
We will continue to monitor the effects of these schedule changes, including the potential that programs may need to consider tradeoffs such as reduced residual capability at the completion of the MTA effort.

Examples of MTA Programs with Reported Delays

The Air Force's Air-launched Rapid Response Weapon (ARRW) rapid prototyping effort had an aggressive, time-compressed flight test schedule. The plan included three booster tests in fiscal year 2021. However, after two failed attempts to execute the first test, initial testing was paused to find the cause of these failures. The program subsequently experienced another booster test failure during the first quarter of fiscal year 2022. As a result, the remaining test schedule was compressed and MTA completion was delayed by 11 months, exhausting the remaining schedule margin within the original 5-year schedule.

The program requested procurement funding for 12 missiles and was planning to move forward with initiation of a new rapid fielding effort in fiscal year 2022. However, the Joint Explanatory Statement accompanying the Consolidated Appropriations Act, 2022 stated that no procurement funds were being provided for ARRW, and instead provided additional research, development, test and evaluation funds to support an extension of the testing program and mitigate a projected funding shortfall for the prototyping effort.

Figure 13: Optimistic Development Schedule for Air-launched Rapid Response Weapon (ARRW) Program Compressed Following Early Testing Challenges



★ **EOC** = Early Operational Capability

Source: GAO analysis of program office documentation. | GAO-22-105230

We reported last year that critical technologies for the **Army's Extended Range Cannon Artillery (ERCA)** program were generally less mature than officials were expecting. However, the program planned to make significant progress on maturing these technologies before the end of the effort. This year, we found that the program's technology readiness assessment, completed in July 2021, revealed issues that testing officials said would require additional effort for maturing technologies. Programs officials also cited delays related to COVID-19, prototype manufacturing, and the availability of ammunition for testing. As a result, the program is pursuing a request for a waiver to extend the effort an additional year beyond the 5-year MTA time frame in DOD policy.

The **Army's Lower Tier Air and Missile Defense Sensor (LTAMDS)** program delayed planned operational testing from November 2021 to the third quarter of fiscal year 2023 due to integration challenges. The program also delayed its expected MTA completion date by one year to the fourth quarter of fiscal year 2023—2 months before the 5-year point since initiation. Officials acknowledged hardware delivery delays increase risk to the program, but told us they still expect to complete testing and program activities during fiscal year 2023.

DOD MTA Portfolio

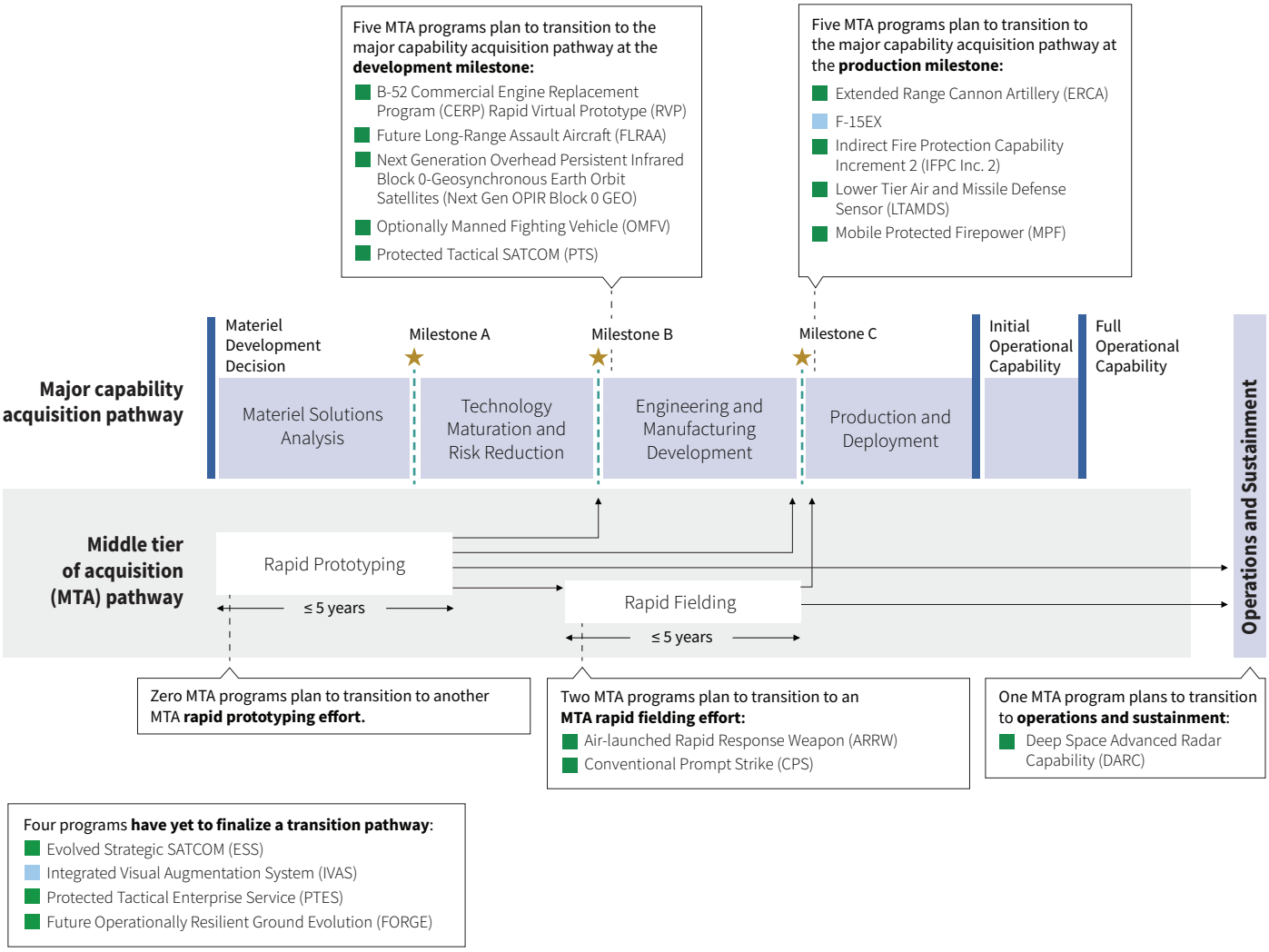
TRANSITION PLANS

Most MTA programs now plan to transition to the major capability acquisition pathway.

Of the 13 MTA programs that identified a specific transition plan, 10 expect to transition to the major capability acquisition pathway—up from six of 13 last year. This includes two programs—the Air Force's B-52 CERP RVP and the Army's LTAMDS—that previously planned to transition to another MTA effort. An additional program, the Space Force's ESS, is also considering a similar shift.

It is too soon to tell what effect the progress made during current MTA efforts will have on overall time frames for capability delivery. We will continue to monitor these programs as they transition to follow-on pathways. Figure 14 shows transition plans for MTA programs we reviewed.

Figure 14: Planned Transition Pathway of Current MTA Programs GAO Reviewed



Source: GAO analysis of Department of Defense data. | GAO-22-105230

Notes: MGUE Inc. 2 is developing receiver cards that the individual military services will produce and field. Thus, it does not have a transition path aligned with the AAF. F-22 Rapid Prototyping plans to transition most selected capabilities as individual programs to different pathways. F-15EX will transition during production, which is already ongoing for the program's first two lots.

DOD MTA Portfolio

TRANSITION PLANS

Examples of programs' changes to transition plans since our prior assessment

Conventional Prompt Strike (CPS) changed its transition plan from executing another rapid prototyping effort to transitioning to rapid fielding following funding cuts, the impending retirement of a submarine, and new Navy mission requirements, according to program officials.

Source: U.S. Navy. | GAO-22-105230

B-52 Commercial Engine Replacement Program (CERP) Rapid Virtual Prototype (RVP) planned to transition to another rapid prototyping effort. However, officials now say the program will transition to the major capability acquisition pathway at system development due to a high level of interest in the B-52 program and to facilitate more oversight from OSD.

Source: U.S. Air Force. | GAO-22-105230

Lower Tier Air and Missile Defense Sensor (LTAMDS) planned to transition to a rapid fielding MTA effort, but officials said they would be unable to produce all radars within the 5-year timeline established by DOD policy. The program now plans to transition to the major capability acquisition pathway at production.

Source: Copyright 2020 Raytheon Company. | GAO-22-105230

Evolved Strategic SATCOM (ESS) planned to transition to a rapid fielding effort, but is now considering instead a transition to the major capability acquisition pathway at system development. Program officials are unsure whether they could meet the 5-year MTA timeline established by DOD policy for the follow-on effort.

Source: U.S. Air Force. | GAO-22-105230

Protected Tactical Enterprise Service (PTES) planned to transition to a rapid fielding MTA effort, but officials said the software acquisition pathway is a potential option now that the pathway has matured and has been more clearly defined since it was rolled out in 2020.

Source: LinQuest. | GAO-22-105230

DOD MDAP Portfolio

DOD MTA Portfolio

COVID-19

Programs continue to report challenges related to COVID-19.

SSN 774 *Virginia* Class Submarine

Source: U.S. Navy photo courtesy of Huntington Ingalls Industries. I GAO-22-105230

Examples of COVID-19-related challenges reported by programs

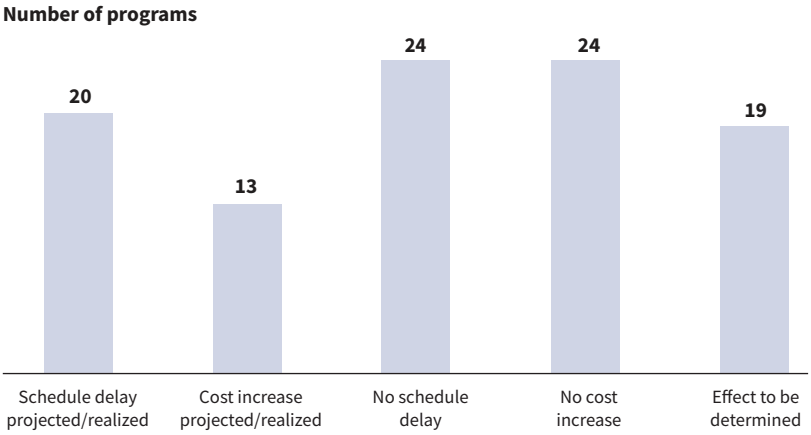
SSN 774 *Virginia* Class Submarine
The program reported that COVID-19 challenges exacerbated existing issues from its missile tube and casting vendors. Additionally, experience levels, inefficiencies, staffing shortfalls, and a temporary shutdown of hiring and training pipelines as a result of COVID-19 resulted in delays to Block IV construction. The program reported that COVID-19 effects added schedule risk in the form of material delivery delays and production inefficiencies related to workforce attendance, growth, and training.

Improved Turbine Engine Program
The program reported nearly a 16-week delay due to material or supplier delays as a result of COVID-19 challenges. In addition, the program reported that the contractor is experiencing higher than anticipated costs due to COVID-19 and is currently negotiating an equitable adjustment. Program officials stated they did not know the total effect on costs as of August 2021.

Next Generation Jammer Mid-Band
The program reported that COVID-19 challenges delayed the delivery of system components by 10 weeks and led to a cost increase of over $4 million due to supplier challenges caused by COVID-19.

For the second consecutive year, we surveyed MDAPs and MTA programs on challenges associated with COVID-19. This year, 35 of the 40 MDAPs and 10 of the 19 MTAs we surveyed reported challenges associated with COVID-19. In particular, more than half of the programs reported that they expect to experience or experienced cost or schedule challenges associated with COVID-19. Figure 15 shows the count of MDAPs and MTA programs that reported cost and schedule challenges associated with COVID-19.

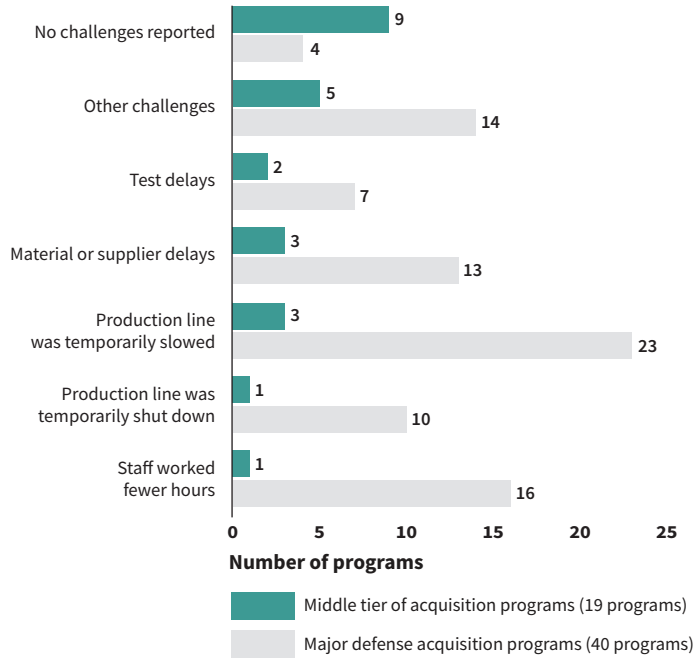
Figure 15: Extent to which Programs Reported Cost or Schedule Effects Associated with COVID-19 as of July 2021



Source: GAO analysis of questionnaire responses. | GAO-22-105230

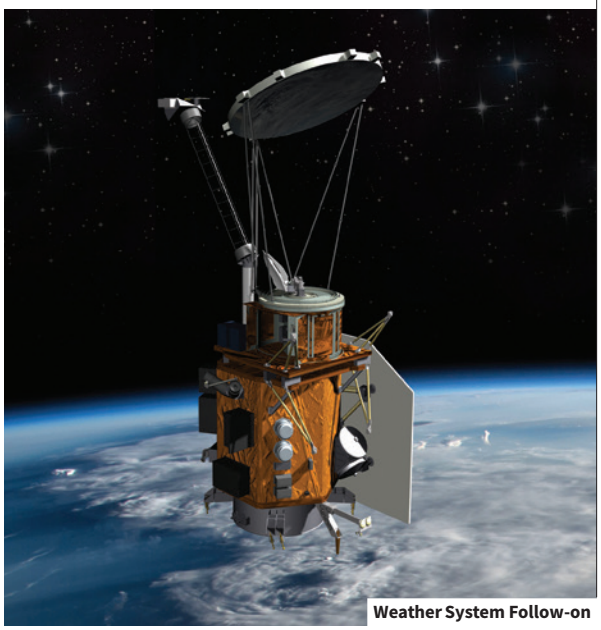
Note: We asked 59 programs if they experienced cost or schedule challenges. The counts above do not sum to 59 because programs could select more than one option.

Figure 16: Reported Challenges due to COVID-19 as of July 2021



Source: GAO analysis of questionnaire responses. | GAO-22-105230

Note: In some cases programs reported multiple challenges. As such, the totals in figure 16 above do not sum to 59 programs.



Weather System Follow-on

OVERVIEW

GAO Knowledge-Based Practices

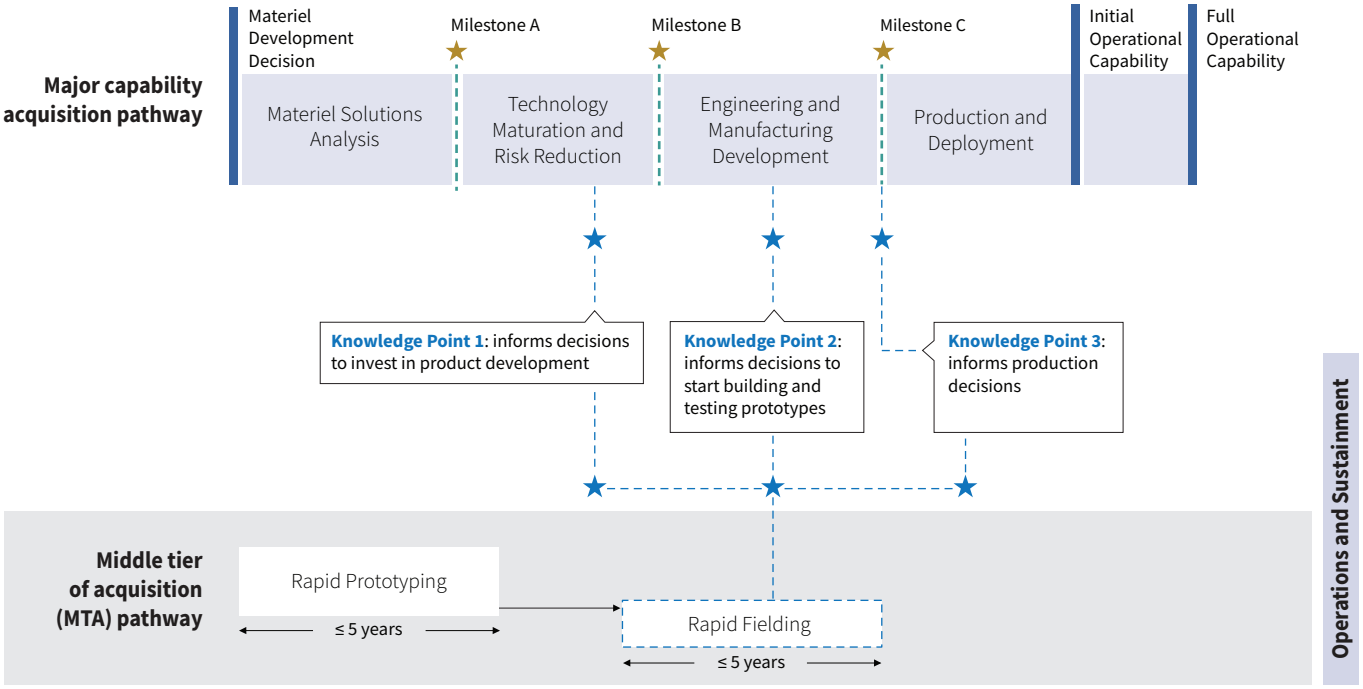
Programs' attainment of knowledge is limited, potentially increasing weapon system costs and slowing delivery.

Our body of work on MDAPs shows that attaining high levels of knowledge before programs make significant commitments during product development drives positive acquisition outcomes. A knowledge deficit early in a program can cascade through design and production.

For the second consecutive year, we assessed the extent to which MTA programs plan to obtain acquisition knowledge in preparation for planned follow-on efforts.[38] Our past work shows that gaining appropriate knowledge during the MTA effort will help ensure the program is well-positioned to field its eventual planned capabilities in a timely manner. For MTA programs, a knowledge deficit at the end of the current MTA effort poses cost and schedule risks after the program transitions to a follow-on effort.

Figure 17 depicts our knowledge-based acquisition practices.

Figure 17: GAO-Identified Knowledge Points Depicted on the Major Capability Acquisition and Middle Tier of Acquisition Pathways



Source: GAO analysis of Department of Defense Instruction 5000.80, 5000.85, and leading acquisition practices. | GAO-22-105230

[38]We applied our knowledge-based acquisition practices to MTA programs based on a program's specific transition plan. For example, if an MTA program planned to transition to the major capability acquisition pathway at system development, we assessed the extent to which the program planned to demonstrate knowledge that informs the decision to invest in product development by the end of the current MTA effort.

Knowledge-Based Practices

MDAPs

MDAPs continue to proceed with limited knowledge, but some have opportunities to improve knowledge to inform future investments.

CH-47F Modernized Cargo Helicopter Block II

Source: U.S. Army. I GAO-22-105230

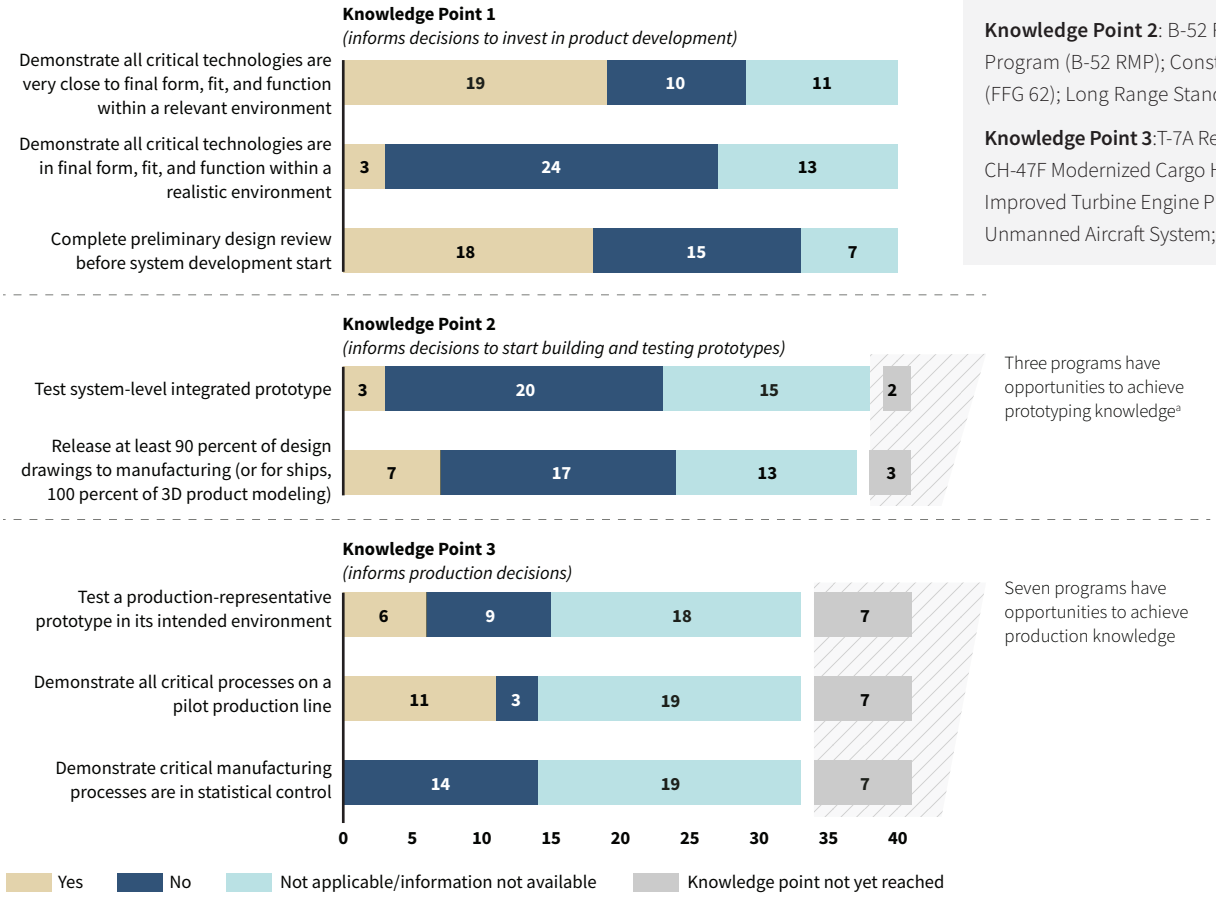
We continue to find that many MDAPs missed opportunities at key acquisition milestones to make knowledge-based decisions that can lead to improved cost and schedule outcomes. However, a limited number of MDAPs that have yet to reach key milestones still have opportunities to achieve knowledge to inform investment decisions for testing and production.

Observations

- Over half of the MDAPs we reviewed did not demonstrate critical technologies in a realistic environment before beginning system development—a practice that informs decisions to invest in product development.
- Additionally, 20 programs did not test a system-level integrated prototype, which informs decisions to build and test prototypes.
- Opportunities remain for three programs that have yet to reach their critical design review (knowledge point 2) to gain sufficient knowledge to inform decisions to build and test prototypes.
- Similarly, seven programs that have yet to reach their production milestone (knowledge point 3) still have the opportunity to gain sufficient knowledge to inform decisions to invest in production.

Figure 18 identifies the number of programs that have implemented key knowledge practices by the expected milestone.

Figure 18: Over Half of 40 Major Defense Acquisition Programs Did Not Implement Key Knowledge Practices



Programs that have opportunities to attain knowledge before key milestones

Knowledge Point 2: B-52 Radar Modernization Program (B-52 RMP); Constellation Class Frigate (FFG 62); Long Range Stand Off Weapon (LRSO)

Knowledge Point 3:T-7A Red Hawk; B-52 RMP; CH-47F Modernized Cargo Helicopter Block II; Improved Turbine Engine Program; LRSO; MQ-25 Unmanned Aircraft System; Precision Strike Missile

Source: GAO analysis of questionnaire data. I GAO-22-105230

Notes: DOD guidance calls for programs to demonstrate critical manufacturing processes on a pilot production line, but does not call for statistical control of those processes until the full-rate production decision. Leading acquisition practices, in contrast, call for this knowledge to be in hand at production start in order to ensure manufacturing processes are repeatable, sustainable, and capable of consistently producing parts within quality standards. We scored a knowledge-based practice as "not applicable" for a program if the particular practice was not relevant to the program, such as test of a production-representative satellite prototype in its intended environment of space. We also scored our six MDAP increments as "not applicable ."

[a]Testing a system-level integrated prototype does not apply to shipbuilding programs, thus FFG 62 is counted as "not applicable" for that knowledge point.

Knowledge-Based Practices

MDAPs

Certain knowledge-based practices are linked to better program outcomes.

For the fifth consecutive year, we found that, in general, MDAPs that completed certain knowledge-based practices had better cost and schedule outcomes. We conducted a statistical correlation analysis to determine whether a statistically significant link exists between non-shipbuilding MDAPs' unit costs and schedule performance and their implementation of leading acquisition practices.[39]

Observations

- We observed three knowledge-based practices with a statistically significant correlation to improved program cost and schedule performance, as shown in table 7.

Table 7: Statistically Significant Knowledge-Based Acquisition Practices and Corresponding Performance Outcomes among 27 Selected MDAPs

Knowledge practice	Net performance difference from programs that implemented the practice
Complete a preliminary design review before system development start	**36.4%** less unit cost growth **31.7%** less schedule growth
Release at least 90 percent of design drawings by critical design review	**49%** less unit cost growth **46.1%** less schedule growth
Test a system-level integrated prototype by critical design review	**26.4%** less unit cost growth **31.4%** less schedule growth

Source: GAO analysis of Department of Defense data and acquisition programs' responses to GAO questionnaire. | GAO-22-105230

Notes: We analyzed 27 major defense acquisition programs (MDAP) initiated between fiscal year 2011 and fiscal year 2021 that were completed programs or had passed all three knowledge points.

- This year, for the first time, we observed that demonstrating critical processes on a pilot production line prior to low-rate production correlated with larger schedule growth compared to programs that did not implement this practice. We do not have insight into the reason for this correlation, but we will continue to assess the effects of this practice in future reports.
- Consistent with prior years, we did not have sufficient data to calculate statistically significant results for some practices because of the insufficient number of programs implementing those practices. As the number of programs completing all three knowledge points increases, it is possible our analysis in future years will identify additional practices that have a statistically significant correlation to program outcomes.

[39]We analyzed 27 MDAPs—an increase of three programs from our 2021 analysis—that have completed system development, held a critical design review, and started production (i.e., completed knowledge points 1 through 3). These 27 programs are a separate subset from the 59 programs included in our questionnaire analysis. For example, shipbuilding projects use different metrics and are, therefore, excluded from the statistical analysis.

Knowledge-Based Practices

MTA PROGRAMS

Current knowledge attainment plans for MTA programs signal risk for some follow-on efforts.

We continued to find that MTA programs' plans to attain product knowledge before starting follow-on development or production efforts fall short of our leading acquisition practices. With DOD's increasing use of the MTA pathway, these programs now account for most of DOD's costliest new weapon acquisitions. Insufficient attainment of knowledge prior to beginning follow-on efforts may increase the risk that these critical capabilities encounter cost, schedule, or technical challenges during development or production.

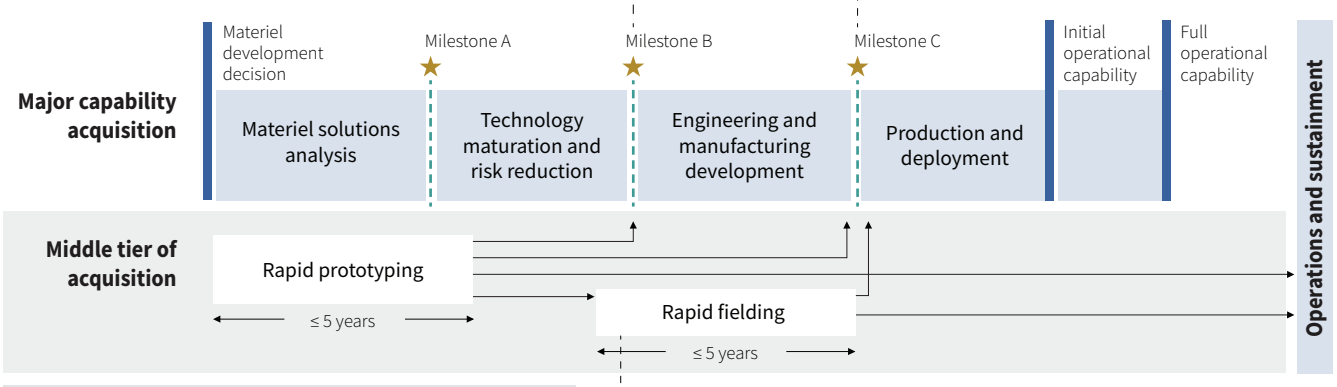
Observations

- This year, we continued to find that most MTA programs that have identified a transition plan do not plan to attain levels of knowledge recommended by leading acquisition practices before transitioning to their follow-on effort (see figure 19).
  - For example, all seven programs planning to transition into production (five at the production milestone of the major capability acquisition pathway and two MTA rapid fielding efforts) have knowledge attainment plans that fall short of leading acquisition practices for manufacturing maturity. This approach helps ensure the system can be produced within the program's cost, schedule, and quality targets.
- Four MTA programs were unsure of their transition plan, inhibiting our ability to assess planned knowledge attainment against our knowledge-based practices.

Figure 19: Overview of Knowledge Attainment Plans for Middle Tier of Acquisition (MTA) Programs GAO Reviewed

MTA programs that plan to transition to the major capability acquisition pathway at the **development milestone**:	**Planned attainment of knowledge**
	Point 1
B-52 Commercial Engine Replacement Program (CERP) Rapid Virtual Prototype (RVP)	●
Future Long-Range Assault Aircraft (FLRAA)	○
Next Generation Overhead Persistent Infrared Block 0-Geosynchronous Earth Orbit Satellites (Next Gen OPIR Block 0 GEO)	●
Optionally Manned Fighting Vehicle (OMFV)	N/A
Protected Tactical SATCOM (PTS)	○

MTA programs that plan to transition to the major capability acquisition pathway at the **production milestone**:	**Planned attainment of knowledge**		
	Point 1	Point 2	Point 3
Extended Range Cannon Artillery (ERCA)	●	●	○
F-15EX	●	●	○
Indirect Fire Protection Capability Increment 2 (IFPC Inc. 2)	N/A	●	○
Lower Tier Air and Missile Defense Sensor (LTAMDS)	●	●	○
Mobile Protected Firepower (MPF)	●	●	○



Programs that have **yet to determine its transition pathway** and for which knowledge attainment plans could not be assessed:

- Evolved Strategic SATCOM (ESS)
- Future Operationally Resilient Ground Evolution (FORGE)
- Integrated Visual Augmentation System (IVAS) Rapid Fielding
- Protected Tactical Enterprise Service (PTES)

Programs that plan to transition to a MTA **rapid fielding effort**:	**Planned attainment of knowledge**		
	Point 1	Point 2	Point 3
Air-launched Rapid Response Weapon (ARRW)	●	●	○
Conventional Prompt Strike (CPS)	●	○	○

● = Knowledge attained or planned ○ = Knowledge not planned **N/A** = Not applicable/information not available

Source: GAO analysis of program questionnaire responses. I GAO-22-105230

Notes: Knowledge point 1 informs decisions on whether to invest in development, whereas knowledge points 2 and 3 relate to design stability and production readiness, respectively. We did not assess Optionally Manned Fighting Vehicle or Indirect Fire Protection Capability Increment 2 against knowledge point 1—which includes demonstrating critical technologies in relevant and realistic environments—because the programs have yet to identify critical technologies. Evolved Strategic SATCOM has yet to determine whether it will transition to the major capability acquisition pathway with entry at system development or to a rapid fielding effort. However, the program does not plan to attain knowledge point 1, which applies to both transition pathways under consideration.

Knowledge-Based Practices

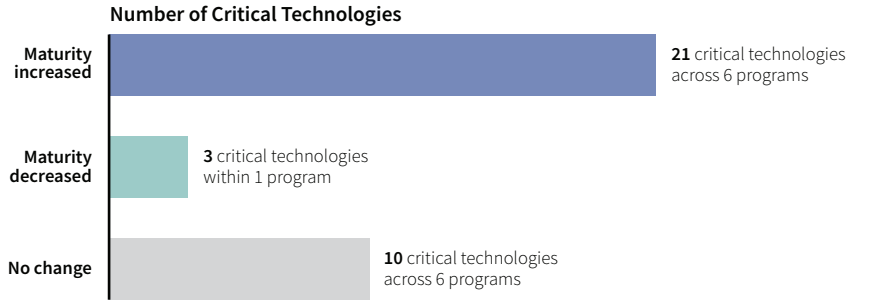
MTA PROGRAMS

Programs reported increasing the maturity of some critical technologies over the past year.

This year, 13 of the 19 MTA programs reported critical technologies, with most having at least one technology that has yet to reach maturity. Programs made progress over the past year towards maturation for some of the technologies that were immature as of our report last year.[40] But the amount of work remaining to reach maturity for all critical technologies varies significantly between programs.[41]

We reviewed the maturation progress over the past year of 34 immature critical technologies across eight MTA efforts. We found that the programs reported making measurable progress in maturing approximately two-thirds of these technologies (see figure 20).

Figure 20: Maturation Progress of Immature Critical Technologies for MTA Programs Since GAO's Prior Report



Source: GAO analysis of Department of Defense data. | GAO-22-105230

Notes: Three additional critical technologies across three programs were reported as mature last year but are at lower technology readiness levels this year and are no longer considered mature. These technologies are not reflected in this figure. Programs with multiple critical technologies could be included in more than one category.

The Army's **Lower Tier Air and Missile Defense Sensor (LTAMDS)** program reported that four of its critical technologies achieved maturity since our last assessment. Officials expect the program's final critical technology to reach maturity in fiscal year 2023.

Source: Copyright 2020 Raytheon Company. | GAO-22-105230

The Navy's **Conventional Prompt Strike (CPS)** program office said it discovered inconsistencies in prior reporting on critical technologies and conducted a review to ensure a more consistent approach, resulting in lower technology readiness levels than reported last year. The program still expects to reach maturity for all critical technologies before the end of the current MTA effort, planned for March 2024.

Source: U.S. Navy. | GAO-22-105230

[40]GAO, *Weapon Systems Annual Assessment: Updated Program Oversight Approach Needed*, GAO-21-222 (Washington, D.C.: June 8, 2021).

[41]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).

Knowledge-Based Practices

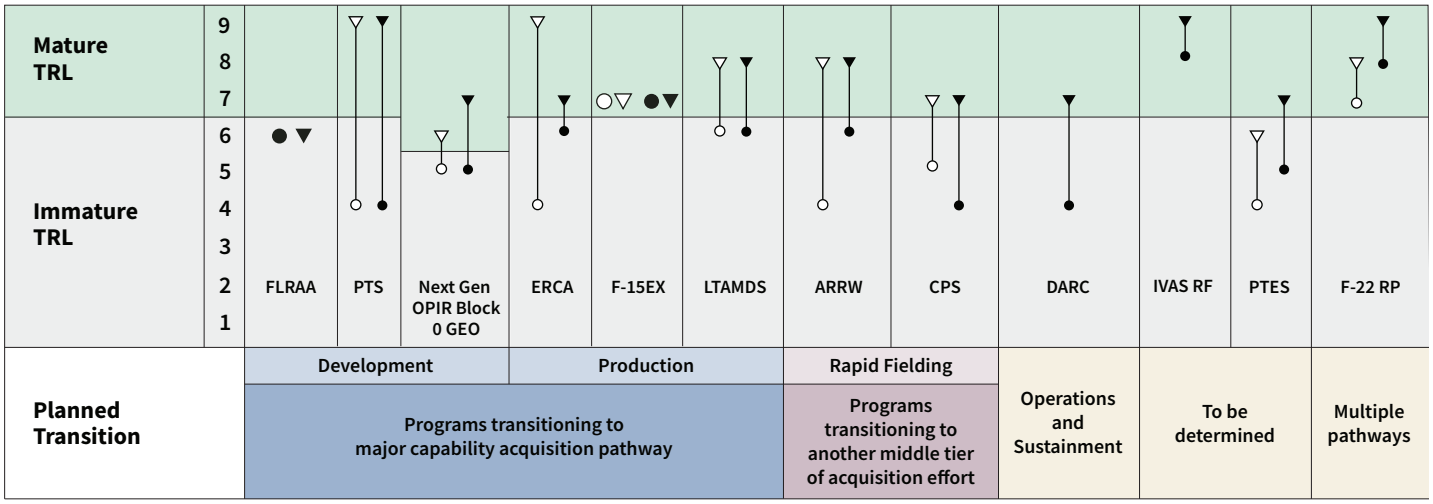
MTA PROGRAMS

Substantial work remains for some programs to fully mature critical technologies.

Nearly all MTA programs that reported having critical technologies plan for them to reach maturity before the end of the current MTA effort. For example, four programs reported that all of their technologies were at least approaching maturity, representing a major step-up in readiness that could include prototype demonstrations in a relevant environment. However, significant work remains for other programs. For example, three programs reported a current technology readiness level (TRL) as low as 4—corresponding with component validation in a laboratory environment.

We reported last year that technology maturation plans for some MTA programs were aggressive. Our analysis included multiple programs that planned to increase more than one TRL by the end of the current effort to achieve maturity. However, our prior work shows increasing even one TRL can take multiple years and becomes more challenging as the technology approaches maturity.[42] Figure 21 summarizes MTA programs' current and planned technology readiness levels as compared with our assessment in our 2021 report.

Figure 21: Current and Planned Technology Readiness Levels for Middle Tier of Acquisition Programs That Identified Critical Technologies, as Compared with GAO's Prior Report



○ Technology Readiness Level (TRL), as of report last year
△ Projected TRL at MTA Completion, as of report last year
ARRW Air-launched Rapid Response Weapon
CPS Conventional Prompt Strike
DARC Deep Space Advanced Radar Capability
ERCA Extended Range Cannon Artillery
F-22 RP F-22 Rapid Prototyping
FLRAA Future Long-Range Assault Aircraft

● Current TRL
▲ Projected TRL at MTA Completion
IVAS RF Integrated Visual Augmentation System (Rapid Fielding)
LTAMDS Lower Tier Air and Missile Defense Sensor
PTES Protected Tactical Enterprise Service
PTS Protected Tactical SATCOM
Next Gen OPIR Block 0 GEO Next Generation Overhead Persistent Infrared Block 0-Geosynchronous Earth Orbit Satellites

Source: GAO analysis of Department of Defense documentation. I GAO-22-105230

Notes: For programs with multiple critical technologies, the figure represents the lowest current TRL and the lowest planned TRL at program completion. Evolved Strategic SATCOM also has critical technologies, but the program reported that the three contractors developing prototypes have technologies at different maturity levels. See GAO-21-222 for the report noted in the figure.

[42]GAO-21-222.

Knowledge-Based Practices

MTA PROGRAMS

New MTA programs continue to start without key documentation to support well-informed initiation decisions.

We continue to find that DOD is initiating MTA programs with incomplete business cases. Our prior work shows that this information is important to help leaders make well-informed decisions about MTA program initiation.

Figure 22 summarizes the status of five key business case documents for the four new MTA programs we reviewed in this assessment.

Figure 22: Completion of Key Business Case Documents for Four New Middle Tier of Acquisition Programs Reviewed in GAO's Assessment, as of January 2022

Program name	Approved requirements document		Approved middle tier of acquisition strategy		Formal technology risk assessment		Cost estimate based on independent assessment		Formal schedule risk assessment	
	Initiation	Jan. 2022	Initiation	Jan. 2022	Initiation	Jan. 2022	Initiation	Jan. 2022	Initiation	Jan. 2022
Deep Space Advanced Radar Capability (Rapid Prototyping)	✓	✓	✓	✓	✗	✗	✗	✓	✗	✗
Future Long-Range Assault Aircraft (Rapid Prototyping)	✓	✓	✓	✓	✗	✗	✓	✓	✗	✗
Indirect Fire Protection Capability Increment 2 (Rapid Prototyping)	✓	✓	✓	✓	✗	✗	✓	✓	✗	✗
Integrated Visual Augmentation System (Rapid Fielding)	✓	✓	✓	✓	✗	✗	✗	✓	✗	✓

✓ Program had business case element ✗ Program did not have business case element

Source: GAO analysis of Department of Defense documentation. | GAO-22-105230

Notes: DOD Instruction 5000.80 requires MTA programs above certain cost thresholds to submit the following elements of a business case to the Under Secretary of Defense for Acquisition and Sustainment (USD A&S) at program initiation: approved requirements; a cost estimate; and an acquisition strategy that includes security, schedule, and technical or production risks, and also includes a test strategy or assessment of test results, and a transition plan. Moreover, DOD Instruction 5000.73 requires the Office of Cost Assessment and Program Evaluation to conduct an estimate of life-cycle costs for programs likely to exceed the acquisition category (ACAT) I threshold using the rapid prototyping path, or the ACAT I or II thresholds using the rapid fielding path.

None of the four new MTA programs included in this year's report completed formal assessments of schedule or technology risk at initiation. These elements help decision makers identify whether MTA programs using the rapid prototyping path are well-positioned to deliver a residual operational capability within 5 years, and MTA programs using the rapid fielding path are well-positioned to complete fielding within 5 years—objectives outlined in statute and DOD policy.

The importance of business case information is underscored by the challenges some programs are now facing. As mentioned above, the **Army's ERCA** and **LTAMDS programs** and the **Air Force's ARRW program** have experienced developmental challenges and schedule delays that now threaten the 5-year timelines.[43] These programs lacked key business case elements at initiation—including approved acquisition strategies and formal technology and schedule risk assessments—that could have helped decision makers assess the programs' likelihood of meeting MTA schedule objectives.

Source: U.S. Army. | GAO-22-105230

The **Army's MPF program**, in contrast, had all elements of its business case at initiation. The program reports that MPF's Soldier Vehicle Assessment and limited user test were completed in 2021 and MTA completion is planned for the third quarter of fiscal year 2022—a date that has remained steady during each of the 3 years we have included the program in our report.

[43]According to DOD Instruction 5000.80, MTA efforts may not exceed 5 years after the start date without a waiver from the Defense Acquisition Executive.

Programs Continued to Report Limited Adoption of Modern Software Practices and Mixed Progress Conducting Cybersecurity Assessments

DOD Continues to Mature Its Implementation of Modern Software Development Approaches

In recent years, DOD has taken steps to modernize its software development and acquisition approach through several initiatives. We reviewed a subset of the initiatives, including the implementation of software acquisition pilot programs and the introduction of a new software acquisition pathway in January 2020.[44] We assessed the current implementation status of these efforts and found the following:

- DOD recently initiated three pilot programs in response to legislation.[45] DOD completed one Agile pilot program and currently is implementing another in response to requirements in the NDAA for Fiscal Year 2018. However, DOD officials told us that they could not implement a third pilot on open source software as proposed due, in part, to the sensitivity of releasing weapon system software. We issued a report in 2019 assessing DOD's implementation of this pilot.[46] Appendix VII provides additional information on these pilots and their implementation status.

[44] A full evaluation of DOD's software initiatives was beyond the scope of this review. A more comprehensive review of DOD's initiatives is included in a separate report that assesses the performance of major information technology programs. That report will issue later this year.

[45]See National Defense Authorization Act for Fiscal Year 2018, Pub. L. No. 115-91, § 873-875 (2017).

[46]GAO, *Information Technology: DOD Needs to Fully Implement Program for Piloting Open Source Software,* GAO-19-457 (Washington, D.C.: Sept. 10, 2019).

Example of a Program Transitioning to a Modern Software Development Approach

The Army's Integrated Air and Missile Defense (IAMD) program, initiated in 2009, changed its software development approach from waterfall to Agile in November 2019. The program was part of the Agile pilot program established pursuant to section 873 of the National Defense Authorization Act for Fiscal Year 2018. IAMD subsequently moved its software development efforts to the software acquisition pathway in January 2021, while hardware development continues under the major capability acquisition pathway. The program office stated the main benefits of moving to the software acquisition pathway were more rapid and flexible requirements development, as well as more frequent software releases with key stakeholder involvement.

Source: GAO analysis of Department of Defense provided data. | GAO-22-105230

- Programs are increasingly using the software acquisition pathway. As of February 2022, DOD is tracking 35 programs using the pathway, including programs from each of the military departments. According to DOD officials, these programs include a wide array of software intensive systems to include command and control, cybersecurity, business systems, training, and software embedded weapon programs. Two of these programs are Air Force weapon programs we previously assessed in our annual weapon systems assessment that were using the MTA pathway—Unified Platform and Air Operations Center Weapon System Modifications—that transitioned to the software acquisition pathway in 2020 and 2021, respectively.

Of the 59 MDAP and MTA programs we reviewed this year, only one—the Army's Integrated Air and Missile Defense program—is currently using the software pathway for its software development efforts.[47] According to DOD officials, most hardware programs were established prior to the establishment of the software acquisition pathway, which may present limited opportunities for programs to switch their software development efforts to the software acquisition pathway.

Programs Using Modern Software Development Approaches Do Not Fully Implement Recommended Practices

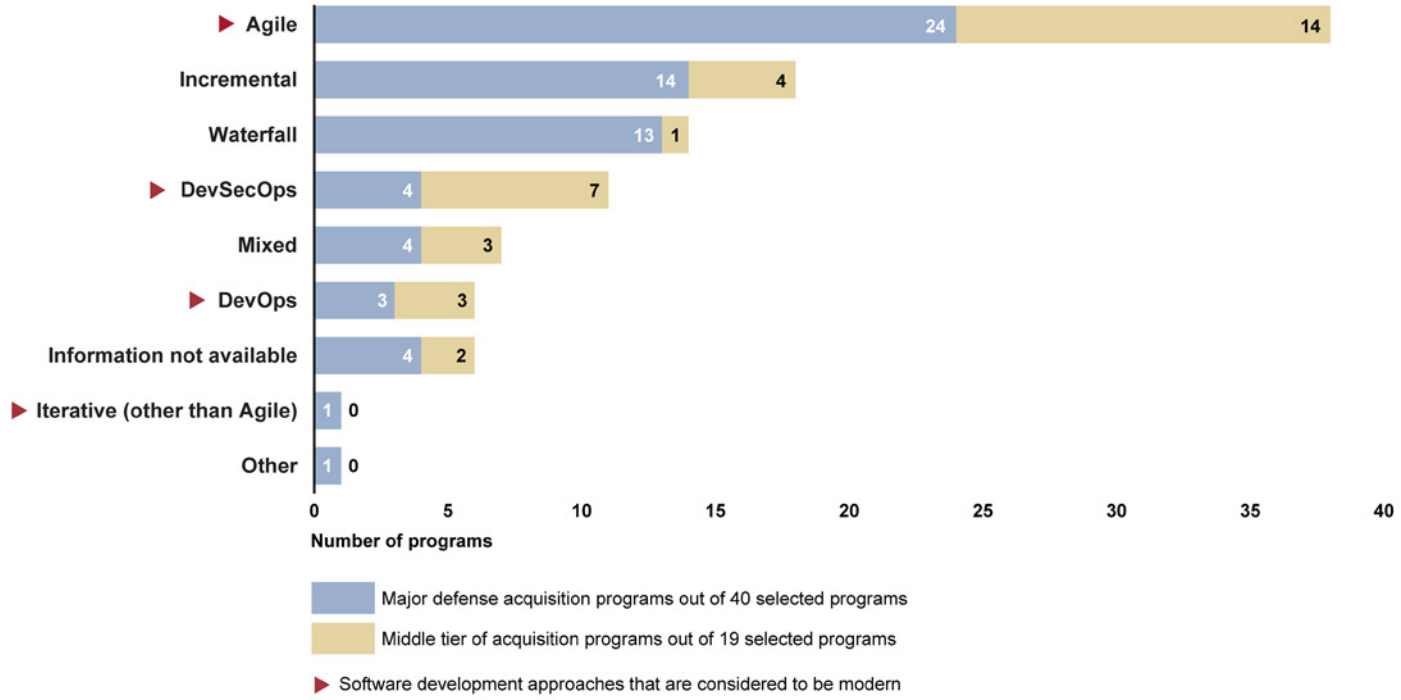
We found programs reporting the use of modern software development approaches (which we defined as either Agile, DevOps, DevSecOps, or an iterative approach) did not fully implement recommended practices—such as early and continuous delivery of software to users.

Use of modern software development approaches. Similar to our prior assessment, the majority of MDAP and MTA programs we reviewed (39 of 59) reported using at least one modern approach. MTA programs reported using modern approaches more frequently than MDAPs, with 15 of the 19 (79 percent) MTA programs reporting using modern approaches compared with 24 of the 40 (60 percent) MDAPs. The number of programs reporting the use of DevOps remained the same since last year, while the number reporting the use of Agile or DevSecOps

[47]We reviewed questionnaire responses from 40 MDAPs and 19 MTA programs on their software and cybersecurity approaches.

increased slightly.[48] Figure 23 shows the software development approaches employed by the programs we reviewed this year.

Figure 23: Programs' Reported Use of Software Development Approaches



Source: GAO analysis of programs' questionnaire responses. I GAO-22-105230

Notes: Programs could select more than one option. "Information not available" includes, among other things, instances where a program did not report a software development effort or had yet to start their software development effort. Programs were considered to be using a modern software development approach if they reported the use of either Agile, DevOps, DevSecOps or an iterative (other than Agile) approach.

Early and continuous delivery of working software. Modern software development approaches, such as Agile, emphasize early and continuous software delivery, and fast feedback cycles so that software is being continuously evaluated on functionality, quality, and user satisfaction. The Defense Innovation Board and industry's Agile practices encourage the delivery of working software to users on a continuing basis—as frequently

[48] Our prior assessments did not include "Iterative development (other than Agile)" as an option for reporting a program's software development approach.

as every 2 weeks.[49] Information obtained during these frequent iterations can effectively assist in measuring progress and allowing developers to respond quickly to feedback from users, thus reducing technical and programmatic risk.

However, most of the 39 programs that reported using a modern software development approach reported delivering software to users much less frequently, sometimes a year or more.[50] DOD officials stated they consider a software delivery goal of 6 months to a year as more suitable to account for the safety and security requirements for many DOD systems. Twenty-two of the 39 programs we reviewed reported delivering software to users every 12 months or less. However, software deliveries for user feedback at a frequency of six months to a year do not align with the Agile principle of delivering working software frequently and would not attain the benefits from fast iterative feedback cycles. Figure 24 illustrates reported delivery times for programs that reported using a modern development approach.

[49]The Defense Innovation Board recommends capability be delivered as frequently as every 2 weeks for many types of software. The National Defense Industrial Association, International Standards Organization, and other industry studies recommend deliveries of working software within a range of 1 to 6 weeks.

[50]Programs reported software delivery frequency as either less than one month, or within predefined 3-month increments. For example, 1 to 3 months, 4 to 6 months, and up to 13 or more months.

Figure 24: Software Delivery Times of the 39 Programs That Reported Using a Modern Software Development Approach

Source: GAO analysis of programs' questionnaire responses. I GAO-22-105230

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

Implementation of Defense Science Board software development recommended practices. Although we found slight improvements from last year, particularly in the delivery of a minimum viable product and software documentation, the 59 programs we reviewed reported that they made limited progress in implementing five practices associated with recommendations made by the Defense Science Board in 2018 to improve software development efforts.[51] For example, 39 programs reported using a modern approach, but only 10 reported using a software factory, which was identified by the Defense Science Board as its base recommendation, underlying all other recommendations.[52]

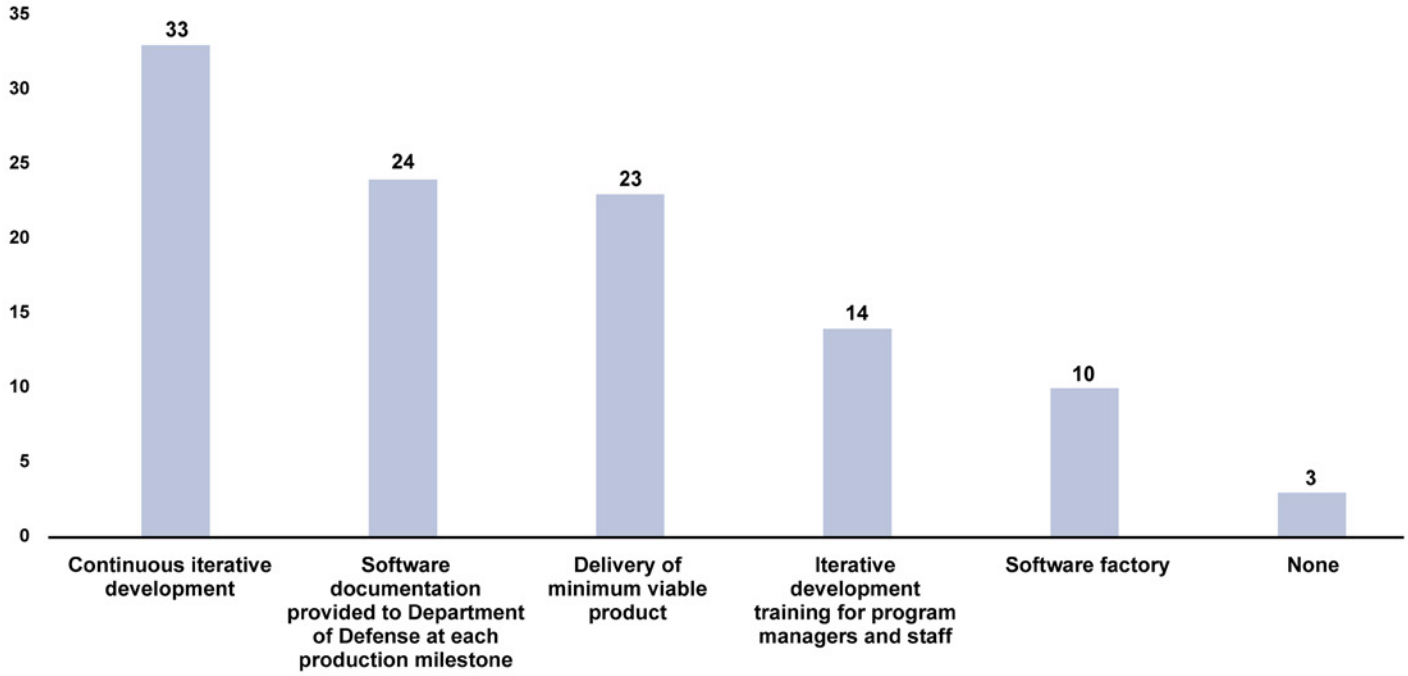
We will continue to review DOD's progress toward implementing these recommendations through our ongoing work examining DOD's implementation of software acquisition reforms. Figure 25 illustrates the

[51]See table 1 in the report background for the recommended practices.

[52]The Defense Science Board recommendation focused on use of a software factory as an evaluation criterion in the source selection process. We asked programs a broader question about whether a software factory was used as part of their software development efforts.

extent to which programs reported using practices recommended by the Defense Science Board in 2018.

Figure 25: Implementation of 2018 Defense Science Board Recommended Practices by the 39 Programs That Reported Using a Modern Software Development Approach



Source: GAO analysis of programs' questionnaire responses. I GAO-22-105230

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

Following our data collection for this year's report, DOD issued a new software modernization strategy in February 2022, which outlines DOD's approach to achieve faster delivery of better software.[53] Several goals and objectives of the strategy are consistent with the practices discussed above, such as emphasizing the efficient use of software factories, advancing DevSecOps, and improving the technical competencies of its workforce. It is too soon to tell whether the implementation of this new strategy will improve the adoption rates of recommended practices by

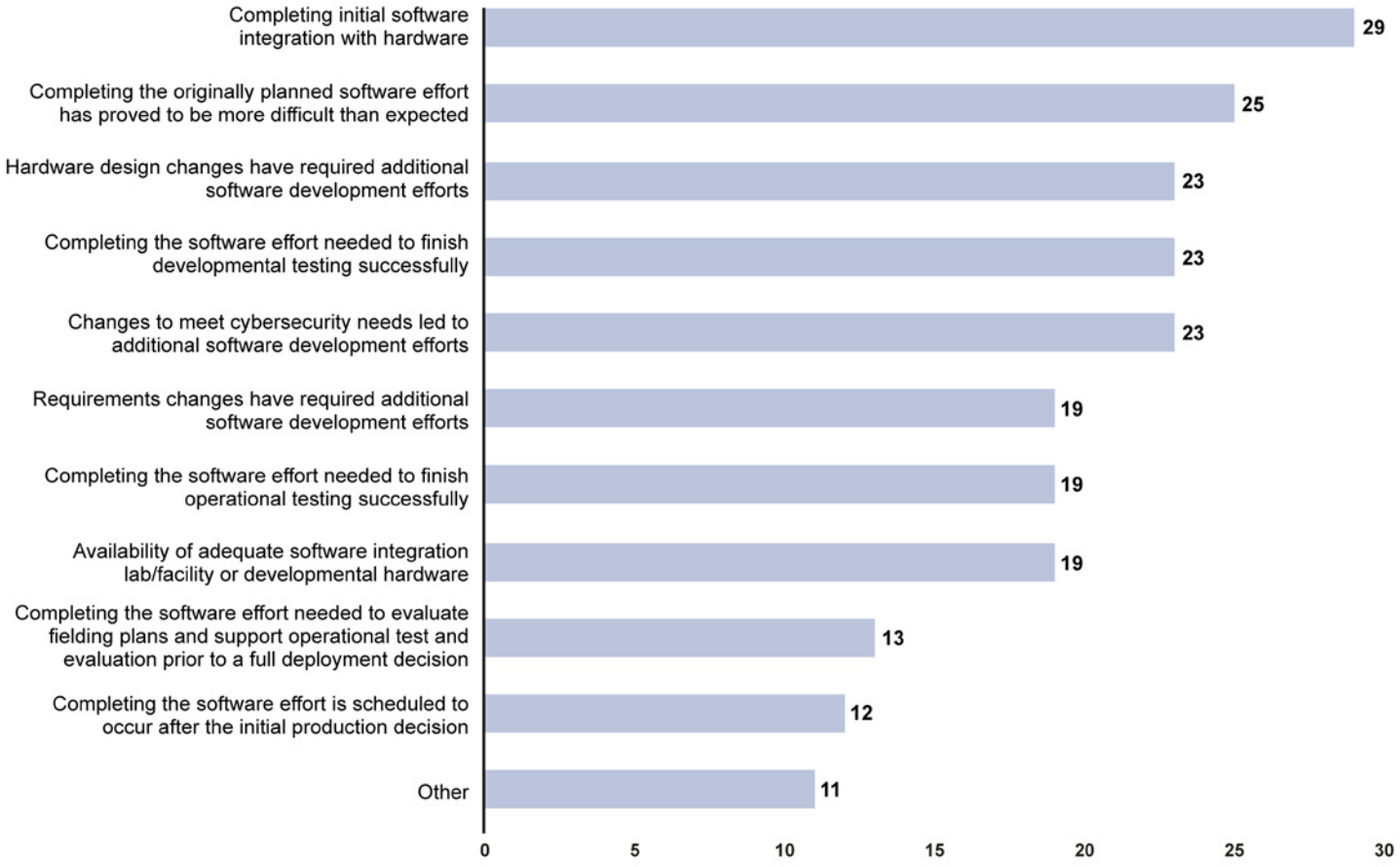
[53]Department of Defense, *Department of Defense Software Modernization Strategy* (Feb. 2021)

weapon programs. We will continue to monitor and report on this topic in future reports.

Programs Reported Software Risks and Staffing Challenges

Similar to our prior assessment, the majority of the MDAP and MTA programs we surveyed (40 of 59) identified software development as a risk. The largest contributing factor to software risk reported by programs was completing initial software integration with hardware. Figure 26 shows the various contributing factors reported by programs we reviewed.

Figure 26: Software Development Risks Reported by the 59 Programs GAO Reviewed



Source: GAO analysis of programs' questionnaire responses. I GAO-22-105230

Note: Programs could select more than one response.

Examples of Software Workforce Challenges

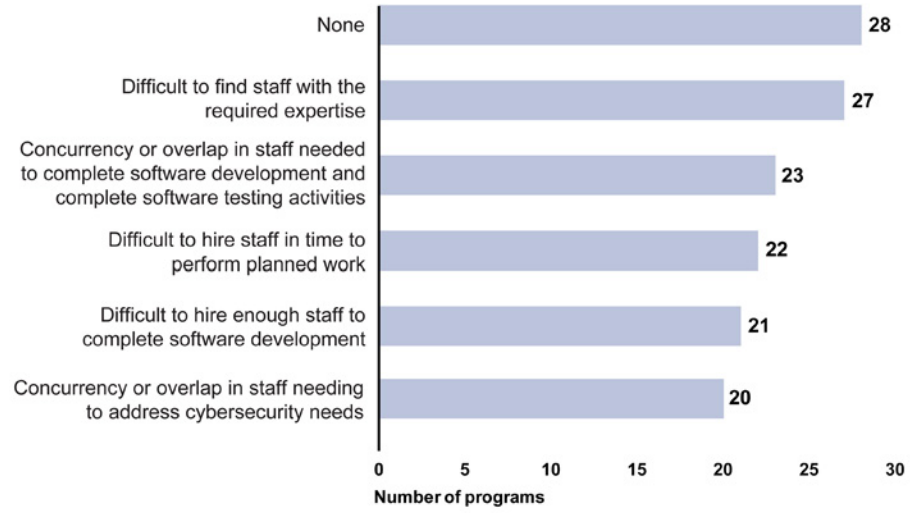
Officials from one program office told us they have challenges in hiring remote civilian candidates. The program office observed that the time needed to hire remote candidates has increased—now taking 140 to 180 days. Program officials said this hiring slowdown has put the program office at an even greater disadvantage in competing with industry to attract and hire technically qualified talent.

Another program office reported a challenge related to the overlap in staff needed to address software development and cybersecurity. Program officials noted a high demand for expertise in cybersecurity and indicated that the government struggles to compete with industry in this area. They said the program has challenges in its ability to hire and retain highly skilled security engineers and has experienced shortages of security engineers during cybersecurity assessments.

Source: GAO analysis of program office data. | GAO-22-105230

In addition, we continue to find that programs report workforce challenges related to their software development efforts, with over half of the programs continuing to report at least one workforce challenge this year. The most commonly reported staffing challenge was finding staff with the required expertise, with nearly half of the programs we reviewed reporting that challenge. Figure 27 lists the software staffing challenges reported by the programs we reviewed.

Figure 27: Software Workforce Challenges Reported by the 59 Programs GAO Reviewed



Source: GAO analysis of programs' questionnaire responses. | GAO-22-105230

Note: Programs could select more than one response.

According to a 2020 RAND study, DOD lacks a workforce model that properly supports a software acquisition workforce, such as an official software career field or a system for identifying or tracking software professionals in the department.[54] This study included a recommendation for the department to identify who is in the software acquisition workforce and presented options for DOD to track and manage this workforce, among other things. We have ongoing work on DOD's implementation of

[54]RAND Corporation, *Software Acquisition Workforce Initiative for the Department of Defense* (Santa Monica, Calif.: 2020)

software acquisition reforms and plan to examine the department's workforce issues as part of this effort.[55]

Programs' Implementation of Cybersecurity Practices Remains Generally Consistent with Our Prior Findings but Programs Report Mixed Progress Conducting Cybersecurity Assessments

Programs' reported implementation of recommended cybersecurity practices has generally not changed since our last assessment. Our analysis continued to focus on the extent to which programs planned for cybersecurity (through developing cybersecurity strategies and addressing cybersecurity in program requirements), and the extent to which programs included cybersecurity testing during developmental and operational testing.

- **Cybersecurity strategies**. Consistent with our prior assessment, we found that all 59 programs we surveyed this year reported either having an approved cybersecurity strategy or planning to have one in the future.[56]
- **Cybersecurity requirements**. We found similar results this year in the number of programs that reported having key requirements addressing cybersecurity. Specifically, 36 of 59 (61 percent) programs reported that at least one key performance parameter or key system attribute addressed cybersecurity, compared to 37 of 59 (63 percent) programs last year.[57] Under the Joint Capabilities Integration and Development System, key performance parameters are most critical to the development of an effective military capability, while key system attributes are considered important to achieving a balanced solution

[55]See William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116-283, § 838 (2021).

[56]DOD policy generally requires all acquisitions containing mission critical or mission essential IT systems to have an adequate and appropriate cybersecurity strategy. See DOD Instruction 8500.01, *Cybersecurity* (Mar. 14, 2014) (Change 1 Effective Oct. 7, 2019); DOD Instruction 8580.1, *Information Assurance (IA) in the Defense Acquisition System* (July 9, 2004).

[57]The planning for some MDAPs occurred prior to updates to guidance that specifically describes cybersecurity attributes in key performance parameters to protect against cybersecurity threats. For example, in 2015, DOD updated its Joint Capabilities Integration and Development System Manual to specify that, if cyber survivability is required, the program should include appropriate cyber attributes in the system survivability key performance parameter. In 2018, the new Manual for the Operation of the Joint Capabilities Integration and Development System replaced this manual and updated the system survivability guide by adding information on cyber survivability. See Department of Defense, *Manual for the Operation of the Joint Capabilities Integration and Development System* (Aug. 31, 2018).

but not critical enough to be designated a key performance parameter.

DOD's cybersecurity instruction for acquisition programs states that cybersecurity is represented within system survivability key performance parameters as a mandatory capability consideration in all DOD acquisitions. It also states that cybersecurity considerations must be addressed in all acquisition programs using any AAF acquisition pathway.[58] However, MTA programs are not subject to the Joint Capabilities Integration and Development System process and therefore may not have specifically defined key performance parameters and key system attributes.

- **Cybersecurity assessments**. All DOD acquisition programs and systems, regardless of acquisition pathway, are required by DOD Instruction 5000.89 to execute cybersecurity testing and evaluation processes detailed in the DOD *Cybersecurity Test and Evaluation Guidebook* throughout the program's life cycle.[59] We asked programs whether they had conducted developmental or operational testing, and if so, whether these test events included cooperative vulnerability or adversarial assessments, which are cybersecurity events aligned with these testing phases.[60]

  This year, the percentages of programs that completed cybersecurity testing during developmental or operational testing changed since last year. Specifically, an increased percentage of programs this year reported conducting cooperative vulnerability and adversarial assessments during developmental testing, while a decreased percentage of programs reported conducting cooperative vulnerability and adversarial assessments during operational testing. Table 8 provides additional details on the reported cybersecurity assessments for the programs we reviewed.

Examples of Cybersecurity Assessments

Developmental cybersecurity testing and evaluation is intended to identify cybersecurity vulnerabilities before program deployment, whereas operational cybersecurity testing evaluates operational programs for effectiveness, suitability, and survivability.

A cooperative vulnerability and penetration assessment examines a system to identify all significant vulnerabilities and assesses the system's ability to execute critical missions and tasks in the expected operational environment.

An adversarial assessment conducts tests to characterize the operational effects to critical missions caused by threat-representative cyber activity against a unit trained and equipped with a system as well as the effectiveness of the defensive capabilities.

Source: GAO analysis of Department of Defense Cybersecurity Test and Evaluation Guidebook and GAO-21-182. | GAO-22-105230

[58]DOD Instruction 5000.90.

[59]DOD Instruction 5000.89, Department of Defense, *Cybersecurity Test and Evaluation Guidebook 2.0, Change 1* (February 2020).

[60]DOD's *Cybersecurity Test and Evaluation Guidebook* calls for DOD acquisition programs to conduct cooperative vulnerability identification during developmental testing. This term is similar to a cooperative vulnerability and penetration assessment. Our questionnaire used the term cooperative vulnerability and penetration assessment.

Table 8: Programs That Reported Conducting Cybersecurity Assessments during Developmental or Operational Testing

	Completion of a cybersecurity assessment for programs that conducted developmental testing		Completion of a cybersecurity assessment for programs that conducted operational testing	
Assessment year	Conducted cooperative vulnerability assessment	Conducted adversarial assessment	Conducted cooperative vulnerability assessment	Conducted adversarial assessment
2022	19 of 29 (66 percent)	13 of 29 (45 percent)	8 of 12 (67 percent)	8 of 12 (67 percent)
2021	17 of 30 (57 percent)	11 of 30 (37 percent)	14 of 19 (74 percent)	14 of 19 (74 percent)

Source: GAO analysis of programs' questionnaire responses. | GAO-22-105230

We will continue to evaluate DOD's implementation of its cybersecurity test and evaluation guidance as part of our ongoing work reviewing weapon system cybersecurity.

DOD Is Working to Address Industrial Base Challenges, but Limited Industrial Base Assessments Potentially Hinder Insight

DOD is in the process of implementing recent legislation related to OSD oversight of the defense industrial base and the challenges encountered. Over half of the weapon programs we surveyed reported tracking one or more industrial base risks, with some of those programs reporting that those risks contributed to cost and schedule challenges. However, nearly half of the programs tracking industrial base risks reported that they do not plan for an industrial base assessment to be conducted specific to their program. DOD policy requires these assessments in certain circumstances to help identify and mitigate industrial capability risks. Our analysis of DOD's industrial base assessment policy shows that DOD did not fully define key phrases, such as a known or projected problem or a substantial risk that a necessary industrial capability may be lost. As a result, DOD components may not have a consistent understanding of when they should conduct these assessments on a case-by-case basis, potentially limiting DOD's insight on critical industrial base issues.

DOD Is Implementing Legislative, Organizational, and Policy Changes to Oversight of Industrial Base Issues

DOD has ongoing efforts to execute legislative, organizational, and policy changes related to oversight of the defense industrial base.[61] For example, DOD has addressed or is in the process of implementing legislative provisions to address industrial base challenges, such as supply chain vulnerabilities.[62]

Based on our analysis of the NDAAs for Fiscal Years 2020 and 2021, we identified 12 provisions related to OSD oversight of the defense industrial base. These provisions ranged from establishing a framework to enhance cybersecurity for the industrial base to assessing the research and development, manufacturing, and production capabilities of the national technology and industrial base, among other things. Table 9 provides information on the implementation status of three selected provisions (for additional details on all of the provisions we reviewed, see appendix VIII).

Table 9: Summary of Selected National Defense Authorization Act Provisions Related to Defense Industrial Base Oversight

Section and title of provision	Brief description of provision	Department of Defense's (DOD) implementation status
Provisions contained in the National Defense Authorization Act for Fiscal Year 2020		
Section 845. Modernization of Acquisition Processes to Ensure Integrity of Industrial Base	Requires the Secretary of Defense to streamline and digitize the existing DOD approach for identifying and mitigating risks to the defense industrial base across the acquisition process, and requires the Under Secretary of Defense for Acquisition and Sustainment, in coordination with certain individuals, to develop an analytical framework for risk mitigation across the acquisition process. The framework's implementation plan was due in March 2020 and a report on the actions taken to implement the framework is due one year after the implementation plan's submission.	As of March 2022, DOD's framework implementation plan was drafted and submitted to the Under Secretary of Defense for Acquisition and Sustainment for final review and signature.

[61]We assessed DOD's effort to incorporate legislative, organizational, and policy changes that occurred since fiscal year 2019 related to the defense industrial base. We assessed changes starting in fiscal year 2019 following DOD's issuance of a report in September 2018 in response to Executive Order 13806 *Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States.* We did not identify any provisions related to OSD oversight of the defense industrial base in the John S. McCain NDAA for Fiscal Year 2019 that met the scope of this report.

[62]A congressional task force reported that supply chain vulnerabilities create significant strategic and competitive risk for the U.S. See House Armed Services Committee, *Report of the Defense Critical Supply Chain Task Force* (July 22, 2021).

Section and title of provision	Brief description of provision	Department of Defense's (DOD) implementation status
Provisions contained in the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021		
Section 850. Implementation of Recommendations for Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency	Requires the Under Secretary of Defense for Acquisition and Sustainment to submit to the Secretary of Defense additional recommendations regarding United States industrial policies. The additional recommendations must consist of specific executive actions, programmatic changes, regulatory changes, and legislative proposals and changes, as appropriate.	According to DOD officials, a report developed pursuant to Executive Order 14017, "America's Supply Chains," is responsive to this requirement.
Section 903. Assistant Secretary of Defense for Industrial Base Policy	Increases the authorized number of Assistant Secretaries of Defense to establish an Assistant Secretary of Defense for Industrial Base Policy.	The Assistant Secretary of Defense for Nuclear, Chemical, and Biological Defense Programs is performing the duties of the Assistant Secretary of Defense for Industrial Base Policy in an acting capacity.

Source: GAO analysis of National Defense Authorization Act for Fiscal Year 2020, Pub. L. No. 116-92 (2019); the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116–283 (2021); and Department of Defense information. I GAO-22-105230

One of the 12 provisions we reviewed authorized a recent organizational change related to defense industrial base oversight, which DOD is in the process of implementing.

Assistant Secretary of Defense position. DOD recently elevated the Deputy Assistant Secretary of Defense for Industrial Policy position to an Assistant Secretary of Defense in response to the NDAA for Fiscal Year 2021.[63] In this elevated role, the Assistant Secretary directly advises the USD(A&S) on industrial base policy related matters. According to officials from the Office of Industrial Base Policy, this change should result in higher visibility for the Office of Industrial Base Policy within OSD.

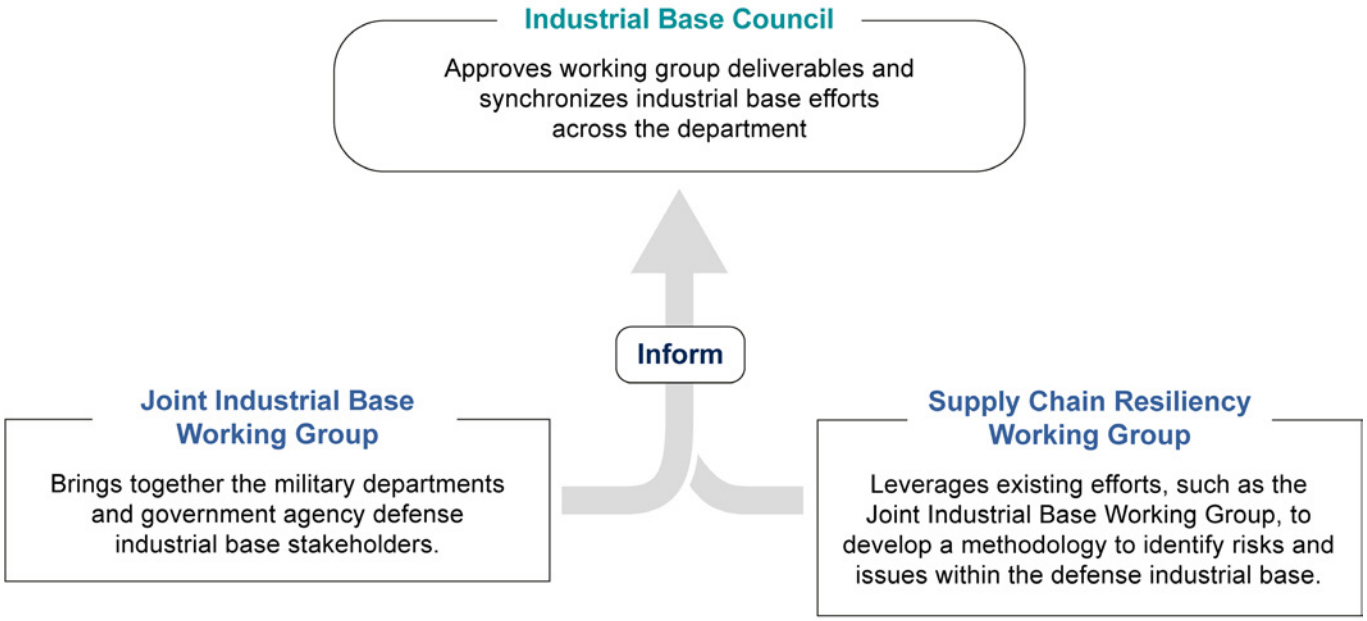
We have ongoing work evaluating DOD's implementation of some of these provisions, including DOD's recent creation of the Assistant Secretary of Defense for Industrial Base Policy position. Additionally, our ongoing work will further describe the department's progress in developing a risk mitigation framework required by section 845 of the NDAA for Fiscal Year 2020. We expect to issue a report that discusses these topics later in 2022.

[63]The William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 increases the number of authorized Assistant Secretaries of Defense to establish an Assistant Secretary of Defense for Industrial Base Policy. Pub. L. No. 116-283, § 903 (2021) (codified at 10 U.S.C. § 138). DOD established the position on February 10, 2022.

DOD has also initiated other recent organizational and policy efforts to address industrial base concerns.

Supply Chain Resiliency Working Group. DOD formed a Supply Chain Resiliency Working Group to develop an analytical framework for risk mitigation across the acquisition process. The working group plans to develop (1) an enterprise-wide risk assessment framework by September 2022 and (2) a supply chain resiliency strategy and implementation plan to institutionalize supply chain visibility, assessment, and mitigation best practices by September 2023. This working group reports to the Industrial Base Council and leverages the existing efforts of the Joint Industrial Base Working Group, as shown in figure 28.

Figure 28: Relationship between Selected Department of Defense Industrial Base Entities



Source: GAO analysis of Department of Defense data. I GAO-22-105230

Diminishing Manufacturing Sources and Material Shortages Management policy. DOD issued Instruction 4245.15 in November 2020, which establishes policy related to diminishing manufacturing

sources and material shortages management.[64] DOD released the policy to address its lack of visibility into the supply chain, according to a recent DOD report to Congress.[65] We have previously reported this lack of insight is a challenge, in part, because of DOD's limited ability to assess risk at lower levels of the supply chain.[66]

Majority of Programs Are Tracking at Least One Identified Industrial Base Risk

This year, we surveyed MDAP and MTA program officials about the industrial base risks that their programs were tracking and found that more than half of programs we reviewed reported tracking one or more industrial base risks. DOD tracks industrial base risks across 10 categories and reports that these risk types have the potential to result in negative effects to DOD and the warfighter, such as cost inefficiencies, program delays, diminished readiness, and decreased lethality.

[64]DOD Instruction 4245.15, *Diminishing Manufacturing Sources and Material Shortages Management* (Nov. 5, 2020).

[65] Department of Defense, *Fiscal Year 2019 Industrial Capabilities Report to Congress* (June 23, 2020).

[66]GAO, *Defense Industrial Base: Integrating Existing Supplier Data and Addressing Workforce Challenges Could Improve Risk Analysis*, GAO-18-435 (Washington, D.C.: June 13, 2018). DOD's visibility into components provided by subcontractors is an ongoing issue because the government only has a direct contractual relationship with the prime contractor and access to subcontractors under the prime contractor can be limited, according to officials from the Office of Industrial Base Policy.

Examples of Programs Facing Industrial Base Risks and Conducting Mitigation Efforts

Next Generation Overhead Persistent Infrared

The Space Force's Next Generation Overhead Persistent Infrared program reported tracking multiple industrial base risks, which it stated led to negative cost and schedule effects. For example, the program reported that dozens of parts and materials are affected by a limited supplier base and capacity. To mitigate this risk, the program reported contracting with multiple companies for the same supplies, when possible, to maintain a healthy industrial base and mitigate supply chain risks.

Armored Multi-Purpose Vehicle

The Army's Armored Multi-Purpose Vehicle program reported tracking multiple industrial base risks. For example, the program reported that a diminishing manufacturing source risk is the highest priority for the program because it has the potential to affect long term sustainment and full rate production. To mitigate this risk, the program reported recently awarding a contract to redesign obsolete components.

Source: GAO analysis of programs' questionnaire data. | GAO-22-105230

Through our questionnaire, we found that,

- of the 59 programs we surveyed, 38 programs reported tracking at least one industrial base risk,
- more than half of those 38 programs reported tracking multiple industrial base risks, and
- 15 of those 38 programs reported that those risks contributed to program cost and schedule challenges.

The top types of risks reported by programs were:

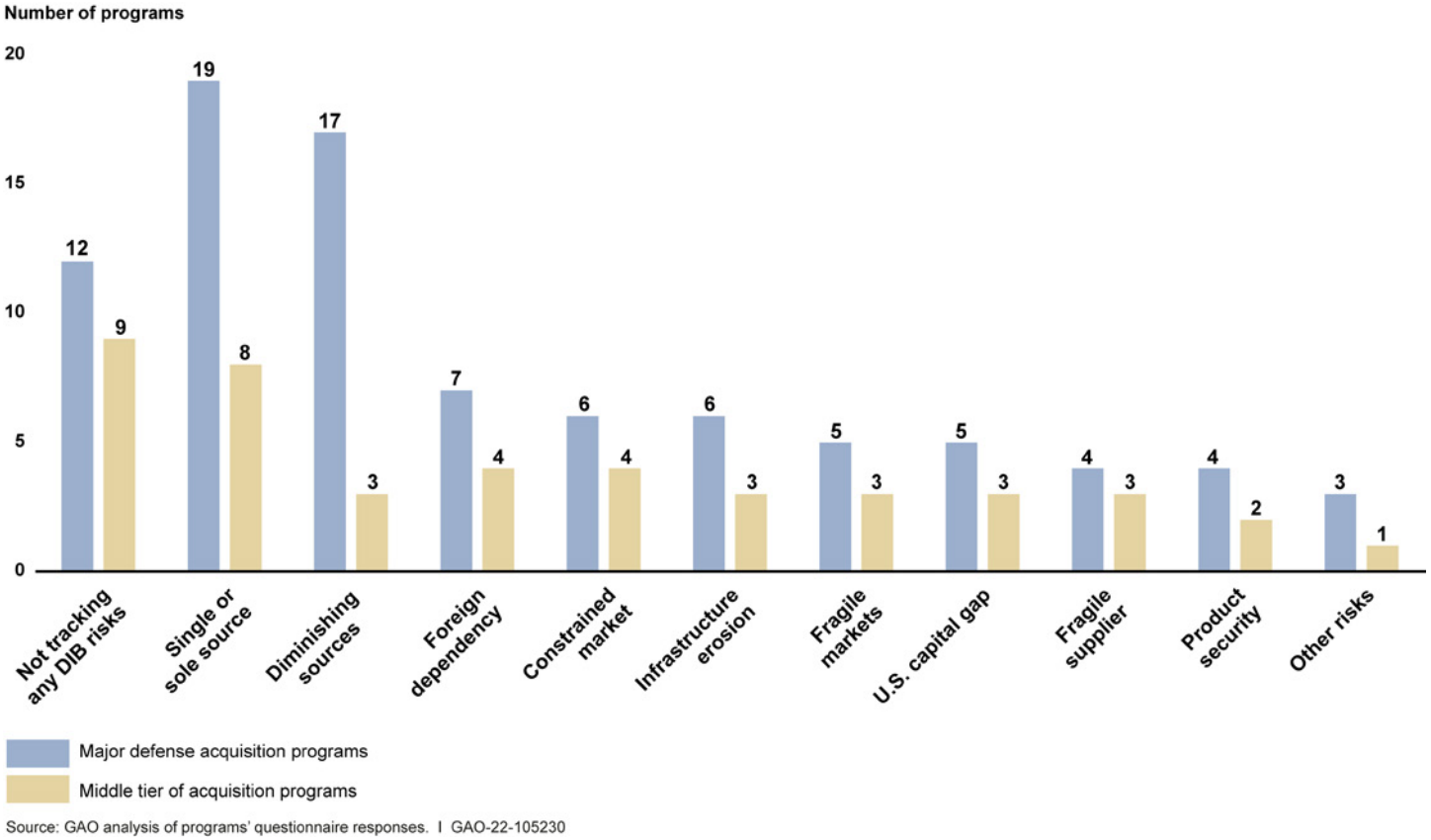
• **Single or sole sources**. Single or sole source risks occur when only one supplier is qualified or able to provide a required capability.

• **Diminishing manufacturing sources and material shortages**. A diminishing manufacturing risk occurs when a product or material faces obsolescence resulting from a decline in relevant suppliers.

Figure 29 shows industrial base risks identified by the programs we surveyed.[67]

[67]See table 4 in the report background for definitions of the industrial base risks we assessed.

Figure 29: Defense Industrial Base (DIB) Risks Identified by 59 Programs GAO Reviewed



Source: GAO analysis of programs' questionnaire responses. I GAO-22-105230

Note: Programs could select multiple risks; thus, total risks do not sum to 59.

Nearly Half of Programs Tracking Industrial Base Risks Are Not Planning to Conduct an Industrial Base Assessment

Eighteen of the 38 MDAP and MTA programs that identified that they were tracking an industrial base risk reported in response to our questionnaire that neither they nor another entity, such as OSD or the military department, planned to conduct an industrial base assessment specific to their programs.[68] Our questionnaire defined an industrial base assessment as, "an assessment of an industry where there's a known problem with the skills and knowledge, processes, facilities, and equipment needed to design, develop, manufacture, repair, and support DOD products."

[68]For DOD's definition of an industrial base assessment, see DOD Instruction 5000.60, *Defense Industrial Base Assessments* (July 18, 2014) (Change 2 Effective Aug. 31, 2018).

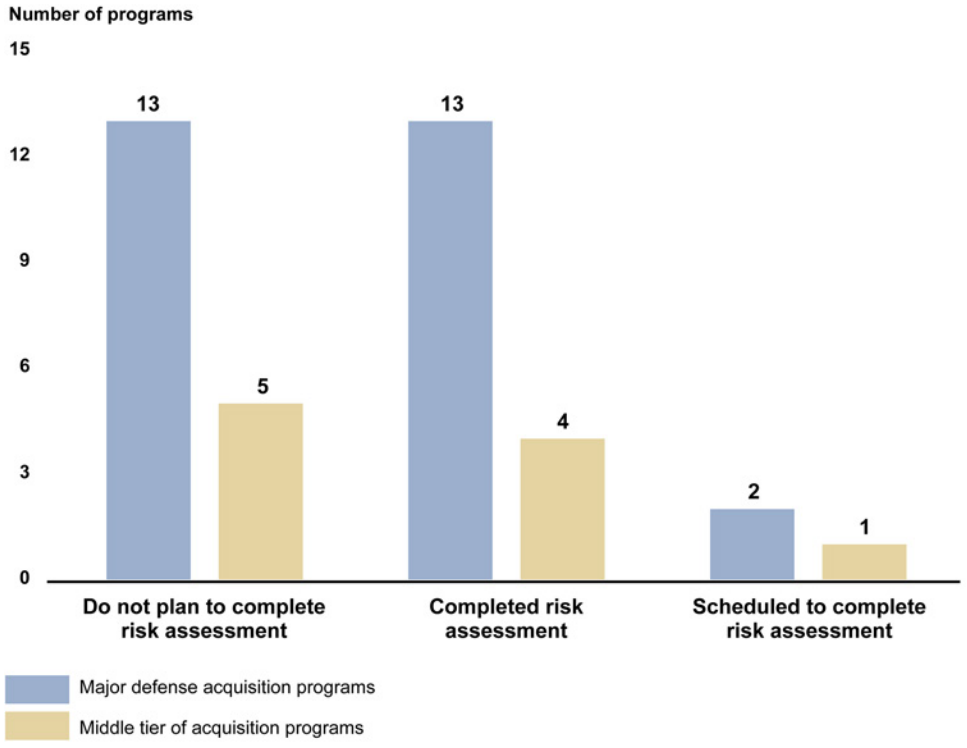
According to DOD policy, industrial base assessments are intended to, among other things, help identify and mitigate supply chain risks and ensure that the industrial capabilities needed to meet current and future national security requirements are available and affordable, as well as to enable effective decision making at the enterprise level.[69]

Representatives from DOD's Office of Industrial Base Policy told us they use summaries of these assessments, and other relevant information, to conduct assessments of defense industrial base industry sectors to identify areas of concern, implement mitigation actions, and share this information with Congress. For example, the office submits an annual report to Congress that describes the risks facing 16 key industrial sectors across the DOD enterprise, such as the aircraft and electronics sectors.

To obtain insight into whether an industrial base assessment had been completed or was planned for programs tracking industrial base risks, we asked programs if any defense industrial base assessments had been completed specific to each program, including those performed by OSD, the military departments, or the program. Figure 30 summarizes the responses of programs tracking at least one industrial base risk.

[69]DOD Instruction 5000.60; DOD Instruction 5000.85.

Figure 30: Status of Industrial Base Risk Assessments for Programs Tracking at Least One Industrial Base Risk



Source: GAO analysis of programs' questionnaire responses. I GAO-22-105230

Note: A program that reported in GAO's questionnaire that it is tracking an industrial base risk may or may not meet the criteria in DOD Instruction 5000.60, *Defense Industrial Base Assessments*, requiring a DOD Component to conduct an industrial base risk assessment on a case-by-case basis when there is a known or projected problem.

Programs cited a variety of reasons for not planning to conduct an industrial base assessment. For example, one program that reported tracking three industrial base risks explained that engagement with industry provided the program with all of the necessary information to identify and manage component obsolescence. Further, the same program stated that a separate assessment was not required to manage risk. Another program tracking five risks reported that it does not plan to conduct an assessment because the program's prime contractor is able to evaluate its own business practices. Representatives from the Office of Industrial Base Policy noted that they found that supply chain risk management efforts vary by program, with some programs having robust efforts while other programs have less robust efforts underway.

DOD Instruction 5000.60, which establishes DOD's industrial base assessment policy, requires DOD components to conduct industrial base assessments on a case-by-case basis when there is a known or projected problem as determined by OSD, the DOD component, program office, or other source.[70] Additionally, the instruction directs DOD components to follow its guidelines when a DOD acquisition manager, inventory control point manager, or other buyer determines there is a substantial risk that an industrial capability needed to support DOD programs or products may be lost.

However, DOD's instruction does not specifically define key terms associated with the circumstances under which DOD components should conduct an industrial base assessment on a case-by-case basis. For example, the instruction does not explain what circumstances constitute a known or projected problem or a substantial risk that a necessary industrial capability may be lost. This lack of detail may make it difficult for DOD components to accurately know the circumstances under which they should conduct an industrial base assessment on a case-by-case basis.

Additionally, the instruction does not specifically address whether industrial base assessments should be conducted for programs using AAF pathways, such as MTA programs, at specific points during the acquisition lifecycle because the policy has not been updated since DOD adopted the AAF. Further, while DOD's major capability acquisition pathway instruction contains provisions related to industrial base analysis, industrial base assessments are not addressed in DOD Instruction 5000.80, DOD's MTA pathway instruction.[71] As noted earlier in this report, DOD is increasingly leveraging the MTA pathway, and other new AAF

[70]According to DOD Instruction 5000.60, programs are also required to conduct assessments as part of technology development before Milestone B to support the engineering and manufacturing development phase and before Milestone C to ensure that the full rate production decision incorporates the knowledge of a well-informed buyer. We did not review program Milestone B or C documentation as part of this review. DOD Instruction 5000.60 refers to DOD components as OSD, the military departments, the Office of the Chairman of the Joint Chiefs of Staff and the Joint Staff, the Combatant Commands, the Office of the Inspector General of the Department of Defense, the Defense Agencies, the DOD Field Activities, and all other organizational entities within the DOD.

[71]See DOD Instruction 5000.85; DOD Instruction 5000.80.

SSN 774 *Virginia* Class Industrial Base Risks and Mitigation Efforts

The SSN 774 *Virginia* class program reported facing multiple industrial base risks. According to the program, increased new construction shipbuilding demand caused some of these risks, which led to schedule and quality challenges in the program's industrial base. Additionally, we previously reported that the *Virginia* class program relies on materials produced by an atrophied supplier base that is roughly 70 percent smaller than in previous shipbuilding booms. To mitigate these risks, the Navy reported conducting annual assessments for critical suppliers in the nuclear shipbuilding industrial base. Based on these assessments, the Navy provided at-risk critical suppliers with milestones that track actions required to improve performance.

Source: GAO analysis of program questionnaire data. | GAO-22-105230

pathways such as the software pathway, to develop or field critical capabilities.

Without policies that facilitate a consistent understanding of when these assessments are needed, DOD may be missing opportunities to gain insight to help understand and address critical industrial base risks. For example, representatives from the Office of Industrial Base Policy stated that their office relies on program-level assessments to inform enterprise-wide assessments that they are responsible for conducting. If DOD's industrial base assessment instruction does not clearly define when and what programs should conduct these assessments, the Office of Industrial Base Policy may lack the information required to inform OSD-level analyses.

Conclusions

In our 20 years of annual reports on DOD's costliest acquisition efforts, we have highlighted the consistent commitment of DOD senior leadership to improving outcomes, including recent efforts to accelerate the development and delivery of capabilities. However, we continue to find that the department misses opportunities to gain appropriate knowledge before making significant investment decisions.

As a result, decision makers in the department and Congress have limited insight into whether programs are likely to succeed in delivering capabilities to the warfighter as promised. As part of our broader body of work on DOD weapon systems acquisition, we have made hundreds of recommendations in the last 20 years to help improve outcomes, many of which have yet to be implemented. We maintain that they must be addressed if DOD is to succeed in accelerating the delivery of capabilities.

This year, we identified opportunities for DOD to strengthen its process for obtaining information about challenges and threats to the defense industrial base, a key resource that affects the department's ability to

keep pace with evolving threats. By clarifying its industrial base assessment instruction (DOD Instruction 5000.60), DOD could provide components with a consistent understanding of the circumstances under which they should conduct an industrial base assessment on a case-by-case basis when there is a known or projected problem or a substantial risk that a necessary industrial capability may be lost.

Additionally, updating the instruction and other policies as necessary to align with the AAF pathways will also help clarify when programs using new AAF pathways should conduct industrial base assessments. Together, these updates would help ensure the department has the information it needs to identify and mitigate critical near- and long-term risks to the defense industrial base.

Recommendations for Executive Action

We are making the following two recommendations to the Department of Defense:

The Secretary of Defense should ensure the Office of the Under Secretary of Defense for Acquisition and Sustainment updates DOD's industrial base assessment instruction to define the circumstances that would constitute a known or projected problem or substantial risk that a necessary industrial capability may be lost. (Recommendation 1)

The Secretary of Defense should ensure the Office of the Under Secretary of Defense for Acquisition and Sustainment updates DOD's industrial base assessment instruction and acquisition policies, as necessary, to specify how industrial base assessment requirements apply to programs using AAF pathways. (Recommendation 2)

Agency Comments and Our Evaluation

We provided a draft of this report to DOD for review and comment. In its comments, reproduced in appendix IX, DOD concurred with our recommendations.

In its written comments, DOD also stated that our conclusion about the usage of the software acquisition pathway does not account for the progress DOD has made. It was not our intent in this report to draw conclusions on DOD's progress implementing the software acquisition pathway based on the number of programs using the pathway. Rather, we describe the extent to which the programs we reviewed were using the pathway. We have updated the report to reflect DOD's observation that existing acquisition programs may have limited opportunities to transition to the software pathway.

DOD also stated that the two to six-week software delivery metric cited in the report does not account for software delivery goals of a longer duration set for DOD. In its technical comments, DOD noted that these goals were identified in the NDAA for Fiscal Year 2020 and the accompanying Joint Explanatory Statement. In addition, DOD's comments stated that the metric does not account for the department's position that the appropriate cadence for delivery capability will vary with context.

We have updated our report to provide additional context on DOD's position on software delivery cadence. We agree that appropriate delivery cadence can vary depending on the context of a specific program. We have ongoing work on DOD software programs that will shed further light on circumstances affecting delivery cadence. However, in general, software deliveries at a frequency of six months or longer do not allow DOD to take advantage of the benefits of modern software development approaches. As we highlight in the report, these approaches are defined in large part by fast iterative feedback cycles that emphasize early and continuous software delivery that is evaluated by users for functionality, quality, and user satisfaction.

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 (202) 512-4841 or oakleys@gao.gov. Contact points for our offices of Congressional Relations and Public Affairs may be found on the

last page of this report. Staff members making key contributions to this report are listed in appendix X.

Shelby S. Oakley
Director, Contracting and National Security Acquisitions

List of Committees

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

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

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

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

Appendix I: Program Assessments

Assessments of Individual Weapon Programs

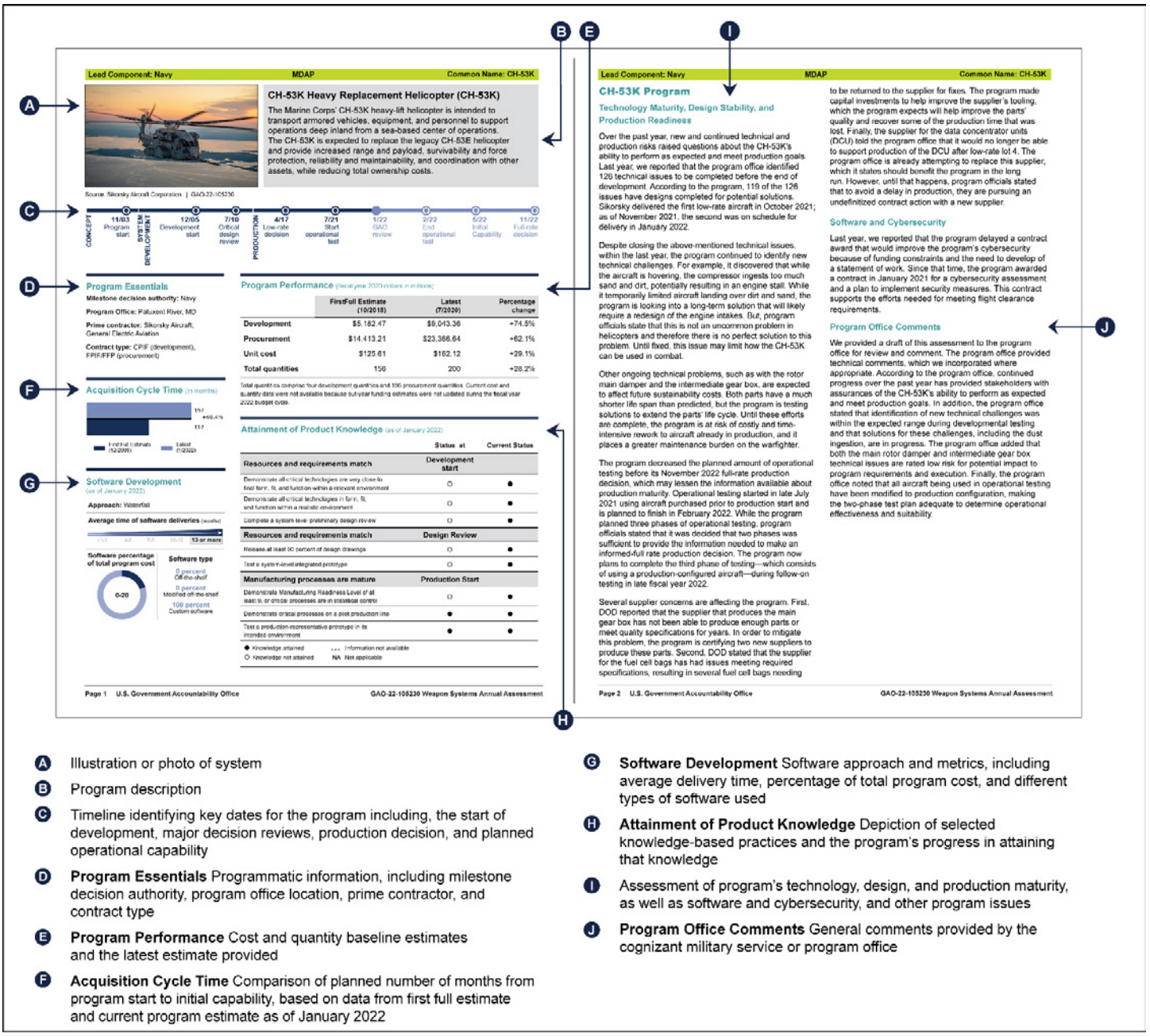
This section contains 63 assessments of weapon programs focused on the extent to which programs are following a knowledge-based acquisition approach to product development.[72]

For 34 MDAPs, we produced two-page assessments discussing cost, schedule, technology, design, and manufacturing knowledge obtained, software and cybersecurity efforts, as well as other program issues.[73] The 34 MDAPs for which we developed two-page assessments are primarily in development or early production. See figure 31 for an illustration of the layout of each two-page assessment.

[72]The assessments also contain basic information about the program, including the prime contractor(s) 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). We did not distinguish between the different forms of FPI contracts.

[73] Due to the lack of future year funding data included in the fiscal year 2022 budget request, we were generally unable to assess MDAP cost performance this year. The most recent complete cost data available were either those reported in our prior assessment, generally as of January 2021, or new Acquisition Program Baselines issued since January 2021. See Appendix II for more details.

Figure 31: 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
- **D** **Program Essentials** Programmatic information, including milestone decision authority, program office location, prime contractor, and contract type
- **E** **Program Performance** Cost and quantity baseline estimates and the latest estimate provided
- **F** **Acquisition Cycle Time** Comparison of planned number of months from program start to initial capability, based on data from first full estimate and current program estimate as of January 2022
- **G** **Software Development** Software approach and metrics, including average delivery time, percentage of total program cost, and different types of software used
- **H** **Attainment of Product Knowledge** Depiction of selected knowledge-based practices and the program's progress in attaining that knowledge
- **I** Assessment of program's technology, design, and production maturity, as well as software and cybersecurity, and other program issues
- **J** **Program Office Comments** General comments provided by the cognizant military service or program office

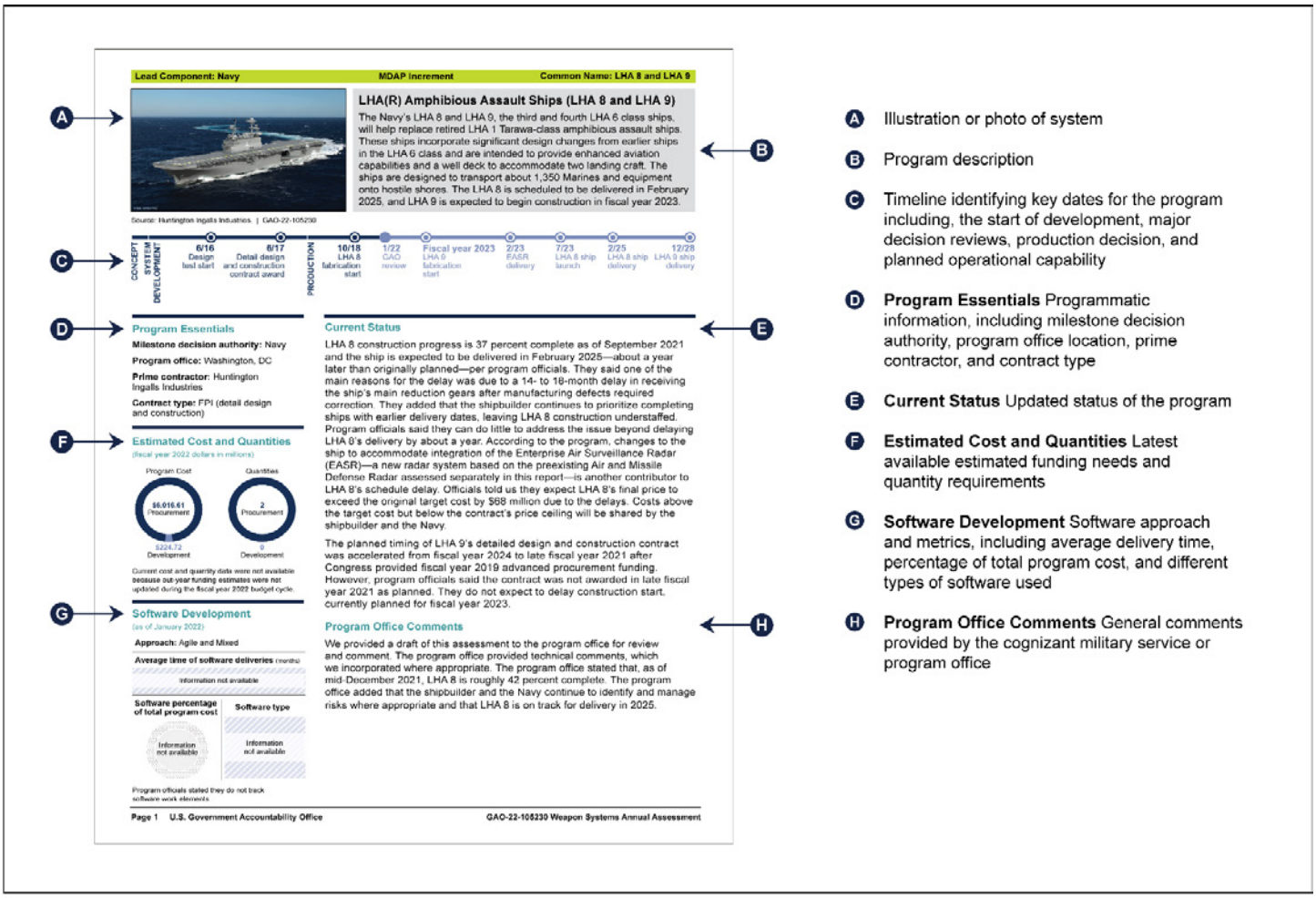
Source: GAO. | GAO-22-105230

In addition, we produced one-page assessments for 10 programs:

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

See figure 32 for an illustration of the layout of each one-page assessment.

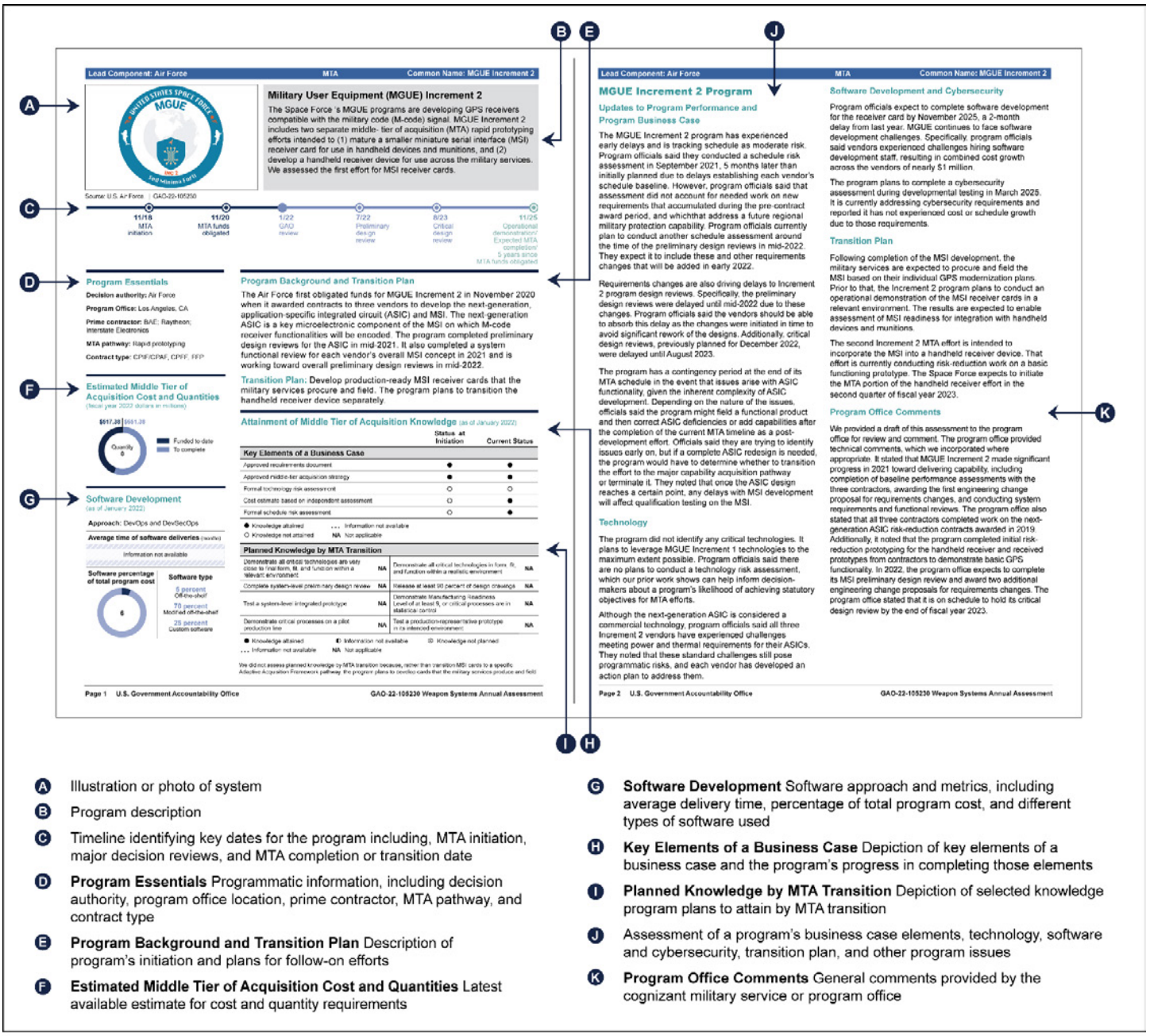
Figure 32: Illustration of One-Page Future Major Weapon Acquisition or Major Defense Acquisition Program Increment Assessment



Source: GAO. | GAO-22-105230

For 19 programs using the MTA pathway, we produced two-page assessments discussing program background and transition plans, technology issues, completion of or updates to key business case elements, planned attainment of applicable product knowledge, and software and cybersecurity issues. Each two-page assessment also provides estimated total program cost and quantities, and software development approach and metrics. See Figure 33 for an illustration of the layout of each two-page MTA program assessment.

Figure 33: 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 including, MTA initiation, major decision reviews, and MTA completion or transition date
- **D** **Program Essentials** Programmatic information, including decision authority, program office location, prime contractor, MTA pathway, and contract type
- **E** **Program Background and Transition Plan** Description of program's initiation and plans for follow-on efforts
- **F** **Estimated Middle Tier of Acquisition Cost and Quantities** Latest available estimate for cost and quantity requirements
- **G** **Software Development** Software approach and metrics, including average delivery time, percentage of total program cost, and different types of software used
- **H** **Key Elements of a Business Case** Depiction of key elements of a business case and the program's progress in completing those elements
- **I** **Planned Knowledge by MTA Transition** Depiction of selected knowledge program plans to attain by MTA transition
- **J** Assessment of a program's business case elements, technology, software and cybersecurity, transition plan, and other program issues
- **K** **Program Office Comments** General comments provided by the cognizant military service or program office

Source: GAO. | GAO-22-105230

For 53 of our 63 assessments, we used scorecards to depict the extent of knowledge that a program has gained or plans to gain. These scorecards display key knowledge-based practices that should be implemented by certain points in the acquisition process to reduce risk, based on leading acquisition practices. For MDAPs and MTA programs, we assessed different points in the acquisition cycle based on differences in characteristics for these program types. Additionally, within our assessments of MDAPs, we assessed different knowledge-based practices for shipbuilding programs at the point a design contract was awarded and at the point ship fabrication starts.[74]

For each scorecard, we used the following scoring conventions:

- **A closed circle** to denote a knowledge-based practice the program implemented.
- **An open circle** to denote a knowledge-based practice the program did not, or has yet to implement. For MTA programs, we used a partially closed circle to denote a knowledge-based practice that the program reported it plans to implement before transitioning to a follow-on effort and an “x” within a circle to indicate that a program did not plan to obtain select knowledge before transitioning to a follow on effort.
- **A dashed line** to denote that the program did not provide us with enough information to make a determination.
- **NA** to denote a practice that was not applicable to the program. For example, a practice may be marked “NA” for a program if it has yet to reach the point in the acquisition cycle when the practice should be implemented.

We included notes beneath the figures to explain information not available or NA scores, and added other explanatory notations for the scorecards where appropriate. Appendix II provides additional detail on our scorecard methodology. Figures 34 and 35 provide examples of the knowledge scorecards we used in our assessments.

[74]These shipbuilding key points and practices were informed by our prior work. See GAO-09-322.

Figure 34: Examples of Knowledge Scorecards on Two-Page Major Defense Acquisition Program Assessments

Non-shipbuilding program

Attainment of Product Knowledge (as of January 2022)

	Status at Development Start	Current status
Resources and requirements match		
Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	○	●
Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
Complete a system-level preliminary design review	○	●
Product design is stable	**Design review**	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	○	○
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	●	●

● Knowledge attained ··· Information not available
○ Knowledge not attained **NA** Not applicable

Shipbuilding program

Attainment of Product Knowledge (as of January 2022)

	Status at Detail Design Contract Award	Current status
Resources and requirements match		
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	●
Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
Complete a system-level preliminary design review	○	●
Product design is stable	**Fabrication start**	
Complete basic and functional design to include 3D product modeling	○	●

● Knowledge attained ··· Information not available
○ Knowledge not attained **NA** Not applicable

Source: GAO analysis of DOD data. | GAO-22-105230

Figure 35: Example of Knowledge Scorecards for Assessments of Programs Using the Middle Tier of Acquisition Pathway

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

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

Planned Knowledge by MTA Transition			
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	**NA**	Demonstrate all critical technologies in form, fit, and function within a realistic environment	**NA**
Complete system-level preliminary design review	**NA**	Release at least 90 percent of design drawings	**NA**
Test a system-level integrated prototype	**NA**	Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	**NA**
Demonstrate critical processes on a pilot production line	**NA**	Test a production-representative prototype in its intended environment	**NA**

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned ... Information not available **NA** Not applicable

Source: GAO analysis of DOD data. | GAO-22-105230

AIR FORCE and SPACE FORCE

Program Assessments

▲ F-22 Rapid Prototyping

Assessment type	Program name
MDAPs	B-52 Radar Modernization Program (B-52 RMP)
	F-15 Eagle Passive Active Warning Survivability System (F-15 EPAWSS)
	Global Positioning System III Follow-On (GPS IIIF)
	HH-60W Jolly Green II (HH-60W)
	KC-46A Tanker Modernization Program (KC-46A)
	Long Range Standoff (LRSO)
	Military Global Positioning System (GPS) User Equipment (MGUE) Increment 1 (MGUE Inc 1)
	MH-139A Grey Wolf Helicopter (MH-139A)
	Next Generation Operational Control System (OCX)
	Small Diameter Bomb Increment II (SDB II)
	T-7A Red Hawk (T-7A)
	VC-25B Presidential Aircraft Recapitalization (VC-25B)
	Weather System Follow-On (WSF)
MDAP Increments	Enhanced Polar System – Recapitalization (EPS-R)
	National Security Space Launch (NSSL)
MTA Programs	Air-launched Rapid Response Weapon (ARRW)
	B-52 Commercial Engine Replacement Program (CERP) Rapid Virtual Prototype (RVP)
	Deep Space Advanced Radar Capability (DARC)
	Evolved Strategic SATCOM (ESS)
	F-15EX
	F-22 Rapid Prototyping
	Future Operationally Resilient Ground Evolution (FORGE)
	Military Global Positioning System (GPS) User Equipment (MGUE) Increment 2 (MGUE Inc 2)
	Next Generation Overhead Persistent Infrared (Next Gen OPIR)
	Protected Tactical Enterprise Service (PTES)
	Protected Tactical SATCOM (PTS)

Source (previous page image): Defense Visual Information Distribution Service. | GAO-22-105230

Source: U.S. Air Force. | GAO-22-105230

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

The Air Force's B-52 RMP is planned 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 Essentials

Milestone decision authority: Air Force

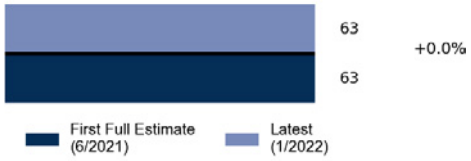
Program office: Wright-Patterson Air Force Base, OH

Prime contractor: Boeing

Contract type: CPFF (risk reduction and requirements development)

Acquisition Cycle Time

(in months)



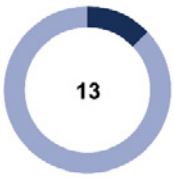
Software Development

(as of January 2022)

Approach: Agile and Incremental

Average time of software deliveries (months)

Software percentage of total program cost



Software type

0 percent Off-the-shelf

15 percent Modified off-the-shelf

85 percent Custom software

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (6/2021)	Latest (6/2021)	Percentage change
Development	$1,177.95	$1,177.95	+0.0%
Procurement	$900.95	$900.95	+0.0%
Unit cost	$27.35	$27.35	+0.0%
Total quantities	76	76	+0.0%

Total quantities comprise two development quantities and 74 procurement quantities.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Development Start**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	NA	NA
Demonstrate all critical technologies in form, fit, and function within a realistic environment	NA	NA
Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	NA	NA
Test a system-level integrated prototype	NA	NA
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA	NA
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

We did not assess B-52 RMP critical technologies because the program said it does not have any. We also did not assess design stability and manufacturing maturity because the program has yet to reach, respectively, critical design review or production start.

B-52 RMP

Technology Maturity

The B-52 RMP identified no critical technologies. The program completed an independent technical risk assessment in December 2020, which determined that the program primarily relies on existing technology and off-the-shelf components. According to program officials, all planned technologies are fully mature.

Design Stability

The B-52 RMP does not plan to demonstrate that the product's design is stable by the critical design review, planned for February 2022. According to program officials, about 80 percent of program design drawings are expected to be releasable by the design review. This approach does not align with leading acquisition practices that call for at least 90 percent of drawings to be released. Moreover, the program does not plan to test a system-level integrated prototype until 1 year after the critical design review. These plans increase the risk of costly and time-intensive design changes if issues are discovered later.

Production Readiness

Since our last assessment, program officials adjusted the program's acquisition strategy to reflect a tailored approach to production start, with two decision points authorizing low-rate initial production. The first decision point in March 2024 would provide approval to begin initial hardware procurement for the first 11 units. This decision is expected to take place 4 months earlier than we reported in last year's assessment, before completion of system-level developmental testing, and 4 months before a production readiness review. The second decision in September 2024 would approve production of all low-rate initial production units. Program officials noted that the two decision points are intended to support the program's schedule by allowing earlier procurement of long-lead hardware items.

The program also increased planned low-rate initial production quantities from 11 to 28 units and plans to buy hardware for the first 11 units prior to completion of developmental testing. Program officials stated they believe there is little risk in procuring hardware items for the first 11 units at the first decision point. They explained that because they believe the hardware design is stable, they expect most of the issues identified during developmental testing will be software, rather than hardware, issues. However, we previously found that significant concurrency between developmental testing and production often results in the discovery of deficiencies that requires time-consuming design changes and costly rework.

Software and Cybersecurity

The B-52 RMP is tracking software completion, integration, and developmental testing as a moderate schedule risk. The program expects 85 percent of software to be custom. We previously reported that custom software generally takes more time and is more expensive to develop than off-the-shelf software.

The program plans to manage this risk by making multiple software deliveries to the flight test effort and developing simulations and functionally equivalent hardware to support early software development. However, officials told us that any software problems found late in flight testing could impact the program's schedule. Moreover, they acknowledged that this strategy depends on the availability of facilities and equipment to conduct formal qualification testing and system-level integration testing prior to flight testing. The B-52 RMP shares integration laboratory resources with multiple programs. If those programs experience delays, the B-52 RMP will also likely be delayed, officials noted. The program began coordinating with other programs to prioritize and de-conflict laboratory usage.

The Air Force approved a cybersecurity strategy for the B-52 RMP in March 2021, and officials told us that the program completed an initial cybersecurity assessment in November 2021. The program plans to begin cybersecurity developmental testing in 2023. Officials told us that cybersecurity has been included in RMP software plans since requirements generation and that the program has integrated cybersecurity requirements as part of the ongoing software development process.

Program Office Comments

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

Source: U.S. Air Force. | GAO-22-105230

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 (EW) system used to detect and identify threat radar signals, employ countermeasures, and jam enemy radars. The program utilizes reconfigured hardware and software from other military aircraft to address current EW threats. The Air Force developed EPAWSS Increment 1 to replace the F-15 legacy EW system. It has yet to budget for a proposed Increment 2, which adds a new towed decoy. We assessed Increment 1.

Program Essentials

Milestone decision authority: Air Force

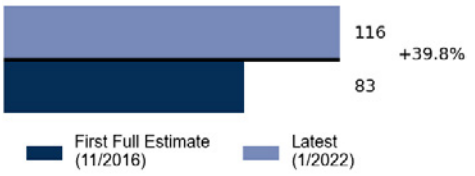
Program office: Wright-Patterson Air Force Base, OH

Prime contractor: Boeing

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

Acquisition Cycle Time

(in months)



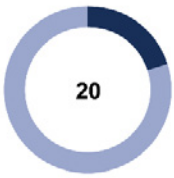
Software Development

(as of January 2022)

Approach: Mixed

Average time of software deliveries (months)

Software percentage of total program cost



Software type

0 percent Off-the-shelf

79 percent Modified off-the-shelf

21 percent Custom software

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (11/2016)	Latest (10/2020)	Percentage change
Development	$973.56	$1,372.88	+41.0%
Procurement	$3,748.75	$3,681.11	-1.8%
Unit cost	$11.43	$13.92	+21.8%
Total quantities	413	363	-12.1%

The latest total quantity includes two F-15C development units, 217 F-15E, and 144 F-15EX production units. Six of the F-15E production units will start as development units before they are refurbished into production units.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Development Start**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	●
Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	○	○
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	○	○

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

F-15 EPAWSS Program

Technology Maturity, Design Stability, and Production Readiness

EPAWSS's four critical technologies are mature and its design is stable, according to the program office. As of October 2021, EPAWSS completed about 70 percent of its developmental flight testing. The rest is planned to be completed by December 2022, with most of what remains involving electronic countermeasure, threat radar warning, and radar location finding capabilities. However, the program encountered challenges in testing over the past year that could lead to future delays—such as identifying the potential for damage to test assets that may result from the remaining hardware testing. Further, flight testing identified some underperformance in dense background frequency environments and with threat radar direction finding. EPAWSS must address these issues to avoid future schedule delays and satisfy its current operational requirements. As a result, the program added additional software integration and test capability and is prepared to accept performance as-is in certain areas, with some requirement changes under consideration.

The program entered production in October 2020 and 2 months later funded the first of 11 planned annual production lots, but has yet to fully meet leading acquisition practices for production. For example, while the program demonstrated critical processes on a pilot production line, it does not plan to test a production-representative prototype in its intended environment until April 2023. This testing will occur after more than $750 million in funding is budgeted for the production of approximately 75 EPAWSS units (43 E-model and 32 EX-model units). Committing to production without testing a production-representative prototype increases the risk of finding issues in testing that may require costly and time-intensive future rework on units already produced. The program stated that the October 2020 date it provided to us last year for testing a production-representative prototype was an error. We updated our Attainment of Product Knowledge table to reflect this change.

Software and Cybersecurity

Program officials stated that software development is complete because the program's software is largely reused from other systems. However, they told us that software integration and testing has been more difficult than expected. Full EPAWSS operational capability will be reached through a series of 15 incremental software releases—only three remain to be delivered to support ongoing developmental testing. Some early releases were delivered late or with diminished content to prioritize functions needed for specific test events and decision points. The program made these changes to mitigate delays related to technology and design issues we reported in prior assessments. Program officials state that software content for must-fix problems takes priority. However, they added that they do not expect this rework or other content deferred into the remaining software releases to delay the December 2022 completion of developmental testing, as this date includes some schedule margin.

Although not specifically addressed by a top-level performance requirement, the program stated that cybersecurity considerations are included in lower-level system attributes that EPAWSS needs to meet. According to program officials, EPAWSS completed the first in a series of cybersecurity tests in August 2020. They expect to finish the testing to find cyber vulnerabilities and examine the risk of exploitation by November 2022, after the last software increment is released for testing. A full system cyber assessment is planned to be completed by April 2023, a year before the full-rate production decision.

Other Program Issues

EPAWSS installation work is moving from Eglin Air Force Base, where the test aircraft were modified, to Boeing's San Antonio facility for the start of hardware installation on fielded F-15E aircraft in June 2022. The program reported that the most significant risk from this move is the knowledge transfer challenge posed by the 10-month gap between closing one modification line and opening the other, which may result in inefficient work due to the loss of experience.

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 it made progress in 2021, including initiating production; delivering the final test aircraft; completing seven ground-based tests and two cyber assessments; and participating in two large operational exercises that provided insights into the system's performance. It noted that hardware testing is 98 percent complete. According to the program office, some risk remains of hardware damage driven by the nature of the indirect lightning tests yet to be completed; the contractor added protective measures to the designs of some hardware subcomponents that are at risk of indirect lightning damage. The program office does not anticipate any additional costly or significant redesigns or retrofits.

According to program officials, the warfighter community is pleased with the system's performance demonstrated to date. They added that the acquisition strategy is to field this capability as soon as possible. Consequently, they decided to start production while finishing development, an approach they expect will take long-lead hardware procurement off the critical path and deliver a capability 16 months earlier than a traditional approach.

Source: Lockheed Martin Corporation. | GAO-22-105230

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 Essentials

Milestone decision authority: Air Force

Program office: El Segundo, CA

Prime contractor: Lockheed Martin

Contract type: FPI (development), FPAF (procurement)

Acquisition Cycle Time

(in months)

Not applicable

We could not calculate cycle time because initial capability depends on the availability of complementary systems.

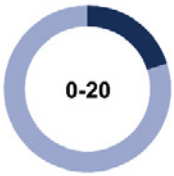
Software Development

(as of January 2022)

Approach: Waterfall and Incremental

Average time of software deliveries (months)

Software percentage of total program cost



Software type

90 percent Off-the-shelf

0 percent Modified off-the-shelf

10 percent Custom software

According to program officials, approximately 90 percent of GPS IIIF software is expected to be reused from the GPS III program.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (9/2018)	Latest (9/2020)	Percentage change
Development	$3,378.01	$3,194.02	-5.4%
Procurement	$6,533.08	$6,686.41	+2.3%
Unit cost	$450.50	$449.11	-0.3%
Total quantities	22	22	+0.0%

Total quantities comprise two development quantities and 20 procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Development Start**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	NA	NA
Complete a system-level preliminary design review	○	○
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	●	●
Test a system-level integrated prototype	○	○
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	○	○
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ... Information not available

○ Knowledge not attained **NA** Not applicable

We did not assess GPS IIIF critical technologies in a realistic environment or test of a production representative prototype in its intended environment due to the difficulty of conducting tests in a realistic or intended environment—space. Also, this graphic reflects that the Air Force waived the requirement for conducting a preliminary design review prior to development start.

GPS IIIF

Technology Maturity, Design Stability, and Production Readiness

As previously reported, the GPS IIIF program's two critical technologies—a linearized traveling wave tube amplifier and a digital waveform generator—have been demonstrated in a relevant environment. According to our leading practices, this maturity level is sufficient to begin satellite system development.

In 2021, the GPS IIIF program encountered and addressed technical challenges in payload development and implemented schedule changes to mitigate risk to the projected February 2026 delivery of the first satellite. The program planned to take delivery of five of six developmental mission data units (MDU)—the brain of the satellite's navigation mission—in 2021. However, since November 2020, the program incurred delays averaging 11 months for each of the six units due to such factors as the redesign of an integrated circuit in the digital waveform generator. As of October 2021, none were delivered and the first delivery is expected in March 2022.

As result of the delays, the program reordered test sequencing so that the planned flight qualification testing for the digital waveform generator will occur before testing the digital waveform generators for three of the developmental MDUs. Previously, this qualification testing was to occur after testing was completed on all six of the developmental units. The program restructured the test plans in order to mitigate potential schedule impacts to delivery of the first GPS IIIF satellite.

In 2023, the program plans to complete testing of a non-flight, system-level integrated prototype prior to the first GPS IIIF satellite's integration and testing, which is planned for early 2024. The prototype includes all key subsystems and components as in the planned GPS IIIF satellites. The program projected that testing on this prototype will be complete in October 2023 and will help the program gain knowledge on fabrication, integration, and testing.

In July 2020, the Air Force approved production for the program, and, in October 2020, the Space Force exercised contract options to procure the third and fourth GPS IIIF satellites. The program bought the first and second satellites prior to the July 2020 production decision, using development funds. In October 2021, the Space Force exercised options to procure the fifth, sixth, and seventh GPS IIIF satellites.

The program has yet to ensure that all GPS IIIF-specific manufacturing processes are in statistical control, as recommended by leading acquisition practices. DOD guidance does not require statistical control of manufacturing processes until a program's full-rate production decision–a milestone that does not apply to the GPS IIIF program. However, our past work shows that attaining this knowledge prior to beginning production helps to ensure that manufacturing processes are repeatable, sustainable, and capable of consistently producing parts within quality standards. Program officials told us that they expect to mitigate the majority of manufacturing risk in the production and testing of the first two satellites. Specifically, they expect assembly and test and evaluation efforts for these two satellites will help ensure that new elements of the satellite design meet program requirements.

Software and Cybersecurity

The GPS IIIF program has an approved cybersecurity strategy and plans to conduct a range of cybersecurity tests from 2023 to 2026. According to program officials, these tests will commence with a 2023 test of a GPS IIIF satellite simulator. Testing will conclude with a full system cybersecurity assessment in 2026, prior to the Space Force's acceptance of the first GPS IIIF satellite.

Other Program Issues

Launch and operation of GPS IIIF satellites depends upon the delivery of Next Generation Operational Control System (OCX) Block 3F, which the Space Force is developing in a separate acquisition program to modify the delayed and as-yet-undelivered OCX ground control system. The Space Force awarded Raytheon a sole-source contract for OCX Block 3F in April 2021, and the program's formal development start is currently scheduled for March 2022. If the delivery of the OCX ground control system is further delayed going forward, it could affect the OCX Block 3F schedule, with potential corresponding effects to the GPS IIIF program.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office stated that it continues to work closely with the contractor to help ensure that schedule milestones are met and that no schedule growth occurs. The program office stated that the program completed its critical design review in March 2020, and the Air Force approved the program's production decision in July 2020. The program office noted that as part of that production decision, an updated program cost and schedule baseline was approved. It also added that in August 2021, DOD's Office of the Director, Operational Test and Evaluation approved an update to the GPS Enterprise Test and Evaluation Master Plan that includes GPS IIIF test plans. According to the program office, development efforts for the first two GPS IIIF satellites are proceeding as planned. It added that five additional satellites were purchased since October 2020—two in October 2020 and three in October 2021.

Source: Sikorsky Aircraft Company. | GAO-22-105230

HH-60W Jolly Green II

The Air Force's HH-60W Jolly Green II (formerly known as the Combat Rescue Helicopter) program will replace the aging HH-60G Pave Hawk rescue helicopter fleet. It will provide 113 new aircraft, related training systems, and support for increased personnel recovery capability. It is a derivative of the operational UH-60M helicopter. Planned modifications to the existing design include a new mission computer and software, a higher capacity electrical system, larger capacity main fuel tanks, and armor for crew protection, among other things.

Program Essentials

Milestone decision authority: Air Force

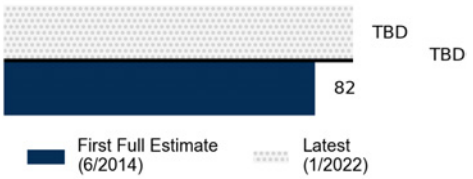
Program office: Wright-Patterson Air Force Base, OH

Prime contractor: Sikorsky Aircraft Co.

Contract type: FPI/FFP/CPFF

Acquisition Cycle Time

(in months)



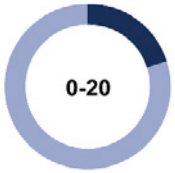
Software Development

(as of January 2022)

Approach: Agile, Waterfall, and Incremental

Average time of software deliveries (months)

Software percentage of total program cost



Software type

0 percent Off-the-shelf

99 percent Modified off-the-shelf

1 percent Custom software

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (6/2014)	Latest (9/2020)	Percentage change
Development	$2,226.16	$2,199.79	-1.2%
Procurement	$6,942.15	$7,447.82	+7.3%
Unit cost	$82.10	$85.83	+4.6%
Total quantities	112	113	+0.9%

Total quantities comprise 10 development quantities and 103 procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at Development Start	Current Status
Resources and requirements match		
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	●
Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	…	…
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	○	○
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	○	●

● Knowledge attained … Information not available

○ Knowledge not attained NA Not applicable

We could not assess HH-60W design drawings because the program no longer tracks these drawings; therefore, there is no total number of drawings against which to measure the program's knowledge.

HH-60W Jolly Green II Program

Technology Maturity and Design Stability

During the past year, the program demonstrated the maturity of its one critical technology—the radar warning receiver—in a realistic environment through integrated testing and evaluation concluding in November 2021, according to program officials. Program officials said they are assessing data related to the most recent testing of the radar warning receiver crew display and its overall performance in preparation for initial operational testing and evaluation, planned to start in February 2022.

Program officials reported a stable design. First, program officials reported no risk related to the helicopter's weight. We previously reported on a September 2019 independent DOD review that found moderate technical risk associated with the aircraft's weight, which the program has since resolved. Second, the program completed testing of a system-level, integrated prototype. Although a key marker of design stability, the testing was completed well after the May 2017 critical design review, the point at which leading acquisition practices recommend conducting such testing.

Production Readiness

HH-60W entered production in September 2019 without fully meeting leading practices for production readiness. For example, it had yet to test a production-representative prototype in its intended environment as recommended by leading acquisition practices. More than 2 years later, the program first conducted such a test as part of operational flight testing for the radar warning receiver completed in November 2021, according to program officials. However, this testing was completed 5 months after the first production unit was delivered in June 2021, according to program officials. Without testing a prototype prior to the production decision, the program missed an opportunity to identify potential issues that could lead to costly, time-intensive rework on production units.

Program officials noted reliance on a single supplier and material obsolescence as production-related risks requiring mitigation. Program officials stated they are working with the contractor to develop strategies that address or mitigate specific obsolescence issues.

Software and Cybersecurity

The program's software strategy is unchanged since our previous assessment, according to program officials. They also noted that the program considers software development to have a moderate level of risk driven by software development efforts proving more complex than originally anticipated, among other reasons. Program officials plan to complete a full system cybersecurity assessment for the program in the spring of 2022.

Other Program Issues

The formal start of HH-60W's full system operational testing is delayed by 8 months and is now planned for March 2022, according to program officials. The program encountered delays due to lack of access to mission-ready aircraft equipped with an operational radar warning receiver. Program officials reported that the COVID-19 pandemic caused reductions in contractor staff hours, slowing of the production line, and delays in materials from suppliers. These delays exacerbated continuing schedule delays in the sustainment, radar warning receiver, gun mount system, and training systems areas.

Program officials told us they attempted to mitigate effects from these delays by conducting some integrated systems testing in advance of full system operational testing. As of October 2021, 41 percent of integrated systems testing was completed, according to program officials. Program officials said they also attempted to mitigate delays by requesting that the Air Force's Air Combat Command prioritize spares and support equipment delivery.

Program officials stated that they anticipate future increases in program costs due to the COVID-19 pandemic's effects on the prime contractor, although they are still in the process of quantifying the specific amount. As HH-60W bases come online, the program office anticipates increasing contract costs as spares and support equipment requirements experience corresponding increases.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office stated that the program made significant progress since the start of production. It reported that it delivered the operational flight trainer and weapon system trainer at Kirtland Air Force Base in December 2021. The program office added that it expects the radar warning receiver test report will be released in March 2022 and that it continues to monitor flight test progress, spares delivery, and potential complications from COVID-19.

Source: U.S. Air Force. | GAO-22-105230

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

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

Program Essentials

Milestone decision authority: Air Force

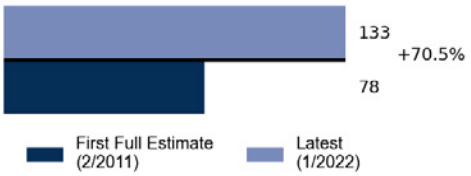
Program office: Fairborn, OH

Prime contractor: Boeing

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

Acquisition Cycle Time

(in months)



Software Development

(as of January 2022)

Approach: Waterfall and Incremental

Average time of software deliveries (months)

Information not available

Software percentage of total program cost

Information not available

Software type

0 percent Off-the-shelf

64 percent Modified off-the-shelf

36 percent Custom software

The program office reported that it does not have a software delivery schedule or track software work elements for current software efforts.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (2/2011)	Latest (7/2020)	Percentage change
Development	$8,109.89	$6,840.28	-15.7%
Procurement	$39,380.57	$33,118.63	-15.9%
Unit cost	$289.77	$239.30	-17.4%
Total quantities	179	179	+0.0%

Total quantities comprise four development quantities and 175 procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Development Start**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	○
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	○
Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	…	…
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	○	○
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	●	●

● Knowledge attained … Information not available

○ Knowledge not attained **NA** Not applicable

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

KC-46A Program

Technology Maturity, Design Stability, and Production Readiness

The KC-46A program continues to experience design instability. Specifically, the program has seven critical deficiencies, three of which are related to the refueling system. The other four are product quality deficiencies. All have various resolution time frames.

- One deficiency relates to the boom—which a crew member operates and extends from the rear of the KC-46 to deliver fuel to the receiver aircraft. The boom is too stiff during refueling attempts with lighter receiver aircraft, and the excessive thrust needed to make contact could cause the receiver aircraft to strike the boom and damage the aircraft. Program officials expect Boeing to complete the redesign of the new boom in 2023.
- Two other deficiencies relate to shortcomings with the remote vision system (RVS)—a set of cameras and a display that a crew member uses to maneuver and insert the boom into receiver aircraft. These issues can cause the operator to scratch stealth aircraft with the boom during refueling due to poor visual acuity and inadequate depth perception. Program officials expect Boeing to complete the design of the new RVS by 2024.
- The other four deficiencies are product quality shortcomings: air refueling drain tube cracks, flight management system instability, fuel system leaks, and drain mast cracks. Program officials expect to develop solutions to these deficiencies by 2022.

The RVS and boom deficiencies contributed to approximately a 7-year delay in the program's planned full-rate production decision from its original schedule, and the decision is now estimated to occur in September 2024. The program began accepting aircraft in 2019 and continued procuring low-rate production aircraft, even though it has yet to fully address the RVS and boom deficiencies. The program will procure 118 of 175 planned aircraft prior to entering full-rate production. According to Air Force officials, maintaining the planned production schedule allows them to receive and use delivered aircraft in limited operations until delivery of the new boom and RVS.

In addition, the program delayed its required assets available milestone—18 aircraft operationally ready with the new boom and RVS—to March 2022, a 5-year delay from its original schedule. However, this date may not be feasible because Boeing will not start retrofitting delivered aircraft with the new boom until July 2025 due to material lead time, according to the program. Retrofits for the RVS are scheduled to begin after the completion of initial operational test and evaluation in May 2024.

Boeing is financially responsible for fixing these critical deficiencies, except the boom stiffness. The Air Force will assume the cost to fix the boom—currently estimated at $113 million, according to the program—because it agreed to an incorrect specification for the stiffness of the boom. Retrofits are estimated to cost another $219.2 million.

The program risks future cost growth and schedule delays due to RVS design immaturity. The new RVS includes three immature critical technologies—the visible camera, the long-wave infrared boom camera, and the primary display. We updated our assessment of the program's current state of knowledge attainment with regard to technology maturity to reflect these immature technologies.

In April 2020, Boeing and the Air Force agreed upon a path forward to redesign the RVS and agreed that the Air Force would be financially responsible for any design changes after the preliminary design review (PDR). While the program does not currently have a planned closure date for this review, program officials said they plan to close the review and commit to the new RVS design despite its immaturity. Program officials acknowledged that the proposed design for the long-wave infrared boom camera will not meet requirements for covert aircraft refueling, and they have not decided on a path forward with Boeing to address this issue. The program also plans to close out the PDR before testing a prototype that integrates these critical technologies on a KC-46, adding risk that issues may be discovered later in development that require costly, time-intensive rework. As of our review period, the Air Force and Boeing had yet to finalize an agreement on the replacement cameras and how the costs will be handled.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office noted that the April 2020 agreement between the Air Force and Boeing established an acquisition framework to accelerate delivery of an improved RVS. The program reported it uses a risk management process to monitor the maturity of the RVS critical technologies. It also noted that testing a prototype prior to RVS 2.0 PDR closure is not practical, stating that the time needed to develop an integrated prototype would delay the program approximately 18 to 24 months. However, we found in our January 2022 report on KC-46 (GAO-22-104530) that these RVS risk mitigation measures are insufficient.

Source: U.S. Air Force. | GAO-22-105230

Long Range Standoff (LRSO)

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

Program Essentials

Milestone decision authority: Under Secretary of Defense, Acquisition and Sustainment

Program office: Eglin Air Force Base, FL

Prime contractor: Raytheon Missiles & Defense

Contract type: CPFF

Acquisition Cycle Time

(in months)

Software Development

(as of January 2022)

Approach: Agile, Waterfall, Incremental, and DevSecOps

Average time of software deliveries (months)

Software percentage of total program cost

Software type

75 percent Off-the-shelf

16 percent Modified off-the-shelf

9 percent Custom software

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (6/2021)	Latest (6/2021)	Percentage change
Development	$6,214.29	$6,214.29	+0.0%
Procurement	$8,151.18	$8,151.18	+0.0%
Unit cost	$13.33	$13.33	+0.0%
Total quantities	1,087	1,087	+0.0%

Total quantities comprise 67 development quantities and 1,020 procurement quantities.

Attainment of Product Knowledge (as of January 2022)

	Status at Development Start	Current Status
Resources and requirements match		
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	○
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	○
Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	NA	NA
Test a system-level integrated prototype	NA	NA
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA	NA
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

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

LRSO Program

Technology Maturity

LRSO started development without fully addressing leading acquisition practices related to technology maturity. The missile has several critical technology areas—including guidance, navigation and control; propulsion; low observable materials; Agile software; nuclear hardness; and a classified subsystem. All are approaching maturity, except nuclear hardness, which is immature and not expected to be tested in a relevant environment until December 2022, 18 months after the start of development.

Additionally, DOE officials identified 48 critical warhead technologies, 60 percent of which are not yet approaching maturity. Maturity of these technologies is not expected until fiscal year 2025. Starting development without successfully demonstrating all critical technologies in a realistic environment increases the risk that issues may arise later in development that require costly and time-intensive rework.

Design Stability

LRSO reported it released 81 percent of the missile's planned design drawings to manufacturing and is on schedule to release 100 percent by the critical design review, currently scheduled for February 2023. Consistent with leading practices, the program plans to test a system-level integrated prototype in December 2022, 2 months prior to the critical design review.

DOE recently delayed an important warhead baseline design review from November 2021 to August 2022, largely because of electrical system test failures and design immaturity. While DOE is on target to complete the design drawings it needs for this design review, overall it released less than 40 percent for the total warhead system design drawings as of September 2021. LRSO program officials told us that DOE recently completed a warhead schedule risk assessment in October 2021, which indicated at least an 18-month delay in the warhead development schedule. The effect of this delay on the overall LRSO schedule has yet to be determined. However, without mature technologies, the program is at greater risk that issues will emerge later in the design process that cause rework to those designs already completed.

Production Readiness

The Air Force plans to demonstrate missile critical manufacturing processes on a pilot production line prior to the production decision. Our prior work found this testing helps provide decision makers confidence that the contractor can meet quality, cost, and schedule goals. The Air Force expects to have 60 missile critical manufacturing processes at production start. Program officials are planning to ensure all key characteristics are either verified through statistical process control or 100 percent inspected prior to the start of production.

Software and Cybersecurity

The program identified missile software development as a medium risk, reporting specific challenges related to hiring enough staff with the required experience. It plans 10 incremental software deliveries throughout development, three of which it delivered so far.

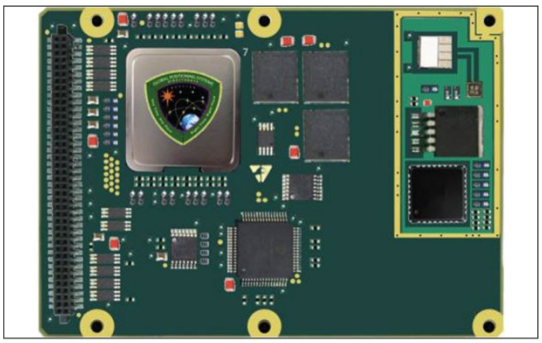
The Air Force approved the program's cybersecurity strategy in March 2021. The program completed the first part of a cybersecurity risk assessment in July 2021, finding some possible vulnerabilities. Program officials stated that this partial assessment will support system design and inform the assessment's second part, planned for February 2022.

Other Program Issues

Two cost estimates prepared for the start of LRSO development in July 2021 reflected significant procurement cost differences. Specifically, an independent cost estimate done by the Office of the Secretary of Defense (OSD) found procurement could cost $1.9 billion more than the Air Force's estimate. Officials explained that the higher OSD estimate used procurement cost data from past nuclear cruise missile programs. Air Force estimators instead used actual cost data from eight recently-built LRSO development test missiles to arrive at a lower estimate. The program's milestone decision authority elected to use the higher OSD estimate for now but to have OSD conduct another estimate in early 2023 using actual information from manufacturing additional LRSO test missiles.

Program Office Comments

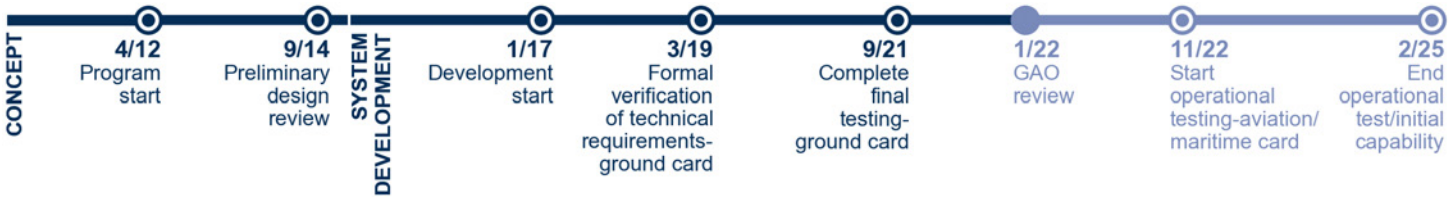
We provided a draft of this assessment to the program office for review and comment. The program provided technical comments, which we incorporated where appropriate. The program reported the system is meeting Air Force requirements. It added that the importance of mature technology, reliability, and mature manufacturing processes were identified in early acquisition planning, and all remain high priority. The program office stated that its focus on leading acquisition practices drove the appropriate technology maturation to support the start of development. It reported that only one critical technology—nuclear hardness—required a waiver for the program to start development, but it is on track to maturity. The program office added it continues to work with DOE for warhead development and that DOE is implementing producibility assessments sooner than any preceding warhead life-extension program. Lastly, the program office stated that the effects of DOE's recent design review delay on the overall LRSO schedule appear to be manageable, if the new date of August 2022 holds.



Source: U.S. Air Force. | GAO-22-105230

Military GPS User Equipment (MGUE) Increment 1

The Space Force's MGUE program is developing GPS receivers compatible with the military code (M-code) signal transmitted by GPS satellites. The receiver cards are expected to provide all the military services with enhanced position, navigation, and timing capabilities and improved resistance to threats. With Increment 1, assessed here, the Space Force is developing two receiver cards for testing: one for aviation and maritime applications and one for ground applications. The military services will make procurement decisions.



Program Essentials

Milestone decision authority: Air Force

Program office: El Segundo, CA

Prime contractor: L3Harris; Raytheon Technologies; BAE Systems

Contract type: CPIF/CPFF/FFP (development)

Acquisition Cycle Time

(in months)

Not applicable

We did not assess acquisition cycle time because the program will end with operational testing.

Software Development

(as of January 2022)

Approach: Agile and Incremental

Average time of software deliveries (months)

1-3 | 4-6 | 7-9 | 10-12 | **13 or more**

Software percentage of total program cost

Information not available

Software type

0 percent Off-the-shelf

0 percent Modified off-the-shelf

100 percent Custom software

The program reported a corrected delivery time this year based on new capabilities provided, rather than on software fixes. Program officials stated software costs are not available.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (1/2017)	Latest (1/2021)	Percentage change
Development	$1,644.5	$1,808.1	+9.9%
Procurement	$0.0	$0.0	N/A
Unit cost	N/A	N/A	N/A
Total quantities	0	0	N/A

We did not assess procurement or unit cost because the program does not intend to procure cards beyond test articles, which are not reported as development or procurement quantities.

Attainment of Product Knowledge (as of January 2022)

	Status at Development Start	Current Status
Resources and requirements match		
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	○
Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	NA	NA
Test a system-level integrated prototype	NA	NA
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA	NA
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ... Information not available

○ Knowledge not attained **NA** Not applicable

We did not assess MGUE design stability or manufacturing maturity metrics because the program is only developing production-representative test items that the military services may decide to procure.

MGUE Inc. 1 Program

Technology Maturity

Four of five critical technologies are fully mature, with the remaining one—anti-spoof software designed to prevent tracking false GPS signals—nearing maturity, consistent with our prior reporting. The program anticipates the anti-spoof software will reach maturity once testing is complete on the first lead platform for the ground and aviation/maritime cards in the second quarter of fiscal year 2025. Officials stated they successfully completed consolidated Army and Marine Corps ground card testing in September 2021. Pending final test data analysis, they expect to complete ground card development by February 2022. Further testing of the aviation/maritime card is scheduled to begin in the first quarter of fiscal year 2023.

Design Stability

The design remains stable despite continued software development challenges over the past year, according to program officials. They reported that hardware deficiencies we reported on in prior years have been resolved, but some additional challenges remain. For example, they stated that the aviation/maritime card encountered signal communication issues. They determined the cause is software-related, and expect that changes in how users integrate receiver systems will resolve this issue.

Production Readiness

Program officials stated that the ground card completed final testing, pending analysis of test results. As of June 2021, the card achieved the manufacturing readiness level necessary for the military services to place orders.

Work to address the causes of prior delays to development of the aviation/maritime card continues. The program reported that it awarded a firm-fixed-price contract for aviation/maritime card development in December 2020—including performance-based schedule incentives—in response to realized cost and schedule risks. In January 2021, the program re-baselined that card's cost and schedule, reflecting delays in areas such as software delivery and testing.

As a part of the new baseline, the program relocated the majority of testing events to the contractor facility to accelerate feedback processes, and relaxed some technical performance targets. Program officials now expect aviation/maritime card testing to conclude in the second quarter of fiscal year 2025. We previously reported that the program expected to complete testing for the aviation/maritime card in April 2021. Ongoing delays to aviation/maritime card development have begun to adversely affect procurement schedules of M-code-capable receivers that are dependent on that card, despite the program's efforts to mitigate future schedule delays. Some weapon systems that plan to use these receivers, such as the B-2 bomber, have also been affected by these delays.

Software and Cybersecurity

The program made progress in addressing software issues but continues to face technical challenges delivering aviation/maritime card software. It identified root causes for 100 percent of issues identified in late 2019 and closed 61 percent of those issues as of June 2021. The contractor delivered aviation/maritime card software on a fully functional card in November 2021 for further testing. Program officials noted the aviation/maritime card contractor continues to experience challenges with hiring and productivity of software development staff. Based on actions taken by the contractor to date, however, program officials do not expect these challenges to result in any delays for new software builds.

The program successfully completed additional ground card cybersecurity testing over the past year and plans to perform further cybersecurity tests on the aviation/maritime card as part of upcoming testing during fiscal year 2023.

Other Program Issues

Industrial base challenges, such as card software development challenges with a sole-source sub-contractor, have contributed to a more than 2-year delay for the aviation/maritime card. In response, the program has supported mitigation efforts including bulk buys of limited availability microelectronics components.

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 MGUE Increment 1 made significant progress in 2021. For example, the program office reported it completed the Manufacturing Readiness Assessment for the ground card and also conducted a field user evaluation for the Army and Marine Corps lead platforms for that card. According to the program office, these activities fulfilled critical steps toward delivering capability. In addition, it stated that a version of the aviation/maritime card that the program expects will meet all requirements was delivered in November 2021.

Source: U.S. Air Force. | GAO-22-105230

MH-139A Gray 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 and transporting senior government officials in the National Capital Region. The MH-139A program is acquiring a militarized version of a commercial helicopter to be integrated with previously developed systems. In addition to the helicopters, the program plans to acquire an integration laboratory, a training system, and support and test equipment.

Program Essentials

Milestone decision authority: Air Force

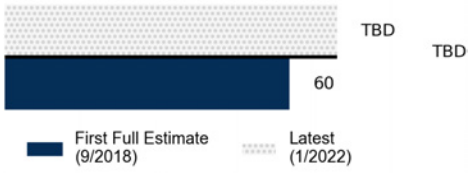
Program office: Wright-Patterson Air Force Base, OH

Prime contractor: Boeing

Contract type: FFP (development)

Acquisition Cycle Time

(in months)



Software Development

(as of January 2022)

Approach: Agile and Waterfall

Average time of software deliveries (months)

Information not available

Software percentage of total program cost

Information not available

Software type

99.6 percent Off-the-shelf

0.4 percent Modified off-the-shelf

0 percent Custom software

The program office reported that, because software is part of the overall firm-fixed-price contract, it does not have insight on the software costs incurred by the contractor.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (9/2018)	Latest (7/2020)	Percentage change
Development	$608.53	$636.74	+4.6%
Procurement	$2,588.97	$2,607.14	+0.7%
Unit cost	$42.10	$41.60	-1.2%
Total quantities	84	80	-4.7%

Total quantities comprise six development quantities and 74 procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle. The program reduced the total quantity to 80 after a mission requirement was removed. Cost figures have yet to be updated to account for this change.

Attainment of Product Knowledge (as of January 2022)

	Status at Development Start	Current Status
Resources and requirements match		
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	NA	NA
Demonstrate all critical technologies in form, fit, and function within a realistic environment	NA	NA
Complete a system-level preliminary design review	NA	NA
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	NA	NA
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA	NA
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

We did not assess MH-139A critical technologies because the program office reported it does not have any. We also did not assess preliminary design review or some design stability knowledge metrics because the program office reported these were not applicable. Further, we did not assess manufacturing maturity because the system has yet to reach production; however, the program stated that it tested a production-representative prototype in the system's intended environment.

MH-139A Program

Technology Maturity and Design Stability

The MH-139A continues to undergo certification testing and, as a result, delayed program milestones. Program officials stated that the program office declared an acquisition program baseline schedule breach in April 2021, but as of January 2022, had yet to determine revised schedule dates.

MH-139A does not have any critical technologies, according to the program office. Over the past 2 years, program officials reported a significant increase in the total number of expected design drawings–from 507 to 7,808–including an increase of 3,689 drawings in 2021. Program officials said that Boeing previously provided the program an inaccurate number of drawings, overstating the stability of the design.

Program officials also stated that the aircraft's design configuration became more stable during 2021. They estimated almost all drawings were released to manufacturing as of September 2021, an indication of design stability.

Program officials stated that Boeing underestimated the scale of design work, impeding the program's ability to stabilize the design and delaying the production decision, which we previously reported was expected in September 2021. Last year, program officials stated that the aircraft design would become more stable once the aircraft obtained certification for demonstrated compliance with Federal Aviation Administration (FAA) requirements. However, according to program officials, the certification has yet to occur because Boeing experienced challenges integrating components that are new to the existing airframe. For example, some of the aircraft's new parts need to be redesigned as a result of certification testing.

Program officials told us they now plan to complete the FAA certification process by February 2022 and begin production in January 2023, a delay of 16 months from last year. This schedule change will also delay the full-rate production decision and initial operational capability. Program officials stated that they continue to work with Boeing to address these significant schedule delays, but Boeing has not submitted some contractually required data on time. Consequently, the program reported withholding 10 percent of its progress payments.

Additionally, in October 2021, Air Force officials told us that they had yet to determine the aircraft's final weight, despite aiming to do so by December 2019. Program officials said they worked closely with Boeing to identify weight risks, and that current estimates project the maximum gross weight will not affect the aircraft's required performance capabilities. Nonetheless, until the program is certain that the aircraft's final weight will not impede range and payload requirements, design rework may be needed to meet those requirements.

Production Readiness

Despite the production decision delay, as of January 2022, the program produced four aircraft and two more were in production. However, given the design instability, there are risks that later design changes could result in significant rework of aircraft already in production and retrofit of aircraft already delivered.

Software and Cybersecurity

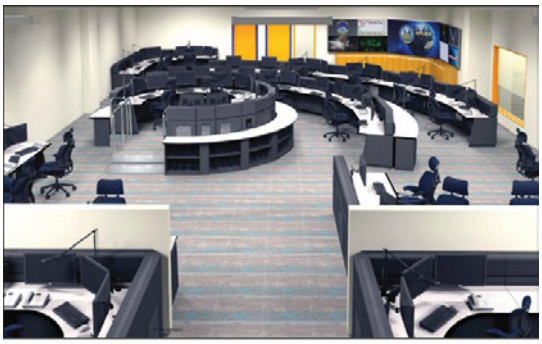
The program did not report any significant changes to its software development since last year's assessment. The program conducted two cybersecurity assessments prior to January 2021, and plans to conduct additional testing on production aircraft, including an upcoming cybersecurity assessment in July 2022. Program office officials said that the program office conducts recurring working groups with the test community to coordinate on potential cybersecurity issues.

Other Program Issues

The program identified diminishing material sources and obsolescence as potential industrial base risks. The program office does not plan to complete a defense industrial base assessment and stated it was working with Boeing to mitigate these risks. Program officials noted that the MH-139A is a commercial-derivative air vehicle and existing manufacturing and support structures are in place to support the MH-139A.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office stated that the MH-139A Grey Wolf is a commercial-derivative aircraft that leverages the parent design's engineering software and hardware foundation to provide military capabilities and training devices. The program noted that Boeing faced challenges achieving schedule benchmarks in civil airworthiness certification with the FAA. It added that to help mitigate delays, the program office revised its test strategy using the four available test aircraft to supplement contractor flight testing, with focused Air Force testing planned to follow. The program stated it continues to closely coordinate with the FAA, Boeing, the Air Force Global Strike Command, and the Air Force test community to develop plans to support a successful low-rate production decision. Further, the program reported that manufacturing readiness assessments were completed and the Air Force determined that manufacturing was sufficiently mature to enter low-rate initial production.



Source: U.S. Air Force. | GAO-22-105230

Next Generation Operational Control System (OCX)

The Space Force's OCX program is developing software to replace the existing GPS ground control system. The Space Force intends for OCX to ensure reliable, secure delivery of position, navigation, and timing information. The Space Force is developing OCX in blocks that add capabilities as they become available. We assessed the first three blocks: Block 0 for launch and limited testing of new satellites; Block 1 for satellite control and basic military signals; and Block 2 for modernized military and additional navigation signals.

Program Essentials

Milestone decision authority: Under Secretary of Defense, Acquisition and Sustainment

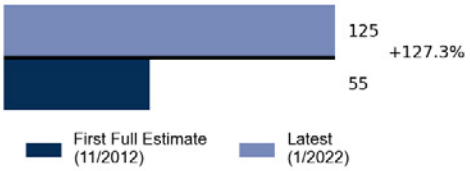
Program office: El Segundo, CA

Prime contractor: Raytheon

Contract type: CPIF/CPAF (development)

Acquisition Cycle Time

(in months)



We calculated acquisition cycle time using the program's initial capability date for Block 2.

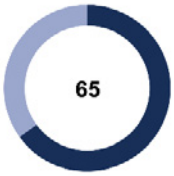
Software Development

(as of January 2022)

Approach: Mixed

Average time of software deliveries (months)

Software percentage of total program cost



Software type

37 percent Off-the-shelf

21 percent Modified off-the-shelf

42 percent Custom software

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (11/2012)	Latest (9/2020)	Percentage change
Development	$3,918.98	$6,789.54	+73.2%
Procurement	$0.0	$0.0	N/A
Unit cost	$3,918.98	$6,789.54	+73.2%
Total quantities	1	1	+0.0%

Total quantities comprise one development quantity and zero procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Development Start**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	●
Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	NA	NA
Test a system-level integrated prototype	NA	NA
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA	NA
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

We did not assess OCX design stability or manufacturing maturity because OCX is primarily a software program and therefore does not track the metrics we use to assess this knowledge.

OCX Program

Technology Maturity and Design Stability

Over the past year, OCX continued to develop and test critical technologies. As we reported last year, the program office reported that all five of its critical technologies, to be delivered as part of Block 1, were mature and had been successfully demonstrated in a realistic environment. OCX is primarily a software development effort. Accordingly, the program does not track the metrics used for this assessment to measure design stability, such as the number of releasable design drawings.

The program continued its qualification testing and plans to complete this testing by April 2022. Following this qualification testing, the program will also conduct a pre-delivery system-level demonstration, which the program expects to complete in May 2022.

Software and Cybersecurity

IBM's production line of the original OCX server hardware incurred cybersecurity risk when a foreign-owned company bought ithe line, as we previously reported. To mitigate this risk, the program modified an existing contract with Raytheon to replace the IBM servers with Hewlett Packard hardware. Defense Contract Management Agency officials stated that while the server replacement effort is considered a hardware replacement effort, the majority of the effort is actually software modifications. Program officials said that these modifications address obsolescence and ensure compatibility with the new hardware.

The program decided to change its software development approach, as we reported last year. The intent of this change was to better manage the program's cost and schedule performance. It employs mixed development approaches for two distinct efforts. For software certification on the old hardware, the program applied a mix of Agile, incremental, and waterfall methods. The program completed this certification in December 2021, a delay from April 2021 that program officials stated was due to COVID-19 effects and the program shifting focus to the hardware replacement effort. For remaining work—including integration with new server hardware—the program employs an Agile approach embedded within a master waterfall schedule. With this approach, Raytheon uses 2-week Agile sprints to meet the phased waterfall development timeline.

DCMA reported that the number of software deficiencies is a risk for the program. Program officials reported that there are over 6,000 software deficiencies as of December 2021. They stated that the contractor made progress reducing the backlog for the old hardware effort and expects the rate of discovery of new deficiencies to start to decrease for the new hardware effort in February or March 2022 after the contractor shifts to focus solely on this effort.

DCMA officials also stated that the potential number of software deficiencies expected to be remaining in the backlog after delivery of Blocks 1 and 2 in October 2022 is a risk. Program officials plan to prioritize addressing deficiencies that affect operations.

Other Program Issues

COVID-19-related challenges resulted in schedule delays and cost increases for the program. Due to travel restrictions and technical issues, the program's global deployment of modernized GPS signal monitoring stations was delayed by 1 year from the program's estimate prior to the pandemic. As of July 2021, the program has now installed all 17 monitoring stations.

Additionally, primarily pandemic-related and technical challenges caused the program to shift the planned delivery date of Blocks 1 and 2 from April 2022 to October 2022, shortening the period between delivery and planned start of operations. This delay reduces the program's time to absorb further delays before operations start or to fix problems after delivery, risking the planned April 2023 initial operational capability date. Because of the pandemic-related challenges and delays, the program reported that it agreed to provide a $13.5 million equitable adjustment to Raytheon.

The Space Force awarded a sole-source contract to Raytheon in April 2021 for OCX Block 3F development. This block is expected to enable launch and operational control of the GPS IIIF satellites currently in development. The preliminary timeline projects a 2025 contractor delivery of Block 3F. The program reported that there was a funding shortfall for upgrading the hardware needed for the GPS IIIF satellite launch and checkout system. To resolve this issue, the program plans to use an existing facility that was built for testing and sustainment.

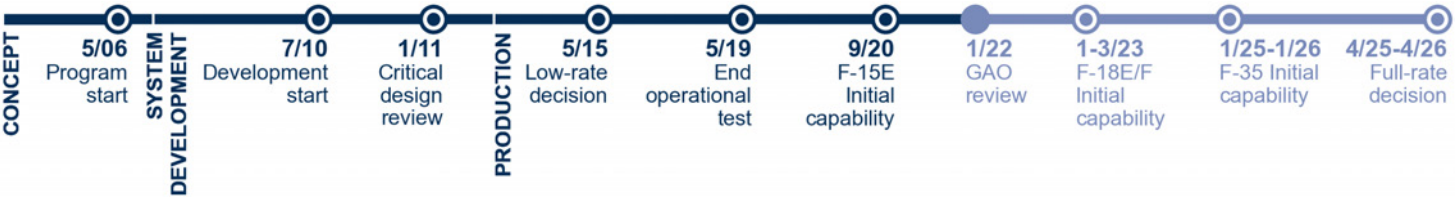
Program Office Comments

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 OCX Blocks 1 and 2 will control all legacy and GPS III satellites and both legacy and modernized signals using an updated cyber architecture. The program office also stated that OCX continues to execute within its program baseline. It also stated that the GPS Launch and Checkout System (OCX Block 0) successfully supported five GPS III launches. Further, the program office stated that the majority of new Hewlett Packard equipment was fielded throughout December 2021. The program added that by December 2021, much of the system's mission software was qualified on the old hardware, which reduces risk going forward. It also stated that system integration and requirements verification continues on the new hardware with transition to operations scheduled for early 2023.

Source: © 2009 Raytheon Company. | GAO-22-105230

Small Diameter Bomb Increment II (SDB II)

The Air Force's SDB II, StormBreaker, is a joint program with the Navy and is designed to provide attack capability against 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 Essentials

Milestone decision authority: Air Force

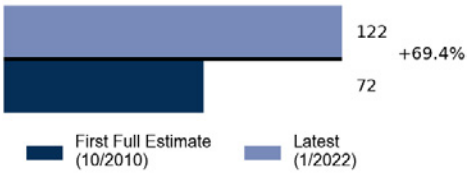
Program office: Eglin Air Force Base, FL

Prime contractor: Raytheon Missile Systems

Contract type: FFI/FFP (procurement)

Acquisition Cycle Time

(in months)



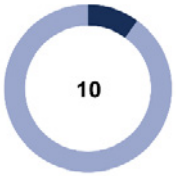
Software Development

(as of January 2022)

Approach: Agile and Iterative

Average time of software deliveries (months)

Software percentage of total program cost



Software type

0 percent Off-the-shelf

15 percent Modified off-the-shelf

85 percent Custom software

The program reported the use of Agile during development and an iterative approach for operations.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (10/2010)	Latest (8/2020)	Percentage change
Development	$1,946.51	$2,226.96	+14.4%
Procurement	$3,618.16	$3,410.86	-5.7%
Unit cost	$0.32	$0.33	+1.3%
Total quantities	17,163	17,163	+0.0%

Total quantities comprise 163 development quantities and 17,000 procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Development Start**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	●
Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	…	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	○	○
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	●	●

● Knowledge attained … Information not available

○ Knowledge not attained **NA** Not applicable

We could not assess SDB II design drawing stability at design review because the program implemented design changes after this event, but did not track how these changes impacted the design stability previously reported at its design review.

SDB II Program

Technology Maturity, Design Stability, and Production Readiness

SDB II has mature critical technologies and a stable design, and the program successfully introduced a component redesign into production this year. However, other ongoing changes to certain components have the potential to affect its design stability.

Last year, SDB II fielded the weapon on the F-15. According to program officials, the program is currently conducting testing to integrate SDB II on the F-18. However, the program experienced delays due to a lack of availability of aircraft and range time for testing. As a result of these delays and software upgrades to both SDB II and the F-18, this event is delayed. Additionally, program officials indicated that initial operational capability on the F-35 and the program's full-rate production decision were delayed indefinitely due to changes in the F-35 program schedule.

Since last year, the program addressed production challenges related to the clip holding the bomb's fins and the guidance component. Specifically, the program previously found that the fin clip could fail due to excess vibration and was susceptible to corrosion. This year, program officials told us that the contractor incorporated a redesigned fin clip into production for lot 5 units and beyond and retrofitted delivered units from the first four lots to address these issues.

The program also previously found that the guidance component was susceptible to shock. Specifically, program officials stated that they observed three guidance component failures in testing. They said they studied the issue and continue to monitor the component through ongoing flight tests. They stated that they do not plan production changes at this time. Program officials indicated that the issue was correlated with the ejection force of a specific weapons rack and that these shock events were outside the shock specification for SDB II. Program officials also added that, according to their analysis, a redesign to address the guidance component issue was too costly, particularly because the issue had a less than 2 percent impact on the weapon's reliability.

Lot 4 deliveries were completed in April 2021 and lot 5 unit deliveries began in June 2021, program officials noted. They told us that, as of October 2021, the contractor delivered 299 lot 5 Air Force units and 245 lot 5 Navy units—about 43 percent of the 1,260 total lot 5 units. Officials expect the remaining lot 5 units to be delivered in April 2022.

Software and Cybersecurity

The program continues to execute its software delivery plans, including a combination of deliveries for testing on a regular basis and to end users annually until fiscal year 2024. Subsequently, the program plans one update biennially. Program officials stated that the weapon successfully completed four of six DOD cybersecurity testing phases and may be included in future aircraft cybersecurity testing, but that the program has no plans to complete specific testing for each aircraft integration.

Other Program Issues

The program is experiencing challenges related to military code (M-code) integration, according to program officials. M-code is a stronger, encrypted, military-specific GPS signal that will help military users overcome GPS signal jamming. Issues facing the program include:

- Space and power: Space and power for M-code-related components are limited within the units, making integration a production challenge.
- Chip production termination: The company that produces the microelectronic component chips used by SDB II—which are critical for M-code integration on the weapons—is halting production to transition to new technology lines. As such, SDB II officials told us that the program must buy all the chips necessary to complete production before August 2022.

The contractor is testing a prototype of the M-code chip and expects to determine if it will meet critical design and production requirements by June 2022, according to program officials. Program officials stated that they will then be able to move forward with the purchase of the chips by the August 2022 deadline.

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 SDB II will field a software upgrade to the weapon in 2022 that will meet modernization requirements from the National Security Agency. Additionally, the program office noted that delivery of lot 6 weapons is expected to begin in May 2022.

Source: Boeing Corporation. | GAO-22-105230

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 by developing and fielding 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 addresses the Air Force's advanced fighter pilot training needs and seeks to close training gaps that the T-38C cannot fully address.

Program Essentials

Milestone decision authority: Air Force

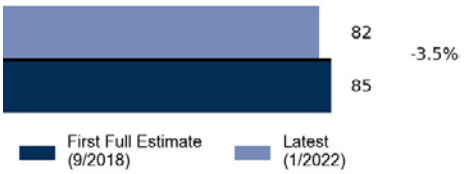
Program office: Wright-Patterson Air Force Base, OH

Prime contractor: Boeing

Contract type: FPI/FFP (development)

Acquisition Cycle Time

(in months)



Cycle time is calculated using the required assets available date.

Software Development

(as of January 2022)

Approach: Agile

Average time of software deliveries (months)

Software percentage of total program cost

Software type

27 percent Off-the-shelf

0 percent Modified off-the-shelf

72 percent Custom software

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (9/2018)	Latest (7/2020)	Percentage change
Development	$1,322.43	$1,285.99	-2.8%
Procurement	$7,127.28	$7,199.64	+1.0%
Unit cost	$24.59	$24.77	+0.7%
Total quantities	351	351	+0.0%

Total quantities comprise five development quantities and 346 procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at Development Start	Current Status
Resources and requirements match		
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	○
Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	●	●
Test a system-level integrated prototype	○	○
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA	NA
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ... Information not available

○ Knowledge not attained **NA** Not applicable

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

T-7A Program

Technology Maturity and Design Stability

T-7A did not fully mature its two critical technologies before starting product development or demonstrate a system-level prototype before the August 2020 critical design review, inconsistent with leading acquisition practices. The program has since fully matured one of its critical technologies—the air vehicle emergency escape system's canopy fracturing system.

However, T-7A has yet to fully mature the ground based training system's projector technology. The contractor transitioned to a backup projector because the original did not meet visual acuity requirements. The backup projector has been demonstrated in a relevant environment, but the program continues to report it as a top performance risk while working to demonstrate it in a realistic environment. In July 2021, the program reported that the first set of backup projectors also did not meet requirements and would need to be replaced. Until this technology is mature, the program risks costly and time intensive rework if it does not address these issues. Officials told us that based on the results of a December 2021 projector demonstration, the visual quality was greatly improved. However, the program will continue to monitor the current design to determine if it can meet the requirements.

The program also reported the schedule for qualifying the emergency escape system as a top program risk. According to program officials, while the program has completed a series of 14 tests to demonstrate the emergency escape system, completion of qualification is at risk, in part due to schedule challenges, including adverse weather. If the program experiences delays in qualifying the emergency escape system, there is increased risk of delay to the November 2023 production decision.

Further, in June 2021, the program began tracking a risk related to protecting the pilot in the event of hitting a 4-pound bird during certain flight conditions. Specifically, officials told us that the program needs to ensure the aircraft's windshield will survive the impact of hitting a bird of this size in flight. Mitigating this risk by working to correct the root cause may lead to additional schedule delays, which program officials told us they are willing to accept to ensure pilot safety. Program officials told us that mitigations include minor redesign of the windshield area.

As we reported last year, the program does not anticipate testing a fully integrated system-level prototype until March 2022, more than 18 months after design review. Our prior work shows such testing is key to avoiding late discovery of design deficiencies that could cause costly, time-intensive rework.

Software and Cybersecurity

Over the past year, the contractor made more software deliveries than planned, largely to correct an issue discovered in May 2020 that caused the aircraft to rock sideways during flight under certain flight conditions—referred to as wing rock. Program officials told us that they successfully corrected the issue in July 2021 with a software update.

Other Program Issues

Over the past year, the program delayed its remaining milestones—some by up to 1 year. Specifically, its planned November 2023 low-rate production decision and July 2025 required assets available date both reflect a 1-year delay since our last report. Last year, we reported that the program accelerated its schedule—moving the production decision forward by 7 months to November 2022, which we noted was aggressive due to ongoing technical risk. Given the scale of the current delay, this indicates the original schedule was already optimistic. In 2021, the program reported that its schedule was aggressive and inefficient. It noted that milestone delays were primarily due to Boeing's continued underestimation of the scope of the work and resources needed to accomplish it. Officials told us that these delays were also driven by the wing rock issue, which has since been addressed.

Program officials told us that they are holding Boeing accountable to meet contract requirements. However, while officials told us the fixed-price development contract limits the Air Force's cost risk, it still faces schedule delays and the risk of future cost growth as the program moves into production.

Program Office Comments

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

This artist rendering may not reflect final appearance decisions

Source: Boeing. | GAO-22-105230

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 Essentials

Milestone decision authority: Under Secretary of Defense, Acquisition and Sustainment

Program office: Wright-Patterson Air Force Base, OH

Prime contractor: Boeing

Contract type: FFP (development)

Acquisition Cycle Time

(in months)

Software Development

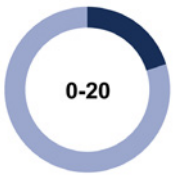
(as of January 2022)

Approach: Mixed

Average time of software deliveries (months)

Information not available

Software percentage of total program cost



Software type

33 percent Off-the-shelf

59 percent Modified off-the-shelf

7 percent Custom software

The program reported it does not track software deliveries as software is managed under the firm-fixed-price development contract.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (12/2018)	Latest (8/2020)	Percentage change
Development	$4,870.69	$4,834.35	-0.7%
Procurement	$54.5	$21.91	-59.8%
Unit cost	$2,679.28	$2,643.32	-1.3%
Total quantities	2	2	+0.0%

Total quantities comprise two development quantities and zero procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Development Start**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	NA	NA
Demonstrate all critical technologies in form, fit, and function within a realistic environment	NA	NA
Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	○
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA	NA
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ... Information not available

○ Knowledge not attained **NA** Not applicable

We did not assess VC-25B critical technologies because the program said the system does not have any. We also did not assess manufacturing maturity because the program stated these metrics are not applicable due to its plan to modify fully-mature commercial aircraft.

VC-25B Program

Technology Maturity, Design Stability, and Production Readiness

VC-25B does not include new technologies; instead, it will integrate mature technology from other platforms into existing commercial aircraft. In March 2020, the program completed a system-level critical design review. However, the program did not test a system-level integrated prototype before design review, which GAO previously found could limit schedule growth. The program's acquisition strategy does not call for a separate system-level integrated prototype.

Boeing started modifying the first aircraft in February 2020 and the second aircraft in June 2020. According to VC-25B officials, Boeing completed major structural modifications on the first aircraft and is now preparing it for wiring installations. They expect to complete the same work for the second aircraft in spring 2022.

The program office is currently tracking four major schedule risks:

First, program officials told us that due to underperformance and financial issues, Boeing terminated the supplier for the aircraft's interior accommodations and transitioned to a new supplier, which is causing schedule delays. Boeing updated the VC-25B schedule in April and August 2021, which indicate a delay of at least 1 year, and the program office is currently conducting a risk assessment, per program officials. They told us they assessed the new interior supplier's schedule in December 2021, and expect to formally update the remaining program milestones and potentially modify the program's contract with Boeing.

Second, wiring remains a risk because over 2,000 wire bundles and 200 miles of wire—almost double that of a commercial B747 aircraft—will be installed on the aircraft. Wiring must meet a broad set of complex requirements from electrical protection to proper separation, according to VC-25B officials. They explained that Boeing is leveraging lessons learned from the Boeing-developed KC-46 tanker in order to avoid on-aircraft wiring issues. According to VC-25B officials, while this takes more time, it increases their confidence in the wiring integration plans.

Third, Boeing is experiencing aircraft mechanic workforce limitations due to a competitive labor market, according to VC-25B officials. They said that an additional limitation is lower-than-planned security clearance approval rates for skilled workers needed to modify the aircraft. Employees must meet stringent security requirements to work on the VC-25B program because of its presidential mission. VC-25B officials said that Boeing continues to work with the program office to improve the prescreening process for applicants to ensure timely processing of security clearances.

Finally, the program is also tracking test completion rates as a risk. Program officials stated that Boeing's planned rates for certain aspects of ground and flight testing are greater than average rates demonstrated by other Air Force aircraft programs. According to VC-25B officials, they relayed this information to Boeing and will continue to work with Boeing to identify a maximum sustainable rate for ground and flight testing. Boeing's failure to meet its test rate assumptions might further delay the currently projected schedule delay for aircraft delivery. We previously found that Boeing's test plans for its KC-46 program were unrealistic, resulting in significant delays.

Software and Cybersecurity

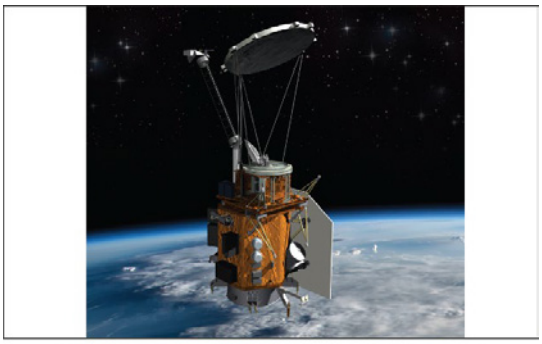
The program reported that there are no significant software or cybersecurity related issues at this time.

Other Program Issues

VC-25B schedule delays could delay retirement of the VC-25A, fielded in 1990 and currently scheduled to retire in 2025.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office stated that it will continue to work with Boeing to manage all program risks and modify, test, and deliver presidential mission-ready VC-25B aircraft.



Weather System Follow-On (WSF)

The Space Force's polar-orbiting WSF satellite is intended to contribute to a family of space-based environmental monitoring (SBEM) systems by providing three of 11 mission critical capabilities in support of military operations. WSF aims to conduct remote sensing of weather conditions, such as wind speed and direction at the ocean's surface, and to provide real-time data for use in weapon system planning and weather forecasting models. The family of SBEM systems replaces the Defense Meteorological Satellite Program.

Program Essentials

Milestone decision authority: Air Force

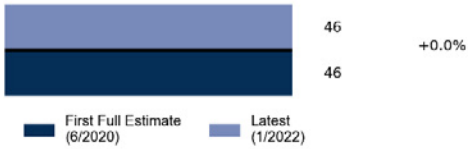
Program office: El Segundo, CA

Prime contractor: Ball Aerospace and Technologies Corporation

Contract type: FFP (development)

Acquisition Cycle Time

(in months)



Software Development

(as of January 2022)

Approach: Agile, Waterfall, and Incremental

Average time of software deliveries (months)

Software percentage of total program cost

Software type

0 percent
Off-the-shelf

95 percent
Modified off-the-shelf

5 percent
Custom software

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (6/2020)	Latest (6/2020)	Percentage change
Development	$1,030.62	$1,030.62	+0.0%
Procurement	$0.0	$0.0	N/A
Unit cost	$515.31	$515.31	+0.0%
Total quantities	2	2	+0.0%

Total quantities comprise two development quantities and no procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Development Start**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	NA	NA
Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	NA	NA
Test a system-level integrated prototype	NA	NA
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA	NA
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ... Information not available

○ Knowledge not attained **NA** Not applicable

We did not assess whether WSF demonstrated critical technologies in a realistic environment because satellite technologies demonstrated in a relevant environment are assessed as fully mature. We also did not assess design stability because the program office reported the metrics were not applicable; or manufacturing metrics because the program does not have a production milestone.

WSF Program

Technology Maturity and Design Stability

The WSF program's eight critical technologies are mature, and the program considers the design complete. The program's August 2020 critical design review report identified two moderate technical risks that the program continued to address over the past year:

- The satellite's hardware could fail to deploy, resulting in mission loss. The program office reported that it completed a redesign and engineering test as of November 2020 to mitigate the risk, and conducted unit-level testing in October 2021. It also reported it delivered the new hardware to the contractor in November 2021 for integration and testing.
- The program risks a mismatch between the planned flight load requirements and the final launch vehicle it selects. The program conducted testing based on specific launch vehicles, so if this happens, the program will need to redesign the hardware to new requirements, potentially delaying the schedule. The program is running analyses of known launch vehicles and maintaining contact with the Space and Missile Systems Center's Launch Enterprise, which selects the launch vehicle, to get early insights. According to the program office, the launch vehicle selection was held in January 2022 and it anticipates the results in February 2022.

DOD's Director, Operational Test and Evaluation approved a formal test and evaluation plan in October 2020. The program has been testing compatibility between the space, ground, and launch segments, with a goal of being ready to launch the first satellite by September 2023. Specifically, according to the program office, flight unit and subsystem testing is ongoing to ensure that the ground segment interfaces with the space vehicle.

According to the program office, in January 2022, the program began testing to ensure mission data can be received and processed by the ground segment. This testing is expected to continue through October 2022. The program also intends to conduct test readiness reviews for the microwave sensor subsystem in April 2022, the space segment in September 2022, and the entire system in November 2022. After launch, the program expects to complete its last planned developmental testing event, validating the sensor with 1 year of on-orbit data collection.

Software and Cybersecurity

Program officials stated that the program completed four of six total software development efforts. In addition, despite a 1-month delay to software delivery, the program plans to deliver the final two efforts in December 2021 and April 2022. These software efforts include builds to convert raw data from the sensor into stored and processed mission data, as well as software builds to command and control the satellites.

The program reported this year that it addressed potential cybersecurity vulnerabilities and system gaps identified in an October 2019 tabletop assessment. The program office completed its first cooperative cybersecurity assessment in August 2021, the results of which are classified. The program office intends to mitigate identified issues by the time the next cooperative assessment is conducted in May 2022. The May 2022 cooperative assessment was initially planned for December 2021, but was delayed to align with ground segment testing to ensure the ground configurations are representative, according to the program office. However, the program office stated that the delay does not affect the overall program schedule. Additional cybersecurity verification and control assessments are planned for November 2022 and March 2023, with an adversarial assessment planned for August 2023.

Other Program Issues

The program modified its contract with the prime contractor in February 2020 to incorporate changes resulting from: a fiscal year 2019 funding shortfall; a 12-month schedule extension for the first satellite due to funding constraints in fiscal year 2018; a transfer of ground operations to another facility; and other items. The contract modification resulted in a $44.3 million increase in the development and fabrication contract price and a $0.3 million increase in the integration, test, and operations contract price for the first satellite.

Maintaining the program schedule continues to be a priority for the Space Force to mitigate potential capability gaps. According to the program office, currently, there is no operating platform that fully meets ocean surface wind data requirements, which WSF will provide once operational.

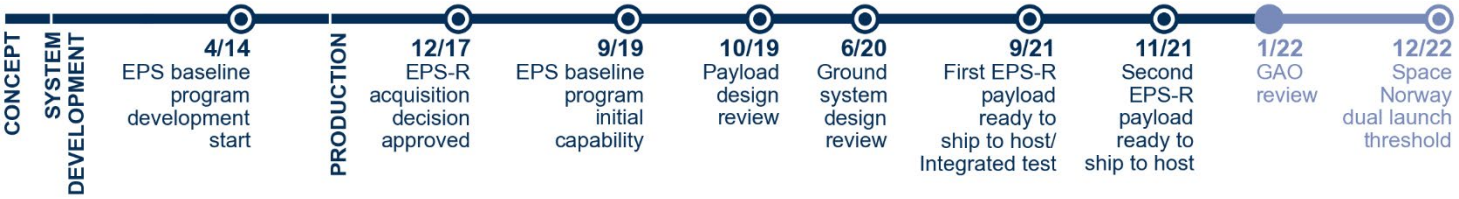
Program Office Comments

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

Source: U.S. Air Force. | GAO-22-105230

Enhanced Polar System – Recapitalization (EPS-R)

The Space Force's EPS-R—a continuation of the EPS program that provides protected communications over the North Polar Region—plans to develop two satellite payloads and update the EPS ground segment to prevent a coverage gap in protected polar satellite communications. The Space Force is collaborating with Norway to host the two payloads on two Space Norway-procured satellites. The updates to the ground system will provide command, control, and mission planning for the payloads.



Program Essentials

Milestone decision authority: Air Force

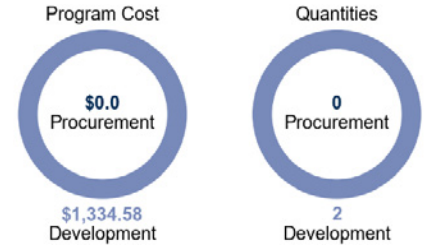
Program office: El Segundo, CA

Prime contractor: Northrop Grumman: Aerospace Systems; Northrop Grumman: Mission Systems

Contract type: CPIF (development)

Estimated Cost and Quantities

(fiscal year 2022 dollars in millions)



Cost and quantities only reflect the EPS-R increment of work.

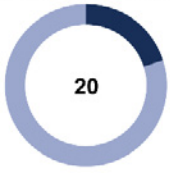
Software Development

(as of January 2022)

Approach: Agile, Waterfall, DevOps, and DevSecOps

Average time of software deliveries (months)

Software percentage of total program cost



Software type

26 percent Off-the-shelf

24 percent Modified off-the-shelf

50 percent Custom software

Current Status

Over the past year, both EPS-R payloads experienced development delays due, in part, to COVID-19 effects and troubleshooting other issues, such as technical challenges caused by aging hardware discovered during integration and test. However, despite these delays, the EPS-R program was ready to ship the first payload for integration with the Space Norway satellite as of September 2021 and the second payload as of November 2021. Space Norway also experienced delays procuring satellites over the past year, which mitigated the effects of the payload delays' and allowed an additional 1 to 2 months for payload delivery. Program officials do not expect the Space Norway delay to affect payload development as they are using simulated data from the satellite to find and fix problems.

The program reported that it is exceeding contract target costs by an estimated 9.3 percent, due in part to material delays, COVID-19 inefficiencies, and the technical issues caused by aging hardware discovered during integration and test. COVID-19 continues to create challenges for the payload contractor, such as backlogs in material inspections and a shortage of staff.

The program office plans to complete a cyber criticality analysis in March 2022 and use that to inform the EPS-R cybersecurity test strategy. It expects the Air Force's independent test agency to finalize the test strategy in August 2022, after payload and ground system integration and developmental tests conclude. The program currently plans to limit pre-orbit cybersecurity testing to paperwork exercises and conduct certain tests on-orbit, among other steps. Program officials noted they believe there is minimal risk to this approach because it will leverage results of heritage EPS testing to allow EPS-R testing to focus on the differences between the two systems, and it will verify payload cybersecurity requirements prior to on-orbit testing. However, our past work shows that delaying cybersecurity testing increases the risk that vulnerabilities will be identified later in development and may 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 also added that it is delivering capability below its baseline cost objective.

Source: SpaceX and United Launch Alliance. | GAO-22-105230

National Security Space Launch (NSSL)

The Space Force's NSSL provides space lift support for national security and other government missions. Currently, NSSL procures launch services from United Launch Alliance (ULA) and Space Exploration Technologies Corporation (SpaceX), supporting U.S. policy, as stated in law, to undertake actions appropriate to ensure, to the maximum extent practicable, the United States has the capabilities necessary to launch and insert national security payloads into space when needed. We focused our review on NSSL's investments in new launch systems from U.S. launch providers.

Program Essentials

Milestone decision authority: Under Secretary of Defense, Acquisition and Sustainment

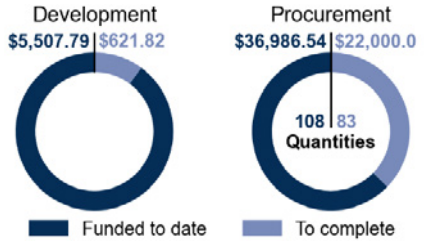
Program office: El Segundo, CA

Prime contractor: Space Exploration Technologies; United Launch Alliance

Contract type: Other Transaction (engines and launch vehicle prototypes); FFP (launch services)

Estimated Cost and Quantities

(fiscal year 2022 dollars in millions)



The cost figure represents costs for the total program. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle

Software Development

(as of January 2022)

Approach: Information not available

Average time of software deliveries (months)

Information not available

Software percentage of total program cost

Information not available

Software type

Information not available

Software is procured from launch service contractors.

Current Status

In 2020, the program awarded launch service contracts to United Launch Services LLC, a subsidiary of ULA, and to SpaceX for launches that the program reported would begin in 2022 and were planned to continue through 2027. In 2021, program officials told us they plan to add launches for the Space Development Agency's low-Earth orbit constellation to the program's existing launch contract. Since our last assessment, the program reported continuing work on developing an acquisition strategy and investing in rocket engine improvements to provide launch services after 2027. It also reported awarding prototype projects for next generation rocket engine technology and upper stage resiliency enhancements such as a combustion stability tool.

Planned first flight and subsequent certification of ULA's Vulcan launch vehicle were delayed from 2021 to 2022 due to continued technical challenges in developing a U.S.-produced rocket engine. The program is also assisting ULA with resolving manufacturing delays associated with the upper stage of the Vulcan launch vehicle and received the first of two qualification test articles in January 2022 to begin upper stage qualification. Until ULA resolves the rocket and engine issues, the program must rely on ULA's Atlas V—with engines manufactured in the Russian Federation—for ULA's national security launches.

SpaceX's Falcon 9 and Falcon Heavy vehicles are certified for national security launches. The Falcon Heavy's first planned national security mission was delayed from May 2021 to May 2022 to sync with the payload schedule. SpaceX is continuing to modify its vehicles so it can perform needed missions, such as developing an extended payload fairing with a planned 2023 completion.

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 continuing NSSL's record of 90 consecutive successful launches is foundational to countering threats in a contested space environment and that industry partnerships and effective independent mission assurance are key. It added that the program expects to continue transitioning away from Russian propulsion with the first NSSL Falcon Heavy launch and Vulcan certification flight this year.

Source: U.S. Air Force. | GAO-22-105230

Air-launched Rapid Response Weapon (ARRW)

The Air Force's ARRW, an MTA rapid prototyping effort, is developing a conventional, long-range, air-launched hypersonic missile that can be carried on the wing of a B-52H bomber aircraft. The program leveraged the Defense Advanced Research Projects Agency's tactical boost glide effort to develop the missile's hypersonic-speed glider component. The program plans to produce eight missiles—four for testing and four spares. Any spares remaining at the conclusion of the MTA rapid prototyping effort would support fielding an early operational capability.

Program Essentials

Decision authority: Air Force
Program office: Eglin Air Force Base, FL
Prime contractor: Lockheed Martin
MTA pathway: Rapid prototyping
Contract type: CPFF (development)

Estimated Middle Tier of Acquisition Cost and Quantities

(fiscal year 2022 dollars in millions)

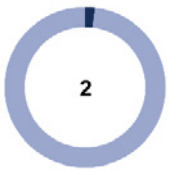
Software Development

(as of January 2022)

Approach: Agile

Average time of software deliveries (months)

Software percentage of total program cost



Software type

0 percent Off-the-shelf
0 percent Modified off-the-shelf
100 percent Custom software

The program office provided a correction for the cost percentage it reported in our last assessment.

Program Background and Transition Plan

The Air Force initiated ARRW as an MTA rapid prototyping effort in May 2018 with an objective to complete prototyping by September 2022. In August 2018, the program awarded a contract for design, development, and demonstration work. Since our last assessment, the ARRW program conducted various component and system-level tests on the ground and in the air during which the B-52H carried but did not release the missile. While three booster test flights were planned for fiscal year 2021, only the first took place, and two subsequent test attempts failed. ARRW officials reported that after pausing testing to examine the failures, another test in December 2021 also failed. As a result, the remaining test schedule is compressed, costs increased, and the expected completion of the MTA effort is delayed by almost 1 year.

Transition Plan: Transition to a new MTA rapid fielding effort.

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

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

Planned Knowledge by MTA Transition			
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	Demonstrate all critical technologies in form, fit, and function within a realistic environment	□
Complete system-level preliminary design review	●	Release at least 90 percent of design drawings	●
Test a system-level integrated prototype	◐	Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	⊗
Demonstrate critical processes on a pilot production line	□	Test a production-representative prototype in its intended environment	□

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned
... Information not available NA Not applicable

ARRW Program

Updates to Program Performance and Program Business Case

Booster and flight testing schedules slipped due to test failures since our last assessment. In April 2021, the program did not complete the first planned booster test because of a hardware fault that, according to program officials, the software detected beforehand. Program officials said they attempted a second test, but the booster rocket failed. Program officials reported the likely causes stem from work that occurred at either missile integration or assembly and took steps to prevent recurrence via design modification and manufacturing and test process changes.

As a result of the first booster test failures, the program delayed two remaining booster tests and four joint developmental/operational flight tests, which delayed the entire effort. The planned date for the first flight test slipped over a year to fall 2022. Program officials now anticipate MTA completion in August 2023. However, the failure of another booster flight test in December 2021 adds risk to those plans. Program officials said an issue caused the launch sequence to be aborted, and the program returned the missile to Lockheed for examination. According to the program, a review determined that a software design issue caused the failure and the contractor implemented corrective actions.

ARRW's estimated costs continued to increase—nearly 7 percent since last year—to reflect the latest cost data for actual performance, contract modifications, and some minor COVID-19 effects, among other reasons. Overall, the Air Force Cost Analysis Agency's annual independent cost assessment increased by almost 69 percent from its first assessment in April 2018 to its latest in June 2021.

ARRW program officials clarified this year that the program completed informal schedule risk assessments, but not a formal assessment, which it has no plans to do. We updated our Key Elements of a Business Case table to reflect this clarification.

Technology

The program identified two critical technologies that help the missile survive extreme temperatures at hypersonic speed. Both are approaching maturity contingent on successfully completing booster testing and the first flight test, currently planned for summer and fall 2022, respectively.

Software Development and Cybersecurity

The program considers software development high risk. Program officials said that the contractor provided seven of nine software deliveries—more than originally planned—enabling additional testing opportunities. ARRW completed a full cybersecurity system assessment in March 2021.

Transition Plan

The ARRW program requested procurement funding for 12 missiles and planned to move forward with initiation of a new MTA rapid fielding effort in fiscal year 2022. However, the Joint Explanatory Statement accompanying the Consolidated Appropriations Act, 2022 stated that no procurement funds were being provided for ARRW, and instead provided additional research, development, test, and evaluation funds to support an extension of the testing program and mitigate a projected funding shortfall for the prototyping effort.

ARRW program officials subsequently told us that the production decision and transition to an MTA rapid fielding is now planned to occur after operational utility is demonstrated through successful flight tests. They stated that the Air Force expects to revisit a procurement decision and the transition to an MTA rapid fielding effort in fiscal year 2024 after specific programmatic milestones are achieved.

Other Program Issues

The program's highest risk to meeting its planned initial production rate for the rapid fielding effort is a limited industrial base with a single supplier and competing market demands for materials used to protect hypersonic missiles in flight, according to program officials. To help overcome this risk, officials said they ordered additional aeroshell test assets that cover and protect missile components from extreme temperatures that occur during flight. Officials anticipate that this approach will help increase manufacturing maturity and reduce lead times at the aeroshell supplier in the short term, while the prime contractor works to expand its facilities to meet production goals.

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, over the past year, it made progress in its ground and warhead test program. It plans six additional tests by the end of the current MTA effort—two booster tests and four flight tests of complete missiles—to demonstrate full-system capability. It added that it plans to achieve a manufacturing readiness level approaching maturity by the end of the current MTA effort, and hold a system production readiness review and attain early operational capability in fiscal year 2023. The program office stated that the current MTA effort will sufficiently inform Air Force and DOD leaders' future decisions related to the capability.

Source: U.S. Air Force. | GAO-22-105230

B-52 Commercial Engine Replacement Program (CERP) Rapid Virtual Prototype (RVP)

The Air Force's B-52 CERP program plans to develop, integrate, and test military-configured commercial engines and associated equipment on two B-52H aircraft through two spirals. We evaluated Spiral 1, which is expected to deliver a virtual system prototype to reduce risk and inform a second spiral. We also provide information on Spiral 2, which is expected to deliver physical prototypes to inform the Air Force's longer-term effort to extend the life of the B-52H fleet beyond 2030.

- **9/18** MTA initiation
- **12/18** MTA funds obligated
- **2/20** Order placed for Spiral 1 virtual system prototype
- **9/21** Single engine supplier selection/ Increment 1 operational demonstration
- **1/22** GAO review
- **7/22** Virtual spiral prototype delivery Increment 2
- **12/23** Expected MTA completion/ 5 years since MTA funds obligated

Program Essentials

Decision authority: Air Force

Program office: Tinker Air Force Base, OK

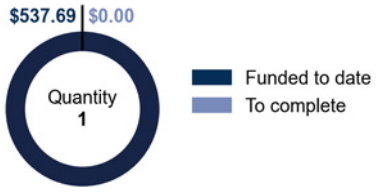
Prime contractor: Boeing; Rolls Royce

MTA pathway: Rapid prototyping

Contract type: CPIF, FFP

Estimated Middle Tier of Acquisition Cost and Quantities

(fiscal year 2022 dollars in millions)



Software Development

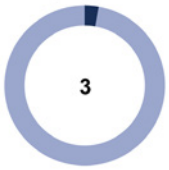
(as of January 2022)

Approach: Agile and Incremental

Average time of software deliveries (months)

Information not available

Software percentage of total program cost



Software type

0 percent Off-the-shelf

0 percent Modified off-the-shelf

100 percent Custom software

Program officials stated software deliveries and data reporting will begin when hardware is delivered during Spiral 2.

Program Background and Transition Plan

Since 2018, the B-52 CERP program has worked with Boeing to conduct risk reduction requirements studies and deliver virtual engine power pod prototypes—computer-modeled, engine-component integration from multiple vendors. In September 2021, the program selected Rolls Royce to work with Boeing to integrate its engine into the virtual system prototype design. Virtual system prototype development is occurring incrementally, with the initial capability delivered in September 2021 (Spiral 1 Increment 1) and full capability expected in July 2022 (Spiral 1 Increment 2).

Transition Plan: Transition to the major capability acquisition pathway with entry at system development.

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

Planned Knowledge by MTA Transition

Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	NA	Demonstrate all critical technologies in form, fit, and function within a realistic environment	NA
Complete system-level preliminary design review	◐	Release at least 90 percent of design drawings	NA
Test a system-level integrated prototype	NA	Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA
Demonstrate critical processes on a pilot production line	NA	Test a production-representative prototype in its intended environment	NA

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned

... Information not available **NA** Not applicable

We did not assess B-52 CERP's planned knowledge by MTA transition for demonstration of critical technologies in relevant or realistic environments because the program stated that the system does not have any such technologies; or planned knowledge by MTA transition for design stability and manufacturing maturity because those metrics are not applicable to programs transitioning at system development.

Updates to Program Performance and Program Business Case

Over the last year, program officials continued to execute the RVP effort but experienced minor delays. In September 2021, the Air Force selected Rolls Royce as the B-52 CERP single engine supplier, 3 months later than planned. According to officials, this delay was a result of officials taking time to ensure the Air Force provided a sound request for proposal. Rolls Royce will work with Boeing to integrate its engine into the virtual system prototype design. Due to delays in awarding the engine contract, the program also delayed its planned preliminary design review and delivery of Spiral 1 Increment 2 from April 2022 to July 2022. According to program officials, the program is currently updating the cost estimate for the virtual system prototype.

Technology

As we reported last year, the program reviewed 19 technologies and did not identify any critical technologies for Spiral 1 or Spiral 2 after conducting a July 2020 technology readiness assessment. The program plans to conduct another technology readiness assessment prior to its July 2022 preliminary design review.

Software Development and Cybersecurity

System software deliveries and software data reporting will not begin until hardware deliveries begin in Spiral 2, according to program officials. For Spiral 2, the program plans to use an Agile development approach to incrementally develop and deliver software. According to program officials, the program plans at least three cybersecurity risk reduction events during Spiral 2 development.

Transition Plan

Upon completion of Spiral 1—full capability delivery expected in July 2022—the Air Force had planned to transition to a follow-on rapid prototyping effort for Spiral 2 to deliver a physical prototype. However, program officials told us that, in order to eliminate confusion among the planned spirals and to enhance oversight, the Air Force is now planning to transition to the major capability acqusition pathway in fiscal year 2023, with entry at system development following the preliminary design review. The program's planned approach of completing a preliminary design review prior to starting system development is consistent with leading practices and helps the program demonstrate an understanding of design and technology prior to committing to system development.

Other Program Issues

Transitioning to a new acquisition phase before technologies are mature may pose cost and schedule risks for the longer-term engine effort. While program officials reviewed 19 technologies, they do not consider any of them critical because they are based on commercially-proven components. However, officials stated that some of these technologies will require modification of their current form, fit, or function for proper integration. Additionally, program officials determined that some technologies for Spiral 2 were not fully mature, although they plan to mature them by the beginning of Spiral 2. If modification of these technologies leads to unexpected challenges or if the modified technologies do not mature as planned, the Air Force's broader effort to modify engines for the B-52H fleet could potentially cost more or take longer than expected.

Finally, program officials identified additional risks that could lead to schedule delays for the overall program including test facility expansion, supply chain challenges, delays in other B-52 modernization programs, and disconnects between the Air Force and Boeing schedule assumptions. Officials are currently working to understand the effects these issues will have on future program efforts.

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 B-52 CERP is an enormous, complex overhaul that replaces the B-52's current engines with new, military-derivative, commercial Rolls Royce F130 engines of similar size, weight, and thrust. It added that the CERP effort updates associated subsystem designs affecting such areas as the wing, wheel well, flight deck, and engine strut areas of the aircraft—to include digital engine controls, avionics, mechanical, airframe, and electrical/aircraft wiring. Additionally, the program office stated that it is incorporating digital engineering principles and virtual prototyping to integrate the engine and all affected subsystem designs at the B-52 system level, and that the virtual prototyping allows for early familiarity to speed readiness. The program office noted that, in September 2021, it delivered the first virtual system prototype 1 month ahead of schedule and awarded a $2.6 billion engine contract to Rolls Royce.

Source: JHU/APL. | GAO-22-105230

Deep Space Advanced Radar Capability (DARC)

The Space Force's DARC, a new MTA rapid prototyping effort, seeks to develop a ground-based radar site. 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 DARC system requires three ground-based radar sites in order to track objects in the entire geosynchronous satellite belt. We assessed the first site, but also provided some information on sites 2 and 3.

- **4/21** MTA initiation
- **8/21** Technology demonstration
- **1/22** GAO review
- **11/22** System critical design review
- **4-9/25** Operational demonstration
- **9/25** MTA effort completion (Delivery of DARC site 1)
- **4/26** 5 years from MTA initiation

Program Essentials

Decision authority: Air Force

Program office: Colorado Springs, CO

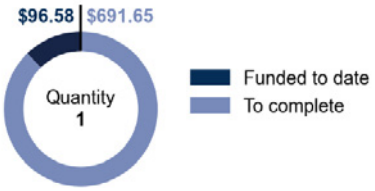
Prime contractor: TBD

MTA pathway: Rapid prototyping

Contract type: CPIF (using other transaction authority)

Estimated Middle Tier of Acquisition Cost and Quantities

(fiscal year 2022 dollars in millions)



Costs reflect those for site 1 only, but include costs that may be after the delivery of site 1.

Software Development

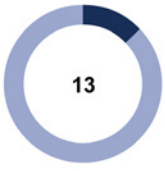
(as of January 2022)

Approach: Agile and DevSecOps

Average time of software deliveries (months)

Information not available

Software percentage of total program cost



Software type

- 39 percent Off-the-shelf
- 12 percent Modified off-the-shelf
- 49 percent Custom software

The program reported it did not provide a delivery time because it had yet to award the program contract.

Program Background and Transition Plan

The Air Force initiated DARC site 1 as an MTA effort in April 2021. The Johns Hopkins University Applied Physics Laboratory was selected to conduct a technology demonstration, which it completed in August 2021. The program office had yet to select a prime system integrator, but as of January 2022, planned to use an other transaction authority to award an agreement in February 2022. The program ultimately plans to field three sites—one in the U.S. and two outside the U.S.—with sites 2 and 3 being developed in follow-on acquisition efforts.

Transition Plan: Site 1 is expected to transition to operations and sustainment at the conclusion of the current effort.

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

Planned Knowledge by MTA Transition

Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	NA	Demonstrate all critical technologies in form, fit, and function within a realistic environment	NA
Complete system-level preliminary design review	NA	Release at least 90 percent of design drawings	NA
Test a system-level integrated prototype	NA	Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA
Demonstrate critical processes on a pilot production line	NA	Test a production-representative prototype in its intended environment	NA

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned

... Information not available **NA** Not applicable

We did not assess DARC planned knowledge by MTA transition because the program is planning to transition site 1 directly into operations and sustainment. Acquisition pathways for sites 2 and 3 have yet to be determined.

DARC Program

Key Elements of Program Business Case

DARC had an approved acquisition strategy and requirements document at initiation. The Air Force Cost Analysis Agency performed a cost assessment in May 2021. The program has not completed other key activities to establish a sound business case, such as formal assessments of technology and schedule risks. Our prior work shows that these assessments help department leadership make well-informed decisions, including the program's ability to demonstrate a prototype in an operational environment within 5 years.

Technology

Program officials identified four critical technologies, none of which are fully mature. Three—the high power transmitter, the calibration system, and the timing and frequency distribution subsystem—are approaching maturity. The remaining critical technology, the radar software, is immature. Program officials stated that the technology demonstration was successfully conducted to reduce developmental and acquisition risks, as well as to demonstrate critical technology viability.

The program does not plan to complete a formal technology risk assessment. Absent such information, the program lacks a solid technical baseline for the design, and officials cannot know whether DARC technologies will provide the range of capability the program seeks to deliver, introducing the risk of producing a design that later requires costly and time-intensive rework.

The program anticipates that by site 1 completion, each of the four critical technologies will be mature. As our prior work shows, design stability and production readiness—necessary to complete a fully capable site—both hinge on first achieving technology maturity. Further, program plans indicate that the Space Force intends to begin construction of sites 2 and 3 before completion of site 1 and expected attainment of technology maturity. Initiating construction of follow-on sites before first demonstrating the basic capabilities associated with site 1 compounds existing risks. In particular, until the Space Force reconciles the knowledge deficits associated with DARC technologies, it cannot be confident that any of the three planned sites are executable within planned costs and schedule.

Software Development and Cybersecurity

DARC officials noted that challenges related to the program's DevSecOps software development environment solution are driving cost increases. Specifically, the Air Force directed the program to use a different development environment than originally planned, which will add costs that were not included in the original cost estimate. The program expects to have more insight into actual costs after the prime system integrator contract is awarded.

The program also identified potential schedule risks related to software development. According to the DARC acquisition strategy, if software development of a final prototype build is not completed by the fourth quarter of fiscal year 2024, site 1 will not achieve the desired residual operational capability.

DARC obtained a threat assessment report and received approval for its cybersecurity strategy in October 2021.

Transition Plan

At the end of the current rapid prototyping effort in September 2025, the program office plans for site 1 to be delivered with a minimally viable mission capability to meet strategic requirements based on threat evaluations. At that point, site 1 is expected to transition directly to operations and sustainment. The program has yet to determine the acquisition pathway that sites 2 and 3 will follow.

Other Program Issues

In December 2021, the Air Force confirmed the location where it will construct the site 1 prototype. The program's acquisition strategy stated that the host nation agreement needed to be in place by the fourth quarter of fiscal year 2022 to achieve the planned schedule. However, DARC officials told us that, as of January 2022, they do not anticipate reaching formal agreement with the host nation until March 2023.

Further, the program stated that the prime system integrator contract award was delayed from January to February 2022 because the agency was operating under a continuing resolution. As a result of these and other delays, the program is at risk of not meeting the planned residual operational capability date, which was already delayed from March 2025 to September 2025.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office stated that, in summer 2021, it successfully completed technology demonstrations at White Sands Missile Range. According to the program office, these successes provided confidence to move forward in bringing on a prime system integrator to build DARC site 1. The program office stated that, as of February 2022, it is in the final stages of completing an other transaction agreement for a prime system integrator to build DARC site 1. The program office further stated that trilateral discussions with international partners are progressing as planned to finalize a host nation agreement by April 2023 to initiate site construction of DARC site 1.

Source: U.S. Air Force. | GAO-22-105230

Evolved Strategic SATCOM (ESS)

The Space Force's ESS, a program using the MTA pathway, is developing space-based capabilities expected to provide worldwide DOD users strategic and secure communications to support DOD's nuclear command, control, and communications mission. ESS expects to develop an advanced satellite communications (SATCOM) payload in the rapid prototyping effort. The Space Force aims to incorporate the payload onto an eventual ESS satellite upon transitioning to a future rapid fielding effort or major capability acquisition pathway.

Program Essentials

Decision authority: Air Force

Program office: Los Angeles Air Force Base, CA

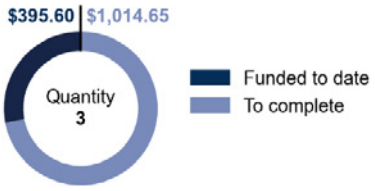
Contractors: Boeing; Lockheed Martin; Northrop Grumman

MTA pathway: Rapid prototyping

Contract type: FFP (development)

Estimated Middle Tier of Acquisition Cost and Quantities

(fiscal year 2022 dollars in millions)



Our prior assessment reported a quantity of one; however, the program reported it had yet to decide how many prototypes will be selected from among the three under development

Software Development

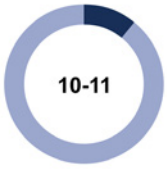
(as of January 2022)

Approach: Mixed

Average time of software deliveries (months)

Information not available

Software percentage of total program cost



Software type

Information not available

The program reported software types and delivery times are different across the three contractors.

Program Background and Transition Plan

The Air Force initiated ESS as an MTA effort in August 2019. From September 2020 through November 2020, the program awarded contracts to three contractors, each to develop an advanced satellite communications payload prototype. By the end of the MTA effort, planned for September 2025, the program expects to test and demonstrate critical payload capabilities for each contractor's payload. Further testing is planned for the follow-on phase.

Transition Plan: Transition to a new MTA rapid fielding effort or the major capability acquisition pathway with entry at system development.

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

Planned Knowledge by MTA Transition

Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	□	Demonstrate all critical technologies in form, fit, and function within a realistic environment	NA
Complete system-level preliminary design review	⊗	Release at least 90 percent of design drawings	NA
Test a system-level integrated prototype	NA	Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA
Demonstrate critical processes on a pilot production line	NA	Test a production-representative prototype in its intended environment	NA

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned

... Information not available **NA** Not applicable

We did not assess ESS planned knowledge by MTA transition for critical technologies in a realistic environment because satellite technologies demonstrated in a relevant environment are considered fully mature. We also did not assess design stability and manufacturing maturity because the program has yet to determine whether it will transition to the major capability acquisition pathway with entry at system development or to an MTA rapid fielding effort. We assessed planned knowledge by MTA transition for critical technologies in a relevant environment and a system-level preliminary design review, which apply to both potential transition pathways under consideration by the program.

ESS Program

Updates to Program Performance and Program Business Case

In March 2021, the program completed its business case, concluding with a formal risk assessment and update of the independent cost assessment. Last year, ESS also completed three system requirements reviews and is now completing a 1-year interim program review to update the Office of the Secretary of Defense on its progress, per officials. Contractor demonstrations of the prototype are expected to begin in December 2022, with multiple demonstrations planned to follow.

Technology

Four of the program's eight critical technologies are fully mature, and one is approaching maturity, consistent with what we reported last year. The remaining three are reported at various levels based on the three contractors' varying proposals. The program reported that contractors might also identify additional critical technologies to counter emerging threats as they mature their designs.

Over the past year, program officials told us they have seen progress on technology development across the contractors. The program expects the contractors to mature all technologies by the planned end of the rapid prototyping effort. However, if the contractors do not meet the planned maturity levels, there is a risk that issues discovered later in testing could cause costly and time-intensive rework and delays in the follow-on phase.

Software Development and Cybersecurity

Each contractor is executing some form of Agile software development, depending upon the specific subsystems under development, and each contractor has a different cadence of software deliveries.

The Space Force approved the program's cybersecurity strategy in April 2020. While the strategy is limited to specific areas including the payloads under development, program officials noted that the cybersecurity strategy was written as a system-level document that will flow across the entire system, including the ground component.

Transition Plan

In our last assessment, the program reported it planned to transition to a rapid fielding effort at the end of the current MTA effort. However, this year, program officials stated that a decision is pending about whether the program will transition to a rapid fielding effort or the major capability acquisition pathway at system development. Program officials said fielding the system 5 years after the end of prototyping—as would be expected if the program selected a rapid fielding effort—is a schedule they are unsure they can support. The program plans to conduct its first satellite launch in fiscal year 2031.

While the program plans to demonstrate that all critical technologies are mature by the time ESS transitions, it does not plan to complete a system-level preliminary design review by that time, as we reported last year, a practice that our past work shows is associated with lower cost and schedule growth. Instead, program officials said that a preliminary design review will now occur early in the follow-on phase. We updated our Planned Knowledge by MTA Transition table to reflect this change.

Other Program Issues

The program is continuing to develop a plan to address the additional work necessary to develop prototypes into fully operational satellites at the end of the current MTA effort. This work will include selecting one or more contractors for the next phase of work, making decisions on the satellite that will host the payload, and integrating the payload with the satellite. The program has yet to fully determine whether a contractor or the government will control interface definition or development of interfaces between certain technical components.

The program noted that it is working to reduce integration risk and already established and released the payload interface standards to the contractors. The program also noted that it is seeing benefits, including to development and innovation, such as in number of satellites in the final design, from the current competition between contractors and is considering ways to continue competition in later program phases.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. According to the program office, it is maturing designs, reducing risks, and building in resiliency while remaining on track to meet all cost, schedule, and performance goals. The program office stated that over the past year, the competitive environment enabled by the MTA rapid prototyping effort created urgency among the contractors. It noted that each contractor is targeting and maturing critical elements through designs and integrated tests that trace to system requirements. The program office added that it is learning how to best respond to the emerging threat, it developed a primary path to onboard resiliency capabilities, and it is studying alternate designs to achieve greater resiliency.

Source: U.S. Air Force. | GAO-22-105230

F-15EX

The Air Force expects the F-15EX program, an MTA rapid fielding effort, to address F-15C/D readiness challenges and eventually replace the F-15C/D fleet. The F-15EX, based on the current foreign military sales (FMS) aircraft, will be upgraded with capabilities unique to the U.S., including operational flight program software and Eagle Passive/Active Warning and Survivability System upgrades. 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 Essentials

Decision authority: Air Force

Program office: Wright-Patterson Air Force Base, OH

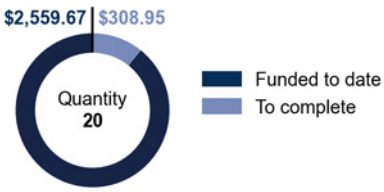
Prime contractor: Boeing

MTA pathway: Rapid fielding

Contract type: IDIQ; future contracts in negotiations; FPIF (Lot 1 and 2 aircraft); CPFF/CPIF/FPIF/FFP (development and product support)

Estimated Middle Tier of Acquisition Cost and Quantities

(fiscal year 2022 dollars in millions)



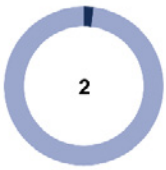
Software Development

(as of January 2022)

Approach: Agile

Average time of software deliveries (months)

Software percentage of total program cost



Software type

0 percent Off-the-shelf

0 percent Modified off-the-shelf

100 percent Custom software

Program Background and Transition Plan

The Air Force initiated the F-15EX program using the MTA pathway in September 2019 to acquire 20 F-15EXs under the rapid fielding effort. In March and April 2021, the contractor delivered two test aircraft as planned. The program reports awarding two contracts to procure 18 low-rate production aircraft. Performance on the contract has begun while contract terms and specifications are negotiated. The program expects to achieve initial operational capability by June 2023, with eight aircraft.

Transition Plan: Transition to the major capability acquisition pathway with entry during production.

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

Planned Knowledge by MTA Transition			
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	Demonstrate all critical technologies in form, fit, and function within a realistic environment	●
Complete system-level preliminary design review	●	Release at least 90 percent of design drawings	●
Test a system-level integrated prototype	●	Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	⊗
Demonstrate critical processes on a pilot production line	●	Test a production-representative prototype in its intended environment	●

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned

... Information not available NA Not applicable

F-15EX Program

Updates to Program Performance and Program Business Case

According to program officials, in January 2021, the program conducted an integrated baseline review to evaluate program risks. In addition, in February 2021, the Defense Contract Management Agency conducted a formal independent schedule risk assessment and found no risks to key schedule milestones. In March 2021, the Air Force Cost Analysis Agency updated its independent cost assessment for the MTA effort, which remains relatively steady at $2.83 billion.

Technology

The program reported that it completed system-level integrated prototype testing in December 2020 and considers all 10 of its critical technologies mature. In October 2021, the Air Force Operational Test and Evaluation Center conducted an operational assessment of an F-15EX production-representative prototype, according to program officials. Program officials stated that the assessment demonstrated both offensive and defensive counter-air missions in a realistic environment.

Software Development and Cybersecurity

Program officials stated that the operational flight program software, Suite 9.1X, flew successfully in two F-15EX aircraft during an operational test event in May 2021.

The program continues to track a cybersecurity vulnerability risk stemming from the F-15EX design, derived from FMS aircraft and, according to the program, not designed to U.S. Air Force cybersecurity requirements. The program office plans to bring subject matter experts together in April 2022 to conduct a tabletop exercise in which they talk through how they would respond to simulated scenarios in identifying vulnerabilities. Subsequently, the program office plans to conduct other cybersecurity assessments, with results from the tabletop exercise determining the scope and dates of these additional assessments.

Transition Plan

The F-15EX program plans to begin transitioning to the major capability acquisition pathway in May 2022. As part of the transition, the program will seek the approval of the Air Force milestone decision authority to move from the MTA pathway into the major capability acquisition pathway. If approved, the program will establish an official Acquisition Program Baseline outlining cost, schedule, and performance objectives for the remainder of the acquisition.

During the transition period, the program plans to complete procurement and fielding of 18 low-rate production aircraft and key test events. At the same time, the program plans to begin procuring long lead items, aircraft engines, and additional production aircraft. As we reported last year, the F-15EX is manufactured on the same production line—using many of the same manufacturing processes that are proven on pilot production lines—as current FMS F-15 aircraft. Program officials noted that the next low-rate production aircraft produced during the MTA effort will pilot new manufacturing processes for the forward fuselage. While this change is aimed at creating manufacturing efficiencies, process changes could pose risk to aircraft delivery time frames. However, program officials told us that the contractor built in schedule margin to account for any delays.

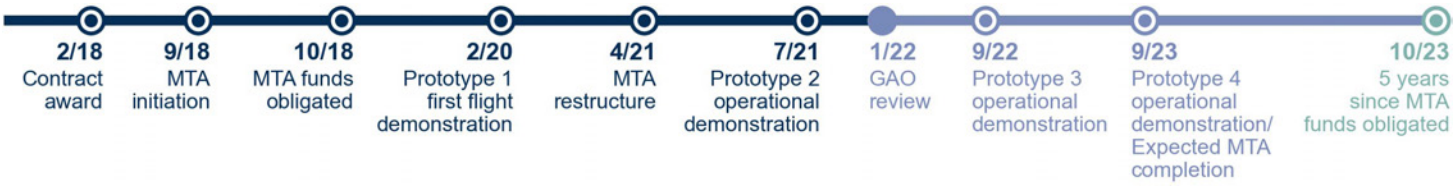
Program Office Comments

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-22-105230

F-22 Rapid Prototyping

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



Program Essentials

Decision authority: Air Force

Program office: Wright-Patterson Air Force Base, OH

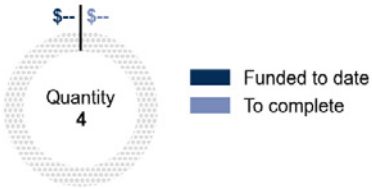
Prime contractor: Lockheed Martin

MTA pathway: Rapid prototyping

Contract type: CPFF/FFP (development)

Estimated Middle Tier of Acquisition Cost and Quantities

(fiscal year 2022 dollars in millions)

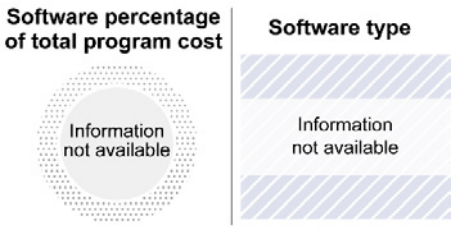


Quantities represent the planned number of prototype demonstrations during the MTA effort. The Air Force deemed cost estimates not suitable for public release.

Software Development

(as of January 2022)

Approach: Agile, DevOps, and DevSecOps



The program reported that the rapid prototyping effort consists of multiple software releases, each composed of multiple capabilities with varying software percentages.

Program Background and Transition Plan

In April 2021, the Air Force approved a restructuring of the F-22 MTA effort known as the F-22 Capability Pipeline into two distinct MTA efforts—one for rapid prototyping and one for rapid fielding. F-22 Rapid Prototyping is expected to demonstrate four prototypes of enhanced capabilities by September 2023. F-22 Rapid Fielding is expected to field capabilities, including those developed under F-22 Rapid Prototyping, by September 2024. As of January 2022, the efforts collectively demonstrated two prototypes and approved production to support fielding the first prototypes—known as Prototype 1.

Transition Plan: Transition most selected capabilities as individual programs to either the rapid fielding effort or to the major capability acquisition pathway with entry at either system development or production.

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

Planned Knowledge by MTA Transition			
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	NA	Demonstrate all critical technologies in form, fit, and function within a realistic environment	NA
Complete system-level preliminary design review	NA	Release at least 90 percent of design drawings	NA
Test a system-level integrated prototype	NA	Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA
Demonstrate critical processes on a pilot production line	NA	Test a production-representative prototype in its intended environment	NA

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned

... Information not available NA Not applicable

We did not assess F-22 planned knowledge by MTA transition because the program is developing multiple, distinct capabilities at different stages of maturity and with differing transition plans at MTA conclusion.

F-22 Rapid Prototyping Program

Updates to Program Performance and Program Business Case

In April 2021, the Air Force restructured the F-22 Capability Pipeline into separate rapid prototyping and rapid fielding efforts. It also extended the rapid prototyping effort from September 2021 to September 2023 and increased the planned number of prototype demonstrations from two to four. Further, the Air Force added requirements to develop enhanced capabilities for fuel tanks and electronic protection. As a result of these changes, the combined estimated costs of the restructured F-22 rapid prototyping and rapid fielding efforts more than doubled. However, program officials said this increase is due to the added time, demonstrations, and requirements and should not be attributed to inefficient performance.

In July 2021, the program demonstrated its second prototype, which primarily consisted of software upgrades. This demonstration followed the first demonstration of hardware and software updates, conducted in February 2020. Both prototypes were expected to demonstrate tactical information transmission capabilities. However, program officials said they were only able to partially meet those expectations because the Air Force had not received authorization from the Federal Aviation Administration to fully test transmission capabilities at the time of the demonstrations. They noted that they plan to finish demonstrating these capabilities in future prototypes after they receive authorization and they do not expect this issue to affect the overall schedule.

Technology

The program has one mature critical technology, its open systems architecture, which provides an interface for legacy systems and enables future capabilities on F-22 aircraft.

Software Development and Cybersecurity

The program office reported no significant changes to its software development efforts since last year and will continue to utilize Agile and DevSecOps. While the program delivers software for testing on a monthly basis, working software is expected to be delivered to end users every 12 months. This approach differs from industry's Agile practices that encourage delivery to users on a continuing basis—as frequently as every 2 weeks.

Air Force testing units performed multiple cybersecurity assessments of F-22 software since our last review, including an assessment of Prototype 1 in April 2021, according to program officials. An updated cybersecurity strategy for F-22 was approved in August 2021.

Transition Plan

Some capabilities developed under rapid prototyping already transitioned to rapid fielding, but going forward, the program plans to transition most capabilities individually to the major capability acquisition pathway with entry at system development or production. Program officials said some capabilities will continue development under rapid prototyping after transitioning to the major capability acquisition pathway. Officials explained that this was to ensure there are no lapses in development or fielding. They said one exception is the electronic protection capability, which does not have a transition plan and is expected to conclude during rapid prototyping.

Other Program Issues

Program officials noted the contracting strategy for F-22 Rapid Prototyping did not fundamentally change from the strategy of the F-22 Capability Pipeline. They explained that prototype development starts under a level-of-effort contract, which requires the contractor to perform a specified amount of work during a stated time period. They also noted that development then transitions to a firm-fixed-price contract after prototype content matures and operational demonstration is complete. Program officials said this construct allows the program to deliver capabilities to the warfighter rapidly and at a regular cadence.

The program started fielding capabilities under the rapid fielding effort, including some Prototype 1 capabilities. The Air Force already approved production to support the initial fielding schedule. Program officials stated, however, that there are challenges to producing and delivering the quantities needed to support rapid fielding. They also noted that as of January 2022, the first three aircraft were on track to receive upgrades and the program will continue to manage delivery risks.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. According to the program office, the Air Force made a fielding decision for Prototype 1 capabilities in October 2021. The program added that this enabled the transition and fielding of the first capability release to the F-22 Rapid Fielding MTA effort, which began installing upgrades on aircraft later that month. The program office stated that it remains committed to maturing technologies across the approved product lines and delivering capabilities annually through the rapid prototyping effort. It also noted that the rapid prototyping MTA effort is currently executing within its cost parameters and is on track to meet its commitment of four prototype demonstrations within the 5-year period as called for by DOD policy.

Source: SAIC. | GAO-22-105230

Future Operationally Resilient Ground Evolution (FORGE)

The Space Force's FORGE program 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 be a government-owned, open-architecture system 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 stations.

Program Essentials

Decision authority: Air Force

Program office: El Segundo, CA

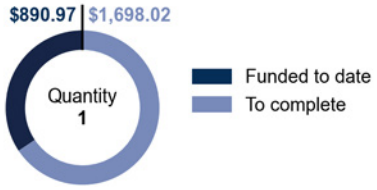
Prime contractor: Raytheon (for MDPAF)

MTA pathway: Rapid prototyping

Contract type: Cost reimbursement with various fee structures (using other transaction authority)

Estimated Middle Tier of Acquisition Cost and Quantities

(fiscal year 2022 dollars in millions)



Estimated FORGE costs decreased since our last assessment after the program adjusted its reported fiscal year 2020 costs from 12 months to 1 month to account for funds first obligated in August 2020.

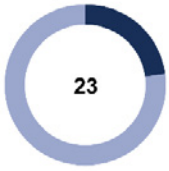
Software Development

(as of January 2022)

Approach: Agile and DevSecOps

Average time of software deliveries (months)

Software percentage of total program cost



Software type

Information not available

The program reported the software type provided for our prior report was an error and has yet to be determined.

Program Background and Transition Plan

The Air Force initiated FORGE as a rapid prototyping effort in December 2019. In August 2020, the program awarded a contract to Raytheon to create a software framework—referred to as the Mission Data Processing Application Framework (MDPAF)—for processing satellite data. Over the past year, the program completed more software for the framework and provided the framework to potential vendors for application integration work.

FORGE is intended to provide enhanced ground processing capabilities for Next Gen OPIR satellites. However, due to the program's challenging schedule, the program office is also funding a separate, interim risk reduction effort—called Next Gen Interim Operations (NIO)—to modify the SBIRS ground processing system to support the initial Next Gen OPIR satellites. The first of these satellites is scheduled to launch in 2025.

Transition Plan: Transition pathway yet to be determined.

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

Planned Knowledge by MTA Transition

Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	NA	Demonstrate all critical technologies in form, fit, and function within a realistic environment	NA
Complete system-level preliminary design review	NA	Release at least 90 percent of design drawings	NA
Test a system-level integrated prototype	NA	Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA
Demonstrate critical processes on a pilot production line	NA	Test a production-representative prototype in its intended environment	NA

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned

... Information not available NA Not applicable

We did not assess FORGE planned knowledge by MTA transition because the program has yet to determine its transition pathway.

FORGE Program

Updates to Program Performance and Program Business Case

Over the past year, FORGE focused on software development efforts for NIO and the MDPAF. The program also held multiple vendor demonstrations to inform the contract award for the Mission Data Processing Application Provider, planned for the third quarter of fiscal year 2022.

In October 2021, the Air Force conducted a critical design review of the Space Force's Next Gen OPIR program and reviewed NIO as part of those efforts. As of January 2022, FORGE program officials are working with stakeholders to address the issues identified during the review.

Air Force officials previously told us that they did not plan to conduct a formal assessment of technology risk because the program planned to use mature commercial off-the-shelf hardware and software to meet FORGE requirements. However, Air Force officials said that the NIO portion of FORGE will be part of a broader assessment of technology risk for the Next Gen OPIR program, which officials expect to be completed by June 2022. Air Force officials stated there are no plans to assess the rest of the FORGE program.

Program officials stated that the Air Force Cost Analysis Agency (AFCAA) plans to complete an updated non-advocate cost assessment no earlier than April 2022 to incorporate the program's estimates for systems engineering and integration. As we reported last year, a June 2020 AFCAA estimate was $900 million higher than the program office's estimate at that time because the program office expected less systems engineering and integration resources than the AFCAA estimate.

Program officials stated that challenges related to chip manufacturing, due in part to the COVID-19 pandemic, and the hiring of qualified personnel affected program cost and schedule. The program is assessing the extent of these effects and risk mitigation approaches.

Technology

According to FORGE program officials, critical technologies have yet to be identified. The program expects to identify them as part of its upcoming technology risk assessment.

Software Development and Cybersecurity

FORGE continues to report cost increases in software development, primarily because of an evolving understanding by the contractors of the extent of software complexity and size. An October 2019 Next Gen OPIR independent technical risk assessment identified software as high risk for FORGE due to the potential for unexpected command and control and mission data processing software development schedule growth. However, the program office continues to report that the software will be delivered on time.

FORGE has an updated cybersecurity strategy, approved in May 2021. The program completed a tabletop exercise in February 2021 and cybersecurity penetration testing in July 2021.

Transition Plan

FORGE officials said the program's transition plan is a living document and the final draft will not be complete until after the program's operational demonstration, of either NIO or FORGE, in September 2024. The program office intends to continue with the current MTA rapid prototyping effort until 2025. Officials reported that at the end of the MTA effort, FORGE efforts that complete operational acceptance will likely transition to sustainment and those that have not will likely transition to the software acquisition pathway.

Other Program Issues

As we reported last year, the program is developing an interim effort, NIO, in the event that FORGE is not available for the first satellite launch, planned for fiscal year 2025. NIO, which the program office expects to complete in 2023, will use portions of the ground system used for the SBIRS satellites—which Next Gen OPIR will replace—for some functions but will not be as robust a capability as planned for the final FORGE system. The program office expects the FORGE system to be operational by September 2025. Program officials plan to assess the development of FORGE in the third quarter of fiscal year 2022 and determine whether the program's schedule risk continues to necessitate continued efforts to develop NIO.

Program Office Comments

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

Source: U.S. Air Force. | GAO-22-105230

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 includes two separate MTA rapid prototyping efforts intended to (1) mature a smaller miniature serial interface (MSI) receiver card for use in handheld devices and munitions, and (2) develop a handheld receiver device for use across the military services. We assessed the first effort for MSI receiver cards.

Program Essentials

Decision authority: Air Force

Program office: Los Angeles, CA

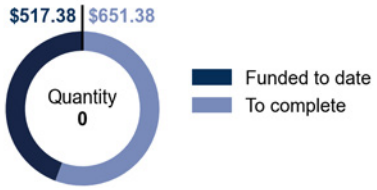
Prime contractor: BAE; Raytheon; Interstate Electronics

MTA pathway: Rapid prototyping

Contract type: CPIF/CPAF, CPFF, FFP

Estimated Middle Tier of Acquisition Cost and Quantities

(fiscal year 2022 dollars in millions)



Software Development

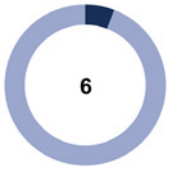
(as of January 2022)

Approach: DevOps and DevSecOps

Average time of software deliveries (months)

Information not available

Software percentage of total program cost



Software type

5 percent Off-the-shelf

70 percent Modified off-the-shelf

25 percent Custom software

Program Background and Transition Plan

The Air Force first obligated funds for MGUE Increment 2 in November 2020 when it awarded contracts to three vendors to develop the next-generation, application-specific integrated circuit (ASIC) and MSI. The next-generation ASIC is a key microelectronic component of the MSI on which M-code receiver functionalities will be encoded. The program completed preliminary design reviews for the ASIC in mid-2021. It also completed a system functional review for each vendor's overall MSI concept in 2021 and is working toward overall preliminary design reviews in mid-2022.

Transition Plan: Develop production-ready MSI receiver cards that the military services procure and field. The program plans to transition the handheld receiver device separately.

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

Planned Knowledge by MTA Transition			
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	NA	Demonstrate all critical technologies in form, fit, and function within a realistic environment	NA
Complete system-level preliminary design review	NA	Release at least 90 percent of design drawings	NA
Test a system-level integrated prototype	NA	Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA
Demonstrate critical processes on a pilot production line	NA	Test a production-representative prototype in its intended environment	NA

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned

... Information not available NA Not applicable

We did not assess planned knowledge by MTA transition because, rather than transition MSI cards to a specific Adaptive Acquisition Framework pathway, the program plans to develop cards that the military services produce and field.

MGUE Increment 2 Program

Updates to Program Performance and Program Business Case

The MGUE Increment 2 program experienced early delays and is tracking schedule as moderate risk. Program officials said they conducted a schedule risk assessment in September 2021, 5 months later than initially planned due to delays establishing each vendor's schedule baseline. However, program officials said that assessment did not account for needed work on new requirements that accumulated during the pre-contract award period, and that address a future regional military protection capability. Program officials currently plan to conduct another schedule assessment around the time of the preliminary design reviews in mid-2022. They expect it to include these and other requirements changes that will be added in early 2022.

Requirements changes are also driving delays to Increment 2 program design reviews. Specifically, the preliminary design reviews were delayed until mid-2022 due to these changes. Program officials said the vendors should be able to absorb this delay as the changes were initiated in time to avoid significant rework of the designs. Additionally, critical design reviews, previously planned for December 2022, were delayed until August 2023.

The program has a contingency period at the end of its MTA schedule in the event that issues arise with ASIC functionality, given the inherent complexity of ASIC development. Depending on the nature of the issues, officials said the program might field a functional product and then correct ASIC deficiencies or add capabilities after the completion of the current MTA timeline as a post-development effort. Officials said they are trying to identify issues early, but if a complete ASIC redesign is needed, the program would have to determine whether to transition the effort to the major capability acquisition pathway or terminate it. They noted that once the ASIC design reaches a certain point, any delays with MSI development will affect qualification testing on the MSI.

Technology

The program did not identify any critical technologies. It plans to leverage MGUE Increment 1 technologies to the maximum extent possible. Program officials said there are no plans to conduct a technology risk assessment, which our prior work shows can help inform decision makers about a program's likelihood of achieving statutory objectives for MTA efforts.

Although the next-generation ASIC is considered a commercial technology, program officials said all three Increment 2 vendors experienced challenges meeting power and thermal requirements for their ASICs. They noted that these standard challenges still pose programmatic risks, and each vendor developed an action plan to address them.

Software Development and Cybersecurity

Program officials expect to complete software development for the receiver card by November 2025, a 2-month delay from last year. MGUE continues to face software development challenges. Specifically, program officials said vendors experienced challenges hiring software development staff, resulting in combined cost growth across the vendors of nearly $1 million.

The program plans to complete a cybersecurity assessment during developmental testing in March 2025. It is currently addressing cybersecurity requirements and reported it has not experienced cost or schedule growth due to those requirements.

Transition Plan

Following completion of the MSI development, the military services are expected to procure and field the MSI based on their individual GPS modernization plans. Prior to that, the Increment 2 program plans to conduct an operational demonstration of the MSI receiver cards in a relevant environment. The results are expected to enable assessment of MSI readiness for integration with handheld devices and munitions.

The second Increment 2 MTA effort is intended to incorporate the MSI into a handheld receiver device. That effort is currently conducting risk-reduction work on a basic functioning prototype. The Space Force expects to initiate the MTA portion of the handheld receiver effort in the second quarter of fiscal year 2023.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. It stated that MGUE Increment 2 made significant progress in 2021 toward delivering capability, including completion of baseline performance assessments with the three contractors, awarding the first engineering change proposal for requirements changes, and conducting system requirements and functional reviews. The program office also stated that all three contractors completed work on the next-generation ASIC risk-reduction contracts awarded in 2019. Additionally, it noted that the program completed initial risk-reduction prototyping for the handheld receiver and received prototypes from contractors to demonstrate basic GPS functionality. In 2022, the program office expects to complete its MSI preliminary design review and award two additional engineering change proposals for requirements changes. The program office stated that it is on schedule to hold its critical design review by the end of fiscal year 2023.

Source: U.S. Air Force. | GAO-22-105230

Next Generation Overhead Persistent Infrared (Next Gen OPIR) Block 0-Geosynchronous Earth Orbit Satellites

The Air Force's Next Gen OPIR Block 0 GEO, a follow-on missile warning system, will consist of three geosynchronous earth orbit (GEO) satellites. The Block 0 GEO MTA rapid prototyping effort will deliver the main mission payload—an infrared sensor. A separate MTA effort will deliver two Block 0 polar coverage satellites. A third MTA rapid prototyping effort, the Future Operationally Resilient Ground Evolution (FORGE), will modernize the ground segment.

- **6/18** MTA initiation
- **10/18** Funds obligated
- **9/19** Preliminary design review
- **10/21** Critical design review
- **1/22** GAO review
- **10/23** 5 years since MTA funds obligated/Expected MTA completion
- **9/25** First GEO satellite launch

Program Essentials

Decision authority: Air Force
Program office: El Segundo, CA
Prime contractor: Lockheed Martin
MTA pathway: Rapid prototyping
Contract type: CPIF (development)

Estimated Middle Tier of Acquisition Cost and Quantities

(fiscal year 2022 dollars in millions)

The program clarified that the estimated costs provided for our prior assessment included both the GEO and polar satellites; consequently, this figure is updated to reflect only the GEO effort, which is delivering an infrared sensor. The program determined that the remaining cost to complete the MTA effort is not publically releasable and so it is omitted here.

Software Development

(as of January 2022)

Approach: Agile and Mixed

Average time of software deliveries (months)

Information not available

Software percentage of total program cost

Information not available

Software type

- 0 percent Off-the-shelf
- 75 percent Modified off-the-shelf
- 25 percent Custom software

The program reported the software types as approximations because specific values are proprietary.

Program Background

The Air Force initiated Next Gen OPIR Block 0 GEO as an MTA effort in June 2018 and plans to complete rapid prototyping in 2023. The Air Force planned for Lockheed Martin to maintain two vendors to competitively develop prototypes of the infrared sensor payload. According to program officials, the two competing vendors are Raytheon Technologies and a team comprised of Northrop Grumman and Ball Aerospace. The payload for the first satellite is expected in 2023, ending the rapid prototyping effort. The program expects the first Next Gen OPIR GEO satellite to launch in 2025.

Transition Plan: Transition to the major capability acquisition pathway with entry in system development.

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

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

Planned Knowledge by MTA Transition			
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	◐	Demonstrate all critical technologies in form, fit, and function within a realistic environment	NA
Complete system-level preliminary design review	●	Release at least 90 percent of design drawings	NA
Test a system-level integrated prototype	NA	Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA
Demonstrate critical processes on a pilot production line	NA	Test a production-representative prototype in its intended environment	NA

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned
... Information not available NA Not applicable

We assessed the GEO portion of the Next Gen OPIR Block 0 program, which contains the MTA deliverable. We did not assess critical technologies in a realistic environment because satellite technologies demonstrated in a relevant environment are considered fully mature. We did not assess design stability or manufacturing maturity metrics because those metrics are not applicable to programs transitioning at system development.

Next Gen OPIR Block 0-GEO Program

Updates to Program Performance and Program Business Case

In June and July 2021, the GEO satellite's competing payload developers—Raytheon Technologies and a team of Northrop Grumman and Ball Aerospace—successfully completed critical design reviews of their respective payloads, according to program officials. These reviews represent a significant accomplishment for the program. The program also completed its system-level critical design review ahead of schedule in October 2021—another significant milestone, which program officials told us assessed subsystems and mission payload, among other elements.

However, a recent independent assessment of schedule risk concluded that delivery of both of the competing prototype payloads is likely to be delayed. Specifically, in August 2021, a federally funded research and development center completed an independent schedule risk assessment for the program. It determined that delivery of the prototype mission payloads would likely be late.

Subsequently, Lockheed Martin conducted its own schedule risk assessment that predicted it would deliver the spacecraft earlier than the original need date. According to the program office, discrepancies among schedule risk assessments conducted by different entities is common and dependent on the various assumptions, tools, and inputs of analysis used by each entity.

Technology

Since our last assessment, eight of the program's 18 critical technologies advanced in maturity, while the maturity levels of two others decreased. According to officials, each decrease was the result of deliberate design modifications that would mitigate program risk and improve system performance. Our prior work shows that increasing even one technology readiness level can take multiple years and becomes more challenging as the technology approaches maturity.

Software Development and Cybersecurity

The program did not report any significant changes in its software development approach over the past year. The Air Force approved the program's revised cybersecurity strategy in August 2021.

Transition Plan

At the completion of the rapid prototyping effort, planned for late 2023, the Air Force plans to transition Next Gen OPIR GEO to the major capability acquisition pathway with entry in system development, at which point it will integrate the sensor on Block 0 satellites. The program plans to acquire at least two additional satellites under a Block 1 acquisition. The program plans to competitively award contracts for Block 1, but has yet to determine which acquisition pathway it will use.

Other Program Issues

In September 2021, we reported that Next Gen OPIR GEO faces significant challenges in developing and integrating new technologies with minimal schedule margin. The Joint Requirements Oversight Council validated a 2025 launch requirement for the first OPIR satellite, driving the program's need to compress some payload development activities in the interest of meeting its launch schedule.

Given the aggressive launch timeline, the program is concurrently developing GEO mission payload engineering and flight units. Concurrent development can accelerate progress in the near-term, but often raises the risk of eventual schedule delays and cost increases. The risk increases because issues identified during engineering unit testing typically necessitate corrective flight unit rework, which adds to a program's schedule and subsequently its costs. Further, the program selected its spacecraft design based on prior performance, but the spacecraft will need to be modified to meet new mission requirements. DOD acknowledged cost and schedule risks presented by the first-time integration of the new GEO sensor with a modified spacecraft.

Program Office Comments

We provided a draft assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office reported that it is making progress toward a 2025 delivery. The program stated that it continues to manage its aggressive launch schedule, but believes it is achievable. Program officials added that over the past year, the program held to its schedule and met major program milestones. For example, they noted that the program completed two sensor critical design reviews and a space vehicle design review.

Additionally, the program office stated that the system's October 2021 design review showed sufficient maturity of the space vehicle, FORGE mission data processing, and interfaces to begin building the flight hardware and ground components. It also reported that this year marked successful completion of both competing mission payload developmental units and their full environmental testing. The program stated that this completion retired several high technical risks, and affirmed that the two designs are capable of meeting the program's requirements.

Source: LinQuest. | GAO-22-105230

Protected Tactical Enterprise Service (PTES)

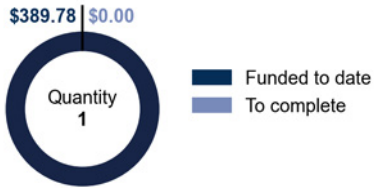
The Space Force's PTES MTA rapid prototyping effort plans to develop and field the ground system for enabling initial capabilities of adaptive, anti-jam, wideband satellite communications under the Space Force's broader Protected Anti-Jam Tactical SATCOM (satellite communications) effort. We evaluated the planning and execution of the MTA rapid prototyping effort that the Space Force expects will demonstrate initial operational readiness for anti-jam tactical communications in the Pacific theater.

Program Essentials

Decision authority: Air Force
Program office: El Segundo, CA
Prime contractor: Boeing
MTA pathway: Rapid prototyping
Contract type: CPIF (development)

Estimated Middle Tier of Acquisition Cost and Quantities

(fiscal year 2022 dollars in millions)



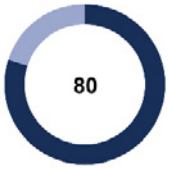
Software Development

(as of January 2022)

Approach: Agile and DevSecOps

Average time of software deliveries (months)

Software percentage of total program cost



Software type

0 percent Off-the-shelf

44 percent Modified off-the-shelf

56 percent Custom software

Program Background and Transition Plan

The Air Force initiated PTES as a rapid prototyping effort in June 2018. Program officials stated that the program began producing and testing prototype units in April and May 2020, respectively, and intends to complete an operational demonstration by June 2022 to complete the current rapid prototyping effort. The program then plans to transition to either an MTA rapid fielding effort or the software acquisition pathway.

Subsequently, the program expects to field the prototyped capabilities, referred to as release 1, to the Pacific theater to reach initial operational capability by December 2023. The program plans a follow-on effort for release 2, with the goal of providing full operational capability for Air Force, Army, and Navy operations by fiscal year 2026.

Transition Plan: Transition either to a new MTA rapid fielding effort or to the software acquisition pathway.

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

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

Planned Knowledge by MTA Transition

Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	NA	Demonstrate all critical technologies in form, fit, and function within a realistic environment	NA
Complete system-level preliminary design review	NA	Release at least 90 percent of design drawings	NA
Test a system-level integrated prototype	NA	Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA
Demonstrate critical processes on a pilot production line	NA	Test a production-representative prototype in its intended environment	NA

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned
... Information not available NA Not applicable

We did not assess PTES planned knowledge by MTA transition because the program has yet to determine whether it will transition to a rapid fielding effort or to the software acquisition pathway.

PTES Program

Updates to Program Performance and Program Business Case

During the past year, PTES shifted its planned operational demonstration from December 2021 until the third quarter of fiscal year 2022. According to the program office, the user terminals, developed by another program, are not planned to be available until that time. Program office officials stated that they want the demonstration to be as realistic as possible, so they decided to wait until the terminals become available. According to program officials, this delay will shift the planned end of rapid prototyping by a corresponding 6 months, but is not expected to delay the initial operational capability, currently planned for December 2023.

The maturity of hardware designs advanced significantly since our last assessment, according to the program office. Program officials stated that testing at Massachusetts Institute of Technology Lincoln Laboratories to prove out key capabilities was successful and design changes slowed considerably, ahead of schedule.

The remaining business case elements remained stable since our last assessment.

Technology

The program identified three technology areas—Joint Hub and Network, Dynamic Resource Allocation, and Crypto and Cross Domain Solution—critical for development, two of which it reported are mature and one of which it reported is currently immature. According to a program office analysis, critical technologies matured significantly over the past year and program officials expect to validate maturity during the operational demonstration in the third quarter of fiscal year 2022.

Software Development and Cybersecurity

Since initiation, the program completed 10 software demonstration builds. Program officials told us they are working cooperatively with users and test organizations to ensure the software meets desired outcomes. The program plans to field a minimum viable product by December 2023 to support initial operational capability, with the ability to incrementally add features as needed to meet future requirements.

Program officials stated that PTES conducted cybersecurity tabletop exercises in April and June 2021 and a mission-based risk assessment in October 2021. They also said the program is planning a cooperative vulnerability identification in January 2022. Cybersecurity is also continually tested at the end of each build, according to the program office.

Transition Plan

PTES currently plans to transition to either an MTA rapid fielding effort or to the software acquisition pathway. Program officials indicated that, as DOD's software acquisition pathway matured, they identified it as a potential transition option. These officials stated they are analyzing options and intend to provide a detailed briefing to the Air Force Service Acquisition Executive in the early third quarter of fiscal year 2022 in preparation for a transition at the completion of the operational demonstration. Program officials state that they are focused on determining which path is best for transition, but both rapid fielding MTA and software pathway are good options.

The program office identified production during the follow-on effort to be a low-risk item as PTES is a software intensive program primarily using commercial hardware. The developed hardware of the modem and End Cryptographic Unit were both prototyped and demonstrated under the rapid prototyping effort.

Other Program Issues

Certification of the PTES crypto solution by the National Security Agency (NSA) remains a high-risk item and challenge, according to program office officials. They stated that the design and solution are mature and they are confident that they will get through the NSA certification process. They also stated that they are continually communicating with NSA to ensure any risks are addressed early.

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 PTES will continue to demonstrate system maturity and warfighter capabilities as opportunities become available, to include but not limited to, participation in large-scale demonstrations. According to the program office, exercises and demonstrations will inform the program's transition out of the MTA rapid prototyping pathway while further shaping the development effort. The program office stated that it maintains a strong focus on the U.S. Indo-Pacific Command region, and that this area will be the center for PTES initial operational capability. It added that current and future demonstrations will be invaluable opportunities to leverage Agile development—by incorporating test community and warfighter feedback to improve PTES usability in a realistic environment—prior to the operational demonstration and initial operational capability.

Source: U.S. Air Force. | GAO-22-105230

Protected Tactical SATCOM (PTS)

The Space Force's PTS, a rapid prototyping MTA effort, is a space-based system that will transmit a protected, antijamming waveform to users in contested environments. The PTS MTA effort will prototype modular, scalable, hostable payloads. PTS is part of the Space Force's broader Protected Anti-Jam Tactical SATCOM (satellite communications) mission area, which also includes the Protected Tactical Enterprise Service, another MTA effort assessed separately in this report.

Program Essentials

Decision authority: Air Force

Program office: El Segundo, CA

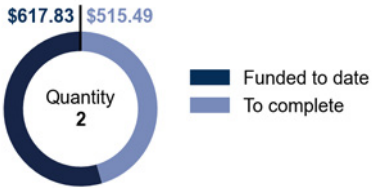
Prime contractor: Boeing; Northrop Grumman

MTA pathway: Rapid prototyping

Contract type: FFP (development)

Estimated Middle Tier of Acquisition Cost and Quantities

(fiscal year 2022 dollars in millions)



Program officials stated that funding reflects the rapid prototyping phase, which includes development and on-orbit operations that span to fiscal year 2029.

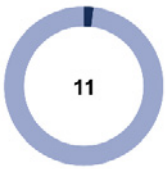
Software Development

(as of January 2022)

Approach: Agile and Mixed

Average time of software deliveries (months)

Software percentage of total program cost



Software type

5 percent Off-the-shelf

25 percent Modified off-the-shelf

70 percent Custom software

Program Background and Transition Plan

The Air Force initiated PTS using the MTA pathway in November 2018. Program officials reported awarding three contracts in February and March 2020 for different vendors to design hosted payload prototypes. Following preliminary design reviews, the program reported selecting two contractors in March 2021 to continue building prototype payloads. The program expects to complete the rapid prototyping effort by May 2024 with the delivery of the two prototype payloads, which are planned to be available-to-launch at that time.

Transition Plan: Transition to the major capability acquisition pathway with entry at system development.

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

Planned Knowledge by MTA Transition

Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	◐	Demonstrate all critical technologies in form, fit, and function within a realistic environment	□
Complete system-level preliminary design review	⊗	Release at least 90 percent of design drawings	NA
Test a system-level integrated prototype	NA	Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA
Demonstrate critical processes on a pilot production line	NA	Test a production-representative prototype in its intended environment	NA

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned

... Information not available NA Not applicable

We did not assess PTS's planned knowledge by MTA transition for design stability and manufacturing maturity because those metrics are not applicable to programs transitioning at system development.

PTS Program

Updates to Program Performance and Program Business Case

In March 2021, based on design reviews for each contractor, the program reported selecting Boeing and Northrop Grumman to continue building prototype payloads.

In August 2021, the program held a technical review to evaluate requirements, designs, interdependencies, and other issues related to both payload prototypes and supporting systems. Program officials also said that between October and December 2021, they held separate critical design reviews for each contractor.

Program officials reported that they are experiencing challenges obtaining approval and receiving required documentation for one component—a critical technology—from the National Security Agency. Program officials said this information is needed to complete a design review. As a result, the program is estimating a 1-year delay to first delivery of the component. Program officials said that although they held a design review meeting for the component in late 2020, they have yet to complete the review due to the delay.

Program officials stated that this delay is hindering their ability to conduct a formal schedule risk assessment, an important element in helping decision makers identify whether MTA programs are well-positioned to meet statute-based schedule objectives. Program officials said that they cannot complete a reliable assessment until the delayed component design review is complete.

Despite the component delays, program officials reported that the MTA effort is still on track to field a prototype within 5 years that can be demonstrated in an operational environment and provide for a residual operational capability. The statute-based objective for a rapid prototyping MTA effort is to field such a prototype within 5 years of the development of an approved requirement. Program officials added that they still need to engage with potential users to establish priorities and goals for the residual operational capability.

Technology

PTS's five critical technologies are currently immature, though the program reported that the maturity levels of three of them increased since our last assessment due to recent demonstration and modeling efforts. Program officials said that the program's technology maturity assessment represents a composite score of the two contractors' designs.

Program officials said that, while the technologies for both designs are mature and in use in other space-based applications, the critical technologies are assessed at lower levels for PTS based on the need to integrate them to deliver protected antijam communication from space. Program officials expect the critical technologies to mature quickly once integration begins and expect them all to be mature by May 2024.

Software Development and Cybersecurity

Cybersecurity requirements for PTS's MTA effort are a tailored set of requirements derived from the overall program. Moreover, according to the cybersecurity strategy for the PTS MTA prototypes, the prototypes will be compliant with the tailored set of requirements to the extent practical. Program officials said that additional tailoring of cybersecurity requirements for the prototypes may be necessary during the MTA effort based on cost constraints.

Transition Plan

PTS plans to transition in August 2023—prior to delivering the MTA prototypes—to the major capability acquisition pathway with entry at system development. This estimated date for starting the major capability acquisition pathway effort is nearly a year earlier than we reported last year. According to program officials, the earlier transition date better supports the timely delivery of capabilities to meet warfighter needs. This accelerated timeline may limit opportunities to incorporate lessons learned from the MTA effort's assembly of prototypes, increasing risk of rework if issues are found after the follow-on program already committed to designs that may have integration issues.

Program Office Comments

We provided a draft of this assessment for program office review and comment. The program office provided technical comments, which we incorporated where appropriate. According to the program office, PTS made substantial progress in its second year and ultimately is expected to provide a robust antijam capability to warfighters in highly contested theaters. The program office stated that both of the payloads and the gateway terminal successfully completed critical design reviews, increasing confidence in the contractors' ability to meet requirements and support a path to production. Officials also said the payload contractors executed 31 demonstrations, which showcased payload capability, matured critical technology, and further reduced technical risk. Officials stated that they plan to conduct a schedule risk assessment later this year. They also noted that the timing of the program's plans to transition to the major capability acquisition pathway could change depending on Space Force priorities.

ARMY

Program Assessments

▲ Indirect Fire Protection Capability Increment 2 (IFPC Inc 2)

Assessment type	Program name
MDAPs	Armored Multi-Purpose Vehicle (AMPV)
	CH-47F Modernized Cargo Helicopter (CH-47F Block II)
	Integrated Air and Missile Defense (IAMD)
	Improved Turbine Engine Program (ITEP)
	Precision Strike Missile (PrSM)
MTA Programs	Extended Range Cannon Artillery (ERCA)
	Future Long-Range Assault Aircraft (FLRAA)
	Indirect Fire Protection Capability Increment 2 (IFPC Inc 2)
	Integrated Visual Augmentation System (IVAS)
	Lower Tier Air and Missile Defense Sensor (LTAMDS)
	Mobile Protected Firepower (MPF)
	Optionally Manned Fighting Vehicle (OMFV)
Future Major Weapon Acquisitions	Future Attack Reconnaissance Aircraft Program (FARA)
	Long Range Hypersonic Weapon (LRHW)

Source (previous page image): © 2021 Dynetics, Inc. | GAO-22-105230

Source: BAE. | GAO-22-105230

Armored Multi-Purpose Vehicle (AMPV)

The Army's AMPV is the replacement to the M113 family of vehicles at the brigade level and below. The AMPV is expected to replace the M113 in five mission roles: general purpose, medical evacuation, medical treatment, mortar carrier, and mission command. The Army determined that development of the AMPV is necessary due to mobility, survivability, and force protection deficiencies identified with the M113, as well as space, weight, power, and cooling limitations that prevent the incorporation of further technologies.

Program Essentials

Milestone decision authority: Army

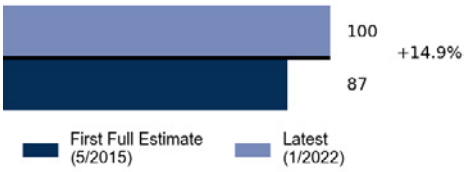
Program office: Detroit Arsenal, MI

Prime contractor: BAE Systems Land & Armaments L.P.

Contract type: CPIF (development), FPI (procurement)

Acquisition Cycle Time

(in months)



Software Development

(as of January 2022)

Approach: Incremental

Average time of software deliveries (months)

Software percentage of total program cost

Software type

10 percent Off-the-shelf

0 percent Modified off-the-shelf

90 percent Custom software

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (5/2015)	Latest (1/2021)	Percentage change
Development	$1,111	$1,081	-2.7%
Procurement	$10,945	$12,144	+11.0%
Unit cost	$4	$5	+11.0%
Total quantities	2,936	2,936	+0.0%

Total quantities comprise 39 development quantities and 2,897 procurement quantities.

Attainment of Product Knowledge (as of January 2022)

	Status at Development Start	Current Status
Resources and requirements match		
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	●	●
Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	●	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	○	○
Demonstrate critical processes on a pilot production line	○	○
Test a production-representative prototype in its intended environment	●	●

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

AMPV Program

Technology Maturity, Design Stability, and Production Readiness

While AMPV critical technologies are mature and its design stable, manufacturing challenges persisted more than 2 years after the program entered low-rate initial production. Consequently, according to officials, the Army modified the delivery schedule in late 2021 to account for these delays and COVID-19 complications. As of the first quarter of fiscal year 2023, the contractor delivered all of the vehicles required by the new schedule, according to the Army. The quantity delivered is less than one-third of the number of AMPVs that program officials expected by this time when production started. Several factors contributed to these delays. Manufacturing process deficiencies—as indicated by continued welding defects, among other things—linger from the earlier prototype build process. Prime contractor supply chain management challenges also led to quality control issues. For example, the prime contractor provided insufficient purchase orders to suppliers, resulting in noncompliant parts needing modification. Additionally, parts shortages from key suppliers resulted in out of sequence work and inefficient assembly.

These issues—which the contractor is working to address—resulted in delays to the overall manufacturing schedule and several key programmatic events. As we reported last year, program officials delayed the start of initial operational testing and the full-rate production decision by approximately 1 year, to the second quarter of fiscal year 2022 and the first quarter of fiscal year 2023, respectively.

While program officials expect to have a sufficient number of vehicles to support initial operational testing in the second quarter of fiscal year 2022, the contractor's ability to meet future, greater production quantities remains a substantial risk. Despite entering low-rate initial production nearly 3 years ago, the program has yet to ensure statistical control of its production processes, a step that helps to verify that the contractor can consistently meet quality, cost, and schedule expectations. While DOD guidance does not require statistical control of production processes until the full-rate production decision, our prior work found that this standard falls short of leading industry practices and increases risk to the program. Further, the program did not demonstrate its critical manufacturing processes on a pilot production line before beginning production, missing an opportunity to identify the challenges that have since emerged before committing to buying additional vehicles.

Software and Cybersecurity

The program has no significant software-related issues, program officials reported. To assess cybersecurity, including mitigation of vulnerabilities identified during initial testing in 2018, program officials stated that a cooperative vulnerability and penetration assessment was completed in September 2021. Initial operational testing is expected to start in the second quarter of fiscal year 2022 and is expected to include a follow-on adversarial assessment.

Other Program Issues

Program officials reported that the contractor requested its fourth rebaseline in 2021 to address cost growth and schedule delays. Despite these adjustments, program officials expect the program's cost and schedule to remain within the Army's current program cost position and acquisition program baseline. Procurement costs have grown by over 10 percent since the program's initial estimate due in part to ongoing manufacturing challenges.

The Army significantly reduced its planned near-term AMPV procurement, due in part to production delays. Specifically, the Army postponed procurement of more than 250 new AMPVs that were originally planned for fiscal years 2021 and 2022. The program office reported it plans to award a full-rate production contract in fiscal year 2023. Further production delays could hinder the Army's ability to deliver needed mobility, survivability, and protection improvements to the warfighter.

Program officials identified diminishing manufacturing sources as a potential risk area for the program. Vehicle components shared with the Bradley fighting vehicle program—also manufactured by BAE—are facing obsolescence issues that could affect the program during full-rate production and sustainment if not addressed. To mitigate this risk, the program reported that it awarded a technical support contract to BAE to potentially redesign obsolete components and adjusted production rates, among other actions.

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 reported that, since the start of production, the program continued to work with the contractor to increase system performance beyond the capability demonstrated during development to address user feedback from limited user testing. Army officials stated that they incorporated most of the user-requested modifications from limited user testing in time for operational testing. Further, the Army reported it expects the initial production AMPVs to outperform the prototype vehicles and provide a substantial improvement over the M113 vehicles they will replace.

Source: U.S. Army. | GAO-22-105230

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

The Army's CH-47F Block II program upgrades existing CH-47F aircraft 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—all expected to increase lift in hot weather conditions. The Army also plans improved fuel and rotor components 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 Essentials

Milestone decision authority: Army

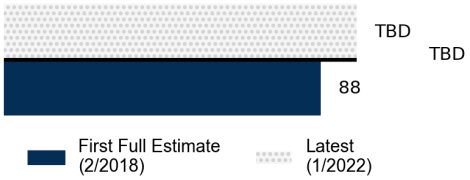
Program office: Redstone Arsenal, AL

Prime contractor: Boeing

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

Acquisition Cycle Time

(in months)



Software Development

(as of January 2022)

Approach: Agile

Average time of software deliveries (months)

Software percentage of total program cost

Software type

5 percent Off-the-shelf

10 percent Modified off-the-shelf

85 percent Custom software

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (2/2018)	Latest (7/2020)	Percentage change
Development	$837	$833	-0.4%
Procurement	$16,611	$16,484	-0.8%
Unit cost	$33	$32	-0.7%
Total quantities	542	542	+0.0%

Total quantities comprise three development quantities and 539 procurement quantities (including 73 MH-47G Block II aircraft for Special Operations Forces). Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Development Start**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	●
Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA	NA
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ... Information not available

○ Knowledge not attained **NA** Not applicable

We did not assess CH-47F Block II manufacturing maturity because the program has yet to reach production. The program stated that, as directed by Congress, it contracted to procure four Block II aircraft prior to the production decision.

CH-47F Block II Program

Technology Maturity and Design Stability

The program previously reported its critical technologies—Advanced Chinook Rotor Blade (ACRB) and Ferrium C61 steel shafts—as fully mature. However, according to the Army, developmental testing revealed problems with the ACRB; specifically, the design induced excessive vibration that led to safety concerns. Additionally, according to the Army, in the fourth quarter of fiscal year 2021, the Army decided to stop development of the ACRB and to procure the first production lot of the CH-47F Block II with the currently fielded fiberglass rotor blades. As we reported last year, there also is the potential that the Ferrium C61 steel shafts are susceptible to stress-related cracking and corrosion. According to program officials, the steel shaft design will not change, but additional stress testing will be performed in fiscal year 2022 to assess mitigations for technical risk. Additionally, the fuel system failed in testing, and some components will need to be redesigned and requalified.

Production Readiness

The low-rate production decision, originally planned for August 2021, was delayed as a result of the ACRB technical issues and funding shortfalls. According to the Army, in the fiscal year 2020 budget submission, the Army removed all procurement funding for the CH-47F Block II. According to Army officials, the program awarded a contract for four aircraft after receiving additional aircraft procurement funding in fiscal year 2021. The Joint Explanatory Statement accompanying the Consolidated Appropriations Act, 2021 stated that the agreement provided funding for the procurement of Block II aircraft in fiscal year 2021 and included all CH-47F Block II upgrades with the exception of the ACRB.

A manufacturing readiness assessment was completed in 2018, but an updated readiness assessment to support initial production is not planned until the third quarter of fiscal year 2022. Our prior work has shown that beginning production without a sufficient level of manufacturing maturity can increase the risk of subsequent rework and associated cost growth. According to program officials, targeted manufacturing readiness assessments of the airframe, fuel system, and transmission have been performed. Future assessments of the rotor components are planned. Currently, the program is monitoring risks, including delays in the procurement of long-lead items and fuel system qualification.

Software and Cybersecurity

The program is utilizing an Agile software development approach, but does not have embedded security testing tools and processes in the software development and release process to continuously integrate and test cybersecurity.

The program completed several cybersecurity assessments including a cooperative assessment, development testing, and tabletop exercises. These assessments identified risks that require additional testing and analysis. According to the Army, further cybersecurity testing for the Block II program, such as an adversarial assessment, is planned. Identified risks and problems may be addressed in future development prior to fielding and may be reevaluated with additional testing and assessments at the completion of development.

Other Program Issues

Funding shortfalls and the ACRB performance issues hindered the program's ability to meet cost, schedule, and performance goals for the development phase, according to program officials. They reported that funding shortfalls were due to receiving less funds than they requested and growing costs to address issues that emerged in development. Due to issues with the ACRB, the program is developing a new cost estimate and updating certain schedule events, resulting in a new program baseline. Program officials say this update may be completed in 2022.

Program Office Comments

We provided a draft of this assessment to the Army for review and comment. The Army provided technical comments, which we incorporated where appropriate. According to the Army, in September 2021, it procured the four CH-47F Block II Lot 1 aircraft with the currently fielded fiberglass rotor blades and discontinued Army-funded ACRB development efforts. Additionally, the Army stated it cannot rebaseline the program without further Army decisions on production and associated funding.

Source: Dynetics. | GAO-22-105230

Integrated Air and Missile Defense (IAMD)

The Army's IAMD program links sensors, weapons, and a common battle command system across an integrated fire control network to support the engagement of air and missile threats. The IAMD battle command system provides a capability for the Army to control and manage IAMD sensors and weapons—such as the Sentinel radar and Patriot launcher and radar—through an interface module that supplies battle management data and enables networked operations.

Program Essentials

Milestone decision authority: Under Secretary of Defense, Acquisition and Sustainment

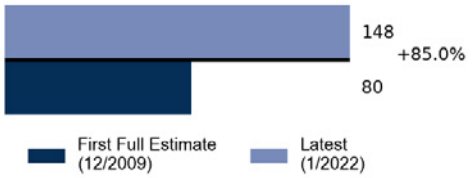
Program office: Redstone Arsenal, AL

Prime contractor: Northrop Grumman Space & Mission Systems Corporation

Contract type: FPIF (development)

Acquisition Cycle Time

(in months)



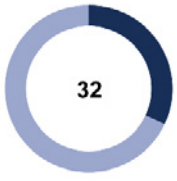
Software Development

(as of January 2022)

Approach: Agile

Average time of software deliveries (months)

Software percentage of total program cost



Software type

5 percent Off-the-shelf

0 percent Modified off-the-shelf

95 percent Custom software

The program office corrected the delivery time to reflect quarterly evaluation and feedback by the user during system testing, as opposed to the anticipated annual deliveries upon system fielding in last year's assessment.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (12/2009)	Latest (4/2021)	Percentage change
Development	$1,888	$4,765	+152.4%
Procurement	$4,064	$3,921	-3.5%
Unit cost	$20	$18	-8.9%
Total quantities	296	479	+61.8%

Total quantities comprise 25 development quantities and 454 procurement quantities.

Attainment of Product Knowledge (as of January 2022)

	Status at Development Start	Current Status
Resources and requirements match		
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	●
Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA	NA
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	●	●

● Knowledge attained ... Information not available

○ Knowledge not attained **NA** Not applicable

We did not assess IAMD's demonstration of critical processes in statistical control or on a pilot production line because the program office reported that there are no such processes, as the program's hardware is primarily integrating commercial off-the-shelf items.

IAMD Program

Technology Maturity, Design Stability, and Production Readiness

The IAMD program demonstrated that its four critical technologies are mature, as we previously reported. The program also released all of its design drawings to manufacturing, indicating a stable design.

IAMD was approved to begin low-rate initial production in January 2021 and reported competitively awarding a production contract in the first quarter of fiscal year 2022. The program office reported that it does not have any critical manufacturing processes and is primarily integrating commercial off-the-shelf items. It also stated that it ensures all components meet design specifications via program requirements and testing.

IAMD participated in a successful developmental test in July 2021 that included a contested electronic environment involving radars that the program uses, according to officials. The Army conducted this test as risk reduction prior to initial operational testing, which was delayed by 1 quarter after the Army determined minor software updates were needed and is now planned to be conducted in the second and third quarters of fiscal year 2022.

Software and Cybersecurity

With the January 2021 production decision, the Under Secretary of Defense for Acquisition and Sustainment also approved IAMD to conduct the software-related efforts of the program under the software acquisition pathway, while the hardware continues under the major capability acquisition pathway. The software portion of the program moved into the planning phase of the software acquisition pathway in January 2021 and was subsequently approved to enter the execution phase in September 2021.

According to the program office, the transition of the software portion of the program to the software pathway formally concluded IAMD's participation in a DOD Agile software pilot program. During the pilot, the program shifted responsibility for software development and performance from a single prime contractor to a government-led team. According to the program office, it worked closely with stakeholders to redefine roles and responsibilities, establish a new cadence, and define expectations. It found that including the user in early Agile planning and transition activities ultimately provided a product that better met user requirements and maximized user support during development. The program office indicated it plans to continue to release new software increments quarterly for evaluation and feedback from the user as it did during the pilot. More flexible requirements development and more frequent software releases—enabling earlier detection of errors and refinement of the software—were cited by the program as the main benefits of moving to the software pathway.

The program said it conducted a cooperative vulnerability and penetration assessment in August 2021 and an adversarial assessment in October 2021. The program also conducted such assessments in 2020.

Other Program Issues

According to the program office, it made progress over the past year addressing deficiencies with a trailer that provides storage space for IAMD's Integrated Collaborative Environment components, which we reported on in our previous assessment. Officials stated that they are in the process of a redesign effort and will be transitioning from an Army common trailer design to a truck-based platform. According to the program office, the truck-based platform will eliminate transportability and mobility challenges and allow for growth to accommodate future hardware updates or obsolescence mitigations. The program started building prototypes and reported placing an order for its first set of trucks, which officials anticipate will be ready for testing in the third quarter of fiscal year 2022. According to the program office, the transition is not expected to affect the program's overall schedule.

The program reported approximately $1 billion more in estimated development costs since our last assessment. A new baseline cost estimate was prepared and validated by the Army and the Office of the Secretary of Defense in support of the January 2021 production decision. According to the program office, the updated cost estimate increased funding through fiscal year 2031 in order to provide additional warfighter capability to respond to emerging threats, such as enabling integration with additional weapons and sensors, as well as continuous software development and testing.

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.

Source: U.S. Army. | GAO-22-105230

Improved Turbine Engine Program (ITEP)

The Army's ITEP is developing a next generation turbo-shaft engine for the Black Hawk, Apache, and Future Attack Reconnaissance Aircraft (FARA) fleets. The new engine is required to fit inside the existing engine compartments of Black Hawk and Apache helicopters and to integrate with FARA. ITEP is also expected to provide an increase in power, improve fuel efficiency, enhance reliability, and lower sustainment costs. The Army plans to field the improved turbine engine for all platforms in fiscal year 2027.

Program Essentials

Milestone decision authority: Army

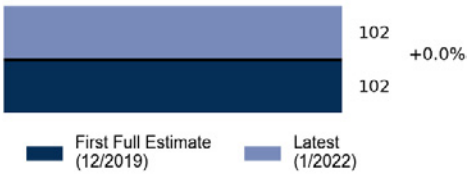
Program office: Redstone Arsenal, AL

Prime contractor: General Electric Aviation

Contract type: CPIF

Acquisition Cycle Time

(in months)



Software Development

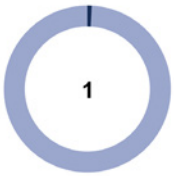
(as of January 2022)

Approach: Agile and Incremental

Average time of software deliveries (months)

Information not available

Software percentage of total program cost



Software type

1 percent Off-the-shelf

0 percent Modified off-the-shelf

99 percent Custom software

ITEP uses a combination of software development approaches with different delivery time frames.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (12/2019)	Latest (8/2020)	Percentage change
Development	$2,080	$2,008	-3.4%
Procurement	$10,520	$10,522	+0.0%
Unit cost	$2	$2	-0.6%
Total quantities	6,258	6,258	+0.0%

Total quantities comprise 69 development quantities and 6,189 procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at Development Start	Current Status
Resources and requirements match		
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	○
Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	●	●
Test a system-level integrated prototype	○	○
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA	NA
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ... Information not available

○ Knowledge not attained **NA** Not applicable

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

ITEP

Technology Maturity and Design Stability

ITEP reported its critical technologies as approaching maturity, a change from last year when the program reported them as fully mature. Program officials told us that this year's levels are based on a more realistic assessment of prototype testing than the assessment supplied last year by the prime contractor. That assessment rated three technologies as mature based on their use in other commercial products. We updated our Attainment of Product Knowledge graphic to reflect the testing-informed assessment.

Program officials plan to verify technology maturity during ITEP's first system-level engine test beginning in the second quarter of fiscal year 2022. The test was initially scheduled for January 2021 but manufacturing was delayed due to COVID-19. Leading acquisition practices call for this testing to be completed prior to design review, but it is now scheduled to begin more than a year and a half after the design review. This could increase the risk of costly, time-intensive rework of the prototype if testing reveals issues. The delay also intensifies existing manufacturing risks discussed below, and delayed delivery of the first ITEP engines for FARA from the first quarter of fiscal year 2022 to the first quarter of fiscal year 2023.

ITEP released over 90 percent of its design drawings for its critical design review in July 2020. Moreover, according to the program, ITEP successfully completed the first incremental critical design review with the Apache program in December 2020 and the FARA system requirements review in February 2021. Blackhawk critical design reviews are scheduled for fiscal years 2022 and 2023. These reviews are critical to ITEP's technology maturation and reduction of integration risk with each aircraft. Without fully mature technologies, however, ITEP risks issues emerging in testing that could require re-designs that disrupt integration with these aircraft.

Production Readiness

Over the past year, engine production start was delayed by several months due to COVID-19 manufacturing impacts and funding cuts in fiscal years 2020 and 2021.

ITEP continues to track two manufacturing risks identified in last year's report, which could affect engine delivery and flight test schedules. The first is a failure of a production instrument to demonstrate expected performance in a production representative environment prior to design review. The program is using new tooling and leveraging parts from other programs to resolve the issue, which could result in rework and delays. The second risk is delayed delivery of the engine's front frame and oil tank due to a 2020 delivery delay of two additive manufacturing machines required for their production. For FARA's first ITEP engines, this issue resulted in a roughly 9-month delivery delay. While traditional manufacturing techniques could be utilized as alternatives, their use would likely result in increased weight, further contributing to the existing weight risk tracked by the program. The program is working to recover schedule delays through multiple engineering efforts to reduce cycle time and improve production.

Software and Cybersecurity

Program officials identified ITEP's software development as a risk due to hardware design changes that required additional software development, but have been unable to provide information about how they plan to mitigate this risk. They did note that contractors completed two of the five developmental software releases planned between September 2020 and the second quarter of fiscal year 2024. The first release was completed in July 2021, a delay of roughly 10 months, and the second in August 2021.

ITEP's software and hardware are not currently mature enough to support developmental and operational cybersecurity testing, according to program officials. They delayed cybersecurity vulnerability and adversarial assessments, tentatively scheduled for July 2021, to the third quarter of fiscal year 2023 and the third quarter of fiscal year 2025, as a result. Our prior work found that focusing on cybersecurity late in the development cycle or after a system is deployed is more difficult and costly than when handled early in the cycle.

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 program noted that during fiscal year 2021, it accomplished several key program events, including the Apache incremental critical design review, Black Hawk integrated baseline review, and FARA software preliminary design review. The program added that it is working toward its next major milestone—testing the first engine—currently planned for the second quarter of fiscal year 2022. In addition, the Army reiterated ITEP's commitment to cybersecurity and noted that the decision to delay formal test events is a demonstration of the program's commitment to deliver a secure product and preserve test resources.

Source: Lockheed Martin. | GAO-22-105230

Precision Strike Missile (PrSM)

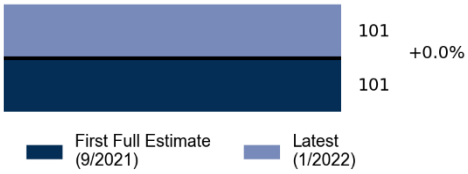
The Army's PrSM is a ballistic missile designed to attack area and point targets at distances ranging from 60 to more than 499 kilometers. Each PrSM missile container will hold two missiles, double the legacy missile container's capacity. The Army designed PrSM as one of a family of munitions for compatibility with existing rocket launcher systems and to comply with statutory requirements for insensitive munitions and DOD policy on cluster munitions.

Program Essentials

Milestone decision authority: Army
Program office: Redstone Arsenal, AL
Prime contractor: Lockheed Martin
Contract type: FFP

Acquisition Cycle Time

(in months)



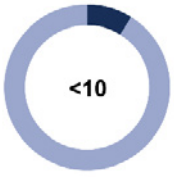
Software Development

(as of January 2022)

Approach: Agile and Waterfall

Average time of software deliveries (months)

Software percentage of total program cost



Software type

0.4 percent Off-the-shelf

0 percent Modified off-the-shelf

99.6 percent Custom software

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (9/2021)	Latest (9/2021)	Percentage change
Development	$1,067	$1,067	+0.0%
Procurement	$5,642	$5,642	+0.0%
Unit cost	$2	$2	+0.0%
Total quantities	4,021	4,021	+0.0%

Total quantities comprise 35 development quantities and 3,986 procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Development Start**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	○
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	○
Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	○	○
Test a system-level integrated prototype	●	●
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA	NA
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained ... Information not available

○ Knowledge not attained **NA** Not applicable

Our scores for PrSM technology maturity reflect critical technologies being developed by the program and other entities. We did not assess PrSM's manufacturing maturity because the program has yet to reach production; however, the program stated that it tested a production-representative prototype in the system's intended environment.

PrSM Program

Technology Maturity and Design Stability

PrSM entered system development in September 2021 with six of its 10 critical technologies fully mature. One critical technology was approaching maturity but is now expected to mature starting in the third quarter of fiscal year 2023, according to program officials, once a prototype completes component qualification and subsequent flight testing. Lockheed was awarded an undefinitized project agreement modification in June 2020 to conduct component qualification and system flight tests. Two additional critical technologies could not be fully assessed for maturity as final testing is planned for fiscal year 2024. The final critical technology is developed by a separate program and is not yet available for testing.

In May 2021, an independent technical risk assessment determined PrSM to be low risk. However, our prior work found that, until all critical technologies are fully mature, programs risk costly and time-intensive redesign work if problems are found later in testing.

PrSM completed its critical design review in November 2021, having met one of two leading acquisition practices associated with design stability. Specifically, PrSM tested a system-level integrated prototype but had yet to release the recommended percentage of design drawings to manufacturing.

In May 2021, PrSM conducted system-level developmental testing on a fully-configured prototype in its intended environment, in accordance with leading acquisition practices. During this time, the PrSM missile successfully completed an approximately 400-kilometer demonstration, confirming flight trajectory, range, and accuracy. In October 2021, the PrSM missile completed its fifth successful flight test where it flew an extended range mission over the Pacific Ocean.

As of its critical design review, PrSM released 82 percent of its design drawings, short of the leading acquisition practice to complete 90 percent before that time. Our prior work found that proceeding without a mature design places programs at significantly higher risk of cost and schedule growth.

Production Readiness

At system development start in September 2021, the Army approved production of hundreds of missiles for an initial early capability fielded via an Urgent Materiel Release authority, according to program officials. Prior to production, the program office plans to finalize the design and establish critical manufacturing processes. However, by committing to purchasing a large quantity before technologies and manufacturing processes are mature and the design is stable, the program is at greater risk if issues emerge in testing that require rework on missiles already in production. According to Army officials, final missile design will be established by the low- and full-rate production decisions in the third quarter of fiscal year 2025.

Software and Cybersecurity

As of July 2021, PrSM reported that it received three planned missile software deliveries to support developmental flight testing. An updated software release will be required prior to the start of functional qualification testing in the fourth quarter of 2022, according to program officials. PrSM updated its cybersecurity strategy in October 2020. The program completed a tabletop exercise and penetration testing in April and August 2021, respectively.

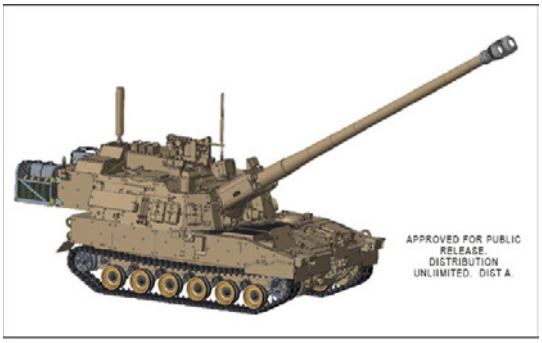
Other Program Issues

Completion of PrSM's capability development document slipped about 3 months to June 2021 due to changes in requirements and delays in the cost estimation process prior to Army leadership review and approval, according to the program office. Specifically, program officials said that PrSM requirements changed to increase the maximum range as well as update survivability requirements. In September 2021, PrSM updated its cost estimate for the development start milestone to reflect these changes to requirements as well as plans to procure roughly 1,500 additional missiles as compared to our prior assessment.

As of July 2021, program officials stated that they are tracking efforts to address supply chain concerns. They noted that these risks have not caused schedule or cost variances as of October 2021.

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 is executing within its cost, schedule, and performance objectives. It added that in September 2021, it awarded a production contract to Lockheed Martin to produce initial PrSM missiles, with missile delivery expected within 24 months. The Army stated that this production contract is being executed under the Adaptive Acquisition Framework's urgent capability acquisition pathway, while system development efforts are being executed under the major capability acquisition pathway.



Source: U.S. Army. | GAO-22-105230

Extended Range Cannon Artillery (ERCA)

The Army's ERCA program is an upgrade to the M109 self-propelled howitzer intended to improve lethality, range, and reliability. The ERCA program, using the MTA rapid prototyping pathway, plans to add armament, electrical systems, and other upgrades to the existing vehicle. Subsequent to the rapid prototyping effort, the program plans to deliver future improvements including the number of rounds fired per minute.

- **9/18** MTA initiation
- **10/18** MTA funds obligated
- **7/19** Contract award
- **9/19** Preliminary design review
- **6/21** Prototype configuration review
- **1/22** GAO review
- **Fiscal year 2023** Critical design review/Operational demonstration/First unit issued
- **10/23** 5 years since MTA funds obligated
- **TBD** Expected MTA completion

Program Essentials

Decision authority: Army

Program office: Warren, MI

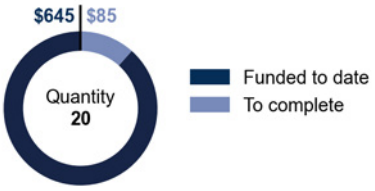
Contractor: BAE Systems, integrated by the Army's Development Command, Armaments Center

MTA pathway: Rapid prototyping

Contract type: CPFF (development) (using other transaction authority)

Estimated Middle Tier of Acquisition Cost and Quantities

(fiscal year 2022 dollars in millions)



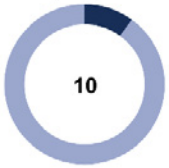
Software Development

(as of January 2022)

Approach: Agile

Average time of software deliveries (months)

Software percentage of total program cost



Software type

- 0 percent Off-the-shelf
- 90 percent Modified off-the-shelf
- 10 percent Custom software

Program Background and Transition Plan

The Army initiated ERCA using the MTA rapid prototyping pathway in September 2018. In March 2020, the program demonstrated the system's extended range capability. In September 2020, the program began its assessment of its first of 20 planned prototypes. The rapid prototyping effort was initially projected to end in the first quarter of fiscal year 2024, at which point the Army planned to issue up to 18 of the prototypes to an artillery battalion. In July 2021, however, testing revealed that key technologies were not as mature as expected, among other issues. Officials subsequently reported that the program cannot meet its goals within the 5-year period established by DOD's MTA policy and are coordinating with stakeholders to determine the program's path forward.

Transition Plan: Transition to the major capability acquisition pathway with entry at production.

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

Planned Knowledge by MTA Transition			
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	Demonstrate all critical technologies in form, fit, and function within a realistic environment	◻
Complete system-level preliminary design review	●	Release at least 90 percent of design drawings	◐
Test a system-level integrated prototype	●	Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	⊗
Demonstrate critical processes on a pilot production line	⊗	Test a production-representative prototype in its intended environment	◻

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned

... Information not available NA Not applicable

ERCA Program

Updates to Program Performance and Program Business Case

ERCA encountered multiple challenges during the past year, including delays in maturing critical technologies. These issues are likely to lead to schedule delays beyond those we reported last year and may lead to cost growth.

The program still lacks a formal technology risk assessment and a cost estimate based on an independent assessment—key elements of a program's business case. Program officials stated that they completed a technology readiness assessment in July 2021 to identify the maturity of ERCA subsystems and components. Program officials stated that they are in the process of developing an approach for the ERCA program's technology risk assessment, which will build on the readiness assessment to help the program identify, assess, and mitigate cost, schedule, and performance risks related to technology. Officials stated that they are working with Army cost analysts to develop a life-cycle cost estimate, which they plan to complete before the program transitions to the major capability acquisition pathway.

Technology

The program completed its prototype configuration review in June 2021—nearly a year later than previously planned—which confirmed ERCA's prototype design. Subsequent to this review, the July 2021 technology readiness assessment identified a critical subcomponent of the cannon assembly, one of ERCA's critical technologies, as immature. The assessment also showed that multiple issues require additional effort for maturation and that any resulting design changes may affect interfaces with the cannon assembly. In addition, officials stated that these changes would have significant cost and schedule effects.

The technology readiness assessment also identified issues with ammunition developed by another Army program that the ERCA program needs to achieve its range requirements. Test officials stated that the program needs to test ERCA with this ammunition. While the program has yet to establish a specific date for this test, this interdependency further increases the program's overall schedule risk.

In response, program officials delayed the program's critical design review to mid-2023, which is about a year later than previously planned. Program officials stated that the additional time is necessary to collect data and mature critical technologies to inform decisions.

Software Development and Cybersecurity

Program officials stated that they use Agile software development to develop a mix of customized government off-the-shelf and custom software to support ERCA fire control software. They also noted that they completed two software deliveries since program initiation. The program plans three additional deliveries before the completion of the MTA effort.

Transition Plan

The Army initially planned to transition ERCA to the major capability acquisition pathway with entry at production in the first quarter of fiscal year 2024 following the completion of the current MTA effort. However, Army officials said the program incurred delays due to COVID-19, prototype manufacturing, and the availability of ammunition for testing. As a result, officials stated that there is a significant risk that the program will not be able to complete planned testing and development efforts within the 5-year MTA time frame. In November 2021, however, the Army Acquisition Executive reviewed the status of the ERCA program and directed program officials to continue to execute while pursuing a waiver to the 5-year MTA time frame as provided in DOD policy through the Under Secretary of Defense for Acquisition and Sustainment. If the requested extension is not approved, the program plans to pursue a transition to the major capability acquisition pathway.

Program Office Comments

We provided a draft of this assessment to the Army for review and comment. Army officials provided technical comments, which we incorporated where appropriate. Army officials stated that the program is on schedule to deliver prototypes to support the planned first unit issued in the fourth quarter of fiscal year 2023 and subsequently conduct an Army-directed year-long operational assessment. These officials stated that the program's schedule slips are a result of developmental challenges, coupled with COVID-19 effects on personnel availability and supply chain shortages that continue to stress prototype and ammunition deliveries.

Army officials also stated that testing indicates the cannon assembly performs well and munitions can achieve the objective range. They added that design updates to key enabling technologies are being evaluated. The program plans to assess test results and validate the production technical data package during fiscal year 2022 to support release of the production request for proposal to industry in fiscal year 2024.

Source: U.S. Army. | GAO-22-105230

Future Long-Range Assault Aircraft (FLRAA)

The Army's FLRAA program plans to develop and produce a medium-sized assault and utility rotorcraft to support the Army's Future Vertical Lift capability needs. The Army expects FLRAA to deliver speed, range, agility, endurance, and sustainability improvements as compared with Black Hawk helicopters. The Army also expects the program to provide combatant commanders with tactical capabilities at operational and strategic distances.

Program Essentials

Decision authority: Army

Program office: Huntsville, AL

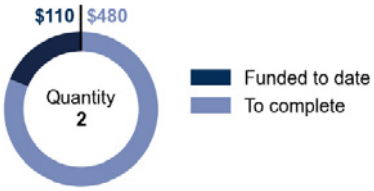
Contractors: Bell Textron, Inc.; Sikorsky Aircraft Corp.- Boeing Co. (partnership)

MTA pathway: Rapid prototyping

Contract type: cost reimbursable with cost share (competitive demonstration and risk reduction) (using other transaction authority)

Estimated Middle Tier of Acquisitions Cost and Quantities

(fiscal year 2022 dollars in millions)



The FLRAA MTA effort will deliver two virtual prototypes.

Software Development

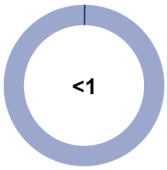
(as of January 2022)

Approach: Incremental, Agile, Model-Based Design

Average time of software deliveries (months)

Information not available

Software percentage of total program cost



Software type

25 percent Off-the-shelf

25 percent Modified off-the-shelf

50 percent Custom software

The Army has yet to fully develop the program's software approach.

Program Background and Transition Plan

The Army initiated FLRAA as an MTA effort in October 2020 to develop two virtual prototypes. In March 2020, it selected two contractors to develop conceptual prototype designs under an existing other transaction agreement prior to deciding on the overall FLRAA acquisition approach. Program officials stated they intend for the two designs to inform the competitive award of a single contract in the fourth quarter of fiscal year 2022. This contract is expected to support development of the virtual prototypes as well as system development and low-rate initial production in follow-on efforts. The virtual prototyping will inform requirement updates before the Army begins system development in the fourth quarter of fiscal year 2023. MTA close-out activities are planned until the third quarter of fiscal year 2024.

Transition Plan: Transition to the major capability acquisition pathway with entry at system development.

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

Planned Knowledge by MTA Transition

Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	Demonstrate all critical technologies in form, fit, and function within a realistic environment	⊗
Complete system-level preliminary design review	◐	Release at least 90 percent of design drawings	NA
Test a system-level integrated prototype	NA	Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA
Demonstrate critical processes on a pilot production line	NA	Test a production-representative prototype in its intended environment	NA

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned

... Information not available NA Not applicable

We did not assess FLRAA's planned knowledge by MTA transition for design stability and manufacturing maturity because those metrics are not applicable to programs transitioning at system development.

FLRAA Program

Key Elements of Program Business Case

The FLRAA program had some key business case elements developed at initiation—an approved requirements document, acquisition strategy, and cost estimate based on an independent assessment—but has yet to complete formal technology and schedule risk assessments. Our prior work shows that these assessments can help inform decision makers about risks to an MTA rapid prototyping effort's ability to meet its statute-based objectives.

The program completed an informal technical risk assessment in 2019 and used risk reduction activities—including the Army's Joint Multi-Role Technology Demonstrator, an air vehicle and mission systems architecture demonstration program begun in 2013—to validate new vertical lift capabilities. The program expects to have a technology risk assessment, an independent technical risk assessment, and a formal schedule risk assessment completed to support the program's transition to the major capability acquisition pathway in 2023.

In October 2020, the Army approved the FLRAA acquisition strategy and program requirements in an abbreviated capability development document. The Army expects a capability development document with refined requirements that align with the winning design to be approved by the Joint Requirements Oversight Council prior to entering system development for the follow-on effort in 2023. The Army—in coordination with DOD's Office of Cost Assessment and Program Evaluation (CAPE)—completed a draft cost position in November 2020 to inform the program's approval to proceed as an MTA effort. CAPE plans to complete an independent cost estimate prior to the program entering system development.

Technology

The FLRAA program's two critical technologies are approaching maturity. Program officials noted that these technologies are considered critical for both aircraft designs currently in competition for the FLRAA program. Program officials stated that aircraft from the Joint Multi-Role Technology Demonstrator program helped evaluate these technologies through flight testing, which will continue on the demonstrator aircraft and in laboratory settings that simulate the FLRAA operating environment.

According to the program office, the maturity of FLRAA's two critical technologies will, at a minimum, meet DOD requirements prior to the start of system development. However, their maturity at that time is not expected to conform to the level recommended by leading practices. Our prior work found that entering system development without mature technologies exposes programs to more risk of costly and lengthy rework if issues are discovered later in development.

Software Development and Cybersecurity

Although software delivery plans are still being defined, FLRAA plans to use a mixture of development approaches—including Agile and incremental—to deliver off-the-shelf and custom software. The program intends to use a modular open system approach to enable rapid insertion of future software technologies to address evolving needs. The program office is in the process of developing a cybersecurity strategy to support the start of system development.

Transition Plan

The Army plans to transition FLRAA to the major capability acquisition pathway with entry at system development in the fourth quarter of fiscal year 2023. Some MTA closeout activities are expected to continue until the third quarter of fiscal year 2024. During the current MTA effort, the program plans to complete the development of two virtual prototypes—specifically, two portable crewstations and a vehicle dynamics model. Prior to the transition, the Army plans to complete initial design concept reviews for the two competing designs in spring 2022 and receive independent preliminary design review assessments for each design. Further, the Army intends to complete a preliminary design review for the winning design in the third quarter of fiscal year 2023 that incorporates additional design knowledge from virtual prototype development efforts. Our prior work has shown that completing a design review prior to development start is associated with lower cost and schedule growth.

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 noted that its use of the MTA pathway accelerates capability maturation and allows for early development of virtual aircraft prototypes. The Army also stated that its goal is an affordable capability for FLRAA that is optimized for performance and schedule, while accounting for budget constraints and future operational requirements. It added that the program is following a disciplined process that includes transparent feedback from industry and active engagement across the Army and with stakeholders from the Office of the Secretary of Defense. Lastly, the Army stated that the program will continue to look for ways to inform technology readiness and mutual opportunities with industry to mitigate risks and achieve a first unit equipped in 2030.

Source: © 2021 Dynetics, Inc. | GAO-22-105230

Indirect Fire Protection Capability Increment 2 (IFPC Inc. 2)

The Army's IFPC Inc. 2 is intended to enhance and extend the range of the first IFPC increment, which provided a short-range capability to counter threats from rockets, artillery, and mortars. IFPC Inc. 2 consists of four subsystems—an existing sensor, a fire control system, an interceptor missile, and a new air defense launcher. We previously assessed IFPC efforts to provide an interim capability, which is now a separate program.

- **8/21** MTA initiation
- **9/21** Contract award
- **1/22** GAO review
- **4-6/22** Design review 2
- **7-9/23** Delivery of combat capability
- **1-3/24** MTA completion
- **8/26** 5 years since MTA initiation

Program Essentials

Decision authority: Army

Program office: Huntsville, AL

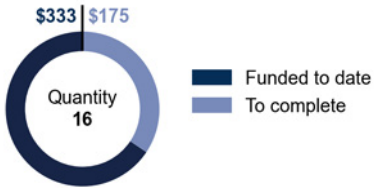
Prime contractor: Dynetics, Inc.

MTA pathway: Rapid prototyping

Contract type: FFP (using other transaction authority)

Estimated Middle Tier of Acquisition Cost and Quantities

(fiscal year 2022 dollars in millions)



Software Development

(as of January 2022)

Approach: Information not available

Average time of software deliveries (months)

Information not available

Software percentage of total program cost

Information not available

Software type

Information not available

The program reported that its software approach, delivery time frames, cost, and type will be determined in the future.

Program Background and Transition Plan

IFPC Inc. 2 was designated as an MTA rapid prototyping effort in August 2021. The Army concluded that pursuing a new air defense launcher using this authority was necessary to meet a statutory fiscal year 2023 deadline for deploying two batteries of the interim missile defense capability. The Army conducted a live-fire demonstration in April 2021 involving two contractors and subsequently awarded a prototype project other transaction agreement in September 2021 to Dynetics, Inc. to develop 16 prototypes of the air defense launcher. Program officials stated that several of these launchers will be consumed during testing and the remaining are expected to be fielded as a battery in late fiscal year 2023.

Transition Plan: Transition to the major capability acquisition pathway with entry at production.

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

Planned Knowledge by MTA Transition			
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	...	Demonstrate all critical technologies in form, fit, and function within a realistic environment	...
Complete system-level preliminary design review	●	Release at least 90 percent of design drawings	◐
Test a system-level integrated prototype	◐	Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	⊗
Demonstrate critical processes on a pilot production line	□	Test a production-representative prototype in its intended environment	⊗

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned

... Information not available NA Not applicable

We could not assess whether IFPC planned to demonstrate critical technologies in relevant or realistic environments by MTA transition because the program has yet to identify its critical technologies.

IFPC Inc. 2 Program

Key Elements of Program Business Case

Several key elements of IFPC's business case were approved prior to initiation, but the program has yet to complete a formal schedule or a technology risk assessment. Program requirements were validated in November 2016. The Army completed an independent cost analysis in July 2021 and approved the program's acquisition strategy at initiation in August 2021.

However, the program does not plan a schedule or technology risk assessment until the third quarter of fiscal year 2023, less than a year before the planned completion of the MTA effort. Our prior work shows that this type of information helps decision makers make well-informed choices about MTA initiation. Further, without the additional insight into schedule risk that could be gained during a formal schedule risk assessment, the program may miss opportunities to mitigate risks to meeting its statutory fiscal year 2023 IFPC battery deployment deadline.

Technology

The program has yet to identify its critical technologies but is developing the schedule for doing so. Once those technologies are identified, the program expects to conduct a technology readiness assessment to evaluate their maturity levels.

IFPC has an aggressive fielding timeline but faces technology integration risks. According to program officials, an early focus of the MTA effort is to integrate the IFPC Inc. 2 system into the Integrated Air and Missile Defense (IAMD) architecture, which must be done successfully prior to production. Officials stated that the April 2021 live-fire demonstration involving the two competing contractors focused on integration with the fire control system. Program officials stated that the IFPC program schedule is aligned with that of IAMD, and they are monitoring its development as part of their risk mitigation efforts.

The AIM-9X missile will be the interceptor used for the IFPC Inc. 2 program. According to program officials, Dynetics provided the Army a risk analysis of its concept design and plans to demonstrate prototype design in accordance with the program's test plan.

Software Development and Cybersecurity

IFPC has yet to finalize details of its software development approach. However, program officials told us they expect that the contractor will use an iterative development process for software development, with two system software releases approximately 1-3 months apart.

According to program officials, a planned update to the IFPC requirements document is expected to include protection against cybersecurity threats as a key performance parameter. The program plans to complete a cybersecurity assessment in mid-2022.

Transition Plan

The program plans to transition to the major capability acquisition pathway with entry at production. Prior to exiting the MTA pathway, the program plans to validate the prototypes' combat capability by conducting testing with soldiers from operational units using four prototypes in an operational environment. This testing is currently planned for the fourth quarter of fiscal year 2023. However, the program is not planning to attain key production knowledge prior to transition, such as by testing a production-representative prototype in its intended environment. Our prior work found that such testing reduces the risk of costly and time-intensive rework during production.

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 IFPC Inc. 2 is executing an aggressive schedule to prove system integration with the fire control system prior to completion of this MTA effort. The Army added that the rapid prototyping effort is on track to deliver a total of 16 IFPC Inc. 2 prototype systems by the fourth quarter of fiscal year 2023.

Source: U.S. Army. | GAO-22-105230

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 head gear. The system includes a heads-up display, sensors, on-body computer, and other elements intended to improve warfighter sensing, decision-making, target acquisition, and target engagement via a 24/7 situational awareness tool. IVAS has rapid prototyping and rapid fielding efforts ongoing. This assessment focuses on the rapid fielding effort.

Program Essentials

Decision authority: Army

Program office: Fort Belvoir, VA

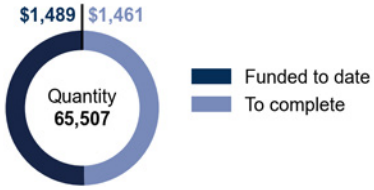
Prime contractor: Microsoft

MTA pathway: Rapid fielding

Contract type: FFP (production) (using other transaction authority)

Estimated Middle Tier of Acquisition Cost and Quantities

(fiscal year 2022 dollars in millions)



Cost and quantity reflect only the IVAS rapid fielding effort.

Software Development

(as of January 2022)

Approach: Agile, DevOps, and DevSecOps

Average time of software deliveries (months)

Software percentage of total program cost

Software type

0 percent Off-the-shelf

100 percent Modified off-the-shelf

0 percent Custom software

The program reported that software costs will be provided by the contractor in the future.

Program Background and Transition Plan

The Army initiated IVAS using the MTA rapid prototyping path in September 2018. After developing and testing a militarized IVAS prototype under the rapid prototyping effort, the Army approved the IVAS rapid fielding effort in December 2020. In March 2021, the Army used other transaction authority to award a follow-on production agreement to Microsoft. In January 2021, the Under Secretary of Defense for Acquisition and Sustainment conditionally approved the rapid fielding effort pending correction and verification of known technical deficiencies prior to operational testing, planned for August 2021. As of October 2021, the program had yet to verify fixes to these deficiencies and stated that it initiated a program replan, which included delaying the operational demonstration to the third quarter of fiscal year 2022 and production start to the fourth quarter of fiscal year 2022.

Transition Plan: Transition pathway yet to be determined.

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

Planned Knowledge by MTA Transition			
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	NA	Demonstrate all critical technologies in form, fit, and function within a realistic environment	NA
Complete system-level preliminary design review	NA	Release at least 90 percent of design drawings	NA
Test a system-level integrated prototype	NA	Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA
Demonstrate critical processes on a pilot production line	NA	Test a production-representative prototype in its intended environment	NA

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned

... Information not available **NA** Not applicable

We did not assess IVAS planned knowledge by MTA transition because the program has yet to determine its transition pathway for the rapid fielding effort.

IVAS Program

Key Elements of Program Business Case

While the IVAS rapid fielding effort had an approved requirement and acquisition strategy at the time of initiation, it did not have several other key elements of its business case recommended by our prior work—a cost estimate informed by independent analysis, or formal schedule and technology risk assessments—approved at that time. Our prior work shows that this type of information is important to help decision makers make well-informed choices about middle-tier initiation, including whether the program is likely to meet the statute-based objective of completing fielding within 5 years of the development of an approved requirement.

The IVAS program office developed a cost estimate in September 2020 to support the rapid fielding decision. The Under Secretary of Defense for Acquisition and Sustainment approved the rapid fielding effort in January 2021, on the condition that the program update its cost estimate to reflect the final negotiated contract price for the full cost of the rapid fielding effort prior to operational testing, scheduled for the third quarter of fiscal year 2022. The Office of the Deputy Assistant Secretary of the Army-Cost and Economics developed an independent cost estimate that is pending final approval. According to program officials, IVAS rapid fielding estimated costs increased since initiation due to the program's plan to spread production over 5 years instead of the initially planned 2 years, and the inclusion of additional costs that were not known or included in the original estimate.

The Office of the Under Secretary of Defense for Research and Engineering conducted an independent technical risk assessment in January 2019 to support the capability set 1 of the rapid prototyping effort. However, the program has not updated this assessment or conducted another formal assessment to support the rapid fielding effort. According to program officials, they have alternative approaches to monitoring technical risk. For example, they stated that the Office of the Director, Operational Test and Evaluation, assumed the role of providing test reports on capability sets 2-4, and they also have a continuous technical risk assessment process in place based in part on the original independent technical risk assessment, as well as other factors.

IVAS program officials said that schedule risk was assessed in September 2021 as part of the system replan, and they determined that schedule is the primary risk for the program.

Technology

All critical technologies were mature at the time of the rapid fielding decision in December 2020, according to program officials. However, as we previously reported, IVAS continues to experience technical challenges with display quality and reliability. The Army tested capability set 4—its expected fielding configuration—from April 2021 to July 2021. The Office of the Director, Operational Test and Evaluation found that capability set 4 showed improvements to the display, but most deficiencies were not corrected and the capability set had yet to demonstrate the capability to serve as a combat goggle.

The Army conducted a system replan review in September 2021 and developed a new program schedule to allow more time to correct the display before fielding. The revised system plan added procurement of roughly 200 prototypes and an additional soldier touch point in in the second and third quarters of fiscal year 2022. Furthermore, the operational demonstration is delayed until the third quarter of fiscal year 2022 and the first unit equipped was delayed from September 2021 to the fourth quarter of fiscal year 2022. Program officials said these delays are not expected to affect their ability to procure the full procurement objective quantity by the expected completion of the rapid fielding effort in the first quarter of fiscal year 2026.

Software Development and Cybersecurity

The IVAS program uses Agile, DevOps, and DevSecOps software development approaches and adopted Microsoft's development practices to deliver customized commercial software to the user for testing every 1 to 3 weeks, according to program officials.

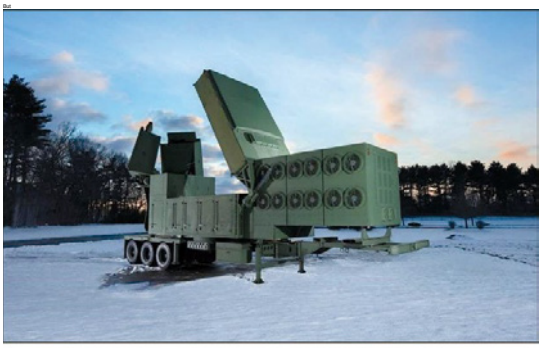
IVAS officials expect the program's cybersecurity plan to be completed in the second quarter of fiscal year 2022. The program conducted a Cooperative Vulnerability and Penetration Assessment in May 2021.

Transition Plan

Program officials told us they have yet to determine how IVAS will proceed at the completion of the rapid fielding effort in the first quarter of fiscal year 2026. They said they are considering the major capability acquisition or software acquisition pathways for future development and procurement.

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.



Source: Copyright 2020 Raytheon Company. | GAO-22-105230

Lower Tier Air and Missile Defense Sensor (LTAMDS)

The Army's LTAMDS, an MTA effort, is planned as a multifunction radar that will replace the legacy Patriot radar. The legacy radar faces changing threats, growing obsolescence, and increasing operational costs. The Army expects that LTAMDS, as the lower-tier component of the Army's Integrated Air and Missile Defense Battle Command System architecture, will enhance radar performance, modernize technology, and improve reliability and maintainability to better address emerging threats. The Army plans to deploy the system worldwide.

Program Essentials

Decision authority: Army

Program office: Redstone Arsenal, AL

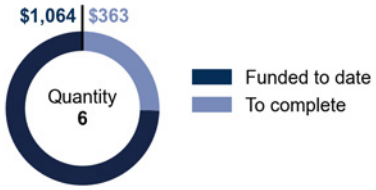
Prime contractor: Raytheon

MTA pathway: Rapid prototyping

Contract type: FFP (build and test prototypes) (using other transaction authority)

Estimated Middle Tier of Acquisition Cost and Quantities

(fiscal year 2022 dollars in millions)



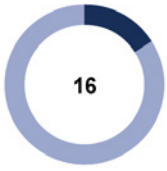
Software Development

(as of January 2022)

Approach: Agile

Average time of software deliveries (months)

Software percentage of total program cost



Software type

0 percent Off-the-shelf

67 percent Modified off-the-shelf

33 percent Custom software

Program Background and Transition Plan

The Army initiated LTAMDS as a pre-major defense acquisition program, but pursued the MTA rapid prototyping pathway in 2018 in response to an analysis of emerging threats and a statutory requirement that the Army issue an acquisition strategy to achieve an initial operational capability by the end of 2023. This change accelerated the program's development by 4 years. Since 2018, the Army employed MTA rapid prototyping with the goal of fielding six representative prototypes by the fourth quarter of fiscal year 2022.

Transition Plan: Transition to the major capability acquisition pathway with entry at production.

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

● Knowledge attained ... Information not available

○ Knowledge not attained **NA** Not applicable

Planned Knowledge by MTA Transition

Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	Demonstrate all critical technologies in form, fit, and function within a realistic environment	◐
Complete system-level preliminary design review	●	Release at least 90 percent of design drawings	●
Test a system-level integrated prototype	◐	Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	⊗
Demonstrate critical processes on a pilot production line	⊗	Test a production-representative prototype in its intended environment	◐

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned

... Information not available **NA** Not applicable

LTAMDS Program

Updates to Program Performance and Program Business Case

Despite being more than 3 years into its rapid prototyping effort, LTAMDS does not have a cost estimate based on an independent assessment or formal schedule and technical risk assessments—key elements of its business case. Our prior work found that these assessments can help identify challenges that could hinder a rapid prototyping effort from meeting its statute-based objective.

Officials stated that the independent technical risk and cost assessments are forthcoming, with the former slated for the first quarter of fiscal year 2023 and the latter planned as the program nears transition to the major capability acquisition pathway in the first quarter of fiscal year 2024. Program officials stated they have no plans to conduct a formal schedule risk assessment. Last year, the program reported that it conducted a formal schedule risk assessment but clarified this year that its schedule risk assessments are informal. The absence of a formal schedule risk assessment conflicts with our prior work, which found that such an assessment can help lead to well-informed decisions on whether a program is likely to meet its objectives. We updated our Key Elements of a Business Case table to reflect this new information.

We also updated the estimated program cost to reflect a significant increase compared to last year. This year, the LTAMDS cost estimate is approximately $1.4 billion, which covers the MTA rapid prototyping effort until fiscal year 2024. In contrast, officials told us that the approximately $600 million that we reported last year only covered developing and fielding six early prototypes through fiscal year 2022.

While LTAMDS officials noted testing began on an integrated prototype in November 2021 and that they expect testing to be completed by the end of the second quarter of fiscal year 2022, the program delayed other test activities. For example, the program delayed testing the prototypes in their operational environment from November 2021 to the third quarter of fiscal year 2023 after Raytheon reported challenges related to integration and the transition of developmental items into production. Officials acknowledge that hardware delays increased program risk, but estimate that all testing will be completed by the end of fiscal year 2023.

Technology

Program officials identified 10 critical technologies, including six identified over the past year. Program officials stated that all but one are mature. Officials anticipate that this technology will reach maturity in fiscal year 2023 after completing final system integration and testing.

Software Development and Cybersecurity

The program reported it uses an Agile software development approach to release software every 3 months. As of July 2021, the program completed 7 of 12 planned engineering releases. The program plans to field working software to warfighters in fiscal year 2023.

LTAMDS has an approved cybersecurity strategy that it plans to update in the fourth quarter of fiscal year 2022. The program planned both a cybersecurity assessment during developmental testing and a full system assessment in the fourth quarter of fiscal year 2022. According to the program office, this testing schedule allows time to incorporate findings before the updated cybersecurity strategy is approved in 2023.

Transition Plan

Program officials told us that the Program Executive Office for Missiles & Space approved a new acquisition strategy for LTAMDS in November 2021 and plans to seek approval from the Army Acquisition Executive in fiscal year 2022. Under the new acquisition strategy, LTAMDS would transition to the major capability acquisition pathway at the production decision in the first quarter of fiscal year 2024. This planned schedule would extend the current rapid prototyping effort an additional year from 2022 to 2023. LTAMDS's original acquisition strategy was to transition from rapid prototyping to the rapid fielding effort in the fourth quarter of fiscal year 2022 for production. However, officials said that the program's funding profile did not support the fielding of these radars within 5 years.

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 it is on track to field one LTAMDS battalion no later than December 2023. It added that it completed the cost, schedule, and technology risk assessments required for MTA rapid prototyping efforts and that it plans to complete formal cost, schedule, and technology risk assessments prior to entering production in the first quarter of fiscal year 2024.

Source: U.S. Army. | GAO-22-105230

Mobile Protected Firepower (MPF)

The Army's MPF, a program using the MTA pathway, is intended to provide a new direct fire capability for support of infantry units across a range of military operations. One key requirement is that MPF be air-transportable to enable initial entry operations. The Army also expects it to work in conjunction with other vehicles such as the Light Reconnaissance Vehicle and Ground Mobility Vehicle. The Army plans to equip the first unit with MPF in fiscal year 2025.

Program Essentials

Decision authority: Army

Program office: Detroit Arsenal, MI

Prime contractor: BAE Systems; General Dynamics Land Systems

MTA pathway: Rapid prototyping

Contract type: FFP

Estimated Middle Tier of Acquisition Cost and Quantities

(fiscal year 2022 dollars in millions)

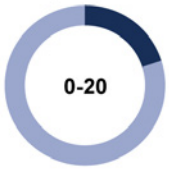
Software Development

(as of January 2022)

Approach: Incremental

Average time of software deliveries (months)

Software percentage of total program cost



Software type

92 percent Off-the-shelf

5 percent Modified off-the-shelf

3 percent Custom software

Program officials said the above time frame reflects the initial software release and subsequent deliveries that are made as required for the platform.

Program Background and Transition Plan

The Army initiated MPF as an MTA rapid prototyping effort in September 2018 with the objective of completing prototyping by the third quarter of fiscal year 2022. In December 2018, the program awarded contracts to two companies to each develop 12 preproduction vehicles for test and evaluation, a total of 24 prototypes. The Army is evaluating the prototype vehicle designs through a series of tests, including a Soldier Vehicle Assessment that commenced in January 2021 and a limited user test in September 2021. The Army intends to demonstrate nearly all required capabilities in an operational environment by the end of the MTA effort, currently planned for the third quarter of fiscal year 2022.

Transition Plan: Transition to the major capability acquisition pathway with entry at production.

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

Planned Knowledge by MTA Transition			
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	NA	Demonstrate all critical technologies in form, fit, and function within a realistic environment	NA
Complete system-level preliminary design review	●	Release at least 90 percent of design drawings	●
Test a system-level integrated prototype	●	Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	⊗
Demonstrate critical processes on a pilot production line	⊗	Test a production-representative prototype in its intended environment	●

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned

... Information not available NA Not applicable

We did not assess MPF's technology maturation plans for critical technologies because the program office stated that the system does not have any such technologies.

MPF Program

Updates to Program Performance and Program Business Case

The Army received prototypes from both vendors and began testing them in 2020 as they were delivered. Program officials stated that prototype vehicles were delivered in fiscal years 2020 and 2021.

The Army is evaluating the vehicle designs through a series of tests, including a Soldier Vehicle Assessment that commenced in January 2021. During this assessment, warfighters tested each vendor's vehicle separately, using the prototypes in unit-level training to assess tactics, techniques, and procedures. The Army completed assessments for both vendors in fiscal year 2021. At the assessment's conclusion, participating units assessed the prototype's current capabilities and provided feedback on the vehicles.

Beginning in September 2021, the Army's Operational Test Command conducted limited user tests—independent tests of the prototypes—to provide early data on mission effectiveness. These tests started later than planned due to part and production delays for the prototypes caused by COVID-19. For example, a 4-week facility closure slowed down testing on the cannon, required prior to the release of the cannon assemblies to vendors. According to the program, delays to the planned testing schedule did not affect the program's planned MTA completion date.

Technology

As we reported previously, the Army determined that MPF does not have any critical technologies as its technologies derive from existing ones approaching maturity or that are mature. Program officials told us that both vendors' vehicles went through system integration and are progressing through their test plans. The program does not plan further development or integration during the MTA phase.

Software Development and Cybersecurity

As of August 2021, the vendors delivered four software releases. The program office discussed software considerations prior to testing the vehicles. Once it awards a contract to a single vendor, the program office expects software updates to occur yearly to support baseline changes to the program and obsolescence issues.

While the program plans some cybersecurity testing during the rapid prototyping effort—such as conducting cooperative vulnerability identification and cybersecurity development tests in the second quarter of fiscal year 2022—some network components that the program will rely on are still under development. Full cybersecurity testing in an operational environment will not occur until after the program transitions to the major capability acquisition pathway. This timing risks costly, time-intensive rework of vulnerabilities later in development.

Transition Plan

The program released a request for proposals in November 2021 to support a planned production decision in the third quarter of fiscal year 2022 and a contract award to a single vendor. If the contract award occurs as scheduled, the program expects to conclude the MTA effort and transition to the major capability acquisition pathway with entry at production.

As we reported last year, the program does not plan to fully meet our leading acquisition practices for acquiring knowledge prior to production start. For example, it does not plan to test critical manufacturing processes on a pilot production line before entering production. We continue to be concerned that not taking these steps could increase the risk that the program may not be able to meet its cost, schedule, and quality targets for production units if the process does not meet efficiency or quality assumptions.

Additionally, program officials clarified that a date provided to us last year for completion of system-level integrated prototype testing referred to vendor testing of prototypes, which did not meet our criteria for a system-level integrated prototype test. They stated that they completed testing of an integrated prototype in the second quarter of fiscal year 2022.

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 MPF program is on schedule to award a low-rate initial production contract in fiscal year 2022 to the vendor with the solution it determines to be the best value. It also noted that the Soldier Vehicle Assessment, Limited User Tests, and other performance tests completed in 2021 provided valuable insights for the Army and industry.

Source: U.S. Army. | GAO-22-105230

Optionally Manned Fighting Vehicle (OMFV)

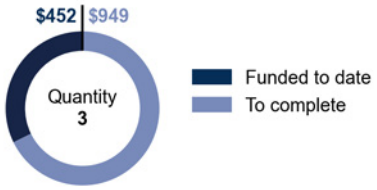
The Army's OMFV, an MTA effort, is the planned solution to maneuver warfighters on the battlefield to advantageous positions for close combat. OMFV is expected to allow for crewed or remote operation. It is intended to replace the existing Bradley Fighting Vehicle, a legacy vehicle that no longer has the capacity to integrate new technologies. The program is now pursuing a five-phase acquisition approach by using the MTA pathway (phases 1 to 3) and the major capability acquisition pathway (phases 4 and 5).

Program Essentials

Decision authority: Army
Program office: Warren, MI
Prime contractor: TBD
MTA pathway: Rapid prototyping
Contract type: FFP

Estimated Middle Tier of Acquisition Cost and Quantities

(fiscal year 2022 dollars in millions)



Software Development

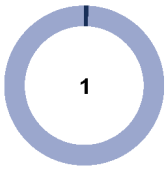
(as of January 2022)

Approach: Information not available

Average time of software deliveries (months)

Information not available

Software percentage of total program cost



Software type

Information not available

The program reported an estimated software cost, but the software approach and type have yet to be determined.

Program Background and Transition Plan

The Army initiated OMFV in 2018 and planned to complete prototyping in fiscal year 2023. In 2020, the program updated its acquisition plan due to difficulty in achieving the Army's desired capabilities and time frames under its initial approach. In July 2021, as part of the second of five planned phases, the program reported awarding five contracts for concept design.

Transition Plan: Transition to the major capability acquisition pathway with entry at system development.

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

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

Planned Knowledge by MTA Transition

Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	...	Demonstrate all critical technologies in form, fit, and function within a realistic environment	...
Complete system-level preliminary design review	◐	Release at least 90 percent of design drawings	NA
Test a system-level integrated prototype	NA	Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA
Demonstrate critical processes on a pilot production line	NA	Test a production-representative prototype in its intended environment	NA

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned
... Information not available **NA** Not applicable

We did not assess OMFV planned knowledge by MTA transition for demonstration of critical technologies in relevant or realistic environments because the program has yet to identify its critical technologies. We also did not assess planned knowledge by MTA transition for design stability and manufacturing maturity because those metrics are not applicable to programs transitioning at system development.

OMFV Program

Updates to Program Performance and Program Business Case

The OMFV program initiated in 2018 without any of the business case elements that our prior work shows help decision makers make well-informed choices. Over the past year, however, OMFV continued to work to develop its business case.

In May 2021, OMFV program officials finalized an updated acquisition strategy for a new five-phase approach, which detailed plans to award up to five contracts for the concept design phase (phase 2) as part of the MTA rapid prototyping effort. The Army reported awarding these five contracts—with a combined value of nearly $300 million—in July 2021 to American Rheinmetall Vehicles, BAE Systems, General Dynamics Land Systems, Oshkosh Defense, and Point Blank Enterprises. Program officials plan to utilize a full and open competition to award up to three contracts for the combined detailed design phase (phase 3) and prototype build and test phase (phase 4) in early 2023, which will include further design, production, and testing of prototypes.

The Army also completed a formal schedule risk assessment as part of OMFV's updated acquisition strategy. Program officials told us they do not anticipate approval of formal requirements documentation until the second quarter of fiscal year 2024, several months before the planned completion of the MTA effort and the transition to the major capability acquisition pathway at system development. Further, according to officials, while the program is currently in the process of conducting informal technology risk assessments, it does not plan a formal assessment until 2023.

Technology

The Army has yet to identify OMFV's critical technologies. The Army plans to delay identifying them until it evaluates concept designs, which will allow vendors to identify new technologies that may expand program capabilities. Army officials said they plan to evaluate the risks associated with technologies for each of the vendors to support the award of combined phase 3 and phase 4 contracts in the second quarter of fiscal year 2023, and define critical technologies by the fourth quarter of fiscal year 2023. Program officials stated that their goal is to achieve full maturity for all technologies before completion of the MTA effort, which is consistent with our leading practices. If a significant number of technologies are identified that require maturation, however, the proposed time frame could be challenging. Our prior work on MDAPs shows that increasing technology levels can take several years and becomes more challenging as the technology approaches maturity.

After the program completes the rapid prototyping effort, program officials plan to field prototype vehicles from three contractors for demonstrations and testing during phase 4, the prototype build and test phase.

Software Development and Cybersecurity

The completion of the program's software development plan is contingent upon the design selected at the end of phase 3 and the vendors' software development plans. According to officials, completing initial concept reviews for the phase 2 designs at the end of fiscal year 2021 contributed to their understanding of the vendors' potential software plans.

Program officials stated that they plan to have an approved cybersecurity strategy by the third quarter of fiscal year 2024.

Transition Plan

According to the memorandum signed by the Under Secretary of Defense for Acquisition and Sustainment, the program was approved to use the engineering and manufacturing development contract award date as the date from which funds were first obligated. MTA policy provides that for programs designated before December 30, 2019, the 5-year time frame for MTA completion generally starts when funds are first obligated. OMFV plans to transition to a major capability acquisition program with entry at system development at the beginning of phase 4 in 2024. According to the program's updated acquisition strategy, the low-rate production decision is planned to occur at the start of phase 5 in the fourth quarter of fiscal year 2027, at least a 9-month delay from the date expected as of April 2020. This change also delayed the planned date for the first unit equipped, which is now in the second quarter of fiscal year 2029, rather than the end of fiscal year 2028.

Other Program Issues

The planned program schedule includes a 4-month gap between phase 2 and phase 3. Program officials stated that this gap is a function of plans to conduct a full and open competition for phase 3. Officials stated that the gap will provide time for vendors to incorporate the results of phase 2 testing into their final proposals and for the Army to make contract award decisions.

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.

Source: U.S. Army. | GAO-22-105230

Future Attack Reconnaissance Aircraft Program (FARA)

FARA is part of the Army's Future Vertical Lift family of systems and a top modernization priority of the Army. It is intended to provide capabilities to replace the mission of the OH-58D Kiowa Warrior and reconnaissance role of the AH-64E Apache to enable U.S. dominance on the multi-domain battlefield. The Army expects FARA to provide attack and reconnaissance capabilities with increased lethality, agility, range, survivability, and sustainability over the current fleet. The Army plans to acquire FARA using the major capability acquisition pathway.

Program Essentials

Milestone decision authority: Army

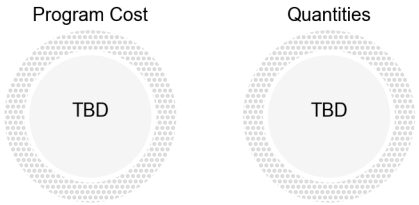
Program office: Redstone Arsenal, AL

Prime contractor: Bell Helicopter Textron, Inc; Sikorsky Aircraft Corporation

Contract type: FFP (prototype design and build) (using other transaction authority)

Estimated Cost and Quantities

(fiscal year 2022 dollars in millions)



Software Development

(as of January 2022)

Approach: Information not available

Average time of software deliveries (months)

Information not available

Software percentage of total program cost

Information not available

Software type

Information not available

The program reported that details on software development were yet to be determined.

Current Status

The Army is using a two-phase competitive prototyping strategy to select a contractor to design the aircraft. Phase one of the selection process began in April 2019 when five vendors were selected to participate in the initial design phase. In March 2020, two of the five vendors—Bell Helicopter Textron, Inc. and Sikorsky Aircraft Corporation—were selected to continue to phase two. Each of the two contractors is expected to develop and test a prototype aircraft.

At the conclusion of phase two, the Army plans to conduct a flight test evaluation of both Bell's and Sikorsky's prototype vehicles. This testing, in addition to ongoing government reviews and further proposals from the vendors, is expected to inform the Army's selection of a vendor to continue engineering and manufacturing development.

FARA is currently tracking four critical technologies that the program will evaluate for maturity prior to reaching development start in 2023, including the Improved Turbine Engine (ITE). FARA will use the ITE in both prototypes for flight testing. However, the ITE's first system-level engine test, currently scheduled for the second quarter of fiscal year 2022, was previously delayed several months due to COVID-19 manufacturing delays. FARA program officials stated that they are closely tracking potential schedule risks to ITE delivery, currently scheduled for the first quarter of fiscal year 2023. Program officials stated that they will reassess the viability of the current prototype flight schedule after the ITE testing in the second quarter of fiscal year 2022 is complete.

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 continues to reduce risk by spending more time upfront to inform requirements and prepare for system development. It also noted that the prototype aircraft were 80 percent complete and their construction was on schedule as of March 2022.

Source: U.S. Army. | GAO-22-105230

Long Range Hypersonic Weapon System (LRHW)

Through LRHW, the Army seeks to develop and field a ground-launched hypersonic missile as part of the Army's strategic long-range precision fires portfolio. The LRHW prototype is funded as a research and development effort, managed by the Army's Rapid Capabilities and Critical Technologies Office (RCCTO). RCCTO expects to deliver a residual operational capability by the end of fiscal year 2023. Army officials stated that they are still determining LRHW's ultimate acquisition strategy. LRHW is a joint effort with the Navy's Conventional Prompt Strike (CPS) program, a ship-fired version of the same system.

Program Essentials

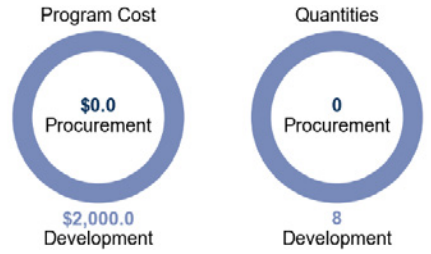
Program office: Huntsville, AL

Prime contractor: Lockheed Martin; Dynetics; General Atomic; Raytheon; Northrop Grumman

Contract type: CPIF/CPFF/FFP

Estimated Cost and Quantities

(fiscal year 2022 dollars in millions)



Software Development

(as of January 2022)

Approach: Agile and DevSecOps

Average time of software deliveries (months)

Software percentage of total program cost

Software type

0 percent
Off-the-shelf

89 percent
Modified off-the-shelf

11 percent
Custom software

The Army reported that it does not currently track estimated software costs separately from total program costs, but plans to do so in the future.

Current Status

LRHW seeks to rapidly develop a truck-mounted hypersonic weapon with residual operational capability by the end of fiscal year 2023. The Army and the Navy partnered to build the All Up Round (AUR) missile, with the Army producing the Common Hypersonic Glide Body and the Navy producing the missile booster. Each service has a unique canister supporting the launching platform. LRHW officials stated that their only development work involved minor adaptations to existing ground equipment. Army officials stated that the funding supports a prototype battery, joint design and testing, and building of AURs. After delivery of the prototype system, RCCTO expects to transfer LRHW to the Program Executive Office for Missiles and Space.

Although Army officials stated that the program is currently on track for a fiscal year 2023 delivery, the schedule depends on the Army and Navy both meeting schedule milestones, which a recent test failure complicated. In the event of another test failure in the future, Army officials stated that the Army and Navy will need to jointly re-evaluate the delivery schedule to ensure the system meets safety and performance expectations. Following funding cuts to CPS, the Army and Navy already reduced test plans substantially. Per officials, the final three flight tests originally included two missiles each—one from each service—but due to budget cuts, only one Army missile will be fired at each test, with no spares. Officials said they increased the use of modeling and simulations to make up for decreased flight testing. The joint LRHW/CPS effort experienced a test failure in October 2021, but potential schedule impacts have yet to be determined.

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 reported that it fielded the first launcher unit in September 2021 and completed related training, which will support all future flight tests. It stated that the Army-Navy partnership remains strong and is governed by a joint deliberate decision-making process to manage risk and execute the program. Lastly, the Army noted that full and stable funding is critical to the program's success.

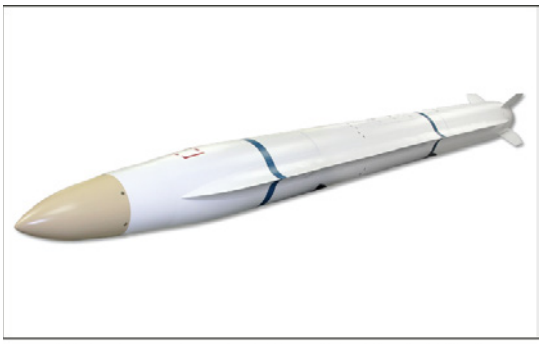
NAVY and MARINE CORPS

Program Assessments

▲ CVN 78 *Gerald R. Ford* Class Nuclear Aircraft Carrier (CVN 78)

Assessment type	Program name
MDAPs	Advanced Anti-Radiation Guided Missile-Extended Range (AARGM-ER)
	Air and Missile Defense Radar (AMDR)
	CH-53K Heavy Replacement Helicopter (CH-53K)
	CVN 78 *Gerald R. Ford* Class Nuclear Aircraft Carrier (CVN 78)
	DDG 1000 *Zumwalt* Class Destroyer (DDG 1000)
	FFG 62 *Constellation* Class Frigate (FFG 62)
	F/A-18E/F Infrared Search and Track (IRST)
	Littoral Combat Ship-Mission Modules (LCS Packages)
	MQ-25 Unmanned Aircraft System (MQ-25 Stingray)
	MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)
	Next Generation Jammer Mid-Band (NGJ MB)
	SSBN 826 *Columbia* Class Ballistic Missile Submarine (SSBN 826)
	Ship to Shore Connector Amphibious Craft (SSC)
	John Lewis Class Fleet Replenishment Oiler (T-AO 205)
	VH-92A® Presidential Helicopter Replacement Program (VH-92A)
MDAP Increments	DDG 51 *Arleigh Burke* Class Destroyer, Flight III (DDG 51 Flight III)
	LHA(R) Amphibious Assault Ships (LHA 8 and LHA 9)
	LPD 17 *San Antonio* Class Amphibious Transport Dock, Flight II (LPD 17 Flight II)
	SSN 774 *Virginia Class* Submarine (VCS) Block V
MTA Programs	Conventional Prompt Strike (CPS)
Future Major Weapon Acquisitions	DDG(X) Guided Missile Destroyer (DDG(X))
	Light Amphibious Warship (LAW)

Source (previous page image): U.S. Navy. | GAO-22-105230



Source: Northrop Grumman Innovation Systems (NGIS). | GAO-22-105230

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. The AARGM-ER will reuse sections of the AARGM and incorporate a new rocket motor 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 internally on the F-35 aircraft.

Program Essentials

Milestone decision authority: Navy

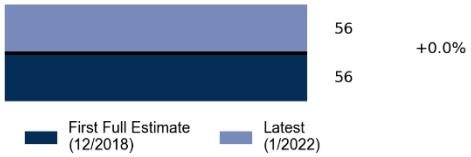
Program office: Patuxent River, MD

Prime contractor: Alliant Techsystems Operations, LLC

Contract type: CPIF (development), FFP (procurement)

Acquisition Cycle Time

(in months)



Software Development

(as of January 2022)

Approach: Spiral

Average time of software deliveries (months)

Software percentage of total program cost

Software type

0 percent Off-the-shelf

0 percent Modified off-the-shelf

100 percent Custom software

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (12/2018)	Latest (9/2021)	Percentage change
Development	$785.11	$795.79	+1.4%
Procurement	$2,824.86	$2,819.3	-0.2%
Unit cost	$1.72	$1.72	+0.1%
Total quantities	2,097	2,097	+0.0%

Total quantities comprise 17 development quantities and 2,080 procurement quantities.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Development Start**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	●
Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	○
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	○	○
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	○	○

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

AARGM-ER Program

Technology Maturity, Design Stability, Production Readiness

The Navy approved the program to enter production in August 2021 having met some, but not all, leading practices for production readiness. The production decision occurred 5 months later than planned because of delays completing a required test. The program demonstrated that its critical technology—a flame-retardant insulation for the rocket motor—is fully mature; released all of its design drawings; and demonstrated its critical manufacturing processes on a pilot production line.

Contrary to leading practices, however, the Navy did not test either a system-level integrated prototype or a production-representative prototype in an operational environment prior to production start. In July 2021, the program completed its first missile free flight test with rocket motor ignition. The test demonstrated that the missile can be safely launched by an F/A-18 aircraft. The missile experienced a temporary loss of control but travelled most of its required range—the test's key objective. According to the program, the contractor is implementing a correction that will allow the missile to fully meet the range requirement. However, the missile tested was not a fully-configured, production-representative prototype because it did not include an upgraded processor or tactical software that will ultimately be produced.

Due to the unavailability of key hardware, the AARGM-ER program does not plan to test a missile with these items until the third quarter of fiscal year 2022, after it plans to award its second low-rate production contract. Independent and Navy assessments both identified risks related to this testing approach, including the possibility of discovering design deficiencies that could pose a risk to production or the test schedule. We also found that starting production before demonstrating a system will work as intended increases the risk of discovering deficiencies that require costly and time-intensive rework.

The program has taken steps to manage other potential production risks. For example, it has planned for a fourth lot of low-rate initial production to help manage the transition to a new, permanent production facility before the planned full-rate production decision in December 2024. According to program officials, the new facility already produces the missile rocket motor and warhead. Program officials expect the new facility to provide a more stable production capacity and have lower labor costs.

Software and Cybersecurity

Software development and integration challenges remain one of the program's highest risks. Last year, we reported that the program relied on the baseline AARGM program for a key software upgrade that gives its missile upgraded capabilities related to advanced threats. We also reported the development effort fell behind schedule. The AARGM-ER program office took over responsibility for this software effort in September 2020; broke out key capabilities into multiple, concurrent software releases; and accelerated the releases' development.

While this approach may result in key capabilities being delivered for testing sooner, which would help reduce risk, it presents staffing challenges. According to an April 2021 independent DOD assessment, the execution of concurrent, highly technical software development efforts would require additional resources, which were already strained. The program office also identified software and cybersecurity staffing challenges, including difficulties hiring enough government and contractor staff with the right expertise and overlapping needs for staff for software development, testing, and cybersecurity activities. According to program officials, the contractor is actively working to bring in additional software personnel.

Other Program Issues

The program experienced a variety of COVID-19-related impacts from production line shutdowns or slowdowns to supplier delays to delays in testing. But, according to the program office, these impacts have yet to present a risk to the overall program schedule. The program is also projecting about $2 million in potential cost impacts but is working to minimizing those by pursuing efficiencies in other areas.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. According to the program office, the program uses leading practices for overall production readiness. The program office stated that the reuse of baseline AARGM electronics, ground-based testing of the rocket motor, aircraft integration testing, and flight testing provided the confidence behind the initial production decision. The program office added that while the first two low-rate initial production contracts have been awarded due to the procurement lead times of materials, all developmental testing will be complete and operational testing of the final production-representative weapon configuration will be underway prior to beginning production of the first lot of missiles. The program office also noted that the concurrency of software releases is recognized and mitigated, but necessary to meet the warfighter needs in response to evolving threats.

Source: Raytheon Company. | GAO-22-105230

Air and Missile Defense Radar (AMDR)

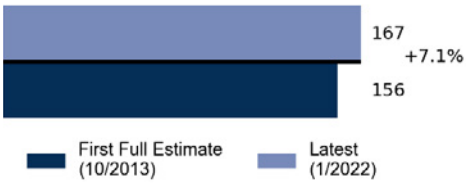
The Navy's AMDR is a next-generation radar program supporting surface warfare and integrated air and missile defense. The Navy expects AMDR's radar—known as AN/SPY-6(V)1—to provide increased sensitivity for long-range detection to improve ballistic missile defense against advanced threats. The program office is also developing a radar suite controller that is expected to interface with an updated Aegis combat system to provide integrated air and missile defense for DDG 51 Flight III destroyers, starting with the lead ship—DDG 125.

Program Essentials

Milestone decision authority: Navy
Program office: Washington, DC
Prime contractor: Raytheon
Contract type: FPI (procurement)

Acquisition Cycle Time

(in months)



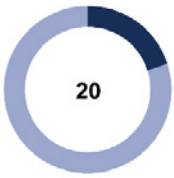
Software Development

(as of January 2022)

Approach: Agile

Average time of software deliveries (months)

Software percentage of total program cost



Software type

0 percent Off-the-shelf
0 percent Modified off-the-shelf
100 percent Custom software

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (10/2013)	Latest (7/2020)	Percentage change
Development	$2,145.58	$2,270.62	+5.8%
Procurement	$4,437.54	$3,689.12	-16.9%
Unit cost	$300.74	$299.64	-0.4%
Total quantities	22	20	-9.1%

Total quantities comprise zero development quantities and 20 procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Development Start**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	●
Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	●	●
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA	NA
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	○	○

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

We did not assess AMDR's demonstration of critical processes in statistical control or on a pilot production line because the program office stated that no critical manufacturing processes are used on this program.

AMDR Program

Technology Maturity, Design Stability, and Production Readiness

AMDR fully matured its critical technologies when the Navy activated AMDR and the Aegis combat system on DDG 125 in December 2021. Following combat system activation, the Navy plans to conduct operational testing on AMDR and Aegis at sea on DDG 125 starting in March 2024.

While AMDR's overall design is stable, previous issues with a critical technology component resulted in significant design changes over the past few years. Specifically, in 2020, the program redesigned the Digital Receiver Exciter (DREX) because it did not meet vibration specifications, according to Navy officials. Program officials stated that the new design met all qualification testing specifications. However, the fourth radar array, which completed the AMDR unit for DDG 125, was delivered to the shipyard in October 2020, 2 months later than planned due in part to the redesign. In October 2021, program officials stated that tests have shown that the new design is reliable, and they consider DREX issues resolved. Any deficiencies the Navy discovers during testing could result in costly and time-intensive revisions to existing design drawings or retrofitting to already-built radars.

By the end of 2021, the AMDR program delivered the radar arrays for DDG 128 and DDG 129—the third and fourth Flight III ships under construction, respectively. However, program officials stated that they delayed delivery of an array to DDG 129 by a few weeks due to a manufacturing issue. They explained that a microelectronic circuit within the transmit/receive modules in the arrays was not functioning properly and the receiver could become overloaded. Program officials stated that they had to replace some modules in the array and the two arrays that followed it on the production line. While these manufacturing issues delayed delivery of one of the arrays to the shipyard, they ultimately did not affect the DDG Flight III program's schedule because the shipbuilder was able to install the AMDR shipsets as planned.

Also in 2021, the program addressed a manufacturing issue we reported on last year related to the incorrect adhesive application on Transmit/Receive Integrated Microwave Module components—another critical technology—that caused cost increases and rework. Officials told us this year that Raytheon fixed the issue for future deliveries and offered a warranty on the components.

We updated our Attainment of Production Knowledge table to reflect that we did not assess whether critical manufacturing processes are in statistical control because the AMDR program office stated that there are no critical processes.

Software and Cybersecurity

AMDR used an Agile development approach to complete nine software deliveries that support core radar capabilities. Program officials stated that the 10th software delivery will be the final one for DDG 51 Flight III.

Officials said that AMDR cybersecurity is addressed within the Aegis combat system and cybersecurity testing will not occur until at least 2023.

Other Program Issues

The Navy continues to integrate and test AMDR and Aegis at land-based test sites and these activities supported combat system activation. AMDR program officials stated that, while they experienced some challenges integrating the radar and combat system, the shipbuilder successfully activated the radar and combat system in December 2021, nearly 1 month ahead of its contracted schedule date.

In 2021, the Navy established the Enterprise Air Surveillance Radar (EASR) as a subprogram within AMDR, which is expected to increase the program's total cost estimate. The Navy designed the AN/SPY-6(V)1 to be a family of radars that are scalable and adaptable across multiple ship programs. Through the EASR subprogram, the Navy is developing two variants of the AN/SPY-6 radar that are planned for installation on CVN 68, CVN 78, LHA 8, LPD 17 Flight II, and FFG 62 class ships. Program officials stated that the updated acquisition program baseline reflecting this change is awaiting final approval and, as of January 2022, a DOD official confirmed that the updated baseline had not yet been approved.

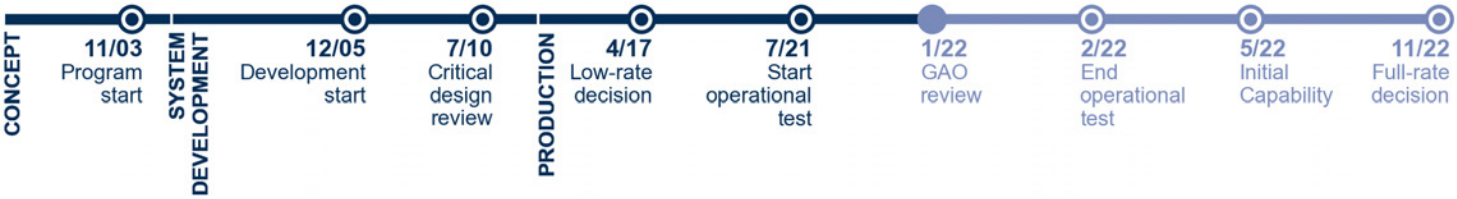
Program Office Comments

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 on track to support DDG 125's schedule. It noted that it successfully completed two phases of testing at the land-based test site and plans to complete full-array power testing of the radar by the end of fiscal year 2022. The program office also stated that the DDG 51 program successfully activated the Aegis combat system on time on DDG 125. According to the program office, it is in the process of making the two AN/SPY-6 EASR variants major subprograms of the AMDR program, and noted that six EASR radars are in procurement and are on schedule to meet required ship dates. The program office also stated that it began testing the EASR radar with air traffic control systems in 2020 and the Ships Self-Defense System in 2021.

Source: Sikorsky Aircraft Corporation. | GAO-22-105230

CH-53K Heavy Replacement Helicopter (CH-53K)

The Marine Corps' CH-53K heavy-lift helicopter is intended to transport armored vehicles, equipment, and personnel to support operations deep inland from a sea-based center of operations. The CH-53K is expected to replace the legacy CH-53E helicopter and provide increased range and payload, survivability and force protection, reliability and maintainability, and coordination with other assets, while reducing total ownership costs.



Program Essentials

Milestone decision authority: Navy

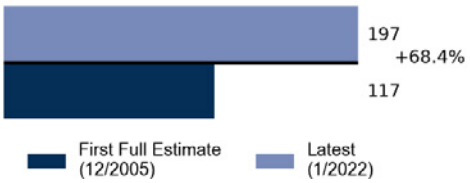
Program office: Patuxent River, MD

Prime contractor: Sikorsky Aircraft; General Electric Aviation

Contract type: CPIF (development), FPIF/FFP (procurement)

Acquisition Cycle Time

(in months)



Software Development

(as of January 2022)

Approach: Waterfall

Average time of software deliveries (months)

Software percentage of total program cost

Software type

0 percent Off-the-shelf

0 percent Modified off-the-shelf

100 percent Custom software

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (12/2005)	Latest (7/2020)	Percentage change
Development	$5,182.47	$9,043.36	+74.5%
Procurement	$14,413.21	$23,366.64	+62.1%
Unit cost	$125.61	$162.12	+29.1%
Total quantities	156	200	+28.2%

Total quantities comprise four development quantities and 196 procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Development Start**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	●
Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	○	○
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	●	●

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

CH-53K Program

Technology Maturity, Design Stability, and Production Readiness

Over the past year, new and continued technical and production risks raised questions about the CH-53K's ability to perform as expected and meet production goals. Last year, we reported that the program office identified 126 technical issues to be completed before the end of development. According to the program, 119 of the 126 issues have designs completed for potential solutions. Sikorsky delivered the first low-rate aircraft in October 2021; as of November 2021, the second was on schedule for delivery in January 2022.

Despite closing the above-mentioned technical issues, within the last year, the program continued to identify new technical challenges. For example, it discovered that while the aircraft is hovering, the compressor ingests too much sand and dirt, potentially resulting in an engine stall. While it temporarily limited aircraft landing over dirt and sand, the program is looking into a long-term solution that will likely require a redesign of the engine intakes. But, program officials state that this is not an uncommon problem in helicopters and therefore there is no perfect solution to this problem. Until fixed, this issue may limit how the CH-53K can be used in combat.

Other ongoing technical problems, such as with the rotor main damper and the intermediate gear box, are expected to affect future sustainability costs. Both parts have a much shorter life span than predicted, but the program is testing solutions to extend the parts' life cycle. Until these efforts are complete, the program is at risk of costly and time-intensive rework to aircraft already in production, and it places a greater maintenance burden on the warfighter.

The program decreased the planned amount of operational testing before its November 2022 full-rate production decision, which may lessen the information available about production maturity. Operational testing started in late July 2021 using aircraft purchased prior to production start and is planned to finish in February 2022. While the program planned three phases of operational testing, program officials stated that it was decided that two phases was sufficient to provide the information needed to make an informed-full rate production decision. The program now plans to complete the third phase of testing—which consists of using a production-configured aircraft—during follow-on testing in late fiscal year 2022.

Several supplier concerns are affecting the program. First, DOD reported that the supplier that produces the main gear box has not been able to produce enough parts or meet quality specifications for years. In order to mitigate this problem, the program is certifying two new suppliers to produce these parts. Second, DOD stated that the supplier for the fuel cell bags has had issues meeting required specifications, resulting in several fuel cell bags needing to be returned to the supplier for fixes. The program made capital investments to help improve the supplier's tooling, which the program expects will help improve the parts' quality and recover some of the production time that was lost. Finally, the supplier for the data concentrator units (DCU) told the program office that it would no longer be able to support production of the DCU after low-rate lot 4. The program office is already attempting to replace this supplier, which it states should benefit the program in the long run. However, until that happens, program officials stated that to avoid a delay in production, they are pursuing an undefinitized contract action with a new supplier.

Software and Cybersecurity

Last year, we reported that the program delayed a contract award that would improve the program's cybersecurity because of funding constraints and the need to develop of a statement of work. Since that time, the program awarded a contract in January 2021 for a cybersecurity assessment and a plan to implement security measures. This contract supports the efforts needed for meeting flight clearance requirements.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. According to the program office, continued progress over the past year has provided stakeholders with assurances of the CH-53K's ability to perform as expected and meet production goals. In addition, the program office stated that identification of new technical challenges was within the expected range during developmental testing and that solutions for these challenges, including the dust ingestion, are in progress. The program office added that both the main rotor damper and intermediate gear box technical issues are rated low risk for potential impact to program requirements and execution. Finally, the program office noted that all aircraft being used in operational testing have been modified to production configuration, making the two-phase test plan adequate to determine operational effectiveness and suitability. After our review period ended, program officials reported that CH-53K achieved initial operational capability in April 2022.

Source: U.S. Navy. | GAO-22-105230

CVN 78 *Gerald R. Ford* Class Nuclear Aircraft Carrier (CVN 78)

The Navy developed the CVN 78 (or *Ford* class) nuclear-powered aircraft carrier to introduce new propulsion, aircraft launch and recovery, and survivability capabilities to the carrier fleet. The *Ford* class is the successor to the *Nimitz* class aircraft carrier. Its new technologies are intended to create operational efficiencies and enable a 33 percent increase in sustained operational aircraft flights over legacy carriers. The Navy also expects the new technologies to enable *Ford* class carriers to operate with reduced crew.

Program Essentials

Milestone decision authority: Navy

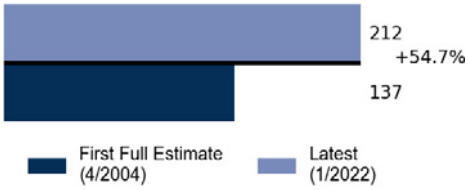
Program office: Washington, DC

Prime contractor: Huntington Ingalls Industries Newport News Shipbuilding

Contract type: FPI (CVN 79) detail design & construction; FPI (CVN 80) detail design & construction

Acquisition Cycle Time

(in months)



Software Development

(as of January 2022)

Approach: Information not available

Average time of software deliveries (months)

Information not available

Software percentage of total program cost

Information not available

Software type

Information not available

The program office reported it does not separately track software as software is provided by other Navy programs.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (4/2004)	Latest (9/2020)	Percentage change
Development	$5,685.59	$6,646.57	+16.9%
Procurement	$36,422.98	$43,265.85	+18.8%
Unit cost	$14,036.19	$12,548.23	-10.6%
Total quantities	3	4	+33.3%

Total quantities comprise zero development quantities and four procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Construction Preparation Contract Award**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	●
Complete a system-level preliminary design review	○	●
Product design is stable	**Fabrication Start**	
Complete basic and functional design to include 3D product modeling	○	●

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

We assessed the CVN 78 resources and requirements knowledge metrics at the time of the construction preparation contract award, rather than the detail design contract award, because that is the point at which the program began CVN 78 development.

CVN 78 Program

Technology Maturity, Design Stability, and Production Readiness

While CVN 78's 12 critical technologies are mature, according to the program office, challenges persist in demonstrating their reliability. As of December 2021, the Navy delivered all 11 weapons elevators to operate on the ship. If future testing identifies issues with the elevators, changes are likely to be costly and time-consuming to address.

The Navy also continues to struggle with the reliability of the electromagnetic aircraft launch system and advanced arresting gear needed to meet requirements to rapidly deploy aircraft. Since our last detailed report on these systems in 2014, reliability has only slightly increased. The Navy anticipates achieving reliability goals in the 2030s. Until then, however, these low levels may prevent the ship from demonstrating one of its key requirements—rapidly deploying aircraft.

The Navy declared initial operational capability for the lead ship (CVN 78) in December 2021, 5 months later than the planned date the Navy reported last year and 8 months before starting operational testing, which determines the effectiveness of ship systems. In August 2021, CVN 78 completed at-sea trials to test the ship's ability to withstand shock from underwater explosions. Officials from the office of the Director, Operational Test and Evaluation (DOT&E) said the trials were generally successful, but identified vulnerabilities in ship systems.

Program officials anticipate receiving approval of their updated test and evaluation master plan before operational testing begins in August 2022. DOT&E officials described risks if the test plan was not approved before testing starts, namely that the program may not be properly planning and budgeting for needed resources, which could delay testing's start. Program officials told us there had been no impact to testing as a result of the test plan pending approval. The Navy recently provided a draft version of the updated test plan, which included information on CVN 79 testing, such as incorporating that ship's new radar, but did not include detailed test dates that we could compare to previous test schedules. We plan to conduct a more detailed review of the test plan in future assessments.

Software and Cybersecurity

The CVN 78 program's software and cybersecurity approach has not changed since last year. Dates for completing evaluation of cybersecurity vulnerabilities vary by system and test event. The Navy plans for continuous testing over system life cycles through 2024.

Other Program Issues

The CVN 78 cost cap is currently $13.2 billion—more than $2.7 billion higher than its initial cap—as a result of construction and critical technology issues. If testing reveals deficiencies, the Navy may continue requesting additional funding, further increasing the true cost of the ship. In addition to the class's baseline capabilities, CVN 78 is also relying on different types of funding, such as operations and maintenance or research and development—not subject to the construction cost cap—to address issues like modernization to support the Joint Strike Fighter.

As of September 2021, the Navy increased the CVN 79 cost cap by $1.3 billion primarily due to contract overruns. According to the CVN 79 program office, these overruns are mainly due to shipbuilder performance. At over 85 percent complete, CVN 79 is in a phase of construction when additional cost growth is most likely. Cost growth also resulted from changes for CVN 79 such as shifting to a single-phase delivery schedule and incorporating F-35 modifications, among other things. It is unclear how this updated delivery schedule will affect testing time frames for CVN 79. If the new schedule results in less time for testing in a maritime environment, it will introduce greater risk to the CVN 79 schedule. The Navy plans to address this cost growth in future budget submissions. According to program officials, the shipbuilder's COVID-19 pandemic mitigations reduced construction efficiency, although the shipbuilder has yet to provide assessments of the cost and schedule effects.

The Navy reported awarding fixed-price contracts for CVNs 80 and 81 in January 2019 and expects to save over $4 billion combined based on optimistic cost estimates. However, the Navy already identified additional funds needed to transition CVN 80 to a digital construction model. Based on our past findings that the *Ford* class cost estimate was based on optimistic assumptions, additional costs are likely.

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 Navy, CVN 78 completed five testing and maintenance periods in 2021 and the program addressed nearly all the issues identified when the ship was delivered. Further, the Navy reported declaring initial operational capability for the electromagnetic aircraft launch system and advanced arresting gear in 2021. For CVN 79, the Navy reported that $313 million in other cost offsets will help mitigate the increase in CVN 79 costs to $12.7 billion, though that ship still has a net procurement cost increase of nearly $1 billion. The Navy is also still planning for cost savings from its two-ship acquisition of CVNs 80 and 81. Keel-laying for CVN 80 and CVN 81 is scheduled for the third quarter of fiscal year 2022 and in fiscal year 2026, respectively.

Source: BAE Systems San Diego. | GAO-22-105230

DDG 1000 *Zumwalt* Class Destroyer (DDG 1000)

The DDG 1000 is a multimission surface ship initially designed to provide advanced capability to support forces on land. DDG 1000 class ships feature stealth design, an integrated power system, and a total ship computing environment. The Navy adopted a phased acquisition strategy, which separates delivery and acceptance of hull, mechanical, and electrical systems from combat system activation and testing. In addition to the strike mission, the Navy now plans to add hypersonic missiles to the ship.

Program Essentials

Milestone decision authority: Navy

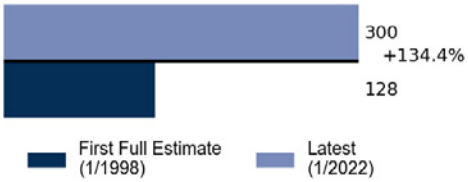
Program office: Washington, DC

Prime contractor: General Dynamics Bath Iron Works; Huntington Ingalls Industries; Raytheon

Contract type: FPI/FFP/CPFF (ship construction); CPFF/CPAF (mission systems equipment)

Acquisition Cycle Time

(in months)



Software Development

(as of January 2022)

Approach: Agile and DevOps

Average time of software deliveries (months)

Software percentage of total program cost

Software type

10 percent Off-the-shelf

20 percent Modified off-the-shelf

70 percent Custom software

The program stated that software cost elements are not tracked.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (1/1998)	Latest (9/2020)	Percentage change
Development	$2,695.97	$12,598.92	+367.3%
Procurement	$38,490.62	$14,837.36	-61.4%
Unit cost	$1,287.08	$9,145.43	+610.6%
Total quantities	32	3	-90.6%

Total quantities comprise zero development quantities and three procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Detail Design Contract Award**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	○
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	○
Complete a system-level preliminary design review	●	●
Product design is stable	**Fabrication Start**	
Complete basic and functional design to include 3D product modeling	○	●

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

DDG 1000 Program

Technology Maturity, Design Stability, Production Readiness

The DDG 1000 program has yet to mature three of its nine original critical technologies as it nears completion of construction of the final ship in 2021. The program is also adding a new weapon system with more immature technologies. According to the program, the Navy intends to mature the three remaining original technologies—infrared signature, volume search radar, and total ship computing environment—during operational testing, conducted in realistic combat conditions. The Navy now plans to complete operational testing for the DDG 1000 in December 2022—a 15-month delay compared to last year's date. This delay is a result of the Navy's efforts to support industry workload balance, and the Navy requiring the ship to be elsewhere to support other fleet activities.

Last year, we reported that three critical technologies had been added to the original nine technologies to enable the new offensive surface strike mission. According to the Navy, one of those three—a communication system—has since matured and will be installed in 2023. The second technology—a surface strike missile with a new seeker that was approaching maturity—is no longer planned for this class. The Navy expects the third technology—an intelligence system—to reach maturity by installation in 2024.

In addition to this strike mission, this year, the Navy announced plans to incorporate the Conventional Prompt Strike (CPS) hypersonic weapon system—a separate development effort that we also assess in this report—on the class starting in 2024. CPS has four immature technologies. The program currently has $15 million in funding to begin CPS incorporation design efforts and finalize requirements, and requested over $100 million in fiscal year 2022. The Navy plans to install CPS on the DDG 1000 in fiscal year 2024, and on the other ships during their first planned dry docking maintenance periods.

DDG 1000 completed final delivery in April 2020 and is undergoing at-sea testing ahead of planned initial operational capability. According to the Navy, initial operational capability was delayed from December 2021 to December 2022 due to the rescheduling of test events. The DDG 1000 also successfully completed rough-water testing of the ship which, according to the program manager, validated the hull form design in harsh sea states.

The other two ships of the class are facing delays. According to the program manager, DDG 1001's delivery was delayed until the fourth quarter of fiscal year 2022 due to challenges with developing some needed range testing equipment. Delays also continue for DDG 1002, as delivery of the ship was delayed until November 2021 to resolve deficiencies and create a COVID-19 safe workplace, among other reasons. While the Navy still plans for final delivery of DDG 1002 with its combat systems in 2024, further delays are possible. For example, due to delays and crew habitability concerns, a different contractor will install weapon systems on DDG 1002 than the contractor used on the other two hulls, which could result in some loss of efficiencies gained by the contractor on the other two ships.

Other Program Issues

According to the program manager, one of the primary engineering efforts to incorporate CPS is to design a launching system that enables a cold launch missile, meaning that the missile is ejected from the ship before its rocket motor ignites. The DDG 1000 class would be the first surface ship that uses cold launch missile technology. Design efforts are also required to remove the existing Advanced Gun System turrets and replace them with the CPS payload launcher system that will house the CPS missiles. The program manager further stated that the funding provided constitutes a fraction of the total expected funding necessary for complete CPS integration. For example, integration of the CPS weapon system across all three ships was estimated in June 2021 at approximately $900 million. The first live demonstration of a hypersonic weapon from the DDG 1000 is currently scheduled for fiscal year 2025.

Program Office Comments

We provided a draft of this assessment for program office review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office stated that the DDG 1000 completed a key maintenance event and several test events, and was transferred to in-service sustainment in 2021. It added that the DDG 1001 participated in underway test events and fleet exercises, including an aviation test, an integrated fleet exercise, and torpedo defense tests in 2021. Further, it noted that the Navy accepted completion of DDG 1002 from Bath Iron Works in November 2021, and that DDG 1002 departed in January 2022 and arrived at Huntington Ingalls Industries' shipyard for completion of combat systems installation and activation. According to the program office, the Navy commenced engineering design planning to allow for integration of CPS in support of the *Zumwalt* class being the first platform to field these missiles.

Source: Fincantieri Marinette Marine. | GAO-22-105230

FFG 62 Constellation Class Frigate (FFG 62)

The Navy's FFG 62 guided missile frigate program is intended to develop and deliver a small surface combatant based on a modified design of Italian and French Navy frigate variants. The Navy expects the frigates to operate independently or as part of groups to support Navy and joint maritime operations. Planned capabilities include anti-submarine warfare, surface warfare, electronic warfare, and air warfare operations.

Program Essentials

Milestone decision authority: Navy

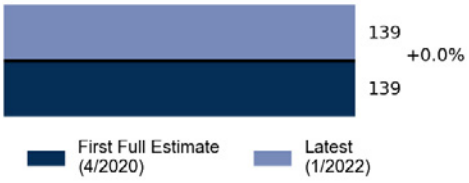
Program office: Washington Navy Yard, DC

Prime contractor: Fincantieri Marinette Marine

Contract type: FPI (detail design and construction)

Acquisition Cycle Time

(in months)



Software Development

(as of January 2022)

Approach: Agile, DevOps, and DevSecOps

Average time of software deliveries (months)

Information not available

Software percentage of total program cost

Information not available

Software type

Information not available

The program office stated that it has yet to start tracking software costs.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (4/2020)	Latest (6/2020)	Percentage change
Development	$1,191.84	$1,191.84	+0.0%
Procurement	$19,673.88	$19,673.88	+0.0%
Unit cost	$1,078.77	$1,078.77	+0.0%
Total quantities	20	20	+0.0%

Total quantities comprise zero development quantities and 20 procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at Detail Design Contract Award	Current Status
Resources and requirements match		
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	NA	NA
Demonstrate all critical technologies in form, fit, and function within a realistic environment	NA	NA
Complete a system-level preliminary design review	●	●
Product design is stable	**Fabrication Start**	
Complete basic and functional design to include 3D product modeling	NA	NA

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

We did not assess critical technologies for the FFG 62 because the Navy's technology readiness assessment and independent technical risk assessment for the program found that the ship does not have any. We also did not assess the ship's design stability because the program has yet to reach fabrication start.

FFG 62 Program

Technology Maturity

Based on the program's use of existing mature systems, the Navy identified no critical technologies for FFG 62. The program plans to integrate one key new system—the Navy's new Enterprise Air Surveillance Radar—with the latest baseline of the Aegis combat system on FFG 62 to deliver long-range detection and engagement capability. According to Navy officials, the Aegis software, which is still under development, is expected to begin onboard combat system testing in the 2024–2025 time frame to demonstrate its functionality with the radar. However, with the lead ship scheduled for delivery in 2026, the test plan leaves little margin to address any issues identified in onboard integration testing without risk of costly and time-intensive rework.

Design Stability and Production Readiness

In April 2020, the program competitively awarded a detail design and construction contract for the lead ship. The FFG 62 design incorporates significant changes from the ship's parent design. These changes include a lengthened hull, revised bow, and other changes to incorporate FFG 62 combat and mission systems. The shipbuilder is currently maturing its awarded design to support construction.

As of July 2021, the program had completed 45 percent of the FFG 62 design. Consistent with leading practices for ensuring design stability, the shipbuilder plans to complete the basic and functional design before starting construction. For the March 2022 production readiness review, officials expect 80 percent of the detail design—a composite of the functional design and 3D modeling of each of the ship's 31 design zones—to be completed. They also told us that the contractor is completing the 3D modeling for the most complex zones first to reduce construction risk.

Since our last assessment, the program delayed its planned production readiness review and start of construction by around 6 months each, with both events now planned in 2022. Program officials told us the schedule changes reflect additional time needed for a new prime contractor to establish subcontractor and supply chain management plans. They also said that the revised schedule supports a detail design period and delivery of the lead ship in 2026, consistent with the Navy's projected schedule.

Software and Cybersecurity

The Navy approved the FFG 62 cybersecurity strategy in March 2019. Program officials told us that the software development plan is now expected to be approved in February 2022—11 months later than planned since our last assessment. Officials noted the delay to the plan's approval was due, in part, to being tied to the critical design review, which was also delayed. The independent technical risk assessment identified software and cybersecurity as moderate risks. For software, it noted that the program has an approach in place to mitigate these risks prior to onboard testing. The program also established a test approach to optimize its cybersecurity requirements.

Other Program Issues

In response to the NDAA for Fiscal Year 2021, the Navy began activities to establish a land-based engineering site for FFG 62. The Navy expects to begin using the site in fiscal year 2026 to demonstrate engineering plant operations in the same year the lead ship is scheduled to be delivered. Navy officials told us the site will help with crew familiarization and training, and support sustainment activities.

In December 2020, the Navy's 30-Year Shipbuilding Plan proposed adding a second shipbuilder in fiscal year 2023 to support increased production. The program office stated that if the procurement plan for the frigates increases to where a second yard is required, the Navy has a contract option to acquire the FFG 62 technical data in order to expand production of the same ship design to a second yard.

The Navy continues to identify the availability of high-efficiency super capacity chillers for cooling for ship weapons, command and control systems, and crew spaces as a risk to the program's production schedule. Program officials told us that due to the high demand for the chillers across shipbuilding programs, the Navy provided resources to establish a second production line, which is expected to resolve this supply issue.

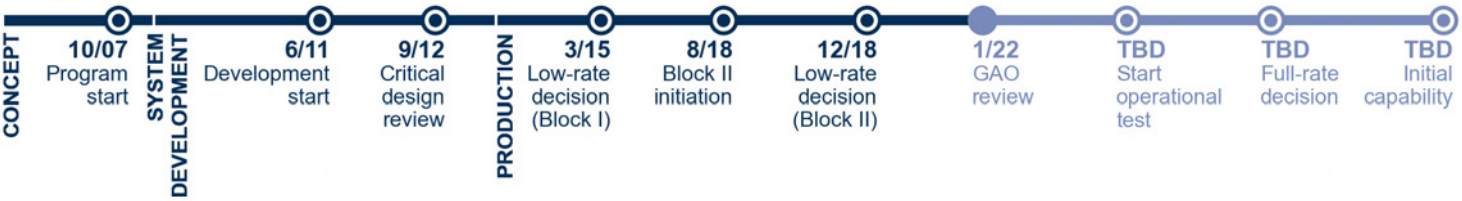
Program Office Comments

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 the FFG 62 program continues moving forward through the detail design phase of the contract toward the start of construction in 2022. It added that the shipbuilder completed updates to the parent design to increase lethality, survivability, and maintainability. The program office also stated that since the contract award to Fincantieri Marinette Marine, the program has continued to mature the functional design using shipbuilding leading practices, and is mitigating technical and integration risks by incorporating mature government-furnished equipment from other Navy programs. Lastly, the program office cited a number of risk reduction efforts it took in 2021, such as the establishment of a land-based engineering site and planning for various combat system test sites for government-furnished equipment integration efforts. Following our review period, an official from the program office confirmed that the program delayed the start of lead ship construction planned for April 2022. The official said that the program now plans to begin construction in July 2022.

Source: U.S. Navy. | GAO-22-105230

F/A-18E/F Infrared Search and Track (IRST)

The Navy is integrating new and existing infrared search and track sensors onto the F/A-18E/F fuel tank. The sensors are intended to enable F/A-18s to detect and track objects from a distance and in environments where radar is ineffective. The Navy is acquiring IRST with an evolutionary acquisition approach, including two system configurations (referred to as blocks). Block I integrates an existing IRST system onto the F/A-18 fuel tank. Block II, which we assessed, develops an improved sensor, upgraded processor, and additional software.



Program Essentials

Milestone decision authority: Navy

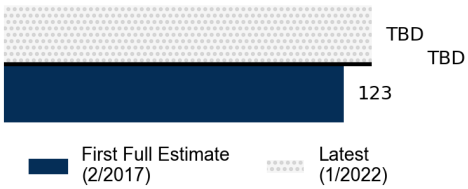
Program office: Patuxent River, MD

Prime contractor: Boeing

Contract type: CPIF (development), FPI (procurement)

Acquisition Cycle Time

(in months)



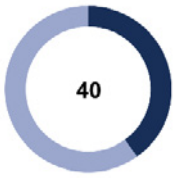
Software Development

(as of January 2022)

Approach: Agile

Average time of software deliveries (months)

Software percentage of total program cost



Software type

0 percent Off-the-shelf

0 percent Modified off-the-shelf

100 percent Custom software

The program office reported an increase from last year in average time of software delivery because it expects the delivery time to be longer for the major software release currently in progress than it was for previous efforts.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (2/2017)	Latest (9/2020)	Percentage change
Development	$950.25	$995.27	+4.7%
Procurement	$1,431.09	$1,410.45	-1.4%
Unit cost	$13.30	$13.91	+4.5%
Total quantities	179	173	-3.4%

Total quantities comprise three development quantities and 170 procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Development Start**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	●
Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	○	○
Demonstrate critical processes on a pilot production line	○	○
Test a production-representative prototype in its intended environment	○	●

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

IRST Block II did not have a separate development start date from Block I; therefore, we assessed Block II's critical technology based on its technology readiness level at the time Block I development started.

IRST Program

Technology Maturity, Design Stability, and Production Readiness

IRST matured its one critical technology and has a stable design, but it has yet to mature manufacturing processes. Further, production quality issues are delaying developmental testing and full-rate production.

Officials said the program breached its baseline schedule due to the delayed start of operational testing, which they previously planned to begin in February 2021. In response, the program completed a schedule risk assessment in October 2021, which will be used to inform a revised baseline schedule. Officials reported that the revised baseline schedule was submitted to the program executive office in February 2022.

Until the revised schedule is approved, however, the program cannot provide a date for making a full-rate production decision—the date when critical manufacturing processes are mature and within statistical control. The program is also unable to demonstrate critical processes on a pilot production line because delivery of the production representative article is delayed until March 2022.

IRST officials attributed these schedule delays to production quality issues at three suppliers and other supplier challenges caused by the COVID-19 pandemic. Officials reported that they adopted a recovery plan and invested in test equipment to help suppliers accelerate their schedules. Further, IRST officials noted that one of their key suppliers placed their subject matter experts onsite at sub-tier supplier facilities—increasing the production yield at one sub-tier supplier and resolving technical issues at another. In an effort to identify remaining risks to production, the program also reported that the Defense Contract Management Agency is assessing IRST industrial base capabilities. This assessment, however, will not be done until April 2022 at the soonest.

To avoid production line gaps, officials reported the addition of a sixth low-rate initial production (LRIP) lot. This would increase the number of systems acquired during LRIP to 55—representing 32 percent of the program's total quantity. Our prior work shows programs can reduce the risk of costly rework by maturing manufacturing processes before production. However, IRST officials told us the Navy accepted this risk in pursuit of schedule goals, citing an urgent operational need and reliance on long-lead procurement items.

Software and Cybersecurity

Hardware delivery delays caused corresponding 4- to 6-month delays to software deliveries, IRST officials told us. In response, the program adopted a more concurrent approach than originally planned and the software contractor hired more staff in support of this approach. However, the program will likely face challenges addressing software deficiencies found in testing due to its accelerated schedule and concurrent activities. The program plans to conduct cybersecurity penetration testing and a full system cybersecurity assessment in July 2022.

Other Program Issues

IRST continues to identify average procurement unit costs (APUC) as a program risk. Last year, we reported that the program's preliminary estimate indicated APUC may exceed the baseline cost by 8.2 percent due to cuts in LRIP quantities caused by funding constraints.

This year, the program reported an estimated $33 million in cost growth due to production quality issues, placing overall contractor cost growth at 9 percent per year. Additionally, the program faces a 62 unit cut in purchases between fiscal years 2021 and 2023—a deficit only partially offset by the 12 units the IRST contractor will produce for foreign militaries during LRIP IV. This dynamic creates risk that the program's unit costs will continue to rise. The program reported it is mitigating cost growth caused by production delays through contracting directly with suppliers of key components and managing the shipment of these components to the prime contractor. Program officials report that by taking these actions, they eliminate pass-through fees on roughly 70 percent of the IRST system and achieve economies of scale savings by combining production and spare parts orders.

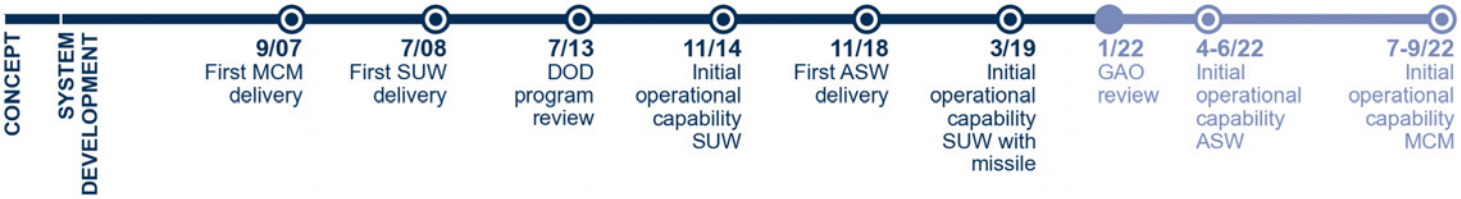
Program Office Comments

We provided a draft assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. IRST officials report that the program's critical manufacturing processes have been demonstrated and assessed as mature—to DOD's standards—with the exception of the three parts produced by suppliers currently resolving production quality issues. According to program officials, production readiness, manufacturing readiness, and industrial capability assessments are planned to be conducted for those sub-tier suppliers by the end of fiscal year 2022 so the suppliers can demonstrate their manufacturing readiness. Program officials also confirmed they anticipate approval and release of a new acquisition program baseline that will include reduced initial production quantities. The program will reflect these adjustments in their fiscal year 2023 budget submission.

Source: U.S. Navy. | GAO-22-105230

Littoral Combat Ship-Mission Modules (LCS Packages)

The Navy's LCS packages—composed of helicopters and systems like weapons, boats, sensors, and uncrewed vehicles deployed from LCS—are intended to provide mine countermeasures (MCM), surface warfare (SUW), and antisubmarine warfare (ASW) capabilities. The Navy planned to swap packages among LCS but has now assigned each LCS a semipermanent package. It delivers some systems and their support equipment when available, rather than as full packages. We assessed the status of delivered systems against the threshold requirements for baseline capabilities for the complete package.



Program Essentials

Milestone decision authority: Navy

Program office: Washington Navy Yard, DC

Prime contractor: Northrop Grumman Systems Corp

Contract type: FFP/CPFF/FPI/CR (procurement)

Acquisition Cycle Time

(in months)

Not applicable

We do not calculate cycle time for this program because there are separate initial operational capability dates for each of the three packages.

Software Development

(as of January 2022)

Approach: Incremental

Average time of software deliveries (months)

Software percentage of total program cost

Software type

0 percent Off-the-shelf

0 percent Modified off-the-shelf

100 percent Custom software

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (8/2007)	Latest (9/2020)	Percentage change
Development	N/A	$2,905.06	N/A
Procurement	$3,857.44	$3,970.09	+2.9%
Unit cost	N/A	$141.05	N/A
Total quantities	64	49	-23.4%

Total quantities comprise five development quantities and 44 procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at Development Start	Current Status
Resources and requirements match		
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	●
Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	…	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA	NA
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained … Information not available

○ Knowledge not attained **NA** Not applicable

We did not assess LCS package drawings at design review because the program held separate reviews for each LCS package. We also did not assess manufacturing maturity metrics because the program office delivers systems over time and considers a production date as not applicable.

LCS Packages Program

Mine Countermeasures (MCM)

DOD approved revised requirements for the MCM package in January 2021 that focus on the ability of each system in the package to integrate with and communicate on LCS. The Navy revised the requirement for the package's multiple systems to demonstrate they could clear mines together from a LCS, resulting in changes to operational testing. Instead of package-level testing to confirm the systems can work together to clear mines in a certain amount of time, program officials stated that the Navy will test each system individually on a LCS, and they expect each to demonstrate mine clearance capabilities equivalent to the prior package-level metric. According to program officials, package-level testing would be duplicative, so the Navy will leverage individual system testing and operational package testing for the revised requirements to show that the systems can perform together as expected. Operational package testing will only focus on whether all of the systems can integrate and communicate with each other and the LCS. DOD test officials have yet to approve revised test plans. Without testing of the full MCM package to clear mines in a certain amount of time, the Navy risks that the systems may not perform as expected in combat after they are deployed.

Both the MCM package's Remote Minehunting Module (RMH)—which detects mines near or on the seabed—and Unmanned Influence Sweep System (UISS)—which provides semiautonomous minesweeping—may not be ready to support the package's upcoming initial operational test and evaluation (IOT&E) and planned initial operational capability in 2022. The RMH has not completed system-level testing, and program officials stated that contractor testing was completed in October 2021. This leaves less than 8 months for the program to address potential problems and to conduct RMH developmental and operational testing before the start of MCM package IOT&E. In addition, according to DOD test officials, the UISS has not collected sufficient mine clearance data during system testing, and the program has not scheduled additional testing to collect more data. Program officials stated that they disagree with the testers' assessment and that the UISS test analysis will likely show the program does not need to collect additional mine clearance data. However, if data analysis or additional testing do not validate expected performance for either module, program officials stated they may need funding for additional testing. More system testing could also delay MCM package IOT&E.

Antisubmarine Warfare (ASW)

The program planned to achieve ASW initial operational capability in the third quarter of fiscal year 2022—a 9-month delay since our last assessment—because it did not complete Escort Mission Module (EMM) testing as planned. The EMM—the towed system that carries the variable depth sonar—experienced design and quality issues affecting performance. In its fiscal year 2023 budget request, the Navy proposed eliminating the ASW package on the LCS.

Surface Warfare (SUW)

One LCS successfully deployed with a full SUW mission package, including the surface-to-surface missile module. Seven LCS currently operate in the fleet with SUW packages that do not include the surface-to-surface missile module. The Navy will continue to add this missile module as it takes delivery of more systems beginning in early 2022. Five more are currently in production, and the program expects final delivery in September 2023.

According to program officials, SUW package cybersecurity testing did not take place as planned in August 2021 due to changes in the availability of ship and test resources, and the program now plans to complete testing in February 2022.

Other Program Issues

The Navy proposed retiring up to six LCS well before the end of their intended life spans. If the program does not reduce the number of mission packages it plans to acquire, additional early retirements could leave mission packages without host LCS, which may require the Navy to identify alternate host platforms or remove them from the fleet. Navy officials stated that mission packages without assigned LCS could be partially or fully deployed on other LCS as part of tailored, hybrid mission packages.

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 the Navy will demonstrate full MCM capability by completing operationally-realistic, system-level testing for each component prior to package-level testing. It added that MCM package test plans, which were coordinated with DOD test officials, include a demonstration of the DOD-approved command and control and integration requirements. The program office stated that the Navy is fielding modular MCM capabilities as systems mature and testing on LCS is completed, and that aviation modules have successfully deployed. It added that the Navy completed RMH shipboard integration testing in October 2021, and early analysis has not identified issues that would impact MCM package testing. It also stated that all SUW package capabilities are certified for deployment and that 10 packages with gun mission modules and maritime security modules were delivered.

Source: © 2021 Boeing. | GAO-22-105230

MQ-25 Unmanned Aircraft System (MQ-25 Stingray)

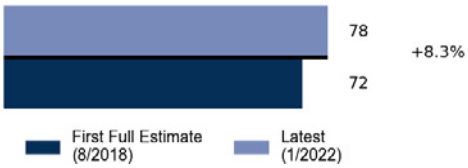
The Navy's MQ-25 is a catapult-launched, uncrewed aircraft system designed to operate from aircraft carriers. The Navy plans for MQ-25 to provide a refueling capability for the carrier air wing. The MQ-25 is also expected to eventually provide the intelligence, surveillance, and reconnaissance capabilities 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 identified related control station issues.

Program Essentials

Milestone decision authority: Navy
Program office: Patuxent River, MD
Prime contractor: Boeing
Contract type: FPI (development)

Acquisition Cycle Time

(in months)



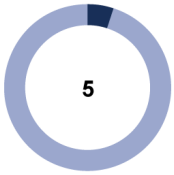
Software Development

(as of January 2022)

Approach: Agile, Waterfall, and Incremental

Average time of software deliveries (months)

Software percentage of total program cost



Software type

22 percent
Off-the-shelf

28 percent
Modified off-the-shelf

50 percent
Custom software

The program office stated there were no changes in software costs, but the percentage decreased due to other scope increases in the program.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (8/2018)	Latest (8/2020)	Percentage change
Development	$3,729.08	$2,315.81	-37.9%
Procurement	$9,368.49	$8,902.85	-5.0%
Unit cost	$177.44	$156.89	-11.6%
Total quantities	76	76	+0.0%

Total quantities comprise seven development quantities and 69 procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Development Start**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	●
Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	●	●
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	NA	NA
Demonstrate critical processes on a pilot production line	NA	NA
Test a production-representative prototype in its intended environment	NA	NA

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

While the Navy identified no critical technologies for MQ-25, the program relies on two critical technologies being developed under another program. Our scores for technology maturity reflect these two technologies. We did not assess MQ-25 manufacturing process maturity because the system has yet to reach production.

MQ-25 Stingray Program

Technology Maturity and Design Stability

The MQ-25 program relies on two fully mature critical technologies developed under another program, and the design is stable.

The program completed system-level integrated prototype flight testing by September 2021 with successful aerial refueling of three different aircraft types. The program is evaluating data collected during test flights to assess the potential for inlet distortion. Last year, we reported on concerns that the engine inlet's shape could lead to engine damage during flight, requiring further examination to determine the extent of the risk and potential fixes. Program officials have yet to determine how they will address the issue but stated that changes in the engine design could range in complexity. The program acknowledged that any design changes would need to be incorporated into test aircraft or retrofitted after the first test aircraft has been delivered, potentially resulting in additional delays and costs to the program.

Production Readiness

As of August 2021, Boeing's fixed-price incentive development contract performance report showed it was 10 percent behind schedule and 18 percent over budget for the value of work performed, due to delayed supplier deliveries and design and quality issues. Program officials noted, however, that due to the fixed-price nature of the development contract, any additional costs related to this contract will be borne by the contractor.

The Navy plans to award a low-rate initial production contract to Boeing on a sole-source basis in the second quarter of fiscal year 2023 for an initial quantity of 12 aircraft across 3 fiscal years. The October 2017 base development contract did not include defined options for production, and the Navy and Boeing have yet to negotiate the price for the aircraft. Given the challenges experienced on the development contract, production costs may be significantly higher than currently estimated.

Program officials told us they expect to complete a production readiness review and manufacturing readiness assessment by October 2022. However, we reported last year that, according to program officials, Boeing is currently not contractually required to provide manufacturing readiness level data. Consequently, the program lacks insight into whether Boeing will be able to consistently produce the aircraft while meeting cost, schedule, and quality expectations at the start of production. The program reported that it is pursuing a contract modification to require manufacturing readiness level data in the future. The program reported that Boeing is making investments to help ensure it is able to meet production objectives in the future, including increasing tooling availability and a new manufacturing facility.

Software and Cybersecurity

The program made fewer software deliveries than planned. Hiring and retaining key software personnel remains a risk area for the contractor. Program officials continued to report that they are on track to complete software integration efforts by initial operational capability, now planned for February 2025. They expect remaining software integration efforts to address vulnerabilities identified in forthcoming cybersecurity assessments.

Other Program Issues

Program officials told us that they anticipate additional development costs and a delay to the planned initial operational capability date (now planned for February 2025). They attribute these changes to the incorporation of new ground control stations expected to be interoperable with other future uncrewed platforms. According to program officials, the Navy awarded a contract in April 2021 to develop eight stations, including stations for use during developmental testing that can be transferred from ship to ship.

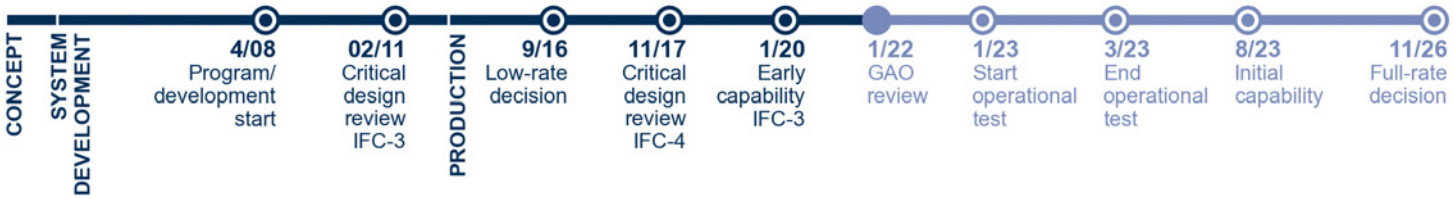
Program Office Comments

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

Source: U.S. Navy. | GAO-22-105230

MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)

The Navy's MQ-4C is an uncrewed aircraft system intended to replace aging EP-3 aircraft and provide intelligence, surveillance and reconnaissance, and data collection and dissemination. Each system includes an air vehicle, communications suites, and mission payload, among other components. The baseline variant, Integrated Functional Capabilities (IFC)-3, includes two assets with early operational capability. The second version, IFC-4 with signals intelligence capability, is in development. The Navy is revising the MQ-4C acquisition strategy and plans to develop IFC-4 in increments.



Program Essentials

Milestone decision authority: Navy

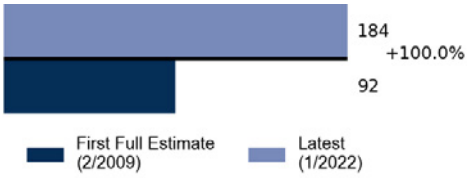
Program office: Naval Air Station Patuxent River, MD

Prime contractor: Northrop Grumman

Contract type: Cost-sharing (development), FPI (procurement)

Acquisition Cycle Time

(in months)



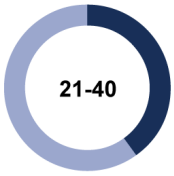
Software Development

(as of January 2022)

Approach: Agile and Incremental

Average time of software deliveries (months)

Software percentage of total program cost



Software type

22 percent Off-the-shelf

45 percent Modified off-the-shelf

33 percent Custom software

Average time of software deliveries reflects software for the IFC-4 aircraft. The program reported revised percentages for software types from last year based on updated code counts.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (2/2009)	Latest (7/2020)	Percentage change
Development	$3,718.03	$6,641.01	+78.6%
Procurement	$11,033.83	$10,778.96	-2.3%
Unit cost	$217.21	$254.16	+17.0%
Total quantities	70	70	+0.0%

Total quantities comprise five development quantities and 65 procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Development Start**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	NA
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	NA
Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	○	○
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	○	○

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

We did not assess MQ-4C critical technologies because the program stated it no longer has any such technologies. We assessed the design stability and manufacturing maturity of the IFC-4 aircraft because that is the program's current development effort.

MQ-4C Triton Program

Technology Maturity, Design Stability, and Production Readiness

Although the program office reports no critical technologies and the release of over 90 percent of IFC-4 design drawings, the Navy paused production during fiscal years 2021 and 2022 to focus on IFC-4 development. The program also is continuing efforts to establish a new cost and schedule baseline. The latest dates for operational test start in January 2023 and initial operational capability (IOC) in August 2023 are, respectively, slips of about 11 months and a year from our last assessment. According to the program, the delays resulted in part from technical problems.

The program is in the process of testing the IFC-4 aircraft. IFC-4 completed its first flight test in July 2021 and concluded a system-level integrated prototype test in November 2021, about 8 months later than planned. The delay was in part due to problems modifying an IFC-3 aircraft for use as the IFC-4 test asset and, according to the program, funding constraints that impacted test plans. The program plans to continue system integration and performance evaluation during ground and flight tests on IFC-4 aircraft in 2022, which it expects will help determine whether problems we reported last year, including difficulties with sensor integration, have been resolved.

The program is monitoring several risks with potential cost and schedule implications. For example, technical issues with IFC-4 development could further delay IOC. The program added test events through March 2023 to help mitigate the risk and stated it has 4 months of schedule margin between the end of operational testing in April 2023 and expected IOC. However, it shortened operational testing by 2 months since last year and now has one IFC-4 test asset instead of the two originally planned, adding risk that key tests may be delayed. Failure to complete timely testing could in turn affect the Navy's plans for IOC and retirement of EP-3 aircraft.

IFC-3 and IFC-4 concurrency—the overlap of development, production, and testing—is also contributing to risk. Three IFC-3 aircraft completed production and are in storage awaiting future retrofit to the IFC-4 configuration. Another three IFC-3's are in production, and the contractor plans to insert engineering changes from the IFC-4 development effort into those aircraft on the production line. This overlap between IFC-3 production and IFC-4 development drives the possibility of costly, lengthy rework and performance shortfalls. The program stated it has an engineering change process in place to manage the concurrency. However, as we concluded in the past, added concurrency-related costs can potentially carry affordability implications.

Software and Cybersecurity

The program stated that it is not tracking any program-level software risks. Three of four planned software blocks are complete, and the fourth started on-aircraft testing. The program plans for a final software correction of deficiencies period starting in June 2022. However, a 2021 Defense Contract Management Agency assessment raised concerns that there may not be enough time to correct all software issues. The program conducted penetration and adversarial cybersecurity assessments in July 2021 and September 2021, respectively.

Other Program Issues

The Navy, citing funding constraints, is revising Triton's acquisition strategy—to include re-evaluating requirements and quantities. The program expects to focus initially on the delivery of a minimum viable product (the first IFC-4 increment) by IOC to provide multi-intelligence, surveillance, and reconnaissance capabilities and facilitate EP-3 retirement. It plans to subsequently release follow-on upgrades—expected to require additional funding—to pace evolving threats.

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, since the production pause and minimum viable product determination in December 2020, it tracked as planned toward IOC and implemented a test approach that increases test efficiency and creates schedule margin. It added that it accomplished early operations events, including for software installation and tests, laboratory check-out of hardware and software, and the start of ground testing on the first IFC-4 multi-intelligence aircraft. It stated that IFC-4 first flight remains on track for March 2022 and it expects to find minor issues during testing, but anticipates no delay in IOC and has plans for post-IOC correction of any software deficiencies. It anticipates Increment 2 development to start in fiscal year 2024 and expects to field follow-on capability at regular intervals. Additionally, the program stated that, in 2021, its two baseline IFC-3 variants successfully executed missions and continued to provide lessons learned for IFC-4 operations.

After our January 31, 2022 cut-off date for new information, the program stated that it no longer expected to pause production due to fiscal year 2021 congressionally-added funding for one aircraft, combined with two aircraft already on order by the Commonwealth of Australia.

Source: U.S. Navy. | GAO-22-105230

Next Generation Jammer Mid-Band (NGJ MB)

The Navy's NGJ MB is an external jamming pod system the Navy plans to integrate on EA-18G Growler aircraft. NGJ MB is expected to augment, then replace, the ALQ-99 jamming system in the mid-band frequency range and provide enhanced airborne electronic attack capabilities to disrupt adversaries' electromagnetic spectrum use for radar detection, among other purposes. The Navy also has a low-band frequency program and will roll out a high-band program at a later date. We assessed the mid-band program.

Program Essentials

Milestone decision authority: Navy

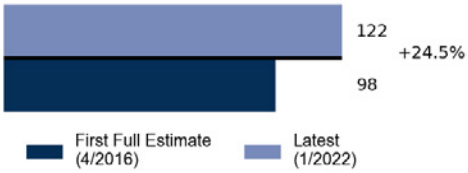
Program office: Patuxent River, MD

Prime contractor: Raytheon; Boeing

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

Acquisition Cycle Time

(in months)



Software Development

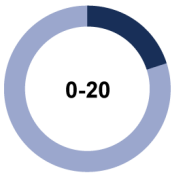
(as of January 2022)

Approach: Agile

Average time of software deliveries (months)

Information not available

Software percentage of total program cost



Software type

2 percent Off-the-shelf

2 percent Modified off-the-shelf

96 percent Custom software

According to program officials, time of software deliveries is not applicable because the program has yet to make any software deliveries to the user, which in this case is the fleet.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (4/2016)	Latest (6/2021)	Percentage change
Development	$3,836.61	$4,331.78	+12.9%
Procurement	$4,445.85	$4,375.76	-1.6%
Unit cost	$61.41	$64.56	+5.1%
Total quantities	135	135	+0.0%

Total quantities comprise six development quantities and 129 procurement quantities.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Development Start**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	●
Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	○	○
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	○	○

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

NGJ MB Program

Technology Maturity, Design Stability, and Production Readiness

The Navy approved the NGJ MB program to start production in June 2021 having met some, but not all, of the leading practices for production readiness and delayed delivery of capabilities by about 1 year. The program demonstrated that its critical technologies are mature, released all of its design drawings, and demonstrated its critical manufacturing processes on a pilot production line.

However, contrary to leading practices, the Navy did not test a production-representative NGJ MB prototype in an operational environment prior to beginning production, and does not plan to do so until February 2022. Program officials told us that they mitigated this risk by gathering hundreds of hours of test data on the pod's performance. They also stated that the system is on track to meet all of its key performance requirements. However, we have found that starting production before demonstrating a system will work as intended increases the risk of discovering deficiencies that require costly rework. A February 2021 independent DOD assessment similarly noted that the Navy would have limited test data to assess NGJ MB performance in an operational environment by the program's June 2021 production decision.

The Navy also delayed initial operational capability, operational testing, and full-rate production by 11 to 14 months since our last assessment due to design and testing issues. In December 2020, program officials determined the flight test pods could not be used to demonstrate the performance of the system in the full range of operational flight conditions, which is needed to qualify the system. Officials stated that they first discovered a design issue with the test pod fan blades in the power generation system in 2019 but did not anticipate it would affect flight testing. Program officials stated that the contractor completed redesign of the fan blades as of May 2021 and will begin flight testing in March 2022. We previously reported that the program had not matured its design or tested a system-level prototype prior to its 2017 design review, missing an opportunity to identify and mitigate these issues earlier in the acquisition process. In total, these issues have contributed to the program delaying its planned date for initial capability by 2 years—from September 2021 to September 2023—since its 2016 first full estimate.

When the Navy approved the NGJ MB program to enter production in June 2021, the program also had yet to demonstrate that its production processes were in statistical control, which is inconsistent with leading practices. Instead, the program demonstrated its manufacturing processes on a pilot production line to the level that DOD guidance calls for to begin low-rate initial production. In addition, the DOD independent assessment noted that concurrency between development and production posed a manufacturing risk if issues were found that required rework on production units.

Software and Cybersecurity

The program continues to identify software development as a risk, stating that the effort is more difficult and costly than expected. It reported that the complexity of pod integration and delayed hardware deliveries drove the risk. Those issues prevented the contractor from delivering the final fully capable software before developmental testing as planned. As a result, the contractor had to complete software development while fixing issues identified in testing, which contributed to program cost increases.

While the program does not plan to complete various cybersecurity assessments until August 2023, it conducted limited cybersecurity testing before production. A February 2021 independent DOD assessment noted that the discovery of security issues after the pod is in production could result in increased costs or decreased mission capability.

Other Program Issues

The NGJ MB program began production 3 months later than the planned date we reported last year. Program officials explained that several factors caused the delay, including delays in pod deliveries and integration challenges, which were exacerbated by COVID-19. The program's reported COVID-19 impacts included temporarily slowed production lines, material and supplier delays, and delays in testing availability, which as of July 2021, had resulted in 10 weeks of delays and over $4 million in cost increases.

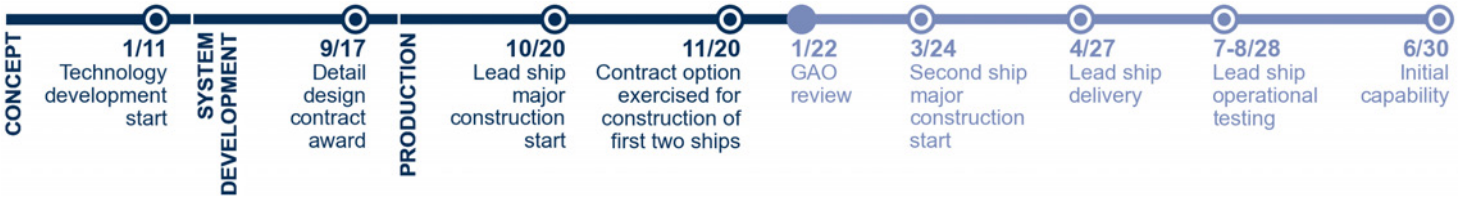
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office stated that the program remains on the schedule approved at the June 2021 production decision, and identified completion of certain flight tests as the largest schedule risk. According to the program office, the pod hardware design remains stable with no major changes anticipated. The program office also noted that it is on track for correcting critical software deficiencies prior to operational testing and built time into the schedule to mitigate software risks. In addition, the program office stated that it continuously evaluates cybersecurity and does not expect cybersecurity deficiencies to affect the program. According to the program office, fleet training for aircrew and maintenance personnel will start in fiscal year 2022, and the program expects that this early fleet involvement will help mitigate risk to operational testing and identify any supportability issues.

Source: General Dynamics Electric Boat. | GAO-22-105230

SSBN 826 *Columbia* Class Ballistic Missile Submarine (SSBN 826)

The Navy's Columbia class (SSBN 826) will replace its current fleet of Ohio class ballistic missile submarines, which the Navy plans to retire starting in 2027. The submarine will serve as a 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 Essentials

Milestone decision authority: Under Secretary of Defense, Acquisition and Sustainment

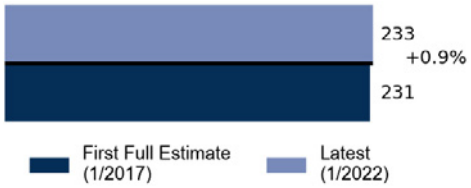
Program office: Washington Navy Yard, DC

Prime contractor: General Dynamics Electric Boat

Contract type: CPIF (development and construction)

Acquisition Cycle Time

(in months)



Software Development

(as of January 2022)

Approach: Incremental

Average time of software deliveries (months)

Software percentage of total program cost

Information not available

Software type

0 percent Off-the-shelf

0 percent Modified off-the-shelf

100 percent Custom software

Program officials stated that software costs are not tracked because software was developed by another Navy program or is reused with minor modifications.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (1/2017)	Latest (2/2021)	Percentage change
Development	$13,814.0	$14,232.96	+3.0%
Procurement	$95,485.47	$97,684.58	+2.3%
Unit cost	$9,121.70	$9,355.10	+2.6%
Total quantities	12	12	+0.0%

Total quantities comprise zero development quantities and 12 procurement quantities.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Detail Design Contract Award**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	○
Complete a system-level preliminary design review	●	●
Product design is stable	**Fabrication Start**	
Complete basic and functional design to include 3D product modeling	●	●

● Knowledge attained … Information not available

○ Knowledge not attained NA Not applicable

The program office completed SSBN 826 *Columbia* class basic and functional design. It is further developing the ship's model to include detail design and construction planning data.

SSBN 826 Program

Technology Maturity, Design Stability, and Production Readiness

The program considers all of SSBN 826's critical technologies mature, though three systems remain below our definition of maturity, consistent with our last assessment. Based on leading acquisition practices, we consider technologies mature after successful testing of a prototype near or at the planned operational system configuration in a realistic environment. Under current plans, one additional technology will reach maturity in fiscal year 2022 and another will in fiscal year 2023, but one will remain immature until after lead submarine delivery, currently planned for April 2027. Until testing is complete, the program risks costly, time-intensive rework if deficiencies emerge during production or testing.

The shipbuilder completed basic and functional design before the lead submarine's start of formal construction—consistent with leading practices for ensuring design stability. But, the program remained behind on producing design products. Products included work instructions that detail how to build the submarine, contributing to construction delays.

In an effort to reduce the risk of delivery delays, the shipbuilder accelerated its build schedule and now plans to deliver the lead submarine in 78 months—6 months faster than initially planned. The program began formal construction in October 2020 and by that time had already completed 5 percent of the lead submarine through early construction. The shipbuilder began building parts of the submarine early as part of the Navy's strategy to achieve the program's aggressive delivery schedule. Program officials and shipbuilder representatives stated they believe that with early design, construction, and material ordering, and with plans to complete more activities in parallel, they can accelerate lead submarine delivery. However, at the time formal construction started, there was little to no margin for constructing the submarine's super modules under the initial 84-month schedule. The Navy assessed that there is medium risk to the program's ability to achieve the accelerated schedule during the integrated baseline review.

As of August 2021, the shipbuilder completed less construction than planned due to errors and quality problems that resulted in rework, as well as late supplier materials, among other things. The shipbuilder rebaselined the schedule for one section of the submarine—shifting work on the submarine's missile tubes to later in the schedule—in an effort to achieve on-time delivery of this section of the submarine and support its plans for the accelerated schedule. The shipbuilder is mitigating delays by prioritizing construction of the *Columbia* class over its other submarine work. For example, it added workers to the *Columbia* class rather than the *Virginia* class program, which contributed to delays on that program.

Additionally, according to Navy officials, the shipbuilder is using management reserves to pay for the added workers to mitigate additional contract cost increases. Management reserves are typically used to address unforeseen issues, and the shipbuilder stated that there are considerable unknowns for the first submarine. With only 14 percent of construction complete as of November 2021, should the shipbuilder need management reserves beyond what they have planned, the total estimated contract costs are likely to increase.

Software and Cybersecurity

According to the program office, the shipbuilder estimated the cost to implement a portion of new DOD cybersecurity requirements for the first two submarines, and this is included under the contract.

Other Program Issues

The Navy updated its acquisition program baseline in 2021 and its estimated acquisition costs increased by over $3.4 billion since our last assessment. This increase reflects the August 2020 independent cost estimate for the whole class, expenditures on the supplier base, missile tubes that required costly rework, poor contractor performance during design, and updated construction costs, among other things.

Program officials stated that Electric Boat, Newport News Shipbuilding, and a missile tube supplier experienced inefficiencies in 2020 due to COVID-19. However, the shipbuilders prioritized *Columbia* class work over other programs at the shipyards, which minimized additional cost and schedule implications.

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 took actions to reduce risks, such as ensuring stable requirements, executing manufacturing readiness and supplier base efforts, and pursuing cost reduction actions. It added that the program exceeded the 83 percent overall design maturity required by the milestone decision authority by the start of lead ship construction, and it worked through initial design tool issues that led to delayed design products. The program office also stated that the program's budget for fiscal year 2022 reflects increased costs for shipyard performance and materials. Further, it noted that the Navy took actions to address construction performance challenges in 2021 and that the program continues to comply with all Navy, DOD, and statutory requirements associated with managing critical technologies and engineering integration efforts.

Source: Textron Systems. | GAO-22-105230

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. SSC 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 assault and nonassault operations.

Program Essentials

Milestone decision authority: Navy

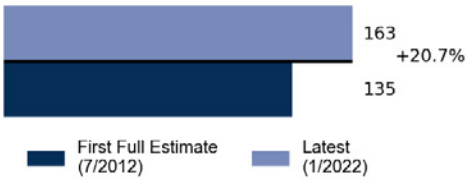
Program office: Washington, DC

Prime contractor: Textron, Inc.

Contract type: FPI (detail design and construction)

Acquisition Cycle Time

(in months)



Software Development

(as of January 2022)

Approach: Modified Waterfall

Average time of software deliveries (months)

Software percentage of total program cost

Information not available

Software type

73 percent Off-the-shelf

2 percent Modified off-the-shelf

25 percent Custom software

Program officials stated they do not track software in their cost reporting system.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (7/2012)	Latest (5/2021)	Percentage change
Development	$658.76	$687.01	+4.3%
Procurement	$3,998.09	$4,842.07	+21.1%
Unit cost	$64.09	$75.97	+18.5%
Total quantities	73	73	+0.0%

Total quantities comprise one development quantity and 72 procurement quantities, compared to prior estimates that had two development quantity and 71 procurement quantities.

Attainment of Product Knowledge (as of January 2022)

	Status at Development Start	Current Status
Resources and requirements match		
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	●	●
Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	○	○
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	○	●

● Knowledge attained … Information not available

○ Knowledge not attained NA Not applicable

SSC Program

Technology Maturity, Design Stability, and Production Readiness

SSC's one critical technology—the fire suppression system—and its design are mature. The program also considers its top two technical issues, cracking propeller blades and premature gearbox wear, to be retired. According to program officials, the program and contractor developed a solution for the propeller issue that involved reinforcing and shaping the blade. Officials also reported that testing of the reinforced solution was completed and reinforced blades have been installed on all completed craft and will be installed on all craft moving forward. The program expects to validate the new propeller's performance against requirements by June 2022. It also incorporated the final gearbox design into the latest craft, which addressed previous concerns over premature wear, and is completing design reviews.

Resolving these technical issues delayed operational testing and initial capability by 8 and 11 months, respectively, since our last assessment. The program also delayed the full-rate production decision by nearly 6 years, until 2028, in order to incorporate the resolutions into the product baseline, and increased the number of low-rate initial production craft from 29 to 50. This increase represents a potential risk to the program, as it will be buying significant quantities before making a full-rate production decision. By deferring the full-rate decision, the Navy may lack knowledge while buying a large number of craft.

During LCAC 102's acceptance trial in May 2021, the program found two issues that would prevent the program from accepting the craft, down from four on earlier craft, according to program officials. The first issue related to erosion on propeller blade edges. Program officials reported that they included an edge guard in the blade reinforcement design, but the part had yet to be installed for testing, and installation is now in progress. The second issue related to air leakage due to non-flush surfaces in a module of the craft's air cushion vanes. According to program officials, they made changes to the module's design to eliminate this leakage. The program officials also said they reinforced a second component so that it would remain closed to avoid further air leakage.

The program kicked off post-delivery trials in late 2020 on the first two craft and, as of September 2021, is conducting beach landing tests, according to program officials. It began testing vehicle loading with the Marine Corps in September 2021, which is expected to continue in 2022. According to program officials, the program also plans to conduct testing during which they load an SSC on and off amphibious ships in 2022 when a ship becomes available.

Software and Cybersecurity

There are no particular software risks or challenges to the program at this time, according to program officials, and the program completed full craft cybersecurity scanning and vulnerability patching ahead of schedule in April 2021.

Other Program Issues

The program breached statutory unit cost thresholds in March 2021 due to its technical challenges, along with labor and material cost growth. The next 14 craft on the follow-on contract, for example, are expected to have increased unit costs, according to program officials. These costs led the program to increase the life cycle baseline costs in an updated Acquisition Program Baseline by over $700 million in May 2021. Program officials noted that they are working with the contractor to find future cost reduction opportunities.

The program also decreased the threshold capacity requirements for the craft by 11.5 tons in the latest acquisition program baseline. According to program officials, the original capacity requirement was driven by the M1 Abrams tank, which the craft was intended to transport. However, the Marine Corps' latest force restructure divested the M1 Abrams tank.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. According to the program office, the cushion vane and propeller erosion issues identified during LCAC 102 acceptance trials were corrected prior to LCAC 103 trials, and LCAC 103 was successfully delivered in December 2021. LCAC 104 is expected to complete trials and be delivered in the spring of 2022.

The program office stated that it is working to complete the testing needed to demonstrate the SSC meets its requirements and that the first two craft are planned to be assigned to an assault craft unit in 2022.

Source: General Dynamics, National Steel and Shipbuilding Company (NASSCO). | GAO-22-105230

T-AO 205 *John Lewis* Class Fleet Replenishment Oiler (T-AO 205)

The *John Lewis* Class Fleet Replenishment Oiler (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 oiler is to replenish bulk petroleum products, dry stores and packaged cargo, fleet freight, mail, and personnel to other vessels at sea. The Navy plans to procure these ships at a rate of roughly one ship per year until 2036.

Program Essentials

Milestone decision authority: Navy

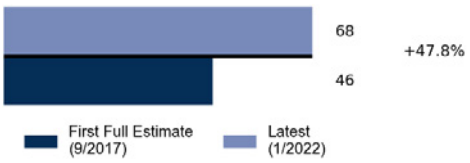
Program office: Washington Navy Yard, DC

Prime contractor: General Dynamics National Steel and Shipbuilding Company

Contract type: FPI (detail design and construction)

Acquisition Cycle Time

(in months)



Software Development

(as of January 2022)

Approach: Information not available

Average time of software deliveries (months)

Information not available

Software percentage of total program cost

Information not available

Software type

95 percent Off-the-shelf

5 percent Modified off-the-shelf

0 percent Custom software

The program reported it is using off-the-shelf software systems and does not collect information on software delivery time frames or cost.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (9/2017)	Latest (8/2020)	Percentage change
Development	$75.09	$74.86	-0.3%
Procurement	$9,414.53	$12,041.87	+27.9%
Unit cost	$558.21	$605.84	+8.5%
Total quantities	17	20	+17.6%

Total quantities comprise zero development quantities and 20 procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at Detail Design Contract Award	Current Status
Resources and requirements match		
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	●	●
Complete a system-level preliminary design review	○	●
Product design is stable	**Fabrication Start**	
Complete basic and functional design to include 3D product modeling	●	●

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

T-AO 205 Program

Technology Maturity, Design Stability, and Production Readiness

All *Lewis* class critical technologies were mature and the design was stable prior to construction start in 2018. However, over the past year, the program experienced challenges that led to further delays in the planned delivery dates for the first two ships. We reported last year that the lead ship's planned delivery date was delayed by 7 months to June 2021. Over the past year, additional issues further delayed the planned delivery to March 2022. Program officials attributed these delays to four factors:

- High levels of rework, which the program stated is normal for a first-of-class ship.
- Late deliveries related to materials.
- Propulsion faults that required the ship to be dry-docked from March 2021 to May 2021.
- COVID-19 caused the shipyard's absentee rate to spike in fall 2020 to nearly 20 percent.

Program officials stated that the delay in the lead ship's planned delivery affected other program events. For example, the planned date for operational testing slipped by 9 months (from January to October 2022) and planned initial operational capability slipped by 3 months (from February to May 2023). As a result, the planned date for the full-rate production decision was delayed by 14 months. These issues, among others, also led to a 12- to 15-month delivery delay for each of the remaining five ships under contract.

The program is experiencing cost growth that program officials reported will be borne by both the shipbuilder and the government. Among other factors, the program attributed recent cost growth to Economic Price Adjustments for labor and material costs. We previously reported that the program experienced cost overruns for higher-than-expected inflation, especially for materials like steel, due to increased tariffs. The program estimates the first and second ships will exceed their original target costs. Program officials stated that the parties will share costs to a target amount, but the government will not pay an amount above the contract ceilings for the ships except for Economic Price Adjustments.

The program is actively working on cost reduction initiatives through a Cost Reduction Working Group. As of January 2022, the Navy funded and implemented 91 cost savings initiatives. The Navy projects that the program's return on investment from these initiatives will be significant over the life span of the program.

Software and Cybersecurity

The program reported it does not have any software development efforts and that its software is almost entirely commercial-off-the-shelf. The program satisfied all cyber requirements and received its Authorization to Operate on October 7, 2021.

Program officials stated that they anticipate potential cost growth related to cybersecurity in the future as a result of DOD's Cybersecurity Maturity Model Certification requirements. They told us that the magnitude of the cost growth is unclear at this point but will not affect the cost of any ships currently under contract.

Other Program Issues

For the seventh ship, the Navy now plans to award a contract modification on a sole-source basis to the current T-AO 205 contractor. The Navy included up to six ships in its original contract and originally planned to purchase future ships through competitively awarded contracts. According to the program office, its original approach was intended to allow the program to receive more detailed production information developed through manufacturing the first ship before competing future procurements. The program office noted that the Navy is currently analyzing its acquisition strategy to award follow-on vessels, which may involve a combination of sole-source or competitive contract awards and will consider the Navy's requirement for deactivating the existing class of Fleet Replenishment Oilers.

Program Office Comments.

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. According to the program office, the program continues to follow shipbuilding best practices along with leveraging commercial vessel design practices to minimize risks, reduce ship costs, and drive affordability into the design. The program office noted that while the program experienced cost growth, the program office and the shipbuilder continue to look for additional opportunities to reduce costs in the design while balancing life-cycle costs and fleet requirements. Additionally, it stated that the lead ship of the class completed a series of in-port and at-sea demonstrations in early February 2022. Finally, the program office stated that the Navy is working with the shipbuilder on the delivery of all ships under contract as COVID-19 continues to affect the shipbuilder's workforce and supply chain.

Source: USMC. | GAO-22-105230

VH-92A® Presidential Helicopter Replacement Program (VH-92A)

The Navy's VH-92A program provides new helicopters in support of the presidential airlift mission. It supersedes the VH-71 program that DOD canceled due to cost growth, schedule delays, and performance shortfalls. Twenty-three VH-92As—21 in-service and two test aircraft—will replace the current fleet of VH-3D and VH-60N aircraft. The VH-92A is expected to provide improved performance, communications, and survivability capabilities, while offering increased passenger capacity.

Program Essentials

Milestone decision authority: Navy

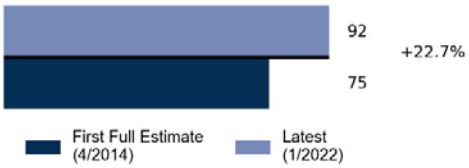
Program office: Patuxent River, MD

Prime contractor: Sikorsky Aircraft Corporation, a Lockheed Martin Company

Contract type: FPI (development), FFP (production)

Acquisition Cycle Time

(in months)



Software Development

(as of January 2022)

Approach: Agile and Waterfall

Average time of software deliveries (months)

Software percentage of total program cost

Information not available

Software type

80 percent Off-the-shelf

3 percent Modified off-the-shelf

17 percent Custom software

The program office stated that its overall software costs do not meet the dollar threshold that would require them to be independently tracked.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (4/2014)	Latest (4/2021)	Percentage change
Development	$2,961.81	$2,799.75	-5.5%
Procurement	$2,322.54	$2,223.66	-4.3%
Unit cost	$229.75	$218.41	-4.9%
Total quantities	23	23	+0.0%

Total quantities comprise six development quantities and 17 procurement quantities.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Development Start**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	NA	NA
Demonstrate all critical technologies in form, fit, and function within a realistic environment	NA	NA
Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	●	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	○	●
Demonstrate critical processes on a pilot production line	●	●
Test a production-representative prototype in its intended environment	●	●

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

We did not assess VH-92A critical technologies because, according to the program office, the Navy certified VH-92A at development start as not having any.

VH-92A Program

Technology Maturity, Design Stability, and Production Readiness

VH-92A has no critical technologies and entered production in June 2019 with a stable design. According to program officials, design drawings increased following the critical design review to reflect changes incorporated into production aircraft. Operational testing during 2021 highlighted issues with performance and reliability that the program is working to address.

As we previously reported, performance issues with VH-92A's government-developed mission communications system (MCS) impeded VH-92A's operational effectiveness and entry into service. GAO reviewed the report from operational testing, completed in April 2021; however, the specific details of this report are not publicly releasable. During operational testing, test officials identified deficiencies that affirmed the need for planned improvements that were incorporated subsequent to completion of testing. Consequently, the Director, Operational Test and Evaluation (DOT&E) is planning follow-on operational testing. The program office reported that all test aircraft and aircraft delivered to the Marine Corps have an upgraded version of the MCS installed, which, according to the program office, is expected to correct the deficiencies.

The program exercised options to procure its final production lot in February 2021 and took delivery of the first two production aircraft at the end of November 2021. However, technical modifications may be needed to address issues identified in follow-on operational testing. Specifically, DOT&E recommended the Navy work to improve MCS performance; increase aircraft availability; and reduce engine exhaust and fluid discharges on landing zones. Program officials told us they started implementing solutions to address identified effectiveness and suitability issues, which did not impact achieving initial operational capability in December 2021. However, because the program bought all planned aircraft before completing operational testing, it increased the risk that identification of any further issues could require costly and time-intensive modifications to aircraft already in production.

The program has also yet to meet a key system attribute to avoid aircraft exhaust from damaging the landing zone. Heat from the engines, with the rotors turning, causes discoloration of the grass at the landing zone on a hot day. The exhaust limits the number of landing zones from which the aircraft can operate. Design changes to the auxiliary power unit, tested in 2020, redirect exhaust away from the landing zone. Sikorsky installed this improvement on all delivered aircraft and is incorporating it into those still under production. Program officials shared that changes were incorporated on aircraft to prevent fluid discharge. However, according to the program office, the risk of grass damage when the rotors are not turning is fully resolved. Program officials told us they are continuing to evaluate the effectiveness of blade pitch changes—the proposed solution provided by Sikorsky to the program in April 2021—to mitigate landing zone damage when the rotors are turning. It reported that these landing zone suitability challenges did not prevent the program from achieving initial capability but do continue to present a mission execution risk. Further, according to program officials, the changes will require the aircraft to undergo certification for landing zone suitability from the Federal Aviation Administration.

Software and Cybersecurity

Over the past year, the program conducted a Cooperative Vulnerability Penetration Assessment and an Adversarial Assessment following operational testing to assess the system's cybersecurity. While a different government agency conducted MCS cybersecurity survivability testing, DOT&E representatives reviewed the assessment to ensure that the crossover points between the aircraft and MCS were adequately assessed.

Other Program Issues

The four system demonstration test articles, considered early production aircraft, are now with the Marine Corps squadron as operational aircraft. According to program officials, two test aircraft are at the Presidential Helicopter Support Facility. Full operational capability of 15 available aircraft within the squadron is expected no later than January 2023.

Program Office Comments

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

Source: Huntington Ingalls Industries. | GAO-22-105230

DDG 51 *Arleigh Burke* Class Destroyer, Flight III

The Navy's DDG 51 Flight III destroyer is planned to be a multimission ship designed to operate against air, surface, and underwater threats. Compared with existing Flight IIA ships of the same class, the Navy expects new Flight III ships to provide the fleet with increased ballistic missile and air defense capabilities. Flight III's changes include replacing the current SPY-1D(V) radar with the Air and Missile Defense Radar (AMDR) program's AN/SPY-6(V)1 radar and upgrading the destroyer's Aegis combat system.

Program Essentials

Milestone decision authority: Navy

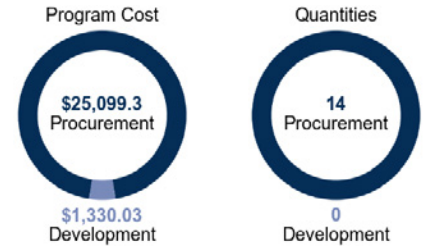
Program office: Washington, DC

Prime contractor: General Dynamics-Bath Iron Works; Huntington Ingalls Industries

Contract type: FPI (construction)

Estimated Cost and Quantities

(fiscal year 2022 dollars in millions)



These procurement costs reflect costs for 13 Flight III ships included in the fiscal year 2022 budget request. The program plans to procure 14 ships, but the costs for the 14th ship are not reflected in the fiscal 2022 budget request.

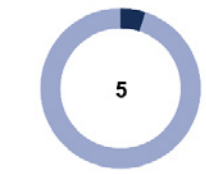
Software Development

(as of January 2022)

Approach: Agile, Incremental, and DevSecOps

Average time of software deliveries (months)

Software percentage of total program cost



Software type

0 percent Off-the-shelf

0 percent Modified off-the-shelf

100 percent Custom software

Current Status

Construction on the lead Flight III ship—DDG 125—is on schedule to deliver in April 2023, but the schedule leaves minimal time to address unexpected issues identified during sea trials or operational testing to meet its August 2024 initial capability date, according to program officials. Contractor performance reports show that the first two Flight III ships saw cost growth since construction began. Both ships are above target costs due to first time build challenges and ongoing impacts of COVID-19, per program officials. In October 2021, program officials said DDG 125 was 67 percent complete, and the second Flight III ship—DDG 126—was 11 percent complete. Program officials report they plan to procure 14 Flight III ships through fiscal year 2022 with additional ships subject to future funding. We previously reported the Navy planned to procure 18 Flight III ships through fiscal year 2025.

The program continues to make progress testing and integrating ship components with AMDR components and Aegis software, but faced technical challenges over the last year. Officials said these challenges resulted in re-phasing AMDR testing 9 months later than planned, but did not delay planned ship delivery and have since been resolved. The Navy activated Aegis onboard DDG 125 in December 2021. The program is integrating and testing ship power components with AN/SPY-6(V)1 and Aegis hardware and software at land-based test sites. Flight III ships will also receive a new 400Hz power distribution system after tests on Flight IIA ships showed the initial system did not meet requirements, per program officials. The new system required design updates and retrofitting to areas on Flight III ships, but has been tested on a Flight IIA ship and meets all requirements.

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 it delivered 70 DDG 51 ships with an additional 19 under contract, 14 of which are Flight III ships. Officials said AN/SPY-6(V)1 and electrical plant installations are complete on DDG 125, which is on track to be delivered in April 2023. Land-based integration testing is ongoing and continues to reduce risk to the ship's production schedule, per officials. Program officials said the use of fixed-price incentive contracts with cost ceilings have minimized cost overrun risks to the government.

Source: Huntington Ingalls Industries. | GAO-22-105230

LHA(R) Amphibious Assault Ships (LHA 8 and LHA 9)

The Navy's LHA 8 and LHA 9, the third and fourth LHA 6 class ships, will help replace retired LHA 1 *Tarawa*-class amphibious assault ships. These ships incorporate significant design changes from earlier ships in the LHA 6 class and are intended to provide enhanced aviation capabilities and a well deck to accommodate two landing craft. The ships are designed to transport about 1,350 Marines and equipment onto hostile shores. The LHA 8 is scheduled to be delivered in February 2025, and LHA 9 is expected to begin construction in fiscal year 2023.

Program Essentials

Milestone decision authority: Navy

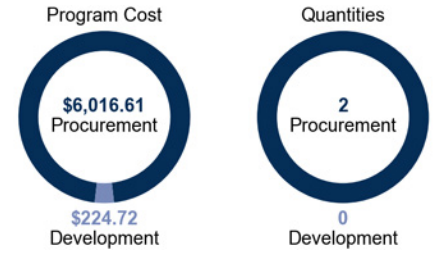
Program office: Washington, DC

Prime contractor: Huntington Ingalls Industries

Contract type: FPI (detail design and construction)

Estimated Cost and Quantities

(fiscal year 2022 dollars in millions)



Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Software Development

(as of January 2022)

Approach: Agile and Mixed

Average time of software deliveries (months)

Information not available

Software percentage of total program cost

Information not available

Software type

Information not available

Program officials stated they do not track software work elements.

Current Status

LHA 8 construction progress is 37 percent complete as of September 2021 and the ship is expected to be delivered in February 2025—about a year later than originally planned—per program officials. They said one of the main reasons for the delay was due to a 14- to 18-month delay in receiving the ship's main reduction gears after manufacturing defects required correction. They added that the shipbuilder continues to prioritize completing ships with earlier delivery dates, leaving LHA 8 construction understaffed. Program officials said they can do little to address the issue beyond delaying LHA 8's delivery by about a year. According to the program, changes to the ship to accommodate integration of the Enterprise Air Surveillance Radar (EASR)—a new radar system based on the preexisting Air and Missile Defense Radar assessed separately in this report—is another contributor to LHA 8's schedule delay. Officials told us they expect LHA 8's final price to exceed the original target cost by $68 million due to the delays. Costs above the target cost but below the contract's price ceiling will be shared by the shipbuilder and the Navy.

The planned timing of LHA 9's detailed design and construction contract was accelerated from fiscal year 2024 to late fiscal year 2021 after Congress provided fiscal year 2019 advanced procurement funding. However, program officials said the contract was not awarded in late fiscal year 2021 as planned. They do not expect to delay construction start, currently planned for fiscal year 2023.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office stated that, as of mid-December 2021, LHA 8 is roughly 42 percent complete. The program office added that the shipbuilder and the Navy continue to identify and manage risks where appropriate and that LHA 8 is on track for delivery in 2025.

Source: U.S. Navy. | GAO-22-105230

LPD 17 *San Antonio* Class Amphibious Transport Dock, Flight II (LPD 17 Flight II)

The Navy's LPD 17 Flight II program will replace retiring transport dock ships. The Navy intends to use LPD 17 Flight II ships to transport Marines and equipment to support expeditionary operations ashore, as well as noncombat operations for storage and transfer of people and supplies. The Flight II ships include a larger hull than the ships they replace, and the Navy expects them to provide additional capabilities. The Navy plans to acquire 13 Flight II ships, beginning with LPD 30.

Program Essentials

Milestone decision authority: Navy

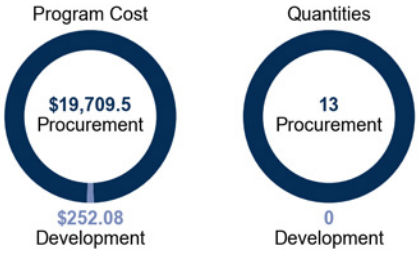
Program office: Washington Navy Yard, DC

Prime contractor: Huntington Ingalls Incorporated

Contract type: FPI (detail design and construction)

Estimated Cost and Quantities

(fiscal year 2022 dollars in millions)



Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Software Development

(as of January 2022)

Approach: Information not available

Average time of software deliveries (months)

Information not available

Software percentage of total program cost

Information not available

Software type

Information not available

The program reported it does not track these metrics because software is not a significant work element.

Current Status

The LPD 17 Flight II designs are complete and include roughly 200 changes from the prior flight, according to the program. As we reported last year, the Navy is adding some planned Flight II enhancements to the last Flight I ships, LPD 28 and 29, to lower risk for Flight II ships. Navy officials told us that one key enhancement for LPD 29 and Flight II ships, the Enterprise Air Surveillance Radar, is on track to deliver as planned by summer 2022.

Program officials said that work on LPD 30 and 31 is underway, with keel-laying for LPD 30 in October 2020 and construction scheduled to begin on LPD 31 in April 2022. COVID-19 led the shipbuilder to draw workers from LPD 30 to mitigate shortages on LPD 28. As a result, construction of LPD 30 is delayed and the schedule is currently being reassessed. The LPD 30 workforce—which was about half of planned levels in mid-2020—is now approaching 70 percent of planned levels. Program officials told us they intend to assess COVID-19-related cost and schedule changes for LPD 30 in spring 2022.

The program plans to begin operational testing for LPD 30 in fiscal year 2024. Program officials told us that over the past year, the program's testing approach changed. They originally planned for some testing conducted on LPD 28 to count toward Flight II testing because this ship will have some Flight II equipment. However, the testing authority clarified that LPD 28 testing could not replace testing on Flight II. Revisions to the test and evaluation master plan are underway, and several decisions regarding testing remain, such as a requirement for a Full Ship Shock Trial.

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 Flight II will provide increased capability, including improved command and control capabilities, and ensure the Navy meets evolving missions using the new technologies. It added that the shipbuilder and Navy continue to identify and manage risks for all LPD 17 class ships currently under construction.

Source: U.S. Navy photo courtesy of Huntington Ingalls Industries. | GAO-22-105230

SSN 774 *Virginia* Class Submarine (VCS) Block V

VCS is a class of nuclear-powered, attack submarine capable of performing multiple missions. The Navy implemented major upgrades to the class in blocks. The most recent upgrade, Block V, is expected to include enhanced undersea acoustic improvements called acoustic superiority and increase the strike capacity for Tomahawk cruise missiles by inserting the Virginia Payload Module, a new midbody section. General Dynamics Electric Boat is the lead contractor, with substantial work performed by a subcontractor, Huntington Ingalls Industries Newport News Shipbuilding.

Program Essentials

Milestone decision authority: Navy

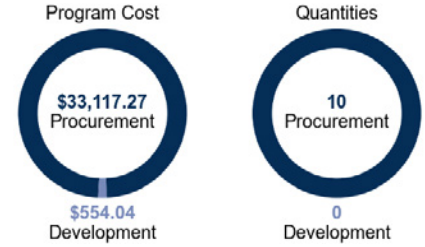
Program office: Washington, DC

Prime contractor: General Dynamics Electric Boat

Contract type: FPI (procurement)

Estimated Cost and Quantities

(fiscal year 2022 dollars in millions)

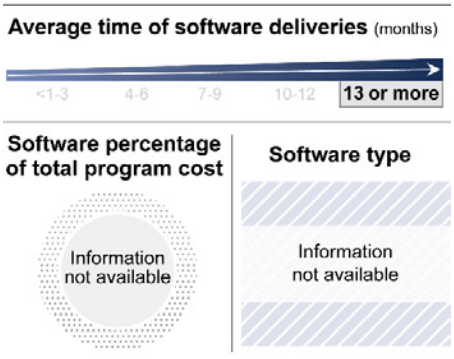


Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle. The program reported awarding a contract option for a 10th submarine in March 2021.

Software Development

(as of January 2022)

Approach: Waterfall



The program office stated it does not track software cost and type because all software has been developed and tested.

Current Status

Over the past year, work on Block V submarines fell further behind schedule and construction costs continued to grow above original targets due to overall higher workforce demand and additional factors such as correspondingly less experienced workers.

The Navy's prioritization of the *Columbia* class submarine relative to the *Virginia* class submarine exacerbated the effect of these workforce trends for *Virginia* class construction. The same companies build both submarine classes and have been challenged to meet both programs' increasing workforce needs. Program officials reported that the shipbuilders added more workers to the *Columbia* class construction efforts than the *Virginia* class, contributing to delays on the *Virginia* class submarines.

Consequently, program officials expect that the first three Block V submarines will be delivered late. Additional cost increases and schedule delays are likely. The Navy's current cost and schedule projections may be optimistic because they assume a significant amount of improvement in construction efficiency that has yet to be achieved, and the *Columbia* class's growing staffing needs continue to add risk for the *Virginia* class.

Program officials reported that acoustic superiority improvements were installed on a Block III submarine delivered in September 2018 in an effort to reduce risk to Block V. Program officials reported that no issues were found with integrating acoustic superiority during that submarine's construction and it successfully completed initial at-sea testing in October 2021.

Program Office Comments

We provided a draft assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office reported that it began full-rate production of two submarines per year in 2011, but it also stated that the shipbuilders are not currently meeting that delivery pace. It also stated that two Block IV *Virginia* class submarines—SSN 793 and SSN 794—are scheduled to be delivered in early 2022.

Source: U.S. Navy. | GAO-22-105230

Conventional Prompt Strike (CPS)

The Navy's CPS program plans to develop an intermediate-range, hypersonic missile via three phases. The first phase plans to demonstrate a cold-gas launched missile system by 2024 via an MTA rapid prototyping effort. The second phase aims to launch from a surface ship by 2025 via an MTA rapid fielding effort. The third phase expects initial capability on *Virginia*-class submarines by 2028 via the major capability acquisition pathway. We evaluated the first phase. CPS is partnered with the Army's Long Range Hypersonic Weapon Program, which is developing a version for land launch

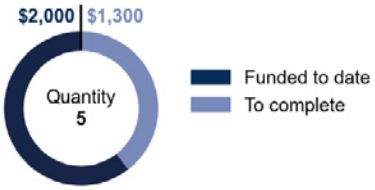
- **8/19** MTA initiation
- **10/19** MTA funds obligated
- **3/20** Interim program review
- **1/22** GAO review
- **Mid-2022** First CPS demonstration
- **3/24** Expected MTA completion
- **10/24** 5 years since MTA funds obligated

Program Essentials

Decision authority: Navy
Program office: Washington, DC
Prime contractor: Lockheed Martin
MTA pathway: Rapid prototyping
Contract type: CPIF

Estimated Middle Tier of Acquisition Cost and Quantities

(fiscal year 2022 dollars in millions)



The program clarified the unit quantity specific to the Phase 1 rapid prototyping effort.

Software Development

(as of January 2022)

Approach: Agile, Waterfall, Incremental, and DevSecOps

Average time of software deliveries (months)

Information not available

Software percentage of total program cost

Information not available

Software type

0 percent Off-the-shelf

0 percent Modified off-the-shelf

100 percent Custom software

Program Background and Transition Plan

The Navy initiated CPS in 2019 based on a 2009 technology development effort. CPS plans to complete the first phase—a rapid prototyping effort—in 2024 after testing the CPS missile from a cold-gas launch system. This test, originally planned for the second phase, was added to the first phase after the Navy restructured the program in 2021. In 2022, CPS plans to launch the common hypersonic glide body using a CPS-designed booster, followed by three more missile flight tests. In March 2020, the Navy and Army successfully flight tested the glide body using a surrogate missile booster.

Transition Plan: Transition to an MTA rapid fielding effort.

Attainment of Middle Tier of Acquisition Knowledge (as of January 2022)

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

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

Planned Knowledge by MTA Transition			
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	◐	Demonstrate all critical technologies in form, fit, and function within a realistic environment	□
Complete system-level preliminary design review	◐	Release at least 90 percent of design drawings	◐
Test a system-level integrated prototype	⊗	Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	⊗
Demonstrate critical processes on a pilot production line	◐	Test a production-representative prototype in its intended environment	⊗

● Knowledge attained ◐ Knowledge planned ⊗ Knowledge not planned
... Information not available NA Not applicable

CPS Program

Updates to Program Performance and Program Business Case

CPS underwent program restructuring in fiscal year 2021 and supply risks remain. CPS received 24 percent less funding than requested in fiscal year 2021. Program officials stated that, as a result, they halted in-air launch testing and the construction of the Underwater Launch Test Facility. Testing and construction on the Underwater Launch Test Facility resumed during fiscal year 2022. Testing delays and the restructure of the second phase shifted the planned completion of the current MTA effort 3 quarters later than expected, to the second quarter of fiscal year 2024.

The program identified a capacity-constrained supply market and limited manufacturing sources as high-priority risks. For example, officials noted risks linked to the shared supplier base between the Navy's CPS and Army's Long-Range Hypersonic Weapon programs. Further, the delivery of critical components was significantly delayed, impacting the flight test schedule. To address these risks, the program plans targeted investments starting in fiscal year 2022 to create dedicated CPS component production lines.

The Office of the Director of Cost Assessment and Program Evaluation (CAPE) updated its independent cost estimate in October 2021. CAPE estimated a 6-month developmental delay relative to the CPS planned schedule. This is an improvement from CAPE's prior estimate completed in June 2020, which projected an 18-month delay.

Technology

CPS identified six critical technologies, reporting two more than last year, after conducting an assessment to resolve technology-related reporting discrepancies. As of September 2021, the program assessed five of the technologies as immature, with one approaching maturity. Officials indicated that each technology is expected to reach maturity by completion of the MTA rapid prototyping effort in March 2024–a year later than originally planned. According to officials, CPS has not conducted a formal technology risk assessment for the MTA effort, because it is not required for MTAs. However, the program risks costly, time-intensive rework if deficiencies emerge in these immature technologies during testing.

Software Development and Cybersecurity

Software development is more difficult than originally anticipated and poses significant cost, schedule, and performance risks, according to program officials. A lack of adequate software integration facilities or developmental hardware, and hardware design changes requiring additional software development, were cited as major contributions to the risk. Officials also noted challenges integrating software with hardware.

Program officials said that contractor and government program offices experienced difficulty hiring and retaining sufficient staff, resulting in the need to use staff from other programs to address software and cybersecurity needs. Officials stated that these challenges led to the contractor providing interim engineering deliveries with fewer capabilities instead of final builds. To address ongoing hiring difficulties, the contractor is sharing staff across programs, using automation, and developing a longer-term staffing plan.

In July 2021, the program completed the first in a series of cybersecurity assessments that are expected to conclude in October 2027.

Transition Plan

In 2021, the program revised its transition plan to rapid fielding on DDG 1000 class destroyers, instead of rapid prototyping on a submarine as originally intended. Officials stated that this change was due to the funding reduction in fiscal year 2021, the near-term retirement of nuclear-powered guided missile submarines for testing, and a new Navy mission set for DDG 1000s to use CPS. The program plans to transition to the major capability acquisition pathway in fiscal year 2026 and launch on a *Virginia*-class submarine by fiscal year 2028.

However, the program does not plan to test a production-representative prototype in its intended environment prior to transitioning to the rapid fielding effort. Our prior work found that completing this test reduces the risk of costly and time-intensive rework during production.

Program Office Comments

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

Source: U.S. Navy. | GAO-22-105230

DDG(X) Guided Missile Destroyer

The DDG(X) program is developing a new multimission large surface combatant to follow the DDG 51 class destroyers, which have reached limitations in size and power margins necessary to accommodate future capability improvements. The Navy expects DDG(X) to incorporate existing weapons onto a new hull with a new integrated power system. The Navy intends for the design of DDG(X) to provide sufficient size and power margins to provide flexibility for incorporating new systems as they become available.

Program Essentials

Milestone decision authority: TBD

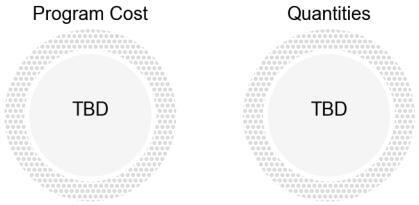
Program office: Washington Navy Yard, DC

Prime contractor: TBD

Contract type: TBD

Estimated Cost and Quantities

(fiscal year 2022 dollars in millions)



The program has yet to determine its estimated cost and quantities.

Software Development

(as of January 2022)

Approach: Information not available

Average time of software deliveries (months)

Information not available

Software percentage of total program cost

Information not available

Software type

Information not available

Program officials stated that it is too early in the program to know the need for or extent of software development.

Current Status

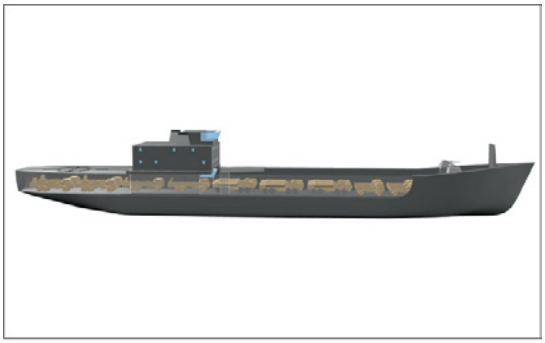
Established in April 2021, the Navy's DDG(X) program office is responsible for the development of the program's acquisition strategy, ship design, and testing, among other things. According to program officials, the program plans to tailor its acquisition approach to eliminate some documentation requirements and early acquisition oversight reviews. Officials told us that the program will not have a milestone review until fiscal year 2026, but completed analysis to determine that DDG(X) is the best materiel solution for the Navy. Officials told us that senior leadership plans to review the program prior to the 2026 milestone review using the Navy's review process, but did not provide planned dates for these reviews. The involvement of senior leadership in the early stages of the program will be important to ensure that DDG(X) can affordably meet the Navy's future needs—unlike with previous efforts to replace the DDG 51 class, such as DDG 1000, which suffered from cost growth and was ultimately truncated to three ships.

The program reported that it is currently leveraging existing DDG 51 contracts to work with industry to consider options for the DDG(X) design. It plans to complete scale-model testing and simulations to inform the hull form size and shape in fiscal year 2024. The Navy also plans to establish a land-based engineering site—leveraging lessons learned from prior destroyer programs—to inform development of the integrated power system.

The Navy approved a Future Surface Combatant Force Analysis of Alternatives in 2019, informing its decision to pursue a new ship design and preliminary requirements development. In December 2020, the Navy approved the lead ship's preliminary cost target of up to $4 billion (in fiscal year 2019 dollars)—about half the cost of DDG 1000. Since the Navy is still considering the design and quantity of these ships, the estimated cost may change significantly.

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 DDG(X) is required to employ capabilities identified as critical to the future fight including larger missiles, directed energy, and efficient integrated power. The program office added that a collaborative Navy-industry team will accomplish DDG(X) design, which is currently in concept exploration.



Source: U.S. Navy. | GAO-22-105230

Light Amphibious Warship (LAW)

The Navy's LAW program is developing a low-cost, medium-sized, multimission warship to fill a gap in capability between the Navy's large, multipurpose amphibious warfare ships and its smaller landing craft. The Navy plans for LAW to be capable of transporting 50 to 75 Marines and their supplies from shore to shore in contested operational environments. The Navy expects LAW to provide distributed maneuverability, mobility, and logistics in support of near-shore expeditionary operations, such as operations by the new Marine Littoral Regiments.

Program Essentials

Milestone decision authority: Navy

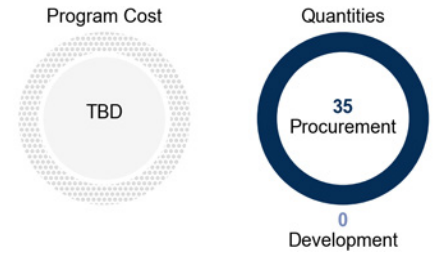
Program office: Washington, DC

Prime contractor: TBD

Contract type: TBD

Estimated Cost and Quantities

(fiscal year 2022 dollars in millions)



The Navy plans to complete an independent cost estimate by the end of fiscal year 2022.

Software Development

(as of January 2022)

Approach: Information not available

Average time of software deliveries (months)

Information not available

Software percentage of total program cost

Information not available

Software type

Information not available

The program office reported the amount and type of software has yet to be determined.

Current Status

The Navy is pursuing a tailored acquisition approach that it expects will accelerate the program's ability to deliver capability to the fleet. In particular, it plans to leverage an existing parent ship design in an effort to shorten development time. The program, which will use the major capability acquisition pathway, also plans to eliminate certain early acquisition oversight reviews, potentially limiting Navy leadership's insight into the program.

In 2020, the Navy identified the program's preliminary requirements and engaged with industry to assess possible commercial ship designs. Program officials told us they identified several designs that could serve as the basis for LAW, but determined all of these options would need to be modified to meet Navy requirements. In June 2021, the program awarded concept study contracts to five companies to continue assessing potential ship designs, and in January 2022, began working with these companies on preliminary designs.

The Navy plans to approve an analysis of alternatives—a key document that will help Navy leadership decide whether a new ship class is necessary to meet mission needs—in support of the program in early 2022. Nonetheless, the Navy is already in the process of defining requirements for LAW and starting ship design efforts. Our prior work shows that moving forward before Navy leadership validates the need for a new ship class can increase the risk of acquiring ships that do not cost-effectively meet mission needs.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office stated that the Navy is reviewing the analysis of alternatives report in advance of a meeting to decide whether it will approve the analysis of alternatives results. It added that moving forward with defining requirements through studies and collaboration with industry on preliminary design concepts are common Navy best practices being used to ensure LAW delivers the capability needed to support the Marine Littoral Regiments.

JOINT DOD

Program Assessments

▲ F-35 Lightning II (F-35)

Assessment type	Program name
MDAP	F-35 Lightning II (F-35)

Source (previous page image): Defense Visual Information Distribution Service. | GAO-22-105230

Source: Department of Defense. | GAO-22-105230

F-35 Lightning II (F-35)

DOD is developing and fielding three strike fighter aircraft variants integrating stealth technologies, advanced sensors, and computer networking for the U.S. Air Force (USAF), Marine Corps (USMC), and Navy (USN); international partners; and foreign military sales customers. The Air Force's F-35A variant will complement its F-22A fleet and replace the F-16 and A-10's air-to-ground attack capabilities. The Marine Corps' F-35B variant will replace its F/A-18A/C/D and AV-8B aircraft. The Navy's F-35C variant will complement its F/A-18E/F aircraft.

Program Essentials

Milestone decision authority: Under Secretary of Defense, Acquisition and Sustainment

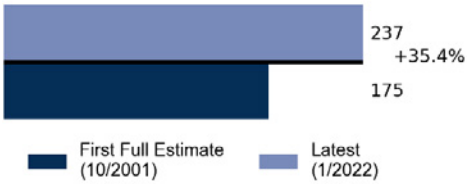
Program office: Arlington, VA

Prime contractor: Lockheed Martin; Pratt & Whitney

Contract type: CPIF (procurement, development), FPI (procurement)

Acquisition Cycle Time

(in months)



Software Development

(as of January 2022)

Approach: Agile

Average time of software deliveries (months)

Software percentage of total program cost

Information not available

Software type

0 percent Off-the-shelf

0 percent Modified off-the-shelf

100 percent Custom software

GAO recently reported that actual delivery times varied from 6 months to over 1 year for the most recent software drop.

Program Performance (fiscal year 2022 dollars in millions)

	First full estimate (10/2001)	Latest (9/2020)	Percentage change
Development	$46,129.68	$84,189.44	+82.5%
Procurement	$204,655.81	$286,876.6	+40.2%
Unit cost	$88.25	$152.37	+72.7%
Total quantities	2,866	2,470	-13.8%

Total quantities comprise 14 development quantities and 2,456 procurement quantities. Current cost and quantity data were not available because out-year funding estimates were not updated during the fiscal year 2022 budget cycle.

Attainment of Product Knowledge (as of January 2022)

	Status at	Current Status
Resources and requirements match	**Development Start**	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	●
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	●
Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
Release at least 90 percent of design drawings	○	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
Demonstrate Manufacturing Readiness Level of at least 9, or critical processes are in statistical control	○	○
Demonstrate critical processes on a pilot production line	○	●
Test a production-representative prototype in its intended environment	○	●

● Knowledge attained ... Information not available

○ Knowledge not attained NA Not applicable

F-35 Program

Technology Maturity, Design Stability, and Production Readiness

The F-35 program's ongoing operational testing continues to experience delays. According to program officials, as of June 2021, the program finished all open air flight tests needed to complete operational testing, but continuing challenges with developing the joint simulation environment—used to conduct virtual tests unreproducible in a real flight—delayed the program's remaining 64 simulated flight tests. The program has yet to identify a new end date for operational testing. The program cannot enter full-rate production until it completes this testing.

While the program found new performance deficiencies in the past year during operational testing, the total number of performance deficiencies the program is tracking decreased slightly as more were resolved. According to program officials, as of December 2021, four category 1 deficiencies that could restrict combat readiness remain, and 822 less-critical category 2 deficiencies remain. An example of a current category 1 deficiency is unreliable horizon imaging from the night vision camera on dark nights. The program office plans to resolve three of the category 1 deficiencies by the middle of 2022 and the final category 1 deficiency is under investigation.

Lockheed continues to deliver aircraft late due to long-standing production challenges, such as parts shortages, exacerbated by the COVID-19 pandemic and technical issues. However, the supply chain is recovering and the program identified fewer part shortages over the last year.

Following Turkey's 2019 suspension from the F-35 program, DOD authorized contractors to continue using Turkish parts through 2022 to alleviate concerns that removing Turkish suppliers would delay aircraft deliveries. Program officials reported that they identified alternative suppliers for all affected parts. DOD expects to finish qualifying all parts' design integrity by the end of March 2022.

The program office reported that it has yet to achieve statistical control of critical production processes, which would demonstrate that Lockheed can consistently meet quality, schedule, and cost expectations in aircraft production. It also reported that it is mitigating this issue through inspections and noted that only 14 percent of its manufacturing processes are at risk of not reaching maturity by full-rate production.

Over the past year, the program's reliability and maintainability performance metrics stayed the same. For example, as of November 2021, the program was close to or met 71 percent of its reliability and maintainability goals, the same as it was in June 2020. Reliability and maintainability determine the likelihood that the aircraft will be in maintenance rather than available for operations. Overall improvement in reliability and maintainability metrics continues to be slow.

Software and Cybersecurity

The program made progress since our last assessment in integrating cybersecurity into its software development process. According to a program official, the program is incorporating cybersecurity processes and tools into government and contractor software development. The program is also adding early and continuous cybersecurity analysis and assessment requirements to capability development.

However, the program continues to face software development challenges with its Block 4 modernization effort. As of August 2021, according to DOD officials, Block 4 capabilities continue to be delivered late to flight testers, and software defects continue to be a problem. The program made some software development improvements, such as increasing automated testing and conducting more tests to ensure that new or updated software does not affect existing software and to help find quality issues earlier. However, it is too early to assess the effectiveness of these initiatives.

Other Program Issues

Total Block 4 development costs grew by 5 percent since the program's September 2020 cost estimate, reflected in the Program Performance table on the prior page. This growth is in part due to a cost overrun in 2021 for Technology Refresh 3 development, which is a hardware processor update needed to implement many Block 4 capabilities.

Program Office Comments

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

Appendix II: Objectives, Scope, and Methodology

This report responds to title 10, section 3072 of the United States Code.[75] Specifically, this report assesses (1) the characteristics of the Department of Defense's (DOD) costliest weapon programs and how these programs have performed according to selected cost and schedule measures; (2) the extent to which programs implemented or planned for knowledge-based acquisition practices; (3) the extent to which programs have implemented modern software development approaches and recommended cybersecurity practices; and (4) how DOD has addressed recent legislative, organization, and policy changes related to the defense industrial base and the extent to which programs reported tracking and assessing defense industrial base challenges.[76] This report also includes information on DOD's efforts to implement software acquisition reform initiatives regarding acquiring software for weapon systems, business systems, and other activities that are part of the defense acquisition system. This information is included pursuant to a provision in the William M. (Mac) Thornberry National Defense Authorization Act (NDAA) for Fiscal Year 2021.[77]

This report also presents individual knowledge-based assessments of 63 Major Defense Acquisition Programs (MDAP), future major weapon acquisitions (previously referred to as future MDAPs), and middle tier of acquisition (MTA) programs. (See appendix I for GAO's assessments.)

Program Selection

To identify DOD's most expensive weapon programs, we took the following steps.

[75]Title 10, section 3072 of the U.S. Code was previously codified at title 10, section 2229b of the U.S. Code until it was transferred on January 1, 2022. This statute was enacted by section 833 of the John S. McCain National Defense Authorization Act for Fiscal Year 2019. See Pub. L. No. 115-232, § 833 (2018). This statute was later amended by section 813 of the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021. See Pub. L. No. 116-283, § 813 (2021). 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 2023. Our assessment of the performance of DOD's IT programs is included in a separate report, which we also prepared in response to title 10, section 3072 of the United States Code. That report will issue later this year.

[76]Due to the limited data included in the fiscal year 2022 budget request and the corresponding lack of updated comprehensive Selected Acquisition Reports, we are unable to make observations about the cost and schedule performance of DOD's current portfolio of MDAPs as we have done in prior years.

[77]William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116-283, § 838 (2021).

- **MDAPs**. We retrieved DOD's list of MDAPs from the Defense Acquisition Management Information Retrieval (DAMIR) system as of April 2021. To identify MDAPs for individual assessments, we narrowed our list to those that were either between the start of development and the early stages of production or well into production but introducing new increments of capability or significant changes expected to exceed the cost threshold for designation as an MDAP.[78]
- **Future major weapon acquisitions**. We retrieved the list of future MDAPs from DOD's DAMIR system that were identified by DOD as pre-MDAPs as of April 2021. We also reviewed budget documentation for other programs with costs expected to exceed thresholds for designation as a MDAP. We identified four programs that were expected to begin development using an Adaptive Acquisition Framework (AAF) pathway within the next two fiscal years.
- **MTA programs**. We obtained a list of programs using the MTA rapid prototyping or rapid fielding path from DOD's Defense Acquisition Visibility Environment that were reported by the military departments, as of May 2021, as having a cost for the current MTA effort above the equivalent threshold cost for designation as an MDAP—$525 million for Research, Development, Test, and Evaluation (RDT&E) or $3.065 billion in procurement (fiscal year 2020 constant dollars) or were included in our scope last year.[79] In some instances, current MTA efforts represent one of multiple planned efforts that are planned as

[78]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); DOD Instruction 5000.85, *Major Capability Acquisition* (Aug. 6, 2020) (Change 1 Effective Nov. 4, 2021) (reflecting statutory MDAP cost thresholds in fiscal year 2020 constant dollars).

[79]We initially identified 19 MTA programs that reported costs in their program identification data with costs greater than the ACAT I threshold that met the scope of the engagement. We subsequently removed three programs: Family of Advanced Beyond Line-of-Sight Terminals Force Element Terminal due to the presence of classified material; Air Operations Center Weapon System Modifications, because the program transitioned to the software acquisition pathway; and Standard Missile-6 Block IB Phase IB All Up Round because the program's costs when deflated to fiscal year 2020 dollars did not meet the ACAT I threshold. In addition, we included four programs in our scope with costs below the ACAT I threshold, but that were included in our prior assessment – B-52 Commercial Engine Replacement Program Rapid Virtual Prototype, Indirect Fire Protection Capability Increment 2, Integrated Visual Augmentation System (IVAS) Rapid Fielding (we assessed IVAS Rapid Prototyping in our prior assessment), and Protected Tactical Enterprise Service.

part of a program's overall acquisition strategy. Our assessment focused on the current MTA effort.

We excluded the Missile Defense Agency's Ballistic Missile Defense System and its elements from all analyses due to the lack of an integrated long-term baseline. We also excluded classified programs and programs considered sensitive from our analyses.

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 or future major weapon acquisitions in our assessment have a separate "program start" date, which begins a pre–system development phase for program definition and risk-reduction activities.

  This "program start" date generally coincides with DOD's milestone A on the major capability acquisition pathway, which denotes the start of technology maturation and risk reduction. The "production decision" generally refers to the decision to enter the production and deployment phase, typically with low-rate initial production. This decision generally coincides with milestone C for non-shipbuilding programs on the major capability acquisition pathway. The "initial capability" refers to the initial operational capability—sometimes called 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.

- For programs using the MTA pathway, the program start date for programs designated on or after December 30, 2019 is generally the date an acquisition decision memorandum was signed initiating an MTA rapid prototyping or rapid fielding program. MTA programs designated before December 30, 2019, and certain programs designated after this date, generally maintain their MTA program start date of funds first obligated.

Programs using the MTA pathway also develop "transition" plans, which refers to the point at which the program begins another effort using the MTA pathway or another acquisition pathway. DOD guidance directs these programs to develop a process for transitioning successful prototypes and programs to new or existing acquisition programs for production, fielding, and operations and sustainment.[80]

Additionally, for all programs we reviewed, we converted all cost information to fiscal year 2022 dollars using conversion factors from DOD Comptroller's National Defense Budget Estimates for Fiscal Year 2022.[81]

Data Collection and Reliability

To assess current costs and changes in costs of the MDAPs and MTA programs we reviewed, we took steps to collect and assess the reliability of this year's data.

- For MDAPs, we were not able to obtain updated cost information on all programs due to the fact that DOD did not include a Future Years Defense Program as part of its fiscal year 2022 President's Budget request. As a result, DOD did not issue comprehensive Selected Acquisition Reports for fiscal year 2021; we have historically relied on December Selected Acquisition Reports to analyze MDAP cost performance. Updated cost information since our last annual assessment was only available for three MDAPs that issued an initial Acquisition Program Baseline and 7 MDAPs that issued an updated Acquisition Program Baseline between January 2021 and January 2022.[82] For the remaining 24 MDAPs, the most recent complete cost data available are those reported in our prior annual assessment, generally as of January 2021.

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

[81]Department of Defense, Under Secretary of Defense (Comptroller), *National Defense Budget Estimates for Fiscal Year 2022* (August 2021), 72.

[82]We used the initial Acquisition Program Baselines for B-52 Radar Modernization Program (B-52 RMP), Long Range Stand Off Weapon (LRSO), and Precision Strike Missile (PRSM). We used Acquisition Program Baseline updates for Armored Multi-Purpose Vehicle (AMPV), Integrated Air and Missile Defense (IAMD), Next Generation Jammer Mid-Band (NGJ Mid-Band), *Columbia* Class Submarine (SSBN 826), VH-92A Presidential Helicopter (VH-92A), Advanced Anti-Radiation Guided Missile-Extended Range (AARGM-ER), and Ship to Shore Connector (SSC).

- For MTA programs, we obtained and analyzed data from each MTA effort's fiscal year 2021 program status reports submitted to the Office of the Secretary of Defense (OSD).

We also distributed a questionnaire to 63 selected program offices:

- 34 MDAPs in development or early production,
- six MDAPs that are well into production but introducing new increments of capability or significant changes,
- four future weapon acquisition programs, and
- 19 MTA programs.

We used the questionnaire to obtain information on programs' schedule, implementation of knowledge-based practices, software and cybersecurity approaches, industrial base challenges, and COVID-19 challenges, among other things. For future major weapon acquisitions and MTA programs, we also used the questionnaire to obtain additional verification of program cost data. We received responses from our questionnaires from August 2021 through October 2021.

To help ensure the reliability of the data collected through our questionnaire, we took a number of steps to reduce measurement and non-response error. These steps included:

- conducting pretests of new questions prior to distribution to ensure our questions were clear, unbiased, and consistently interpreted. Our pretests of questionnaires covered new questions to better ensure the questionnaire could be understood by officials.
- collecting and analyzing supplemental program information, such as budget submissions, acquisition decision memorandums, acquisition strategies, program cost and schedule estimates, service cost positions or independent cost estimates, risk assessments, and documents relating to technology maturity, software development, and cybersecurity. We also interviewed or received written responses from program officials to supplement and clarify this information.

To assess the reliability of the Defense Acquisition Executive Summary (DAES) data and the DAMIR system that houses the data, we relied on a full assessment of DAES and DAMIR conducted in August 2021 as part of this review. For that assessment, we sent questions to DOD related to DAMIR, the DAES data in DAMIR, and the custodians of the data. Specifically, we asked how DOD monitors and updates DAMIR, how the

data is updated over time, and quality assurance steps taken to ensure data accuracy, among other topics.

In November 2021, we held further discussions with Under Secretary of Defense for Acquisition and Sustainment (USD(A&S)) officials and the military departments to discuss the reliability of fiscal year 2021 DAES data specifically. Officials told us this year's DAES data was unreliable due to the lack of Future Years Defense Program in the fiscal year 2022 President's Budget request. As such, we relied on the data collected for our prior assessment as of January 2021 or Acquisition Program Baselines approved between January 2021 and January 2022.

To assess the reliability of MTA cost data, we issued a supplemental data collection instrument to each MTA program to cross-check data and solicit any updates to the numbers, with explanation.

Based on these efforts, we determined that the September 2020 DAES data retrieved from DAMIR and MTA program cost data were sufficiently reliable for the purposes of this report.

Assessment of MDAP Cost and Schedule Performance and Knowledge-Based Practices

MDAP Cost and Schedule Performance

Due to the lack of a Future Years Defense Program included in the fiscal year 2022 President's Budget request, DOD did not issue comprehensive annual Selected Acquisition Reports for fiscal year 2021, which precluded us from analyzing the cost performance of DOD's MDAP portfolio. Instead, our cost analysis is limited to the seven MDAPs that issued an updated Acquisition Program Baseline between January 2021 and January 2022. For those programs, we compared the new baseline costs to the costs we reported in our last assessment to determine the program's cost performance.

To analyze MDAP schedule performance, we assessed the schedule performance of 29 of the 34 MDAPs included in the individual assessments. Five MDAPs did not have initial operational capability data available, either because they did not track initial operational capability or already achieved the milestone as of April 2021 and were excluded from

this analysis. We compared the cycle time—defined as the number of months between program start and the expected or actual achievement of initial operational capability or an equivalent fielding date—reported to us as of January 2022 against the program's initial estimate. We also calculated the one-year cycle time changes for each program by comparing data reported to us as of January 2021 to what programs reported as of January 2022.

Analysis of MDAP Adherence to Knowledge-Based Acquisition Practices

Our analysis of how well MDAPs adhere to a knowledge-based acquisition approach focuses on knowledge attained by key decision points:

- system development start or detail design contract award for shipbuilding programs,
- critical design review or lead ship fabrication start for shipbuilding programs, and
- production start.[83]

Factors we analyzed at each key decision point included those that we have previously identified as underpinning a knowledge-based acquisition approach, including technology maturity, design stability, and production readiness. Additional information on how we collect these data is found in the assessment of MDAPs' attainment of product knowledge section of this appendix. See also appendix III for a list of the practices that are associated with a knowledge-based acquisition approach.

To assess the knowledge attained by key decision points, we collected data using our questionnaire from 34 MDAPs in development or the early stages of production about their knowledge at each point. We did not verify the data provided by the program offices. Rather, we reviewed the data and performed various checks to determine that they were reliable for our purposes. Where we discovered discrepancies, we clarified the data accordingly with program offices.

We reassessed programs' knowledge in cases where the information underpinning the attainment of knowledge had since changed. For example, if we previously assessed a program as having demonstrated a production-representative prototype, but obtained information from the

[83]We assessed the CVN 78 *Gerald R. Ford* Class Nuclear Aircraft Carrier's resources and requirements knowledge metrics at the time of the construction preparation contract award, rather than the detail design contract award, because that is the point at which the program began CVN 78 development.

program this year that clarified it had not obtained this knowledge, we changed our score this year to reflect that knowledge was not attained.

For the fifth consecutive year, we performed a statistical analysis that examined correlations between our knowledge-based practices and selected programs' cost and schedule changes. We focused the analysis on the 27 non-shipbuilding MDAPs that, prior to fiscal year 2022, completed each of the three knowledge points within the acquisition process (i.e., completed development, held a critical design review, and started production). Our statistical analysis compared average cost and schedule changes for those programs that had implemented eight key knowledge-based acquisition practices by the time they reached knowledge points 1 through 3, to those programs that did not complete the leading practices at each knowledge point.

To ensure a reliable estimate of the average in each group, we limited our analysis to those knowledge-based acquisition practices for which at least three programs had engaged in the practice and at least three opted not to engage in the practice. Data were sufficient to meet minimum sample size requirements for six of the eight practices. We did not have sufficient data to analyze the remaining two practices.[84] We assessed the statistical significance of the observed differences between the groups at the 90 percent confidence level.[85] With such a small sample of MDAPs, our estimates are fairly imprecise and do not meet normality assumptions.

[84]MDAP data was sufficient to meet minimum sample size requirements for the following six leading practices: Demonstrates all critical technologies are very close to final form, fit, and function within a relevant environment; completed preliminary design review before system development start; release at least 90 percent of drawings by critical design review; test an early system-level integrated prototype; demonstrate critical processes on a pilot production line; and test a production-representative prototype in its intended environment. MDAP data was not sufficient to meet minimum sample size requirements for two leading practices: demonstrate all critical technologies are in form, fit, and function within an operational environment and demonstrate manufacturing process capabilities are in control.

[85]Statistical significance at the 90 percent confidence level indicates that the chances of observing a statistical difference as large or larger as observed by chance, if no difference existed, is less than 10 percent.

Assessment of MTA Program Cost and Schedule, Critical Technologies, and Knowledge-Based Acquisition Practices

Cost and Schedule

To determine the planned costs for current MTA efforts, we analyzed the most recent cost data reported as of July 2021 in the program status forms that the military departments submitted to the OSD.[86] To assess the accuracy of and supplement that cost data, we provided data collection instruments for the program offices to provide updated cost and quantity data for MTA efforts. To assess the schedules of MTA programs, we reviewed data from the same program status forms, including program start and planned end dates. We also reviewed the specific schedule events that MTA programs reported in their questionnaires.

Critical Technologies

To assess 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 then compared the maturity levels against our knowledge-based acquisition standards for MDAPs for critical technology maturity levels to identify applicable recommended maturity levels at the completion of the current MTA effort based on a program's planned transition pathway. Specifically, if a program indicated that it planned to transition to a rapid fielding effort or enter the major capability acquisition pathway at system development or production, we assessed the program's planned critical technology maturity levels at those respective future points against our knowledge-based acquisition practices.

In addition, 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

[86]The Indirect Fire Protection Capability Increment 2 MTA effort initiated in August 2021; as such, we utilized program data submitted in September 2021.

expected maturation work that remains before the end of the current effort.

Knowledge-Based Practices

Analysis of attained product knowledge by transition. To assess the extent to which MTA programs plan to attain relevant product knowledge prior to their planned transition to the major capability acquisition pathway or to an MTA rapid fielding effort, we asked MTA programs in our questionnaire about their planned next steps after the conclusion of the current MTA effort. We determined, based on programs' responses, that our knowledge-based acquisition practices applied to 13 of the 19 MTA programs we reviewed: five programs that plan to transition to the major capability acquisition pathway with entry at system development, five programs that plan to transition to the major capability acquisition pathway with entry at production, two programs that plan to transition to an MTA rapid fielding effort, and one program that has yet to finalize its transition plan. We included this program because our practices applied to both potential transition pathways under consideration by the program.[87]

For all 13 programs, we analyzed the extent to which they planned to attain knowledge associated with knowledge point 1 by the end of the current MTA effort. In addition, for the seven programs that plan to transition to a rapid fielding effort or the major capability acquisition pathway at production, we also analyzed the extent to which the programs plan to demonstrate knowledge associated with knowledge points 2 and 3 by the end of the current MTA effort.

Analysis of progress in development of business case documentation. To determine whether MTA programs established a sound business case prior to program initiation, we reviewed prior GAO reports that identified elements that would provide a sound business case for MTA programs. These elements include cost estimates based on an

[87]We determined in certain cases that our knowledge-based criteria did not apply to some programs. For example, we did not assess Optionally Manned Fighting Vehicle or Indirect Fire Protection Capability Increment 2 critical technologies because the programs have yet to identify them. Absent such information, we determined that the programs' overall knowledge attainment plans for knowledge point 1—which includes maturation of critical technologies—could not be assessed and scored the point as "information not available". In contrast, if a metric was not applicable to a program, we determined the overall knowledge point score based on the other metrics within that knowledge point. For example, the B-52 Commercial Engine Replacement Program Rapid Virtual Prototype reported not having any critical technologies, resulting in a knowledge point 1 score based on whether the program planned to conduct a system-level preliminary design review.

independent assessment, requirements, acquisition strategies, and formal schedule and technology risk assessments.[88] Our decision to use the program initiation date as a key knowledge point was based on our prior work on business cases that demonstrated that the most significant point of leverage for a decision maker is before the decision to start a program.[89]

In our questionnaire, we asked the program offices whether they had these business case elements in place, and if so, when they had been completed. We then compared dates the program offices provided for completion of the five business case elements above against the program's initiation date to determine whether the program had completed the respective elements prior to initiation or afterwards.[90] For current status, we assessed whether or not the program had completed the above five elements as of January 2022, the end of our review period. We clarified the program's reported completion status of business case elements in instances in which the program reported information that was inconsistent with information reported elsewhere in the questionnaire or program documentation.

Assessment of MDAP and MTA Program Implementation of Software Development Approaches and Cybersecurity Practices

To report on DOD's efforts to implement modern software development approaches, we reviewed DOD guidance, including Department of Defense Instruction 5000.87, *Operation of the Software Acquisition Pathway*, which establishes policies and procedures for programs using the software acquisition pathway. We also obtained from DOD a list of programs following the software pathway.

To identify leading software development approaches, we reviewed several related reports, including our *Agile Assessment Guide* that identifies leading practices for Agile adoption and implementation, a May 2019 Defense Innovation Board report that recommended that DOD weapon acquisition programs use leading commercial software

[88]GAO, A*cquisition Reform: DOD Should Streamline Its Decision-Making Process for Weapon Systems to Reduce Inefficiencies,* GAO-15-192 (Washington, D.C.: Feb. 24, 2015); DOD A*cquisition Reform: Leadership Attention Needed to Effectively Implement Changes to Acquisition Oversight,* GAO-19-439, (Washington, D.C.: June 5, 2019).

[89]GAO-19-439; GAO, *Defense Acquisitions: Joint Action Needed by DOD and Congress to Improve Outcomes*, GAO-16-187T (Washington, D.C.: Oct. 27, 2015).

[90]For status at initiation, if a program stated it had conducted any of the five activities above within 30 days of initiation, we considered that as having achieved the knowledge for that metric.

development approaches, and a February 2018 Defense Science Board report that recommended DOD implement modern software practices.[91]

To report on programs' software development approaches and delivery times, we included a number of software-related questions in our questionnaire, which we relied on to determine the number of programs utilizing various software development approaches and the reported software delivery times.[92] We identified the reported software delivery times for programs that reported the use of a modern software development approach—which we define for this assessment as either Agile, DevOps, DevSecOps or an iterative development (other than Agile) approach. We compared those delivery rates with those of leading commercial companies, as recommended by the Defense Innovation Board, National Defense Industrial Association, International Standards Organization, and other industry studies.[93] We also aggregated program responses to questions about whether they had implemented recommended Defense Science Board practices.[94]

To report on software risk and staffing challenges, we used our questionnaire data to identify programs that reported their software as a risk item and programs that reported challenges related to their software development workforce. We then aggregated the responses they provided for the different types of software development risks and workforce challenges they experienced.

[91]GAO, *Agile Assessment Guide: Best Practices for Agile Adoption and Implementation,* GAO-20-590G (Washington, D.C.: Sept. 28, 2020); Defense Innovation Board, *Software Is Never Done: Refactoring the Acquisition Code for Competitive Advantage* (May 3, 2019); and Defense Science Board, *Final Report of the Defense Science Board Task Force on the Design and Acquisition of Software for Defense Systems* (February 2018).

[92]We also surveyed future major weapon acquisitions on software approach, software type, and average length of time between software deliveries to end users. We did not include aggregate future major weapon acquisitions software data in our analysis because programs reported this information as largely unavailable, in part because programs were early in their life cycles.

[93]ISO/IEC JTC1/SC7, *DevOps & Agile Study Group Report, Version 1.0* (May 2017 to April 2018); National Defense Industrial Association, *An Industry Practice Guide for Agile on Earned Value Management Programs,* (Arlington, Va.: Mar. 31, 2017).

[94]Our questionnaire excluded Defense Science Board recommendations and practices that did not apply at the program level. For example, we did not ask programs about the establishment of research programs on machine learning.

To assess the extent to which DOD had implemented software acquisition reform initiatives, we reviewed sections 873, 874, and 875 of the NDAA for Fiscal Year 2018, DOD reports on the section 873 and 874 pilots, DOD's *Agile Software Acquisition Guidebook*, Office of Management and Budget (OMB) memorandum M-16-21, and a prior GAO report on the status of the section 875 pilot.[95]

To determine the extent to which programs' cybersecurity practices generally aligned with DOD's established cybersecurity guidance, we identified specific DOD guidance pertaining to cybersecurity in weapon systems, including DOD Instruction 5000.89, *Test and Evaluation*, effective November 2020, and DOD's *Cybersecurity Test and Evaluation Guidebook*, issued July 2015 and last updated in February 2020.[96] We included a number of cybersecurity-related questions in our questionnaire, including whether programs had approved cybersecurity strategies, including cybersecurity in requirements planning, and had conducted various cybersecurity assessments. We then summarized programs' responses and compared them with the DOD guidance as appropriate.

Assessment of Information Related to the Defense Industrial Base

To describe recent legislation related to the defense industrial base, we reviewed NDAAs from fiscal year 2019 to 2021 to identify statutes related

[95]National Defense Authorization Act for Fiscal Year 2018, Pub. L. No. 115-91, § 873-875 (2017) (codified at 10 U.S.C. § 2223a note); Department of Defense, Office of the Under Secretary of Defense for Acquisition and Sustainment, *Report to Congress on Section 869 of the John S. McCain National Defense Authorization Act for Fiscal Year 2019 (P.L. 115-232): Status of Pilot Program Required Under Section 873 of the NDAA for FY18 (P.L. 115-91)* (Washington, D.C.: Apr. 2019); Office of the Under Secretary of Defense for Acquisition and Sustainment, *Report to Congress on Software Development Activity Completion Section 874 of the National Defense Authorization Act for Fiscal Year 2018 (P.L. 115-91)* (Washington, D.C.: Oct. 3, 2019); Office of the Under Secretary of Defense for Acquisition and Sustainment, *Agile Software Acquisition Guidebook-Best Practices & Lessons Learned from the FY18 NDAA Section 873/874 Agile Pilot Program* (Washington, D.C.: Feb. 27, 2020); and GAO, *Information Technology: DOD Needs to Fully Implement Program for Piloting Open Source Software,* GAO-19-457 (Washington, D.C.: Sept. 10, 2019).

[96]DOD Instruction 5000.89, *Test and Evaluation* (Nov. 19, 2020) and Department of Defense, *Cybersecurity Test and Evaluation Guidebook 2.0, Change 1* (February 2020).

to defense industrial base oversight at the OSD level.[97] We focused our review on 12 selected statutes from the NDAAs for Fiscal Years 2020 and 2021 that we determined substantially affected DOD's oversight of the defense industrial base. We also corresponded with officials from USD(A&S) to obtain their perspectives on the most significant statutes related to oversight of the industrial base and considered their perspectives when we made our selections. To determine the extent to which DOD had implemented these provisions, we obtained written implementation status updates from USD(A&S) officials.

To identify the extent to which DOD made recent policy changes related to OSD industrial base oversight, we reviewed DOD documents published between 2014 and 2021 that provide instruction and guidance on the defense industrial base.[98] We also reviewed Executives Orders related to the industrial base and annual reports issued to Congress.[99]

To identify the extent to which DOD made recent organizational changes related to OSD industrial base oversight, we reviewed legislation, policy, and guidance that outlined roles and responsibilities for OSD with regard to oversight of the defense industrial base, such as roles and responsibilities for USD(A&S) and the Under Secretary of Defense for Research and Engineering.

[97]We assessed DOD's effort to incorporate legislative, organizational, and policy changes that occurred since fiscal year 2019 related to the defense industrial base. We assessed changes starting in fiscal year 2019 because DOD issued a report in September 2018 in response to Executive Order 13806 *Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States.* We reviewed provisions included in the John S. McCain NDAA for Fiscal Year 2019 related to industrial base oversight, but did not identify any provisions that met the scope of our review.

[98]DOD Instruction 4245.15, *Diminishing Manufacturing Sources and Material Shortages Management* (Nov. 5, 2020); DOD Instruction 5000.60, *Defense Industrial Base Assessments* (July 18, 2014) (Change 2 Effective Aug. 31, 2018); DOD Instruction 5000.85, *Major Capability Acquisition* (Aug. 6, 2020) (Change 1 Effective Nov. 4, 2021).

[99]Exec. Order No. 13806, 82 Fed. Reg. 34,597 (July 26, 2017); Exec, Order No. 14017. 86 Fed. Reg. 11,849 (Feb. 24, 2021); Department of Defense, Office of the Under Secretary of Defense for Acquisition and Sustainment and Office of the Deputy Assistant Secretary of Defense for Industrial Policy, *Annual Report to Congress Fiscal Year 2018 Industrial Capabilities* (Washington, D.C: May 13, 2019); Department of Defense, Office of the Secretary of Defense for Acquisition and Sustainment Industrial Policy, *Fiscal Year 2019 Industrial Capabilities Report to Congress* (Washington, D.C: June 23, 2020); Department of Defense, Office of the Secretary of Defense for Acquisition and Sustainment Industrial Policy, *Fiscal Year 2020 Industrial Capabilities Report to Congress* (Washington, D.C: Jan., 2020);

We also conducted an interview with officials from the USD(A&S) Office of Industrial Base Policy to obtain additional insight into policy, legislative, and organizational changes, and industrial base challenges facing the department.

To report on the extent to which programs we reviewed reported assessing industrial base challenges, we included questions related to the defense industrial base in our questionnaires sent to MDAP and MTA programs. We relied on program office responses to these questions to determine the number of programs tracking industrial base risks, the types of risks tracked by programs, and the number of programs that conducted or planned to conduct an industrial base assessment.[100] To determine the extent to which programs were conducting industrial base assessments to provide DOD with insight into industrial base challenges, we reviewed DOD Instruction 5000.60, and compared requirements for conducting industrial base assessments within the instruction with program office responses.[101]

Individual Assessments of Weapon Programs

This report presents individual knowledge-based assessments of 63 current and future weapon programs. Appendix I contains these assessments. Of the 63 assessments:

- Thirty-four assess MDAPs—in development or early production—in a two-page format discussing each program's knowledge about technology, design, and manufacturing as well as software and cybersecurity, and other program issues.
- Ten assess future major weapon acquisitions or current MDAPs in a one-page format that describes the program's current status. Those one-page assessments include (1) four future major weapon acquisitions not yet in development and (2) six MDAPs that are well into production, but introducing new increments of capability or significant changes.
- Nineteen assess MTA programs in a two-page format discussing each program's completion of business case elements or updates to the

[100]Our questionnaire asked programs to identify the type of industrial base they are tracking, if any. Additionally, we asked if any type of defense industrial base assessment specific to the program had been completed, or was scheduled to be completed, including those performed by OSD, the military departments, and the program. Our questionnaire defined an defense industrial base assessment as an assessment of an industry where there is a known problem with the skills and knowledge, processes, facilities, and equipment needed to design, develop, manufacture, repair, and support DOD products.

[101]DOD Instruction 5000.60.

program's business case; plans to acquire knowledge about technology and design during the current MTA effort; software development and cybersecurity; transition plan; and other program issues.

For all assessments, we obtained the information from sources including DOD's DAES reports, MTA program status forms and program office questionnaire responses. This information is presented in the Program Essentials, Cost and Quantities, and Software Development sections of each one- and two-page assessment. We did not review individual contract documents to verify information in the Program Essentials section.

We obtained the information in the Software and Cybersecurity section of assessments from program office responses to questionnaires, program office documents, and communications with program officials. In their questionnaire responses, program offices self-identified the type of software used, the frequency of software releases, and the types of software development approaches the program is employing.

The paragraphs below provide supplemental information on how we identified and assessed cost and schedule for MDAPs and future major weapon acquisitions, as well as how we assessed attainment of product knowledge for MDAPs. For MTA programs, we used the approach described earlier in this section to assess the planned attainment of knowledge at transition for 13 MTA programs, completion of business case documents for 19 MTA programs, and to summarize cost and quantity data for 19 MTA programs. We reported costs for the current MTA effort only, as reported by the programs in our data collection instrument.

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 at that milestone or decision point. For MDAPs and future major weapon acquisitions assessed in a one-page format, we present the latest available estimate of cost and quantity from the program office.

For the program performance table 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. Because of rounding and these additional costs, in some situations, total cost may not match the exact sum of the research and development and procurement costs.
- The program unit costs are calculated by dividing the total program cost by the total quantities planned. These costs are often referred to as program acquisition unit costs. In some instances, the data were not applicable, for example, because there are multiple different units being developed and fielded under a single program. We annotate this designation by using the term "not applicable (NA)."
- The quantities listed refer to total quantities, including both procurement and development quantities.

The schedule assessment presented in the "Acquisition Cycle Time" graphic is defined as the number of months between program start and the planned or actual achievement of initial operational capability or an equivalent fielding date. In some instances, cycle time is not applicable and we annotate this by using the term "NA." In some instances, planned initial operational capability dates have been delayed, but a new planned date had yet to be determined. We annotate this by using the term "TBD."

Cost and quantity information presented in the MDAP increment and future major weapon acquisitions "Funding and Quantities" figures is drawn from funding stream information from the program office.

Assessment of MDAPs' Attainment of Product Knowledge

For our attainment of product knowledge tables, we assessed MDAPs' current status in implementing the knowledge-based acquisition practices criteria, as well as the programs' progress in meeting the criteria at the time they reached the three key knowledge points during the acquisition cycle.

- **Knowledge Point 1: Match between requirements and resources**. We asked program officials to report TRLs for their program's critical technologies (see Appendix IV for TRL definitions). Our knowledge-based acquisition practices work shows that a TRL 7—demonstration of a technology in its form, fit, and function within a realistic environment—is the level of technology maturity that constitutes a low

risk for starting a product development program.[102] For shipbuilding programs, we have recommended that this level of maturity be achieved by the contract award for detailed design.[103] In our assessment, the technologies that have reached TRL 7 are referred to as mature or fully mature. Those technologies that have reached TRL 6, a prototype very close to final form, fit, and function demonstrated within a relevant environment, are referred to as approaching or nearing maturity.[104] In addition, we asked program officials to provide the date of the system-level preliminary design review. We compared this date to the system development start date. Where practicable, we compared technology assessments provided by the program office to Independent Technology Risk Assessments.

- **Knowledge Point 2: Design stability**. We asked program officials to provide the number of design drawings completed or projected for completion by the critical design review, the production decision, and as of our current assessment in our questionnaire. Completed drawings were defined as the number of drawings released or deemed releasable to manufacturing that can be considered the "build to" drawings. For shipbuilding programs, we asked programs to provide the total number of ship design zones, number of design zones complete at lead ship fabrication, and current estimate of number of design zones complete. To gain greater insights into design stability, we also asked programs to provide the date they planned to first integrate and test all key subsystems and components into a system-level integrated prototype. We compared this date to the

[102]GAO, *Technology Readiness Assessment Guide: Best Practices for Evaluating the Readiness of Technology for Use in Acquisition Programs and Projects*, GAO-20-48G (Washington, D.C.: January 2020); *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO/NSIAD-99-162 (Washington, D.C.: July 30, 1999); *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*, GAO-01-288 (Washington, D.C.: Mar. 8, 2001). While GAO's leading practices work has shown that a TRL 7 is the level of technology maturity that constitutes a low risk for starting development, DOD's guidance permits development to start at TRL 6. DOD's guidance is based on a statute that generally prohibits a MDAP from receiving approval for development start until the milestone decision authority certifies—based on an independent review and technical risk assessment—that the technology in the program has been demonstrated in a relevant environment. 10 U.S.C. § 4252(a)(2).

[103]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).

[104]Satellite technologies that have achieved TRL 6 are assessed as fully mature due to the difficulty of demonstrating maturity in a realistic environment—space.

date of the critical design review. We did not assess whether shipbuilding programs had completed integrated prototypes.

- **Knowledge Point 3: Production maturity**. We asked program offices for the programs' Manufacturing Readiness Level (MRL) for the process capability and control sub-thread. We assessed programs as having mature manufacturing processes if they reported an MRL 9 for that sub-thread—meaning that manufacturing processes are stable, adequately controlled, and capable.[105] To gain further insights into production maturity, we asked whether programs planned to demonstrate critical manufacturing processes on a pilot production line before beginning low-rate production. We also asked programs on what date they planned to begin system-level developmental testing of a fully configured, production-representative prototype in its intended environment. We compared this date to the production start date. We did not assess production maturity for shipbuilding programs because the Navy does not generally produce ships on production lines, or prototype a whole ship due to cost.

We conducted this performance audit from May 2021 to June 2022, 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.

[105]We also gave MDAPs the opportunity to identify the number of critical manufacturing processes and quantify the extent of statistical control achieved for those processes as a measure of manufacturing maturity. Five programs that have reached the production phase responded with data on this metric, but none met our criteria for manufacturing readiness levels.

Appendix III: Knowledge-Based Acquisition Practices

Our prior work on leading product development practices found that successful programs take steps to gather knowledge that confirms their technologies are mature, their designs stable, and that their production processes are in control. Successful product developers ensure a high level of knowledge is achieved at key junctures in development. We characterize these junctures as knowledge points. The Related GAO Products section of this report includes references to the body of work that helped us identify these practices and apply them as criteria in weapon system reviews. Table 10 summarizes these knowledge points and associated practices.

Table 10: Leading Practices for Knowledge-Based Acquisitions

Knowledge Point 1: Technologies, time, funding, and other resources match customer needs. Decision to invest in product development.
Demonstrate technologies to a high readiness level—Technology Readiness Level 7—to ensure technologies are fit, form, function, and work within a realistic environment[a]
Ensure that requirements for product increment are informed by system-level preliminary design review using system engineering process (such as prototyping of preliminary design)
Establish cost and schedule estimates for product on the basis of knowledge from system-level preliminary design using system engineering tools (such as prototyping of preliminary design)
Constrain development phase (5 to 6 years or less) for incremental development
Ensure development phase fully funded (programmed in anticipation of milestone)
Align program manager tenure to complete development phase
Contract strategy that separates system integration and system demonstration activities
Conduct independent cost estimate
Conduct independent program assessment
Conduct major milestone decision review for development start
Knowledge Point 2: Design is stable and performs as expected. Decision to start building and testing production-representative prototypes.
Complete system critical design review
Complete 90 percent of engineering design drawing packages
Complete subsystem and system design reviews
Demonstrate with system-level integrated prototype that design meets requirements
Complete failure modes and effects analysis
Identify key system characteristics
Identify critical manufacturing processes
Establish reliability targets and growth plan on the basis of demonstrated reliability rates of components and subsystems
Conduct independent cost estimate
Conduct independent program assessment
Conduct major milestone decision review to enter system demonstration

Knowledge Point 3: Production meets cost, schedule, and quality targets. Decision to produce first units for customer.
Demonstrate manufacturing processes on a pilot production line
Build and test production-representative prototypes to demonstrate product in intended environment
Test production-representative prototypes to achieve reliability goal
Collect statistical process control data
Demonstrate that critical processes are capable and in statistical control
Conduct independent cost estimate
Conduct independent program assessment
Conduct major milestone decision review to begin production

Source: GAO. | GAO-22-105230

[a]Department of Defense guidance permits development to start at a technology maturity level commensurate with Technology Readiness Level 6—demonstration of program technology in a relevant environment. Therefore, we have assessed programs against this measure as well.

Appendix IV: Technology Readiness Levels

Table 11: Technology Readiness Levels (TRL)

TRL	Definition	Description
1.	Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties.
2.	Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there may be no proof or detailed analysis to support the assumption. Examples are still limited to analytical studies.
3.	Analytical and experimental function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4.	Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in a laboratory.
5.	Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that 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, in a vehicle, or in space).
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-22-105230

Appendix V: Department of Defense Oversight Responsibilities for Weapon System Acquisitions

Table 12: 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 reviews. 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; establish policies and prescribes procedures for MTA cost data and cost estimates; and conduct 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	Align the management of acquisition programs with the principal Department of Defense processes to support affordable design, development, production and sustainment of mission effective capability and services, among other things.
Component Acquisition Executive (also referred to as the Service Acquisition Executive)	Implements DOD acquisition policy within their respective component. In the military departments, the officials delegated as Component Acquisition Executives are respectively, the Assistant Secretary of the Army for Acquisition, Logistics, and Technology; the Assistant Secretary of the Navy for Research, Development and Acquisition; and the Assistant Secretary of the Air Force for Acquisition, Technology, and Logistics. Component Acquisition Executives serve as the milestone decision authority for many MDAPs and MTA programs.

Entity	Responsibilities
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 documents. I GAO-22-105230

Appendix VI: Selected Department of Defense Entities Responsible for Industrial Base Oversight

Table 13: Selected Department of Defense Entities Responsible for Industrial Base Oversight

Office	Oversight role
Under Secretary of Defense for Acquisition and Sustainment's Office of Industrial Base Policy	Develops policies for the maintenance of the U.S. defense industrial base, provides recommendations on budget matters related to the defense industrial base, and anticipates and closes gaps in manufacturing capabilities for defense systems. Manages the Defense Production Act Title III program and Industrial Base Analysis and Sustainment Program, which are defense-wide industrial base investment programs.
Under Secretary of Defense for Research and Engineering's Office of Technology, Manufacturing, and Industrial Base	Translates technology requirements into manufacturing and industrial base requirements. The results of these assessments are used to create technology and industrial base protection and promotion strategies. Oversees the Manufacturing Technology program, which is a defense-wide industrial base investment program.
Industrial Base Council	An executive-level forum for senior Department of Defense leaders to ensure industrial base readiness and resilience by aligning efforts to leverage the full authorities of the department to address industrial base vulnerabilities.
Joint Industrial Base Working Group	A working-level group co-chaired by the Office of Industrial Base Policy that informs the Industrial Base Council. It is comprised of subject matter experts in each industrial base sector. Interagency working groups and task forces bring emerging industrial base risks to the Joint Industrial Base Working Group for discussion and action. Risks and issues that require senior-level intervention are elevated to the Industrial Base Council.
Supply Chain Resiliency Working Group	The Supply Chain Resiliency Working Group reports to the Industrial Base Council through the Office of Industrial Base Policy. The Working Group is a 2-year initiative that was chartered to develop a methodology for supply chain visibility and for assessing supply chain resiliency to identify risks and issues within the defense industrial base.

Source: GAO analysis of Department of Defense information. I GAO-22-105230

Appendix VII: Software Pilots Implemented in Response to the National Defense Authorization Act (NDAA) for Fiscal Year 2018

The NDAA for Fiscal Year 2018, enacted on December 12, 2017, required the Department of Defense (DOD) to implement three software pilot programs.[106] Two of the pilots involved Agile practices and the third pilot focused on open source software. Table 14 summarizes the NDAA requirements and implementation status of the pilots.

Table 14: Summary of Software Pilots Implemented in Response to the National Defense Authorization Act (NDAA) for Fiscal Year 2018

NDAA for Fiscal Year 2018 section	Brief description of pilot	Selected pilot requirements	Status as of January 2022
873	Pilot to use Agile or iterative development methods to tailor major software-intensive warfighting systems and defense business systems.	• The Secretary of Defense shall develop a plan for realigning selected systems by breaking down the system into smaller increments using Agile or iterative development methods. • Each increment shall, among other things: be designed to deliver meaningfully useful capability within the first 180 days following realignment, and subsequent meaningfully useful capabilities in less than 180 days; be staffed with highly qualified, technically trained staff and personnel that have certain types of expertise; and include periodic engagement with the user community and representation by the user community in program management and software production activity. • Section 869 of the NDAA for Fiscal Year 2019 also requires the Under Secretary of Defense for Acquisition and Sustainment to establish a community of practice on Agile or iterative methods to enable sharing of lessons learned, best practices, and recommendations for improvements to acquisition and supporting processes with programs participating in the pilot under section 873 of the NDAA for Fiscal Year 2018.	Ongoing. Scheduled to end on September 30, 2023.

[106]National Defense Authorization Act for Fiscal Year 2018, Pub. L. No. 115-91,§§ 873-875 (2017) (codified at 10 U.S.C. §§ 2223 note; 4571 note).

NDAA for Fiscal Year 2018 section	Brief description of pilot	Selected pilot requirements	Status as of January 2022
874	Pilot to use Agile best practices in software development activities.	• Software development activities identified and selected for pilot development shall be developed without the incorporation of certain contract and transaction requirements. • The Secretary of Defense shall develop a plan for each selected activity under the pilot program, which shall include, among other elements, frequent and iterative end-user validation of features and usability consistent with certain principles; and use of commercial best practices for advanced computing systems, including certain practices outlined in statute. • The Secretary of Defense shall ensure that the selected activities use a modern tracking tool to execute requirements backlog tracking.	Completed. Department of Defense (DOD) submitted a report to Congress on October 3, 2019.
875	Pilot program for open source software.	• The Secretary of Defense shall initiate for DOD the open source software pilot program established by Office of Management and Budget (OMB) Memorandum M-16-21,"Federal Source Code Policy: Achieving Efficiency, Transparency, and Innovation through Reusable and Open Source Software" (Aug. 8, 2016). • According to M-16-21, for the term of the pilot program, each agency must annually release at least 20 percent of new custom-developed code as open source software. Agencies must obtain sufficient rights to custom-developed code to fulfill the pilot program's open source release objectives.	DOD has yet to fully implement the pilot program as mandated.

Source: GAO analysis of the National Defense Authorization Act for Fiscal Year 2018 and the John S. McCain National Defense Authorization Act for Fiscal Year 2019, DOD documentation, and GAO-19-457. | GAO-22-105230

Note: According to OMB Memorandum M-16-21, open source software is software that can be accessed, used, modified, and share by anyone. Open source software is often distributed under licenses that meet the definition of "Open Source" provided by the Open Source Initiative or the definition of "Free Software" provided by the Free Software Foundation.

Additional Details on Implementation Status

Section 873 of the NDAA for Fiscal Year 2018. DOD included seven programs to participate in this pilot.[107] These programs comprise weapon systems and defense business systems, including two programs in our

[107]The seven pilot programs were: (1) Integrated Air and Missile Defense (IAMD, Army), (2) Army Contract Writing System (ACWS, Army), (3) Defense Enterprise Accounting and Management System (DEAMS, Air Force), (4) F-22 Capability Pipeline (Air Force), (5) Item Master Logistics Capability Initiative (IMLCI, Air Force), (6) Aegis Weapon System (AWS) Baseline 10 (Navy), and (7) Information Screening and Delivery Subsystem (ISDS) 8.0 (Navy). The Defense Retired and Annuitant Pay System 2 (DRAS2, Defense Logistics Agency) was designated to participate in the pilot but, according to a DOD official, was removed due to a lack of funding that resulted in program termination.

assessment, the Army's Integrated Air and Missile Defense and the Air Force's F-22 Capability Pipeline. In April 2019, DOD reported on the status of the pilot program, including the establishment of a community of practice for sharing information, training provided, and challenges encountered.[108] Initial observations included needed change in acquisition culture, the steep learning curve, and challenges in transitioning from traditional Earned Value Management to Agile-based costing and scheduling approaches.

As of February 2022, DOD stated additional lessons learned include how the elimination of resource-heavy reporting requirements resulted in a greater focus on delivering a working product. DOD also stated changes are needed to address workforce challenges, such as the shortages in technology talent and competing with the private sector on compensation. DOD stated that two programs—the Integrated Air and Missile Defense, and the Defense Enterprise Accounting and Management System programs—completed their participation in the pilot in 2021. DOD expects to fully complete the requirements of the pilot, with the remaining programs planning to conclude their participation by September 30, 2023.

Section 874 of the NDAA for Fiscal Year 2018. This pilot lasted one year, beginning and ending in the first and fourth quarter of fiscal year 2019, respectively. The pilot included seven programs that represented a cross-section of the military departments, as well as a mix of weapon and business systems.[109] In October 2019, DOD reported on the completion of the pilot, including the following key areas of success and challenges.

- All participating programs had successfully adopted Agile or iterative software practices.
- Participating programs delivered working software far faster than similar traditional acquisition programs.

[108]Department of Defense, *Report to Congress on Section 869 of the John S. McCain National Defense Authorization Act for Fiscal Year 2019 (P.L. 115-232): Status of Pilot Program Required Under Section 873 of the NDAA for FY18 (P.L. 115-91)* (Washington, D.C.: Apr. 2019)

[109]The seven pilot programs were: (1) Defensive Cyber Ops/Cyber Analytics (DCA, Army), (2) Defense Cyber Operations/Mission Planning (DCOMP, Army), (3) Marine Corps Recruiting Information Support System II (MCRISS II, Marine Corps), (4) Air and Space Operations Center (AOC) Pathfinder (USAF), (5) Cyber Mission Platform (CMP, USAF), (6) Maritime Tactical Command and Control (MTC2, Navy), and (7) National Background Investigation Services (NBIS, DISA).

- Streamlined processes resulting from the alleviation of upfront detailed planning and other processes were important accelerators.
- Challenges included the need for additional training in Agile for DOD acquisition staff, better support for cross-team and stakeholder communications, and the lack of existing enterprise infrastructure.

In February 2020, DOD issued an Agile software acquisition guidebook that included best practices and lessons learned from the section 873 and 874 pilots.[110] Examples include the importance of Agile coaching for programs transitioning from waterfall to Agile, and the need for sustainment planning to address activities such as designing for modularity and managing technical debt, among other things.[111]

Section 875 of the NDAA for Fiscal Year 2018. This section required DOD to initiate the open source software pilot program established in 2016 by the Office of Management and Budget (OMB).[112] OMB's pilot set up requirements for federal agencies to improve the way they buy, build, and deliver software solutions through the use of open-source software code. We issued a report in 2019 assessing the extent to which DOD had implemented the open-source software pilot program and found DOD had not fully implemented all of the requirements.[113] We made four recommendations to ensure DOD implements the program and develops milestones for completing requirements in the OMB memorandum. As of September 2021, the department implemented two of our recommendations related to establishing milestones for securing data rights and conducting an inventory, and facilitating an open source software community. However, the department had yet to implement two of our recommendations:

[110]Office of the Under Secretary of Defense for Acquisition and Sustainment, *Agile Software Acquisition Guidebook-Best Practices & Lessons Learned from the FY18 NDAA Section 873/874 Agile Pilot Program,* (Washington, D.C.: Feb. 27, 2020). See National Defense Authorization Act for Fiscal Year 2018, Pub. L. No. 115-91, §§ 873-874 (2017) (codified at 10 U.S.C. §§ 2223a note, 2302 note).

[111]Technical debt is the accumulation of code inefficiencies or redundancies that ultimately limit system performance.

[112]Office of Management and Budget Memorandum M-16-21, *Federal Source Code Policy: Achieving Efficiency, Transparency, and Innovation through Reusable and Open Source Software* (Aug. 8, 2016).

[113]GAO, *Information Technology: DOD Needs to Fully Implement Program for Piloting Open Source Software,* GAO-19-457 (Washington, D.C.: Sept. 10, 2019).

- DOD did not concur with the recommendation to release 20 percent of newly custom-developed code as open-source software. The department stated that it does not agree that the pilot program as described in the OMB memorandum is implementable as proposed. For example, DOD asserts that most of the department's custom developed software is created for weapons systems and releasing the associated code is sensitive for national security reasons.

  In addition, the department stated that the size and complexity of DOD presents unique challenges as compared to other federal agencies, such as the difficulty involved in inventorying all software development projects to establish a baseline. DOD also stated that it recognizes the value of collaborative software development and has plans to release additional guidance on releasing open source software and procedures for maintaining its inventory. Once DOD establishes a baseline inventory of custom-developed software and the procedures for maintaining it, the department states it will be able to determine if the 20 percent is an appropriate goal. However, as of September 2021, it had yet to take these steps.

- The department partially concurred with the recommendation to identify a measure to calculate the percentage of code released to gauge its progress on implementing the pilot program. Specifically, the department stated that the additional guidance it plans to release on open-source software will include measures to gauge how much code has been developed and how much has been released. However, as of February 2022, it had yet to release guidance to fully address this recommendation.[114]

We will continue to follow-up on the status of these recommendations.

[114]In January 2022, DOD issued a memorandum titled "Software Development and Open Source Software" that included guidance on the release of custom-developed code as open-source software. However, the memorandum did not include measures on to gauge how much code has been developed and how much has been released.

Appendix VIII: Summary of Selected Statutory Provisions That Affect Defense Industrial Base Oversight

We identified 12 provisions from the National Defense Authorization Act for Fiscal Year 2020 and the William M. (Mac) Thornberry National Defense Authorization Act 2021 related to the Office of the Secretary of Defense's oversight of the defense industrial base. These provisions ranged from establishing a framework to enhance cybersecurity for the industrial base to assessing the research and development, manufacturing, and production capabilities of the national technology and industrial base, among other things. Table 15 provides information on the implementation status of the 12 selected provisions.

Table 15: Summary of Selected Provisions That Affect Defense Industrial Base Oversight from the National Defense Authorization Act for Fiscal Year 2020 and the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021

Section and title of provision	Brief description of provision	Steps taken by Department of Defense (DOD)
Provisions contained in the National Defense Authorization Act for Fiscal Year 2020		
Sec. 845. Modernization of acquisition processes to ensure integrity of industrial base	Requires the Secretary of Defense to streamline and digitize the existing DOD approach for identifying and mitigating risks to the defense industrial base across the acquisition process, and requires the Under Secretary of Defense for Acquisition and Sustainment, in coordination with certain individuals, to develop an analytical framework for risk mitigation across the acquisition process. The framework's implementation plan was due in March 2020 and a report on the actions taken to implement the framework is due one year after the implementations plan's submission.	As of March 2022, DOD's framework implementation plan was drafted and submitted to the Under Secretary of Defense for Acquisition and Sustainment for final review and signature.
Sec. 846. Report Requirements for the National Technology and Industrial Base	Adds additional reporting requirements related to the National Technology and Industrial Base.	Report submitted to Congress on October 21, 2021.
Sec. 1648. Framework to Enhance Cybersecurity of the United States Defense Industrial Base	Requires the Secretary of Defense to develop a consistent, comprehensive framework to enhance cybersecurity for the U.S. defense industrial base.	The framework was included in a brief provided to the congressional defense committees on January 17, 2020 and briefings continue to be made on a quarterly basis, dependent on the congressional defense committee schedule.
Provisions contained in the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021		
Sec. 213. Modification of National Security Innovation Activities and Pilot Program on Strengthening the Defense Industrial and Innovation Base	Among other provisions, extends the Pilot Program on Defense Industrial and Innovation Base until December 31, 2026 and delays the required briefing on the results of the pilot program to January 31, 2027.[a]	DOD officials from the Office of the Under Secretary of Defense for Acquisition and Sustainment told us they were in the process of determining who will be responsible for leading the effort.

Section and title of provision	Brief description of provision	Steps taken by Department of Defense (DOD)
Sec. 842. Report on Nonavailability Determinations and Quarterly National Technology and Industrial Base Briefings	Requires the Secretary of Defense to include additional information in the National Technology and Industrial Base Annual Report and requires the Secretary of Defense to ensure that the congressional defense committees receive quarterly briefings on the industrial base.[b]	The department is still in the process of establishing formal quarterly briefings on this topic. According to DOD officials, the Office of the Secretary of Defense and the military services have been, and continue to be, in regular contact with the congressional defense committees on this topic through various briefings and engagements. The department plans to time the first formal quarterly briefing with release of the 2022 Industrial Capabilities Report.
Sec. 846. Improving Implementation of Policy Pertaining to the National Technology and Industrial Base	Among other provisions, requires the Secretary of Defense in consultation with the Under Secretary of Defense for Acquisition and Sustainment and the Under Secretary of Research and Engineering to assess the research and development, manufacturing, and production capabilities of the national technology and industrial base and other allies and partner countries.	According to DOD officials, a report produced pursuant to Executive Order. 14017, "America's Supply Chains," and the DOD Annual Industrial Capabilities Report are responsive to this requirement.
Sec. 847. Report and Limitation on the Availability of Funds Relating to Eliminating the Gaps and Vulnerabilities in the National Technology and Industrial Base	Restricts the obligation or expenditure of certain funds unless the Secretary of Defense submits the national security strategy for the national technology and industrial base required by section 2501(a) of title 10, United States Code.	Strategy provided in a report to the congressional defense committees on March 23, 2021.
Sec. 848. Supply of Strategic and Critical Materials for the Department of Defense	Among other provisions, requires the Secretary of Defense, to the maximum extent practicable, to acquire strategic and critical materials required to meet the defense, industrial, and essential civilian needs of the United States in the following order of preference: (1) from sources located within the United States; (2) from sources located within the national technology and industrial base; (3) from other sources as appropriate.	According to DOD officials, a report developed pursuant to Executive Order 14017, "America's Supply Chains," is responsive to this requirement.
Sec. 849. Analyses of Certain Activities for Action to Address Sourcing and Industrial Capacity	Requires the Secretary of Defense to review a list of high priority goods and services and determine and develop appropriate actions under certain statutory authorities that could include restricting procurement, increasing certain investments, or prohibiting procurement from selected sources or nations.	According to DOD officials, a summary of the findings of the analyses is currently with the Under Secretary of Defense for Acquisition and Sustainment for signature.
Sec. 850. Implementation of Recommendations for Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency	Requires the Under Secretary of Defense for Acquisition and Sustainment to submit to the Secretary of Defense additional recommendations regarding United States industrial policies. The additional recommendations must consist of specific executive actions, programmatic changes, regulatory changes, and legislative proposals and changes, as appropriate.	According to DOD officials, a report developed pursuant to Executive Order 14017, "America's Supply Chains," is responsive to this requirement.

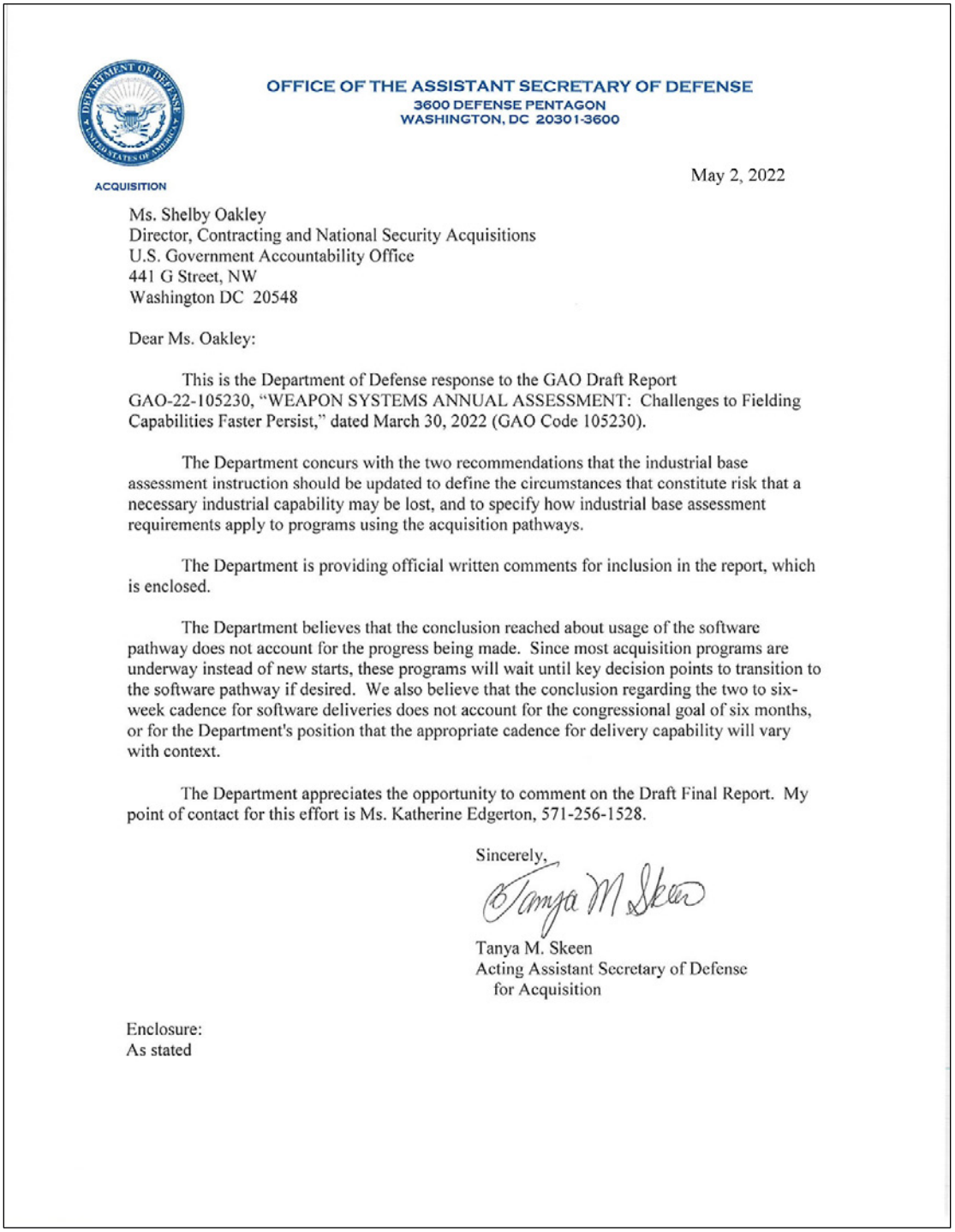
Section and title of provision	Brief description of provision	Steps taken by Department of Defense (DOD)
Sec. 851. Report on Strategic and Critical Materials	Requires the Secretary of Defense to submit an appendix to the National Technology and Industrial Base Annual Report describing strategic and critical materials, including the gaps and vulnerabilities in supply chains of such materials.	Submitted to the armed services committees on May 7, 2021.
Sec. 903. Assistant Secretary of Defense for Industrial Base Policy	Increases the authorized number of Assistant Secretaries of Defense to establish an Assistant Secretary of Defense for Industrial Base Policy.	The Assistant Secretary of Defense for Nuclear, Chemical, and Biological Defense Programs is performing the duties of the Assistant Secretary of Defense for Industrial Base Policy in an acting capacity.

Source: GAO analysis of National Defense Authorization Act for Fiscal Year 2020, Pub. L. No. 116-92 (2019); and the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116–283 (2021); and Department of Defense information. I GAO-22-105230

[a]Section 1711 of the National Defense Authorization Act for Fiscal Year 2018 authorized a pilot program to assess the feasibility and advisability of increasing the capability of the defense industrial base to support (1) production needs to meet military requirements and (2) manufacturing and production of emerging defense and commercial technologies.

[b]10 U.S. Code § 2504 establishes that the Secretary of Defense shall transmit to the Committee on Armed Services of the Senate and the Committee on Armed Services of the House of Representatives by March 1 of each year a report which shall include the following information: (1) A description of the departmental guidance prepared pursuant to title 10, section 2506 of the U.S. Code; (2) A description of the assessments prepared pursuant to title 10, section 2505 of the U.S. Code and other analyses used in developing the budget submission of the Department of Defense for the next fiscal year; (3) Based on the strategy required by title 10, section 2501 of the U.S. Code and on the assessments prepared pursuant to Executive order or title 10, section 2505 of the U.S. Code, provide certain information; (4) Identification of each program designed to sustain specific essential technological and industrial capabilities and processes of the national technology and industrial base; and, (5) A detailed description of any use by the Secretary of Defense or a Secretary concerned, as applicable, during the prior 12 months of a waiver or exception to the sourcing requirements or prohibitions established by title 41, chapter 83 or title 10, chapter 148, subchapter V of the U.S. Code.

Appendix IX: Comments from the Department of Defense



OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE
3600 DEFENSE PENTAGON
WASHINGTON, DC 20301-3600

ACQUISITION

May 2, 2022

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 response to the GAO Draft Report GAO-22-105230, "WEAPON SYSTEMS ANNUAL ASSESSMENT: Challenges to Fielding Capabilities Faster Persist," dated March 30, 2022 (GAO Code 105230).

The Department concurs with the two recommendations that the industrial base assessment instruction should be updated to define the circumstances that constitute risk that a necessary industrial capability may be lost, and to specify how industrial base assessment requirements apply to programs using the acquisition pathways.

The Department is providing official written comments for inclusion in the report, which is enclosed.

The Department believes that the conclusion reached about usage of the software pathway does not account for the progress being made. Since most acquisition programs are underway instead of new starts, these programs will wait until key decision points to transition to the software pathway if desired. We also believe that the conclusion regarding the two to six-week cadence for software deliveries does not account for the congressional goal of six months, or for the Department's position that the appropriate cadence for delivery capability will vary with context.

The Department appreciates the opportunity to comment on the Draft Final Report. My point of contact for this effort is Ms. Katherine Edgerton, 571-256-1528.

Sincerely,

Tanya M. Skeen

Tanya M. Skeen
Acting Assistant Secretary of Defense
for Acquisition

Enclosure:
As stated

GAO DRAFT REPORT DATED MARCH 30, 2022
GAO-22-105230 (GAO CODE 105230)

"WEAPON SYSTEMS ANNUAL ASSESSMENT: Challenges to Fielding Capabilities Faster Persist"

DEPARTMENT OF DEFENSE COMMENTS
TO THE GAO RECOMMENDATIONS

RECOMMENDATION 1: The Secretary of Defense should ensure the Office of the Under Secretary of Defense for Acquisition and Sustainment updates DOD's industrial base assessment instruction to define the circumstances that would constitute a known or projected problem or substantial risk that a necessary industrial capability may be lost. (Recommendation 1)

DoD RESPONSE: Concur.

RECOMMENDATION 2: The Secretary of Defense should ensure the Office of the Under Secretary of Defense for Acquisition and Sustainment updates DOD's industrial base assessment instruction and acquisition policies, as necessary, to specify how industrial base assessment requirements apply to programs using AAF pathways. (Recommendation 2)

DoD RESPONSE: Concur.

Appendix X: GAO Contact and Staff Acknowledgments

GAO Contact

Shelby S. Oakley, (202) 512-4841 or oakleys@gao.gov

Staff Acknowledgments

Principal contributors to this report were Anne McDonough, Assistant Director; Nathan P. Foster, Portfolio Analysis Analyst-in-Charge; Nathaniel Vaught, Program Assessments Analyst-in-Charge; Vinayak K. Balasubramanian, Brandon Booth, Rose Brister, Jeffrey Carr, Tana M. Davis, Lori Fields, Beth Reed Fritts, Jaeyung Kim, Michael H. Moran, and Wendy P. Smythe. Other key contributors included Cheryl K. Andrew, Stephen Babb, Ryan Braun, Robert Bullock, Raj Chitikila, Christopher R. Durbin, Brenna Derritt, Gina M. Hoover, Rich Horiuchi, Justin M. Jaynes, J. Kristopher Keener, James Madar, Stephen V. Marchesani, Travis J. Masters, LaTonya D. Miller, Diana Moldafsky, Carl Ramirez, Ashley Rawson, Ronald E. Schwenn, Jenny Shinn, Alexandra Dew Silva, Eli C. Stiefel, James P. Tallon, Nathan A. Tranquilli, Abby C. Volk, J. Andrew Walker, Alyssa B. Weir, and Khristi A. Wilkins.

Table 16 lists the staff responsible for individual program assessments.

Table 16: GAO Staff Responsible for Individual Program Assessments

Program name	Primary staff
Air Force and Space Force programs	
Air Launched Rapid Response Weapon (ARRW)	Patrick Breiding, Matthew L. McKnight, Margaret Fisher
B-52 Commercial Engine Replacement Program Rapid Virtual Prototype (B-52 CERP RVP)	Megan Setser, Sophia Payind, Nicholas A. Jones
B-52 Radar Modernization Program (B-52 RMP)	Rachel A. Steiner-Dillion, Don Springman
Deep Space Advanced Radar Capability (DARC)	Heather Barker Miller, Jaeyung Kim
Enhanced Polar System - Recapitalization (EPS-R)	Erin Carson, Tana Davis
Evolved Strategic SATCOM (ESS)	Megan Stewart, Laura D. Hook
F-15 Eagle Passive Active Warning Survivability system (F-15 EPAWSS)	Matthew Drerup, Alexander J. Shura
F-15EX (F-15EX)	Megan Setser
F-22 Rapid Prototyping	Dennis A. Antonio, Sean Seales, Adrianne Lewis
Future Operationally Resilient Ground Evolution (FORGE)	Tanya Waller, Alexis S. Olson
Global Positioning System III Follow-On (GPS IIIF)	Jonathan Mulcare, Kimberly Schuster
HH-60W Jolly Green (HH-60W)	Sean Seales, Jenny Shinn
KC-46A Tanker Modernization (KC-46A)	Matthew M. Shaffer, Ashley Rawson
Long Range Standoff (LRSO)	Don Springman, Kathryn C. Long
Military Global Positioning System (GPS) User Equipment Increment 1 (MGUE Inc 1)	Eli C. Stiefel, Andrew Redd, Rachel R. Wexler
Military Global Positioning System (GPS) User Equipment Increment 2 (MGUE Inc 2)	Andrew Redd, Eli C. Stiefel, Rachel R. Wexler

Program name	Primary staff
Multi-Mission Helicopter (MH-139A)	Gina Flacco, Leigh Ann Haydon
National Security Space Launch (NSSL)	Erin R. Cohen
Next Generation Operational Control System (OCX)	Kimberly Schuster, Jonathan Mulcare
Next Generation Overhead Persistent Infrared (Next Gen OPIR)	Claire Buck, Erin R. Cohen
Protected Tactical Enterprise Service (PTES)	Brian D. Fersch, Holly Williams
Protected Tactical SATCOM (PTS)	Andrew Berglund, Brian D. Fersch
Small Diameter Bomb Increment II (SDB II)	Sarah Tempel, Miranda J. Wickham
T-7A Red Hawk (T-7A)	Lisa Fisher, Sophia Payind
VC-25B Presidential Aircraft Recapitalization (VC-25B)	LeAnna Parkey, Jean Lee
Weather System Follow-On (WSF)	Nicole Warder, Lauren M. Wright
Army Programs	
Armored Multi-Purpose Vehicle (AMPV)	Charlie Shivers, Meghan Kubit
CH-47F Block II Modernized Cargo Helicopter (CH-47F Block II)	Wendy Smythe, Jasmina Clyburn
Extended Range Cannon Artillery (ERCA)	Alexis S. Olson, Anastasia Kouloganes
Future Attack Reconnaissance Aircraft Program (FARA)	Lauren M. Wright, Joe E. Hunter
Future Long-Range Assault Aircraft (FLRAA)	Sean Merrill, Koffi Dogbevi, Katheryn Hubbell
Improved Turbine Engine Program (ITEP)	Jasmina Clyburn, Wendy Smythe
Indirect Fire Protection Capability Increment 2 (IFPC Inc 2)	Brian Smith, Brian Tittle
Integrated Air and Missile Defense (IAMD)	Michael H. Moran, Julie Clark, Helena Johnson
Integrated Visual Augmentation System (IVAS)	Beth Reed Fritts, Anastasia Kouloganes
Long Range Hypersonic Weapon System (LRHW)	Matthew J. Ambrose
Lower Tier Air and Missile Defense Sensor (LTAMDS)	John Rastler-Cross, Michael H. Moran
Mobile Protected Firepower (MPF)	Jessica Berkholtz, Sameena Ismailjee
Optionally Manned Fighting Vehicle (OMFV)	Kya Palomaki, Jennifer Dougherty
Precision Strike Missile (PrSM)	TyAnn Lee, Lily A. Folkerts
Joint Department of Defense Programs	
F-35 Lightning II (F-35)	Jillena Stevens, Gioia N. Chaouch
Navy and Marine Corps Programs	
Advanced Anti-Radiation Guided Missile - Extended Range (AARGM-ER)	Adriana Aldgate, Marcus C. Ferguson, Jacqueline W. Wade
Air and Missile Defense Radar (AMDR)	Laura Durbin, Nathan P. Foster
CH-53K Heavy Replacement Helicopter (CH-53K)	Victoria Klepacz, Leigh Ann Haydon
Constellation Class Frigate (FFG 62)	Chad Johnson, Sean Merrill
Conventional Prompt Strike (CPS)	Adrianne Lewis, Matthew L. McKnight, Lisa Fisher
CVN 78 Gerald R. Ford Class Nuclear Aircraft Carrier (CVN78)	Jessica Karnis, Burns C. Eckert
DDG 1000 Zumwalt Class Destroyer (DDG 1000)	Timothy Moss, Laurier Fish
DDG 51 Flt III Arleigh Burke Class guided Missile Destroyer - Flight III (DDG 51 Flight III)	Nathan P. Foster, Laura Durbin

Program name	Primary staff
DDG(X) Guided Missile Destroyer (DDG(X))	Chad Johnson, Anh Nguyen, Laurier Fish
F/A-18E/F Infrared Search and Track (IRST)	Erin Stockdale, Zachary J. Sivo
John Lewis Class Fleet Replenishment Oiler (T-AO 205)	Jeffrey Carr, Cale Jones
LHA (R) Amphibious Assault Ships (LHA 8 and LHA 9)	Jeffrey L. Hartnett, Cale Jones
Light Amphibious Warship (LAW)	Jillian C. Schofield, Meghan C. Perez, Joseph A. Neumeier
Littoral Combat Ship Mission Modules (LCS Packages)	Brendan K. Orino, Jillian C. Schofield
LPD 17 San Antonio Class Amphibious Transport Dock, Flight II (LPD 17 Flight II)	Ann Halbert Brooks, Stephen V. Marchesani
MQ-25 Unmanned Aircraft system (MQ-25 Stingray)	Jennifer Leone Baker, James Kim
MQ-4C Triton Unmanned Aircraft System (MA-4C Triton)	Tana Davis, Charlie Shivers
Next Generation Jammer Mid-Band (NGJ MB)	Claire Li, Daniel Glickstein
Ship to Shore Connector Amphibious Craft (SSC)	Ethan Kennedy, Andrew H. Burton, Shelby Clark
SSBN 826 Columbia Class Ballistic Missile Submarine (SSBN 826)	Lindsey Cross, Nathaniel Vaught
SSN 774 Virginia Class Submarine Block V (VCS Block V)	Nathaniel Vaught, Brandon Booth
VH-92A® Presidential Helicopter Replacement Program (VH-92A)	Andrew N. Powell, Bonita Oden

Source: GAO. I GAO-22-105230

Appendix XI: Additional Source Information for Images and Figures

This appendix contains credit, copyright, and other source information for images, tables, or figures in this product when that information was not listed adjacent to the image, table, or figure.

Front cover banner graphic: (rocket) Lockheed Martin, (airplanes) U.S. Air Force, (armored vehicle) BAE.

Front cover: (ship) U.S. Navy.

Appendix I (Individual Assessments): GAO analysis of Department of Defense data and documents (all figures).

Related GAO Products

Annual Weapon Systems Assessments

Weapon Systems Annual Assessment: Updated Program Oversight Approach Needed. GAO-21-222. Washington, D.C.: June 8, 2021.

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

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

Weapon Systems Annual Assessment: Knowledge Gaps Post Risks to Sustaining Recent Positive Trends. GAO-18-360SP. Washington, D.C.: April 25, 2018.

Defense Acquisitions: Assessments of Selected Weapon Programs. GAO-17-333SP. Washington, D.C.: March 30, 2017.

In-Depth Assessments of Selected Weapon Programs

Missile Defense: Addressing Cost Estimating and Reporting Shortfalls Could Improve Insight into Full Costs of Programs and Flight Tests. GAO-22-104344. Washington, D.C.: February 2, 2022.

KC-46 Tanker: Air Force Needs to Mature Critical Technologies in New Aerial Refueling system Design. GAO-22-104530. Washington, D.C.: January 27, 2022.

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

Satellite Communications, DOD Should Explore Options to Meet User Needs for Narrowband Capabilities. GAO-21-105283. Washington, D.C.: September 2, 2021.

Missile Defense: Fiscal Year 2020 Delivery and Testing Progressed, but Annual Goals Unmet. GAO-21-314. Washington, D.C.: April 28, 2021.

Hypersonic Weapons: DOD Should Clarify Roles and Responsibilities to Ensure Coordination across Development Efforts. GAO-21-378. Washington, D.C.: March 22, 2021.

F-35 Joint Strike Fighter: DOD Needs to Update Modernization Schedule and Improve Data on Software Development. GAO-21-226. Washington, D.C.: March 18, 2021.

GPS Modernization: DOD Continuing to Develop New Jam-Resistant Capability, But Widespread Use Remains Years Away. GAO-21-145. Washington, D.C.: January 19, 2021.

Columbia Class Submarine: Delivery Hinges on Timely and Quality Materials from an Atrophied Supplier Base. GAO-21-257. Washington, D.C.: January 14, 2021.

Next Generation Combat Vehicles: As Army Prioritizes Rapid Development, More Attention Needed to Provide Insight on Cost Estimates and Systems Engineering Risks. GAO-20-579. Washington, D.C.: August 6, 2020.

Presidential Helicopter: Program Is Meeting Cost Goals but Some Technical and Schedule Risks Remain. GAO-20-356. Washington, D.C.: April 16, 2020.

Guided Missile Frigate: Navy Has Taken Steps to Reduce Acquisition Risk, but Opportunities Exist to Improve Knowledge for Decision Makers. GAO-19-512. Washington, D.C.: August 9, 2019.

Acquisition Policy and Reform

High-Risk Series: Key Practices to Successfully Address High-Risk Areas and Remove Them from the List. GAO-22-105184. Washington, D.C.: March 3, 2022.

Defense Acquisitions: Additional Actions Needed to Implement Proposed Improvements to Congressional Reporting. GAO-22-104687. Washington, D.C.: February, 28, 2022.

DOD Acquisitions: DOD Should Take Additional Actions to Improve How It Approaches Intellectual Property. GAO-22-104752. Washington, D.C.: November 30, 2021.

Missile Defense: Recent Acquisition Policy Changes Balance Risk and Flexibility, but Actions Needed to Refine Requirements Process. GAO-22-563. Washington, D.C.: November 10, 2021.

Navy Shipbuilding: Increasing Focus on Sustainment Early in the Acquisition Process Could Save Billions. GAO-20-2. Washington, D.C.: March 24, 2020.

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

Software and Cybersecurity in Acquisition Programs

Defense Contractor Cybersecurity: Stakeholder Communication and Performance Goals Could Improve Certification Framework. GAO-22-104679. Washington, D.C.: December 8, 2021.

DOD Software Acquisition: Status of and Challenges Related to Reform Efforts. GAO-21-105298. Washington, D.C.: September 30, 2021.

Software Development: DOD Faces Risks and Challenges in Implementing Modern Approaches and Addressing Cybersecurity Practices. GAO-21-351. Washington, D.C.: June 23, 2021.

Weapon Systems Cybersecurity: Guidance Would Help DOD Programs Better Communicate Requirements to Contractors. GAO-21-179. Washington, D.C.: March 4, 2021.

Information Technology: DOD Software Development Approaches and Cybersecurity Practices May Impact Cost and Schedule. GAO-21-182. Washington, D.C.: December 23, 2020.

Defense Acquisitions: Joint Cyber Warfighting Architecture Would Benefit from Defined Goals and Governance. GAO-21-68. Washington, D.C.: November 19, 2020.

DOD Space Acquisitions: Including Users Early and Often in Software Development Could Benefit Programs. GAO-19-136. Washington, D.C.: March 18, 2019.

Weapon Systems Cybersecurity: DOD Just Beginning to Grapple with Scale of Vulnerabilities. GAO-19-128. Washington, D.C.: October 9, 2018.

GAO Guides

Agile Assessment Guide: Best Practices for Agile Adoption and Implementation. GAO-20-590G. Washington, D.C.: September 28, 2020.

Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Program Costs, GAO-20-195G. Washington, D.C.: March 2020.

Technology Readiness Assessment Guide: Best Practices for Evaluating the Readiness of Technology for Use in Acquisition Programs and Projects. GAO-20-48G. Washington, D.C.: January 7, 2020.

Leading Acquisition Practices

Leading Practices: Agency Acquisition Policies Could Better Implement Key Product Development Principles. GAO-22-104513. Washington, D.C.: March. 10, 2022.

Defense Acquisitions: Senior Leaders Should Emphasize Key Practices to Improve Weapon System Reliability. GAO-20-151. Washington, D.C.: January 14, 2020.

Navy Shipbuilding: Past Performance Provides Valuable Lessons for Future Investments. GAO-18-238SP. Washington, D.C.: June 6, 2018.

Best Practices: DOD Can Achieve Better Outcomes by Standardizing the Way Manufacturing Risks Are Managed. GAO-10-439. Washington, D.C.: April 22, 2010.

Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding. GAO-09-322. Washington, D.C.: May 13, 2009.

Defense Acquisitions: A Knowledge-Based Funding Approach Could Improve Major Weapon System Program Outcomes. GAO-08-619. Washington, D.C.: July 2, 2008.

Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes. GAO-02-701. Washington, D.C.: July 15, 2002.

Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes. GAO-01-288. Washington, D.C.: March 8, 2001.

Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes. GAO/NSIAD-99-162. Washington, D.C.: July 30, 1999.