



WEAPON SYSTEMS ACQUISITION

DOD Needs Better Planning to Attain Benefits of Modular Open Systems

Report to Congressional Committees

January 2025

GAO-25-106931

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GAO Highlights

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Why GAO Did This Study

A MOSA enables weapon programs to better respond to changing threats by allowing them to replace components more easily. Further, a MOSA can help address concerns like high weapon system sustainment costs that GAO has reported on.

House and Senate reports include provisions for GAO to review DOD's use of MOSAs. This report assesses the extent to which (1) programs implemented MOSAs and why; (2) programs and portfolios planned for MOSAs; (3) the military departments invested in necessary resources for MOSAs; and (4) DOD developed policy, regulations, and guidance for MOSAs.

GAO reviewed planning documents for 20 acquisition programs that started after relevant laws were passed in 2016. GAO selected the programs based on their acquisition approach and military service. GAO also reviewed policy and guidance documents and interviewed DOD and military department officials.

What GAO Recommends

GAO is making 14 recommendations to DOD, including that it develop a process to analyze MOSA costs and benefits; improve military department processes for ensuring quality MOSA planning documents and for coordinating MOSA implementation across programs; and address gaps in MOSA policy and guidance. DOD concurred with these recommendations.

What GAO Found

A modular open systems approach (MOSA) is a strategy that can help the Department of Defense (DOD) design weapon systems that take less time and money to sustain and upgrade. Recent legislation requires acquisition programs to implement a MOSA to the maximum extent practicable. GAO found that 14 of the 20 programs it reviewed reported implementing a MOSA to at least some extent. Other programs cited barriers to doing so, such as added cost and time to conduct related design work. While a MOSA has potential benefits, it may also require programs to conduct additional planning, such as to ensure they address cybersecurity aspects related to a MOSA.

Potential Benefits of a Modular Open Systems Approach

Increased innovation

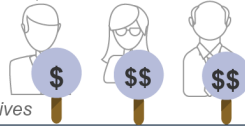


Enhanced interoperability

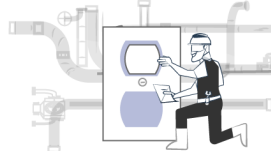


Fosters competition, which can lower prices

industry representatives



Faster and less costly repairs and upgrades



Source: GAO analysis of Department of Defense and industry data. | GAO-25-106931

However, none of the 20 programs GAO reviewed conducted a formal analysis of costs and benefits for a MOSA because DOD's policy does not explicitly require one. As GAO reported in March 2020, program officials often focus on reducing acquisition time and costs. Unless required to consider the costs and benefits of a MOSA, officials may overlook long-term MOSA benefits.

Further, most programs did not address all key MOSA planning elements in acquisition documents, in part, because the military departments did not take effective steps to ensure they did so. As a result, programs may not be well-positioned to integrate a MOSA into key investment decisions early in the life of the program. Also, DOD's process for coordinating MOSAs across portfolios does not ensure the level of collaboration needed to achieve potential benefits such as lower costs from using common components across programs.

The military departments are statutorily required to ensure availability of certain resources and expertise related to MOSA implementation. However, they have yet to assess their departments' MOSA needs or determine how resources should be aligned across their respective departments. Until they do this, programs risk having insufficient resources and expertise to achieve the potential benefits of a MOSA.

DOD has updated some acquisition and engineering policies and is drafting regulations and guidance to address MOSAs. But gaps remain that could hinder MOSA implementation. For example, DOD policy does not address how MOSA requirements apply to programs using the middle tier of acquisition pathway—those intending to complete rapid prototyping or fielding in 5 years or less.

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Abbreviations

ACAT	acquisition category
CAPE	Cost Assessment and Program Evaluation
DOD	Department of Defense
MDAP	major defense acquisition program
MOSA	modular open systems approach
MTA	middle tier of acquisition
NDAA	National Defense Authorization Act
OSD	Office of the Secretary of Defense
PEO	program executive officer
USD(A&S)	Under Secretary of Defense for Acquisition and Sustainment
USD(R&E)	Under Secretary of Defense for Research and Engineering

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January 22, 2025

Congressional Committees

U.S. adversaries are fielding technically advanced weapons at an accelerating pace. At the same time, the Department of Defense (DOD) continues to struggle with fielding delays for new weapon systems, which results in these systems becoming less relevant as time elapses from when their original requirements were developed. DOD’s practice of frequently developing weapon systems that can only be updated or maintained by a single contractor further complicates the problem by limiting opportunities for the integration of cutting-edge technologies from new vendors or cost-saving competition to sustain weapon systems.

Legislation enacted over the past several years required DOD to change the way it buys and designs weapon systems by implementing a modular open systems approach (MOSA) to the maximum extent practicable.¹ A MOSA, which includes a modular design and standard interfaces, allows programs to easily replace components of a product. This approach allows the product to be competitively upgraded with new, improved components that can be made by a greater variety of suppliers. It may also help address concerns we have previously reported on about rising sustainment costs for programs like the F-35 and the Navy’s shipbuilding portfolio by increasing competition for sustainment among potential vendors.² Otherwise, these costs may limit DOD’s ability to afford the force structure it expects to need in future conflicts.

The benefits of designing weapon systems with a MOSA have been long established. DOD issued policy encouraging weapon system programs to use open systems specifications to acquire weapon systems electronics 30 years ago. However, we reported in 2023 that implementation of a MOSA in acquisition programs was inconsistent. We found that programs implementing a MOSA did not consistently plan to verify successful implementation of the approach before key points in the acquisition process, such as before beginning production.³

The House and Senate committee reports accompanying bills for the James M. Inhofe National Defense Authorization Act (NDAA) for Fiscal Year 2023 include provisions for GAO to review DOD’s use of MOSAs in

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

²GAO, *F-35 Sustainment: Costs Continue to Rise While Planned Use and Availability Have Decreased*, [GAO-24-106703](#) (Washington, D.C.: Apr. 15, 2024), *F-35 Sustainment: DOD Needs to Cut Billions in Estimated Costs to Achieve Affordability*, [GAO-21-439](#) (Washington, D.C.: July 7, 2021) and *Navy Shipbuilding: Increasing Focus on Sustainment Early in the Acquisition Process Could Save Billions*, [GAO-20-2](#) (Washington, D.C.: Mar. 24, 2020). Competition is the cornerstone of a sound acquisition process and a critical tool for achieving the best return on investment for taxpayers. Office of Management and Budget, Office of Federal Procurement Policy, *Increasing Competition and Structuring Contracts for the Best Results* (Washington, D.C.: Oct. 27, 2009); and *Enhancing Competition in Federal Acquisition* (Washington, D.C.: May 31, 2007).

³GAO, *Weapon Systems Annual Assessment: Programs Are Not Consistently Implementing Practices That Can Help Accelerate Acquisitions*, [GAO-23-106059](#) (Washington, D.C.: June 8, 2023).

developing weapon systems.⁴ This report assesses the extent to which (1) selected acquisition programs reported implementing a MOSA and the factors contributing to those decisions, including the use of cost-benefit analysis; (2) DOD has planned for MOSA implementation at the program and portfolio levels; (3) the military departments have identified and invested in necessary resources to implement MOSA; and (4) DOD has developed policy, regulations, and guidance for MOSAs.

To assess the extent to which selected acquisition programs reported implementing MOSA and the factors contributing to those decisions, we reviewed acquisition documentation relevant to MOSAs and interviewed officials among 20 selected programs. These programs are following one of two acquisition pathways: (1) the major capability acquisition pathway, used by major defense acquisition programs (MDAP), and (2) the middle tier of acquisition (MTA) pathway. We selected programs for review based on the following criteria:

- MDAPs (9): We selected unclassified programs that entered technology or system development after January 1, 2019, the date after which the NDAA for Fiscal Year 2017 required all MDAPs obtaining approval to enter technology or system development to implement a MOSA to the maximum extent practicable.⁵
- MTA programs (11): We selected up to three of the most recently initiated programs currently using this pathway from each military service (Army, Air Force, Space Force, and Navy) that DOD reported in its annual submission to Congress in support of the President's budget for fiscal year 2024.⁶

To assess the use of cost-benefit analysis to inform programs' MOSA decisions, we reviewed available documentation related to cost-benefit analyses conducted by all 20 acquisition programs we reviewed. We assessed whether programs completed these analyses as recommended by best practices in cost estimating to help control life-cycle costs.⁷ We also reviewed DOD policy to determine the extent to which programs and acquisition organizations are required to assess MOSA costs and benefits to inform decisions related to MOSA implementation.

To assess the extent to which DOD has planned for MOSA implementation at the program level, we collected and reviewed key planning documents for our selected programs. These documents include systems engineering plans, acquisition strategies, and requests for proposals. We assessed the extent to which these documents addressed MOSA provisions in law and DOD policy and guidance. To assess the effectiveness of DOD's planning at the portfolio level, we obtained written responses from a subset of the organizations' chief systems engineers responsible for our selected programs on the extent to which their offices have established

⁴H.R. Rep. No. 117-397, at 224 (2022); S. Rep. No. 117-130, at 205 (2022); accompanying bills for the James M. Inhofe NDAA for Fiscal Year 2023.

⁵The cost threshold for designation as an MDAP is \$525 million for Research, Development, Test, and Evaluation funding or \$3.065 billion in procurement funding (fiscal year 2020 constant dollars).

⁶The Marine Corps—a separate armed service organized under the Department of the Navy—had no programs that met our criteria. The Navy had two—Conventional Prompt Strike and Hypersonic Air-Launched Offensive Anti-Surface Warfare Weapon System. The Space Force is a separate armed service organized under the Department of the Air Force, but with its own service acquisition executive.

⁷GAO, *Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Program Costs*, [GAO-20-195G](#) (Washington, D.C.: Mar. 12, 2020).

formal MOSA coordination processes for their portfolios of responsibility. We compared these responses to leading practices for portfolio management.

To assess the extent to which the military departments identified and invested in necessary resources to implement MOSA, we requested plans from the military departments related to funding MOSA implementation. We also met with acquisition officials at the program office, military department, and Office of the Secretary of Defense (OSD) levels to obtain their perspectives on the necessary resources to implement MOSAs. We also discussed how the military departments had assessed and planned to meet these resource needs. We compared the military departments' efforts to plan for MOSA-related resources to our past work on planning to achieve organizational goals.

To assess DOD's progress in developing MOSA policy, regulations, and guidance, we collected and reviewed OSD and military department policy and guidance documents and documents related to relevant regulations. We assessed whether military departments issued guidance that addresses legal requirements, including addressing how MOSA is to be documented in acquisition program documentation, considerations regarding MOSA at acquisition milestones, and related topics. We also met with officials responsible for these documents.

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

We conducted this performance audit from June 2023 to January 2025 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

MOSA Definition

A MOSA for weapon systems includes a combination of engineering and business practices in which weapons systems are designed with modular components that are linked by clearly defined system interfaces. The components can be acquired from independent vendors.⁸ Modern weapon systems consist of a major system platform—like an aircraft—that is composed of major system components like engines and optical sensors.⁹ The connections between the platform's components are referred to as interfaces.

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

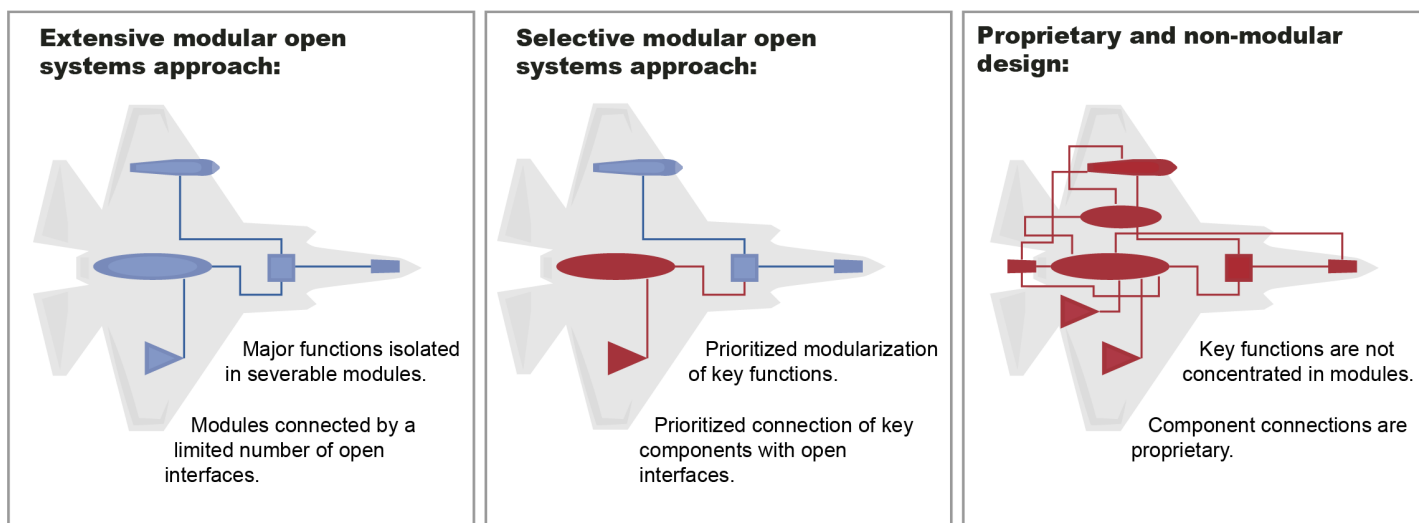
⁸For the current statutory definition of a MOSA, see 10 U.S.C. § 4401(b)(1).

⁹For the current statutory definitions of major system components and major system platforms, see 10 U.S.C. § 4401(b)(2)-(3).

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

When open standards are not available, programs pursuing a MOSA can obtain appropriate data rights to their components’ interfaces. Doing so could enable the government to competitively award contracts for modification and sustainment of weapon systems. Figure 1 illustrates a range of MOSA approaches that a program could select for a notional system.

Figure 1: Notional Modular Open System Approaches



Source: GAO analysis of Department of Defense information. | GAO-25-106931

Potential Benefits of a MOSA

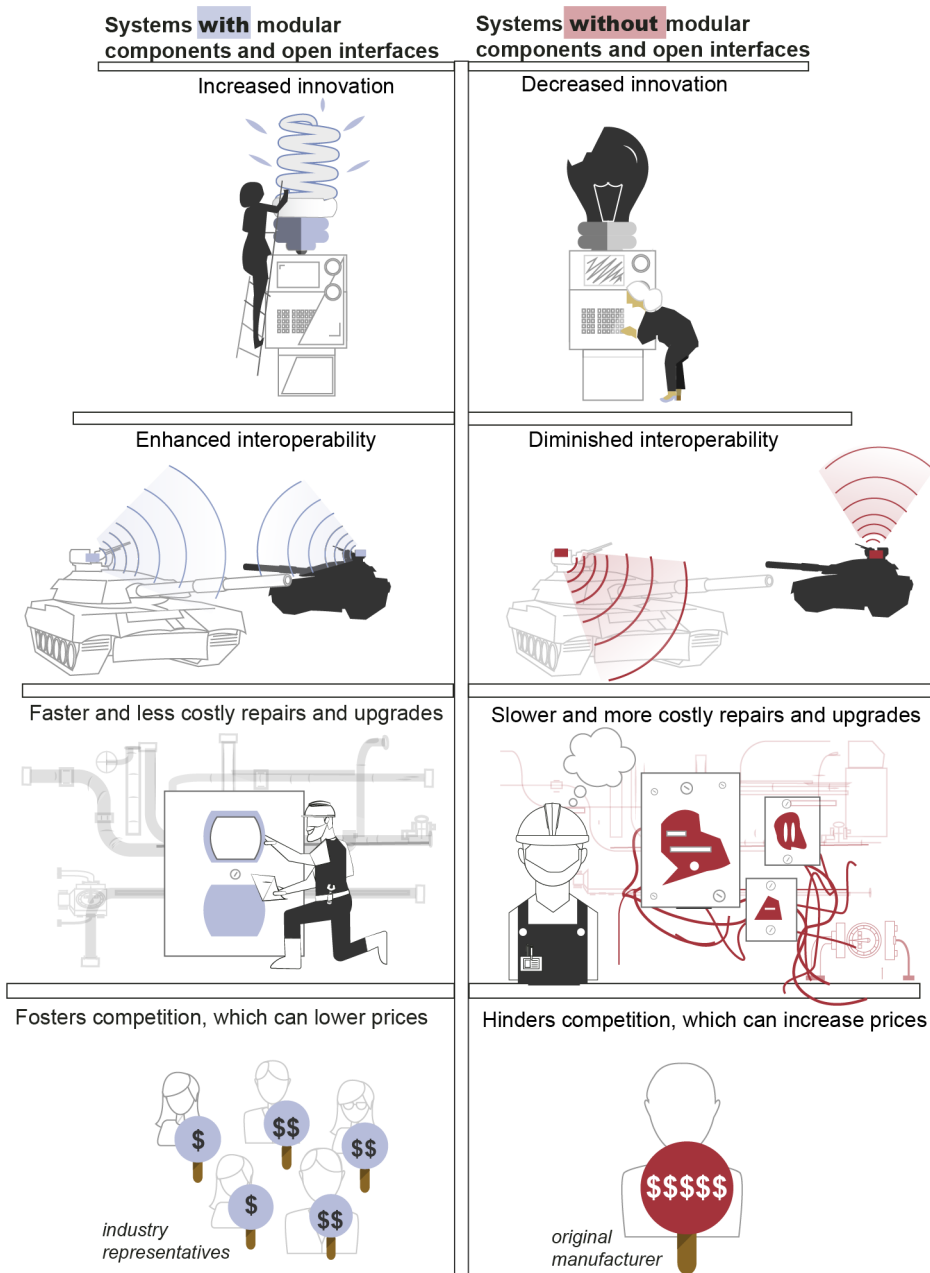
An open system enables DOD to acquire warfighting capabilities with more flexibility and opportunities for competition by allowing independent suppliers to build components that can plug into the existing system through the open connections. We have previously reported on the benefits of a MOSA for weapons programs. These include the potential to reduce operating and sustainment costs—which account for approximately 70

percent of a weapon system's total life-cycle cost.¹⁰ For example, in a 2021 review of DOD's efforts to develop new, alternative navigation technologies, we found that DOD was leveraging a common MOSA to standardize the common elements across the individual military services' reference architectures.¹¹ Figure 2 illustrates potential benefits associated with a MOSA as opposed to systems that do not use modular components or open interfaces.

¹⁰[GAO-13-651](#) and GAO, *Weapon System Sustainment: Aircraft Mission Capable Goals Were Generally Not Met and Sustainment Costs Varied by Aircraft*, [GAO-23-106217](#) (Washington, D.C.: Nov. 10, 2022).

¹¹GAO, *GPS Alternatives: DOD Is Developing Navigation Systems but Is Not Measuring Overall Progress*, [GAO-22-106010](#) (Washington, D.C.: Aug. 5, 2022).

Figure 2: Potential Benefits of a Modular Open Systems Approach versus a System Not Using Such an Approach



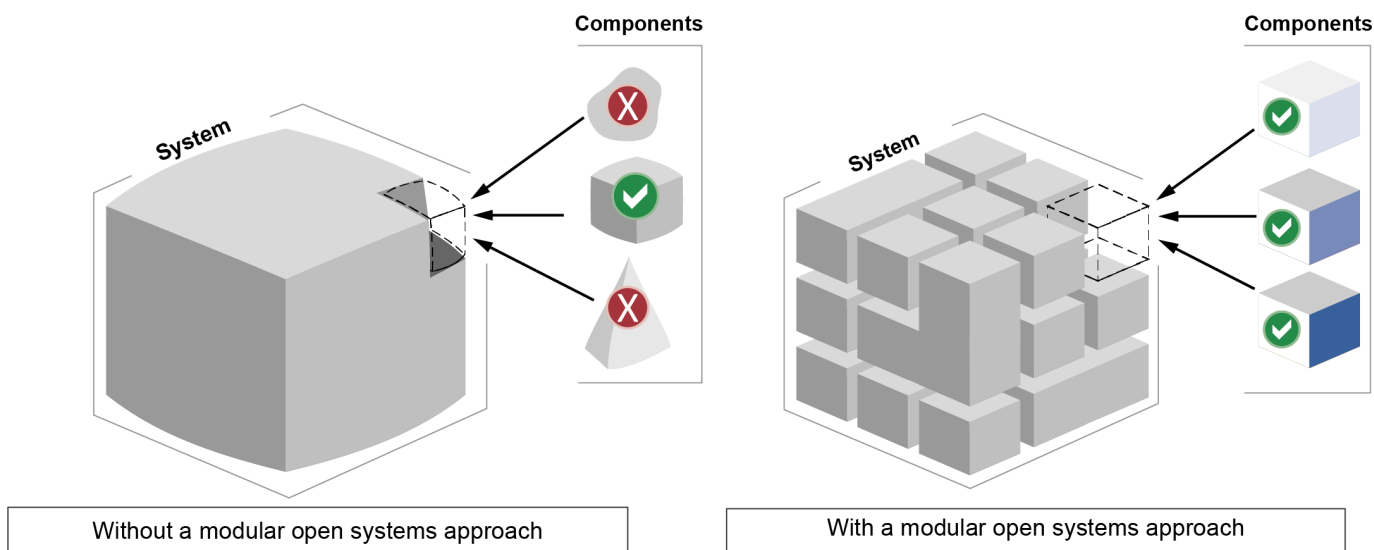
Source: GAO analysis of Department of Defense and industry data. | GAO-25-106931

Acquisition program officials noted there are some potential disadvantages to pursuing a MOSA. For example, publicly available open interfaces may help adversaries identify and exploit cyber vulnerabilities. Thus, using a MOSA may require additional planning to ensure cybersecurity needs are addressed. Further, a 2023 DOD survey found responding programs noted that a MOSA was costly to implement on pre-existing systems because it would require additional engineering costs to modify the design and acquire interface data rights.

Many consumer products, including U.S. appliances, personal computers, and smartphones, are considered open systems because they use widely available hardware and software standards at key interfaces. For example, U.S. appliances are designed to use a particular wall socket standard, so that they can plug into any power outlet without consumers needing to worry about which brand of product is compatible in their homes. This gives customers more choices to best meet their needs and helps keep prices low by fostering market competition.

Similarly, a MOSA can allow DOD weapon system programs to gain efficiencies from competition. Although a MOSA can require more planning and investment in the weapons system development phase, it is intended to enable programs to incorporate new components from additional contractors. These benefits apply both for technology upgrades and to facilitate opportunities for competition for sustainment activities. Figure 3 illustrates how key components in a MOSA can allow a wider variety of components to meet mission needs.

Figure 3: Greater Availability of Suitable Replacements with a Modular Open Systems Approach



Source: GAO analysis of Department of Defense information. | GAO-25-106931

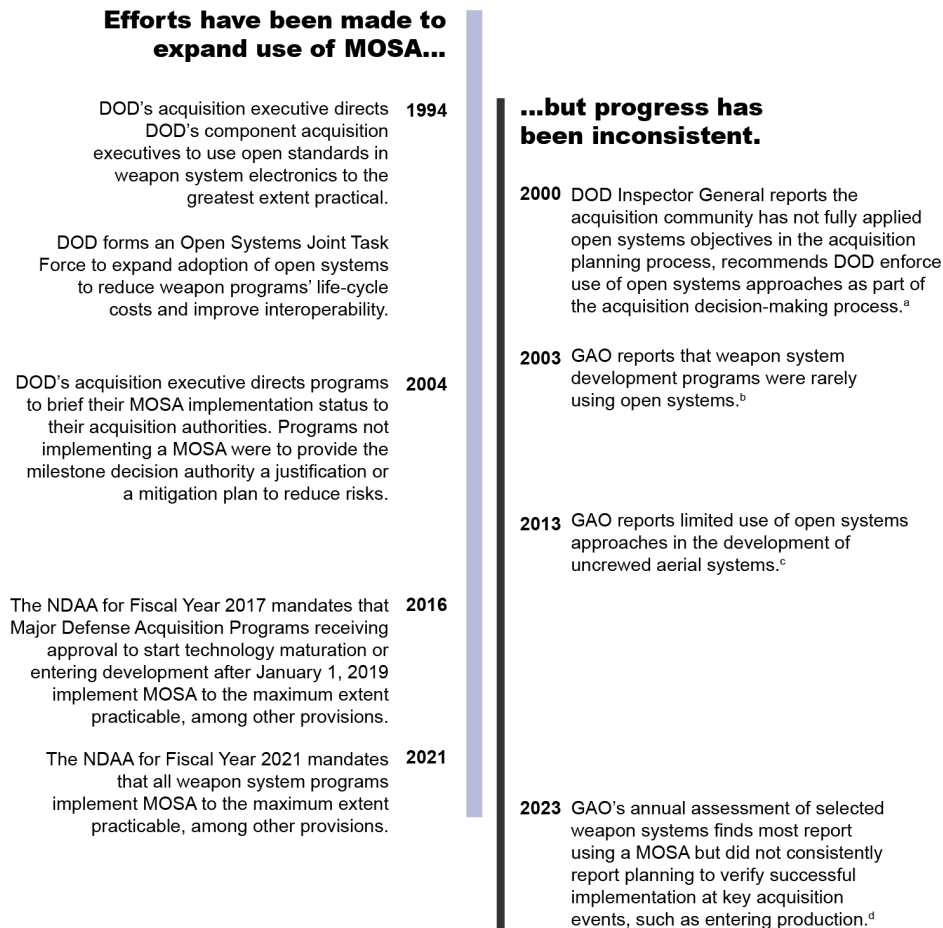
A MOSA can also enable DOD programs to achieve the kind of rapid product development demonstrated by leading commercial companies. In our 2023 report on the product development practices of leading companies, we found they use an iterative process to design, validate, and deliver complex products, such as combined networks of hardware and software—referred to as cyber-physical systems—with speed.¹² These companies focus on first delivering a minimal viable product, a product with the minimum capabilities needed for customers to recognize value and that can be followed by successive updates. Systems with modular designs and open interfaces will be better positioned to accept upgrades rapidly and affordably as part of future iterations.

¹²GAO, *Leading Practices: Iterative Cycles Enable Rapid Delivery of Complex, Innovative Products*, [GAO-23-106222](#) (Washington, D.C.: July 27, 2023).

History of MOSA Implementation at DOD

MOSA is not a new concept in DOD’s weapon system acquisition. However, multiple efforts in legislation and DOD policy over the past 30 years to expand the use of MOSA have yet to yield consistent implementation, as shown in figure 4.

Figure 4: Timeline of Efforts to Expand the Use of MOSAs and Results



DOD Department of Defense
MOSA Modular open systems approach
NDAA National Defense Authorization Act

Source: GAO analysis and presentation of DOD information and statutes. | GAO-25-106931

^aDepartment of Defense, Office of the Inspector General, *Use of An Open Systems Approach for Weapon Systems*, Report No. D-2000-149 (Arlington, Virginia: June 14, 2000).

^bGAO, *Best Practices: Setting Requirements Differently Could Reduce Weapon Systems’ Total Ownership Costs*, GAO-03-57 (Washington, D.C.: Feb. 11, 2003).

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

^dGAO, *Weapon Systems Annual Assessment: Programs Are Not Consistently Implementing Practices That Can Help Accelerate Acquisitions*, GAO-23-106059 (Washington, D.C.: June 8, 2023).

For additional details on MOSA legislation, see appendix II.

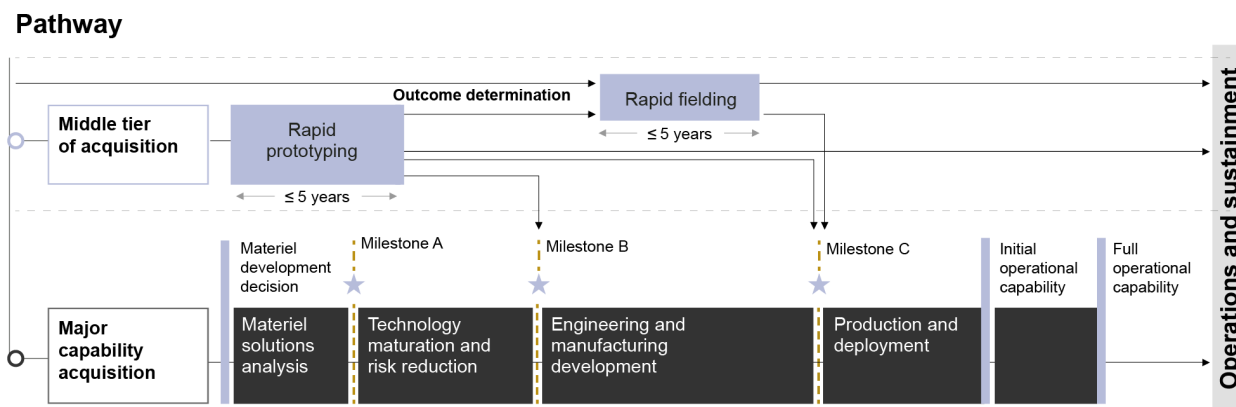
DOD Acquisition Pathways

DOD generally acquires its weapon systems through a management process known as the Defense Acquisition System, governed by the overarching principles and procedures described in DOD Directive 5000.01 and DOD Instruction 5000.02.¹³ DOD Instruction 5000.02 establishes the Adaptive Acquisition Framework to manage DOD acquisition programs. The framework is composed 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.¹⁴ The two that are most relevant for this report are:

- **Major capability acquisition:** supports complex acquisitions, involving the phases of technology development, system development, and production;
- **MTA:** includes expedited paths for rapid prototyping and rapid fielding, each of which is to be completed within 5 years of the program start date.

Figure 5 shows the major capability acquisition and MTA pathways and associated decision points.

Figure 5: Major Capability Acquisition and Middle Tier of Acquisition Pathways



Source: GAO analysis of Department of Defense (DOD) data. | GAO-25-106931

¹³Department of Defense, *The Defense Acquisition System*, DOD Directive 5000.01 (Sept. 9, 2020) (incorporating change 1, July 28, 2022); and *Operation of the Adaptive Acquisition Framework*, DOD Instruction 5000.02 (Jan. 23, 2020) (incorporating change 1, June 8, 2022).

¹⁴Throughout 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.

Major Capability Acquisition Pathway

Under DOD Instruction 5000.02, DOD's major capability acquisition pathway is designed to support certain complex acquisitions such as MDAPs.¹⁵ DOD Instruction 5000.85 established the policy and prescribed procedures that guide acquisition programs using this pathway. Within this pathway, programs generally proceed through four phases:

- technology maturation and risk reduction, starting with milestone A;
- engineering and manufacturing development, starting with milestone B;
- production and deployment, starting with milestone C; and
- operations and sustainment, generally starting after full operational capability is achieved.

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

MTA Pathway

The NDAA for Fiscal Year 2016 required DOD to establish guidance for an alternative acquisition process, now referred to as the middle tier of acquisition, for programs intended to be completed in a period of 2 to 5 years.¹⁶ In December 2019, DOD issued Instruction 5000.80, Operation of the Middle Tier of Acquisition. This instruction formally established the department's MTA policy, assigned responsibilities, and prescribed procedures for the management of the MTA rapid prototyping and rapid fielding paths. The policy states that the MTA pathway is intended to deliver capabilities with a level of maturity that allows them to be rapidly prototyped within an acquisition program or fielded within 5 years of MTA program start. DOD Instruction 5000.80 also outlines the distinctions between the two MTA paths as described in statute:

- The **rapid prototyping path's** objective is to field a prototype that meets defined requirements, which can be demonstrated in an operational environment and provide for residual operational capability within 5 years of the MTA program start date.¹⁷
- The **rapid fielding path's** objective is to begin production of a new or upgraded system with minimal development within 6 months and complete fielding within 5 years of the MTA program start date.¹⁸

¹⁵MDAPs generally include those programs that are not a highly sensitive classified program and that are either (1) designated by the Secretary of Defense as a MDAP; or that are (2) estimated to require an eventual total expenditure for research, development, test, and evaluation, including all planned increments or spirals, of more than \$525 million in fiscal year 2020 constant dollars or, for procurement, including all planned increments or spirals, of more than \$3.065 billion in fiscal year 2020 constant dollars. See 10 U.S.C. § 4201(a); DOD Instruction 5000.85, Major Capability Acquisition (Aug. 6, 2020) (incorporating change 1, Nov. 4, 2021) (reflecting statutory MDAP cost thresholds in fiscal year 2020 constant dollars). Certain programs that meet these thresholds, including programs using the MTA pathway, are not considered MDAPs. See 10 U.S.C. § 4201(b).

¹⁶Pub. L. No. 114-92, § 804 (2015).

¹⁷DOD Instruction 5000.80 states that for rapid prototyping programs, residual operational capability is any military utility for an operational user that can be fielded.

¹⁸The statutory objectives for MTA efforts are outlined in section 804 of the NDAA for Fiscal Year 2016. See Pub. L. No. 114-92, § 804(b) (2015).

Organizations with Key Roles Pertaining to MOSA

Oversight of the department's costliest weapon systems is shared between several entities within OSD and the military departments. Entities within OSD are responsible for overarching oversight of weapon systems across the department. This oversight includes developing policies and supervising all elements of DOD related to acquisition and sustainment; providing capabilities to enable reporting and data analysis; conducting or approving independent cost estimates and cost analyses; and overseeing operational and live fire tests and evaluations.

Regarding MOSA implementation, the following offices within OSD have key roles:

- The **Under Secretary of Defense for Research and Engineering (USD(R&E))** is generally responsible for developing MOSA policy and advancing workforce competency. Its efforts to date include the incorporation of MOSA in the November 2020 DOD Instruction 5000.88 and systems engineering guidebooks. USD R&E also chairs the Modular Open Systems Working Group. The working group, which includes MOSA subject matter experts from across OSD and the military departments, collaborates on MOSA promotion activities like new policy, guidance, and trainings.
- The **Under Secretary of Defense for Acquisition and Sustainment (USD(A&S))** is generally responsible for issuing policy on the operation of the Defense Acquisition System, including the major capability acquisition and MTA pathways, and for overseeing acquisition programs for which it is the milestone decision authority.¹⁹ Within this organization is the Intellectual Property Cadre, an organization of intellectual property acquisition and licensing experts, which provides oversight and coordination on all of DOD's intellectual property acquisition and licensing policy and procedures. The cadre assists programs in developing their approaches to soliciting and negotiating contract provisions for necessary intellectual property.
- The **Director of Cost Assessment and Program Evaluation (CAPE)** conducts or approves independent cost estimates, and cost analyses covering the life cycle of MDAPs, in support of milestone reviews, sustainment reviews, congressional certifications, and budget requests. CAPE also advises USD(A&S) on schedule, resource allocation, affordability, systems analysis, cost estimation, and the performance implications of proposed MTA programs; and establishes policies and prescribes procedures for MTA cost data and cost estimates, as appropriate.

The Joint Capabilities Integration and Development System—the process by which requirements for new performance capabilities shared jointly across military services are reviewed and validated—also has a role in shaping MOSAs. The manual for this process requires the authors of proposed requirements to briefly describe in the capability development document whether the system being designed plans to use a MOSA, including integration of capabilities developed within the system and plan for evolution of capabilities that will be added, removed, or replaced in future increments. It also states requirement authors should discuss how MOSA is being used to enable flexibility in critical technology areas.²⁰

¹⁹Department of Defense, *Operation of the Middle Tier of Acquisition (MTA)*, DOD Instruction 5000.80 (Dec. 30, 2019); Department of Defense, *The Defense Acquisition System*, DOD Directive 5000.01 (Sept. 9, 2020) (incorporating change 1, July 28, 2022); and *Operation of the Adaptive Acquisition Framework*, DOD Instruction 5000.02 (Jan. 23, 2020) (incorporating change 1, June 8, 2022).

²⁰Department of Defense, *Manual for the Operation of the Joint Capabilities Integration and Development System* (October 30, 2021).

At the military department level, the component acquisition executives, also referred to as the service acquisition executives, are responsible for implementing DOD acquisition policy within their respective departments and serve as the milestone decision authority for most MDAPs. Service acquisition executives are also decision authorities for programs using the MTA pathway, with some exceptions. Marine Corps acquisition programs are under the authority of the Navy's service acquisition executive. Space Force acquisition programs are under the authority of the Assistant Secretary of the Air Force for Space Acquisition and Integration.

Below the milestone decision authority level, program executive officers (PEO) oversee portfolios of programs. According to DOD policy, a PEO is responsible for delivering an integrated suite of mission-effective capability to the warfighter. DOD policy further states that PEOs are expected to do this by balancing risk, cost, schedule, performance, interoperability, sustainability, and affordability.²¹ Appendix III provides more detailed overviews of roles and responsibilities for DOD and military department officials in weapons systems acquisitions.

Oversight Process for MOSA Implementation

Military department acquisition and engineering officials oversee acquisition programs' implementation of a MOSA through DOD's established acquisition oversight processes, including milestone decision reviews for MDAPs and MTA program reviews.

MDAP milestone reviews: Milestone decision authorities are responsible for approving MDAPs' acquisition strategies during milestone reviews.²² These reviews are forums for a program to present its progress and risks to its milestone decision authority to decide whether the program is sufficiently prepared to enter the next phase of development. DOD policy states that the milestone decision authority will review the program's approach to implementing MOSA to ensure that the program has addressed and implemented standardized interfaces, and arrangements for obtaining necessary intellectual property rights.²³ Milestone decision authorities are also required to ensure that requests for proposals for a program's development or production phases describe the MOSA, among other things.

At the milestone review for entering the systems development phase, milestone decision authorities are responsible for determining in writing that programs implementing a MOSA incorporate clearly defined major system interfaces, consistent with widely supported and consensus-based standards if available and suitable, and that programs have arranged to obtain appropriate and necessary intellectual property rights with respect to these major system interfaces.²⁴ The milestone decision authorities are also required to review and determine whether any justification to not implement a MOSA is appropriate, and to determine in writing, for each program that does not use a MOSA, that the use of a MOSA is not practicable.²⁵

²¹DOD Instruction 5000.02.

²²10 U.S.C. § 4211.

²³Department of Defense, *Major Capability Acquisition*, DOD Instruction 5000.85 (Aug. 6, 2020).

²⁴10 U.S.C. § 4402(e)(1).

²⁵Department of Defense, *Engineering of Defense Systems*, DOD Instruction 5000.88 (Nov. 18, 2020); 10 U.S.C. § 4402(e)(2).

MTA program reviews: MTA programs' decision authorities review and approve programs' entrance and exit from the pathway, using required documentation. Military department acquisition officials told us they use these reviews to assess MTA programs' MOSA implementation.

As part of the review for entering the MTA pathway, programs that exceed the statutory major system cost threshold prepare and submit the following documents to their decision authorities for their review and approval:²⁶

- Approved performance requirements for the system to be developed
- An acquisition strategy that includes security, schedule, and production risks, a cost estimate, and a test strategy or an assessment of test results, among other things
- A cost estimate for the MTA program
- A life-cycle sustainment plan for major systems seeking to initiate on the MTA rapid fielding pathway

Acquisition and engineering officials also oversee MOSA implementation through systems engineering reviews. According to DOD's engineering instruction, these reviews are generally required for MDAPs unless waived by their systems engineering plan's approval authority.²⁷ DOD's MTA acquisition instruction states program managers will "tailor- in" reviews, assessments, and relevant documentation that results in an acquisition strategy customized to the unique characteristics and risks of their program.²⁸

Program Decisions to Implement MOSA Largely Based on Near-Term Considerations

Most programs we reviewed reported implementing a MOSA to at least some extent, with variations in the types of openness and modularity each program pursued. However, programs generally did not conduct formal assessments of life-cycle costs and benefits associated with the decision to invest in a MOSA. As a result, programs' perceptions of near-term cost and schedule challenges largely drove their decisions on whether to implement a MOSA in the absence of leadership direction above the program to do so.

Programs Reported Varying Degrees of MOSA Implementation

Fourteen of the 20 programs we reviewed—including five of the nine MDAPs and nine of the 11 MTA programs—reported implementing a MOSA. All six Army programs we reviewed reported using a MOSA, while at least half of the programs we assessed at each of the other military services reported using a MOSA. Statute requires programs to implement a MOSA to the maximum extent practicable, giving programs flexibility

²⁶Major 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).

²⁷DOD Instruction 5000.88.

²⁸Department of Defense, Operation of the Middle Tier of Acquisition (MTA), DOD Instruction 5000.80 (Dec. 30, 2019).

in determining whether and how a MOSA would meet their specific business and technical considerations. DOD officials told us that it is important for each program to make investment decisions about using a MOSA that meet the program’s life-cycle cost, schedule, and performance needs. Table 1 shows additional detail on programs’ reported MOSA implementation status by military service and program type.

Table 1: MOSA Implementation as Reported by Selected Weapon Acquisition Programs

MOSA implementation status reported by program	Military service	Program type	Program name	
Not implementing a MOSA	Air Force	MDAP	B-52 Commercial Engine Replacement Program ^a	
			B-52 Radar Modernization Program	
		MTA	Hypersonic Attack Cruise Missile	
	Navy	MDAP	Advanced Anti-Radiation Guided Missile-Extended Range	
		MTA	Navy Conventional Prompt Strike	
Space Force	MDAP	Weather System Follow-on		
Implementing a MOSA^b	Air Force	MDAP	Mark 21 Reentry Vehicle	
		MTA	E-7A Rapid Prototyping	
			Stand-in Attack Weapon	
	Army	MDAP		Future Long Range Assault Aircraft
				Improved Turbine Engine Program
				Precision Strike Missile
		MTA		Indirect Fire Protection Capability Increment 2 - Intercept
				Integrated Visual Augmentation System Rapid Fielding
	Navy			Lower Tier Air and Missile Defense Sensor
		MDAP		Constellation Class Guided Missile Frigate
		MTA		Hypersonic Air-Launched Offensive Anti-Surface Warfare Weapon System
	Space Force	MTA		Tranche 1 Tracking Layer Rapid Prototyping
				Tranche 1 Transport Layer
			Tranche 2 Transport Layer	

Legend:

MDAP: Major Defense Acquisition Program

MTA: Middle Tier of Acquisition

MOSA: Modular open systems approach

Source: GAO analysis of Department of Defense documentation. | GAO-25-106931

^aThe Air Force’s B-52 Commercial Engine Replacement Program initially planned to enter development in December 2023, but has since delayed that event until 2025. We are including it in our review to capture the Air Force’s MOSA planning for its newer programs.

^bStatute requires programs to implement a MOSA to the maximum extent practicable, giving programs flexibility in determining whether and how a MOSA would meet their specific business and technical considerations.

Officials from the programs we reviewed that reported implementing a MOSA told us they selected varying degrees of modularity and openness to meet program priorities. For example, some programs’ MOSAs incorporated a comprehensive system design predicated on enabling competitive upgrades and sustainment. Others had a more limited implementation of MOSA focused on enabling interoperability with other systems.

One program—which decided against implementing a MOSA—still invested in limited open system attributes for peripheral systems. Table 2 provides examples of MOSAs pursued by programs we reviewed.

Table 2: Examples of Modular Open Systems Approaches (MOSA) and Areas of Emphasis Reported by Weapon Programs GAO Reviewed

MOSA emphasis	Program example
Emphasis on reducing life-cycle costs	The Army’s Future Long Range Assault Aircraft program reported that it used data on sustainment cost drivers from aircraft already in service to develop a MOSA that would reduce operating and upgrade costs over its service life. Specifically, the program developed an open architecture framework to guide the aircraft’s design in collaboration with industry groups and academia to ensure its systems would prioritize employing the most relevant and widely used open standards. This design approach maximized the potential pool of vendors and technologies available to meet the program’s needs. These design priorities were used to evaluate the quality of competing vendors’ offers to build the prototype aircraft.
Emphasis on enabling interoperability with multiple systems	The Army’s Improved Turbine Engine Program is developing a new aircraft engine. Program documentation states it is focused on ensuring the engine’s interfaces with the aircraft are defined by open standards or government-owned interface specifications, including engine control software. According to officials, this reduces the risk of encountering integration challenges due to proprietary interfaces when the engine is installed on aircraft built by different contractors.
Emphasis on increasing competition for future upgrades	Space Force officials told us they used a MOSA in the design of satellites in their Proliferated Warfighter Space Architecture. This program involves constellations of large numbers of satellites in the Tranche 1 Tracking Layer Rapid Prototyping (providing warning and tracking capability) and the Tranche 1 and 2 Transport Layers (providing data communications) programs. Officials told us a MOSA enables them to reduce barriers to new companies competing for new iterations and capabilities as the constellations are refreshed over time. Officials stated that by using common communication interfaces and designing for a MOSA, Space Force expects replacing portions of these constellations to be less costly as improved technologies become available. ^a
Invested in limited open system attributes for peripheral systems	The Air Force’s B-52 Radar Modernization Program reported that its primary systems will not incorporate MOSA attributes. Program officials told us they considered adding MOSA attributes to the pre-existing proprietary system design to be cost-prohibitive for most parts of the system. However, officials stated that they did incorporate certain elements of openness by installing an information distribution system and visual displays that used open interfaces.

Source: GAO analysis of Department of Defense documentation and interviews with program officials. | GAO-25-106931

^aThe Senate report accompanying the James M. Inhofe National Defense Authorization Act for Fiscal Year 2023 included a provision for us to review DOD’s efforts to develop space-based optical communications capabilities. The Senate report accompanying the National Defense Authorization Act for Fiscal Year 2022 include a provision for us to review DOD’s efforts to deploy overhead persistent infrared space-based architectures. As of October 2024, our work on both reviews is ongoing.

Programs’ MOSA Implementation Decisions Were Not Informed by Formal Assessments of Life-cycle Costs and Benefits

None of the 20 selected programs we reviewed provided documentation of a cost-benefit analysis conducted to support their decisions about whether and to what extent to pursue a MOSA. For example, officials from three of the five selected programs that decided not to pursue a MOSA told us this decision was due to perceived costs. These officials, however, reported that their decision was not based on a formal analysis of the potential costs to implement a MOSA and the value of its potential benefits over the program’s life cycle.

DOD’s acquisition policy and guidance do not contain an explicit requirement to conduct a cost-benefit analysis of implementing a MOSA. DOD officials provided two documents that assessed the costs and long-term

benefits of MOSA investments. However, the officials who provided us with the documents noted limitations with these analyses. Officials from the Army's PEO Aviation told us they commissioned such an analysis from a consultant to show the potential to reuse parts across their portfolio of programs. The officials said the analysis generally supported cost savings but had not been validated. Officials from the Air Force provided us with an analysis conducted as part of a graduate program and said they refer generally to it when discussing positive return on investment for using a MOSA. Programs' life-cycle outcomes—such as reduced sustainment costs and insertion of new technologies—are in part determined by decisions made early in the acquisition process. In our prior work on cost estimating, we found that cost-benefit analyses can support program decisions when it is important to take a long view of the future.²⁹ When those decisions are not based on both the estimated costs and estimated benefits of a MOSA, programs can miss opportunities for significant cost savings and flexibility to update capabilities to keep pace with threats over their life cycles.³⁰

We previously found that programs reported acquisition cost and schedule concerns when deciding not to implement a MOSA.³¹ Programs' rationales for not implementing a MOSA in this review were consistent with our prior work; program officials generally told us they based their decisions on acquisition cost and schedule implications. For example, officials from programs we reviewed cited perceptions that a MOSA would increase development costs, lengthen development schedules, or not yield sufficient benefits. However, these perspectives focused largely on acquisition costs, which may account for only 30 percent of a system's life-cycle costs.³² Longer term sustainment and modernization costs—which MOSA is intended to mitigate—impose a much larger burden on DOD's budget. Additionally, these perspectives do not account for the potential for a MOSA to accelerate fielding new capabilities to existing platforms, keeping them operationally relevant for longer periods of time. For example, a program using a MOSA would face less costly and time-intensive re-work to incorporate upgraded systems if the systems are built to the same open-interface standards. In two cases, officials told us significant leadership emphasis on implementing a MOSA pre-empted acquisition cost and schedule concerns.

The Navy's **AGM-88G Advanced Anti-Radiation Guided Missile-Extended Range (AARGM-ER)** program and the Air Force's **Stand-in Attack Weapon (SiAW)** program illustrate how perceptions of near-term cost and schedule barriers and the influence of leadership can affect program's MOSA choices for similar programs. Officials from the AARGM-ER program told us it decided not to pursue a MOSA due to near-term cost and schedule concerns. However, Air Force officials told us that the service's acquisition leadership directed the SiAW program, which is modifying the AARGM-ER's design, to implement a MOSA. More specifically, both programs are adapting the Navy's AGM-88E Advanced Anti-Radiation Guided Missile (AARGM) to deliver new capabilities, but Navy and Air Force acquisition officials told us only SiAW requested and received funding to implement a MOSA, as shown in Figure 6.

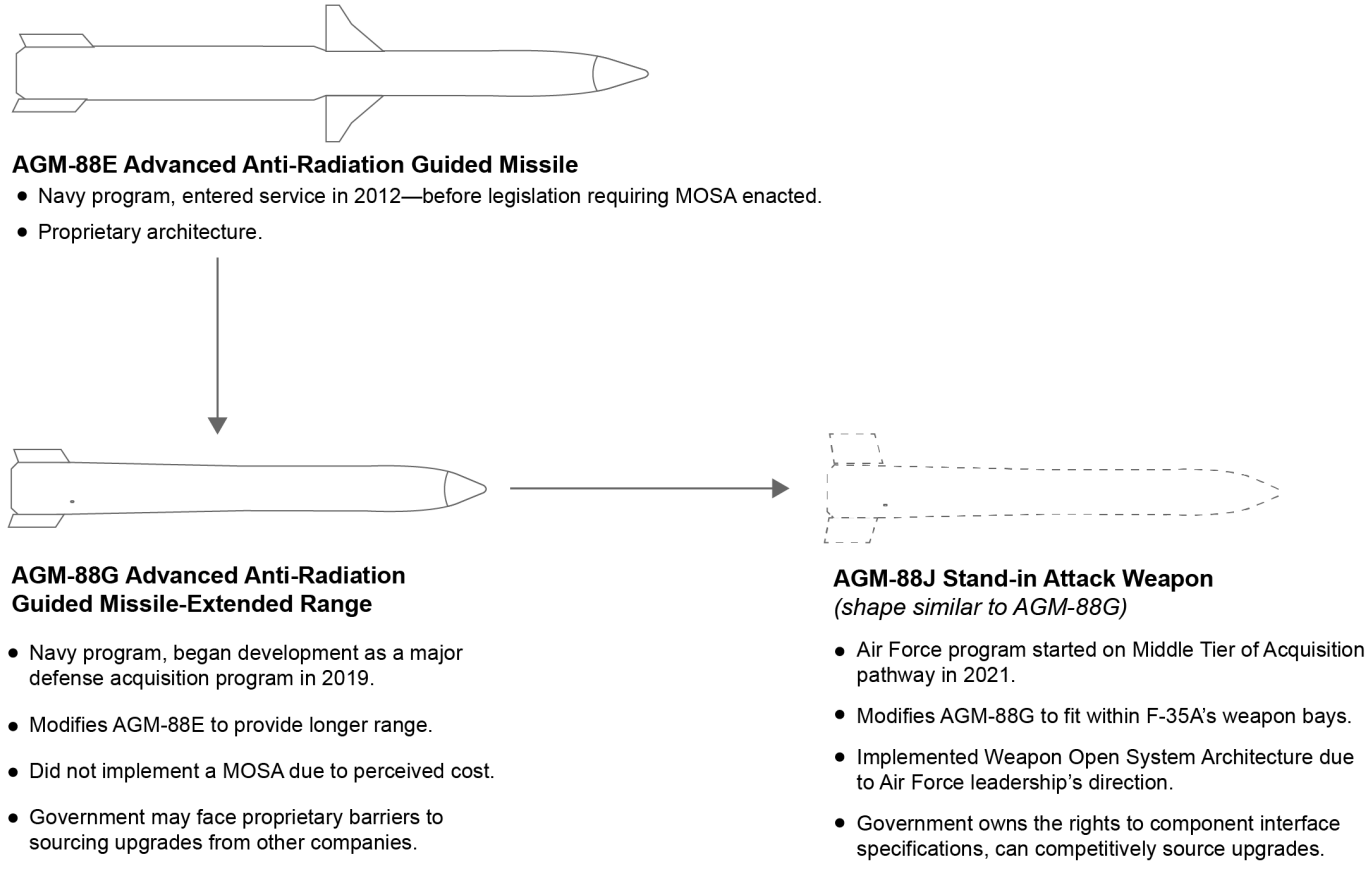
²⁹[GAO-20-195G](#).

³⁰[GAO-20-2](#).

³¹[GAO-23-106059](#).

³²[GAO-20-2](#).

Figure 6: MOSA Development and Differences between Advanced Anti-Radiation Guided Missile-Extended Range and Stand-in Attack Weapon



MOSA modular open system approach

Source: GAO analysis of program documentation. | GAO-25-106931

Leadership Influence on Programs' Modular Open System Approach (MOSA) Decisions

The Air Force's requirement for its air-launched munition programs to use the Weapon Open Systems Architecture (WOSA) standard in their designs illustrates the influence of leadership priorities on program decisions related to a MOSA. WOSA is a standardized design process that requires systems to modularize the components needed to deliver the system's functions and connect these modules with either open interface standards or interfaces for which the government owns the technical specifications.

Air Force Weapons Directorate officials told us the Stand-in Attack Weapon program was required to use the WOSA standard. They added that implementing this standard is mandatory for all of the directorate's new programs. Along with the technical standard for WOSA, Air Force officials told us they also created standardized contract language, tools for verifying the system's interfaces will accept components built to the same standard, and model-based systems engineering assets. These features have the potential to reduce the burden on a program incorporating the standard into its design and contract documents.

Air Force officials stated that these efforts have led to use of the WOSA standard beyond their service, with Navy weapon programs receiving bids from companies that proactively incorporate it. Greater WOSA use can reduce proprietary barriers in the broader marketplace for air-launched munitions.

Source: GAO analysis of Department of Defense documentation and interviews with Air Force officials. | GAO-25-106931

AARGM-ER program officials told us that munition programs like theirs do not typically consider a MOSA for sustainment cost reduction benefits, given that munitions are single-use. However, they noted that a MOSA has more value in enabling rapid upgrades as threats change or technology advances.

The AARGM-ER program entered development after January 2019 and therefore was required to implement a MOSA to the maximum extent practicable. The program decided it was not practicable to implement a MOSA. AARGM-ER officials told us the program's funding was insufficient. However, program officials could not recall if there had been a business case analysis of a MOSA to inform this decision. Because the program did not obtain the data rights needed to implement a MOSA, future upgrades may take longer to complete. Further, having fewer vendors reduces opportunities for competition and could result in higher costs.

Conversely, Air Force officials told us that the SiAW program initially proposed establishing the program as an MTA effort that only repackaged the existing AARGM-ER systems within a physical shape that can fit within the F-35A's weapon bays. Air Force acquisition leadership rejected this approach, noting that it would be more expensive and time-intensive to upgrade these missiles to keep pace with technology advances and changing threats over their service lives if each upgrade required extensive work to adapt the new components to the system's proprietary design. Instead, program officials stated that the Air Force acquisition executive established a clear expectation that the system implement a modular design by obtaining necessary interface data rights specifically developed for air-launched munitions called Weapon Open System Architecture. They told us that, while they expect these modifications to add time and costs to the system's development, they also expect the MOSA to significantly reduce time and costs for later modifications.

Future Long Range Assault Aircraft



Source: Bell Textron, Inc. | GAO-25-106931

Leadership direction at the portfolio level has also shaped programs' MOSA decisions. For example, the Army's **Future Long Range Assault Aircraft** (FLRAA) tilt-rotor aircraft program—an MDAP that began in 2020 as an MTA rapid prototyping effort— set objectives for its MOSA to enable faster fielding of innovations and greater affordability via competition. The program decided to implement a MOSA before there was a statutory requirement for MTA programs to do so.

Army Aviation PEO officials told us this decision was driven by the PEO's leadership team, which conducted an affordability analysis of its portfolio of programs. This analysis found the service could not afford its planned aviation force size without lowering sustainment costs. The sustainment costs for the portfolio were high, according to the analysis, in part because each proprietary system required unique components that were difficult to competitively source, limiting potential savings from economies of scale on larger orders for multiple programs. Army officials told us that they expect that FLRAA's use of common interface standards as part of its MOSA will also lower acquisition costs for other programs in the same portfolio by enabling other Army aviation programs to reuse the same components. FLRAA also established the quality of a proposed MOSA as a criterion to assess competing vendors' proposals for the system development contract.

However, officials from other programs we reviewed determined not to implement a MOSA due to near-term cost and schedule concerns or perceptions of limited benefit. While these decisions may have been logical program decisions based on concerns, without an analysis of estimated life-cycle cost and benefits of implementing a MOSA, it is difficult for program and acquisition officials to understand the full picture. For example:

B-52 Bomber Aircraft



Source: Copyright © Boeing. | GAO-25-106931

- The Air Force's **B-52 Radar Modernization Program** (RMP)—an MDAP that entered development in 2021 and is intended to fit a modern radar onto the almost 70-year-old bomber aircraft—initially planned to implement a MOSA but was deterred by concerns about costs. Program officials told us they initially anticipated that designing RMP's components around a MOSA would reduce development time by enabling the program to leverage more existing components. They expected a MOSA would allow the

radar to easily accept new technologies and adapt to new requirements through 2050 and beyond. Further, the program reported that over the life cycle of the radar system, the components designed using a MOSA would be more easily upgradeable as technology changed and new requirements emerged.

However, program officials told us they have since discontinued plans to incorporate a MOSA in the radar. They told us that after the program was directed to use a pre-existing radar to reduce development costs, they determined—based on informal analysis—that a MOSA was not practicable. This was due in part to the cost and time required to (1) modify a radar that was already in production and used on several other aircraft, and (2) test the new system. More specifically, program officials noted that reduced funding made the \$40 million to \$60 million cost estimated by the program to incorporate the planned MOSA unaffordable when weighed against the program's other priorities. Additionally, they stated that implementing a MOSA would have challenged the program's ability to integrate the new radar in time to meet the warfighter's needs. However, test failures and other factors contributed to schedule delays totaling 10 months over the program's schedule baseline.

Navy Conventional Prompt Strike Hypersonic Missile

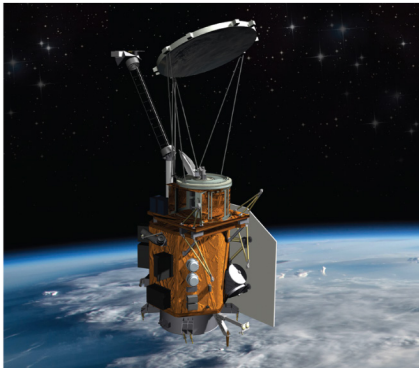


Source: U.S. Navy. | GAO-25-106931

- The Navy's **Conventional Prompt Strike (CPS)** program's rapid prototyping MTA effort—which is being developed in part with the Army—decided not to pursue a MOSA on its current development contract due to schedule pressure. Navy officials told us the prototyping effort was started in response to an urgent operational need to field a hypersonic weapon. They added that the potential to implement a MOSA was limited due to the omission of a MOSA from an earlier prototyping effort. The portion of the missile that achieves hypersonic flight was developed prior to the MTA program's start and did not implement a MOSA. Navy officials told us that for that reason, they determined they would not be able to implement a MOSA within the time available for the MTA prototyping effort.

There was no statutory requirement for MTA programs to implement a MOSA to the maximum extent practicable when the contract was awarded in December 2018, and CPS program officials decided not to use a MOSA with the initial prototyping effort to meet the warfighter's urgent requirement. However, if the hypersonic vehicle had been designed with a MOSA from the start, CPS may have been better positioned to enable rapid iterations and technological advances. CPS missiles are planned to be deployed on ground-based launchers, surface ships, and submarines, exposing the missiles to different combat environments that will likely require the program to incorporate different capabilities over its service life. While program officials told us they are considering a MOSA on later increments, doing so later in the program may require costly design rework to that may have been avoided if a MOSA was implemented from the start. Navy officials stated that they plan to incorporate aspects of a MOSA in later versions of the missile as part of their process for inserting new technologies.

Weather System Follow-On Satellite



Source: © 2020 by Ball Aerospace & Technologies Corp.
All rights reserved. | GAO-25-106931

- Program officials with the **Space Force’s Weather System Follow-On** program—an MDAP that entered system development in 2020, after the statutory requirement for MDAPs to use a MOSA to the maximum extent practicable took effect—told us they determined implementing a MOSA was not practicable. The program plans to launch two satellites and program officials told us they determined that it would be too costly to upgrade systems on a satellite after launch, therefore limiting the benefit that the program could achieve from a MOSA. However, USD(R&E) officials stated that a modular and open design would also enable other satellite programs to re-use components developed by this program, potentially reducing their development time and costs.

DOD officials we spoke with told us that there is no agreed-upon approach for assessing MOSA costs and benefits, but also shared examples of how it could be done. Specifically:

- Officials from CAPE—responsible for ensuring that DOD conducts accurate cost estimation and analyses—told us potential inputs into a MOSA cost-benefit analysis could include increased opportunities for competition—which could reduce sustainment costs—and quicker upgrades, which could keep a program in service longer. They also cited examples of upgrades to the Navy’s P-8A maritime patrol aircraft and submarine combat systems that achieved cost savings and greater flexibility from implementing an open systems approach.
- Officials from the offices of USD(A&S) and USD(R&E) told us they also were not aware of any widely accepted methods for estimating the costs and benefits of a MOSA. However, USD(R&E) officials told us that comparing the cost of replacing part of a fielded system with the development of a brand-new system is one example of how DOD could approach estimating the value of early investment in a MOSA.

In our prior work on evidence-based policymaking, we found that federal organizations should assess the extent to which existing evidence addresses key questions, and then identify and prioritize new evidence needed to manage efforts and assess results.³³ USD(A&S) and USD(R&E) officials said although estimating costs and benefits is an important aspect of managing MOSA efforts, they already have a significant volume of other work related to MOSA implementation, and as a result, have not prioritized developing a method. Similarly, CAPE officials told us they have not been directed to study how a MOSA affects sustainment costs. However, without developing a consistent method to compare MOSA costs and benefits over the life cycle to

³³GAO, *Evidence-Based Policymaking: Practices to Help Manage and Assess the Results of Federal Efforts*, [GAO-23-105460](#) (Washington, D.C.: July 12, 2023).

support early decision-making, DOD risks missing opportunities to field systems that are interoperable, adaptable to emerging threats, and less costly to sustain.

DOD Does Not Use Program- and Portfolio-Level Planning Effectively to Define and Support MOSA Objectives

Most Programs Did Not Address MOSA Planning Elements, Including Those Required by Statute or Policy

The 14 selected programs we reviewed that reported implementing a MOSA generally did not address all key MOSA planning elements, such as documenting which parts of the system will be designed as replaceable modules. Key planning elements that programs should address in their acquisition documents (including acquisition strategies, requests for proposals for the program's development or production phases, and systems engineering plans) are defined in statute or DOD policy.³⁴ As a result of these statutory and policy provisions, programs may need to consider aspects of their MOSA from the early stages of development in planning documents like the acquisition strategy and systems engineering plan, which for MDAPs must be updated and reviewed for major milestones.

Key MOSA planning elements differ somewhat for each type of acquisition document. For example, in acquisition strategies, MDAPs are required to describe the MOSA and differentiate between major system platforms and major system components (modules that can be severed and changed over time). Programs are also required to explain how major system components might evolve in the future. Each module needs a boundary to keep it both part of and separate from the platform. If the program does not design around that boundary from the beginning, it will either incur increased costs and delays to rework the design or fail to achieve the program's MOSA objectives. Figure 7 illustrates the number of the 14 programs implementing a MOSA that addressed key planning elements in their acquisition documents.

³⁴Statutory requirements for documentation apply to MDAPs implementing a MOSA. While there is no statutory or DOD-wide requirement for MTA programs to document their MOSA decisions in their planning documents, we assessed the extent to which selected MTA programs documented two of the same aspects of their MOSA as an indicator for the quality of their MOSA planning. MTA programs are not required to produce a system engineering plan, so we did not assess them.

Figure 7: Number of Programs That Reported Using a MOSA That Addressed Key MOSA Planning Elements in Acquisition Documents

Document and its purpose	Examples of Key MOSA Planning Elements	How many <u>major defense acquisition programs</u> addressed the key planning element?	How many <u>middle tier of acquisition programs</u> addressed the key planning element?
Acquisition strategy: Plan the overall technical and business approach	Differentiate the major system platform and components	●●●○○	●●●●● ●●○○○
	Identify components that may be added later in the life cycle	●●●○○	●●●●● ○○○○○
Request for proposals: Announce the contracting process and communicate needs to industry	Describe the minimum set of major system components	○○○○○	●●●●● ○○○○○
Systems engineering plan: Manage the technical and engineering approach for major capability acquisitions	Identify major system components	●○○○○	●●●●● ●●●●● ^a

- Addressed
- Did not address
- Not applicable

Source: GAO analysis of Department of Defense data. | GAO-25-106931

Note: Key planning elements identified above are those defined in statute or Department of Defense (DOD) policy. While there is no statutory or DOD-wide requirement for middle tier of acquisition programs to document their modular open systems approach (MOSA) decisions in their planning documents, we assessed the extent to which the selected middle tier of acquisition programs documented two of the same aspects of their MOSA as an indicator for the quality of their MOSA planning. Programs we reviewed that reported not using a MOSA are not included in this figure.

^aWe did not assess MOSA aspects of systems engineering plans for selected middle tier of acquisition programs because they are generally not required to complete these plans.

The following examples illustrate the range of how programs addressed MOSA planning elements in acquisition documents.

The Air Force’s E-7A Rapid Prototyping MTA program—which is modifying an existing airborne warning aircraft used by other countries to meet U.S. requirements—addressed key MOSA planning elements in its acquisition strategy and request for proposals.

E-7A



Source: Boeing Defense, Mobility, Bombers and Surveillance. | GAO-25-106931

- **Acquisition strategy:** The program provided a list of subsystems and stated that the system will be compliant with Open Mission Systems, an Air Force standard.
- **Request for proposals:** E-7A was one of only four selected programs that addressed the minimum set of major system components in its request for proposals. The program specified the set of mission support components the contractor must develop, including their functional and physical attributes. For example, the program described some components that support multiple aircraft and others that are portable between single aircraft. However, by specifying the minimum set of major system components, the program increased the likelihood of realizing the potential benefits of using a MOSA.
- **Systems engineering plan:** Not applicable for MTA programs.

Precision Strike Missile



Source: Lockheed Martin. | GAO-25-106931

The Army's Precision Strike Missile (PrSM) program—an MDAP that entered development in 2021— included key MOSA elements in two of its planning documents.

- **Acquisition strategy:** The program identified the components with which the system will be designed and potential capabilities to be added in the future. The program identified major system components like guidance, propulsion, and payload. In its acquisition strategy, the program states that designing major subsystems as severable components will enable an incremental development approach to continuously incorporate new technologies to support future capabilities.
- **Request for proposals:** The program did not include any MOSA elements in its request for proposals. However, contractor ultimately signed an agreement that included provisions requiring them to use a MOSA and identify potential future upgrades.
- **Systems engineering plan:** The program included a list of major system components in its systems engineering plan.

The Navy's Constellation class guided missile frigate (FFG 62)—an MDAP that entered development in 2020 and is modifying the design of a frigate used by the French and Italian navies to meet the U.S. Navy's requirements—did not include key MOSA elements in its planning documents.³⁵

FFG 62 Constellation Class Guided Missile Frigate



Source: Fincantieri Marinette Marine (FMM). | GAO-25-106931

- **Acquisition strategy:** FFG 62 provided general language about the program's MOSA principles but did not address planning elements for modularity.³⁶ Navy officials described FFG 62 as a large and complex system of systems, many of which will be developed by other program offices. However, the acquisition strategy does not describe the major components for which the FFG 62 program is responsible.
- **Request for proposals:** The request for proposals did not identify the minimum set of major system components as required. The program described general attributes its MOSA is intended to achieve, such as reusability and upgradeability in this document.
- **Systems engineering plan:** FFG 62 did not identify major system components as required in the systems engineering plan. The only information related to the MOSA is a statement that the program will require the contractor to conduct an analysis for incorporating MOSA attributes into systems based on information technology.

We found that the military departments generally did not assess whether programs incorporated the required MOSA planning elements in acquisition documentation. Service acquisition executives—the decision authorities for our selected programs—are responsible by law for reviewing acquisition strategies and requests for proposals, including key MOSA planning elements.³⁷ Further, DOD policy states that milestone decision authorities must review MDAPs using a MOSA at Milestone B to ensure that their interfaces are standardized and review a justification by the program if it will not use a MOSA.³⁸ Officials within the offices of the service acquisition executive at the military departments told us that while they review program documentation in advance of milestones or other key program events, they have limited capacity to review MOSA-specific elements in these documents. As a result, they defer to subordinates for their evaluation of programs' MOSA plans.

³⁵We recently reported on the progress of the Navy's frigate program. See GAO, *Navy Frigate: Unstable Design Has Stalled Construction and Compromised Delivery Schedules*, [GAO-24-106546](#) (Washington, D.C.: May 29, 2024).

³⁶10 U.S.C. §4402.

³⁷10 U.S.C. §4211, §4402.

³⁸DOD Instruction 5000.88.

Some program officials told us that they documented key MOSA decisions in other documentation, such as milestone briefing slides or model-based systems engineering software. However, requirements in statute and DOD policy to address MOSA in acquisition documents help keep decision authorities informed about MOSA planning decisions and communicate programs' MOSA requirements to contractors. Without assessing whether programs have identified MOSA planning gaps in key acquisition documents, including as required by law and policy, decision authorities will have limited visibility into whether programs are positioned to achieve potential MOSA benefits such as flexibility in upgrades and more opportunities for competition during sustainment.

Inconsistent Portfolio-Level Planning Further Limits Potential MOSA Benefits

A MOSA has potential benefits when coordinated between programs in a portfolio. These benefits include helping to ensure interoperability between systems, facilitating cost savings through reuse of software and hardware, and enabling faster upgrades in the future. Nevertheless, only two of the nine PEOs overseeing a subset of our 20 selected programs reported that they have a formal process specifically intended to coordinate MOSA opportunities. Two PEOs reported that their offices have no formal process, and one reported that they coordinate for commercial off-the-shelf parts but not for a MOSA. The remaining four PEOs reported that the potential for a MOSA is considered as part of their existing program review processes but did not describe a formal portfolio coordination process. However, existing review processes typically address individual programs rather than portfolio-wide opportunities, so they are unlikely to be sufficient to ensure coordination of MOSA implementation across a portfolio of programs.

PEOs that do not have a process to ensure coordination on MOSA may be missing opportunities to achieve cost reductions and enable faster upgrades in the future. For example, officials in the Navy's Air Combat Electronics office told us that implementing a coordinated MOSA can lead to cost savings. This office is a cross-cutting program office that interfaces with other Navy programs to develop avionic systems that are incorporated on different types of Navy aircraft. In some cases, they develop common capabilities for multiple programs. Officials from this program office told us that MOSAs can drive cost savings when programs buy common parts at the same time and achieve economies of scale. However, they said to sequence upgrades effectively, PEOs need to assess what programs need now and forecast for the future.

One example of a MOSA portfolio coordination process is the MOSA advisory board for the Army's PEO Aviation. Army officials told us the board was established in 2022 and consists of representatives of a cross section of the PEO's programs and functional areas like engineering and budget. The PEO told us the board meets monthly to review programs for components with the potential for reuse and to make investment recommendations to the PEO. This coordination effort could reduce the number of costly efforts to deliver the same capability.

The Project Management Institute, Inc., standard for portfolio management states that organizations should establish strategic objectives for their portfolios, to prioritize components of the portfolio, identify interdependencies between components, and allocate resources. The standard also states that organizations should evaluate their portfolio of programs on an ongoing basis to ensure benefits, risks, and resources are appropriately balanced.³⁹ Further, we have previously reported that developing processes for portfolio

³⁹Project Management Institute, Inc., *The Standard for Portfolio Management*, 4th ed. (Newtown Square, PA: 2017).

management is a leading portfolio management practice.⁴⁰ Until the military department PEOs develop processes to assess MOSA opportunities across their portfolios, they risk missing opportunities to better leverage resources across programs and identify MOSA investment priorities that best reflect portfolio-wide needs.

⁴⁰GAO, *Nuclear Security Enterprise: NNSA Should Use Portfolio Management Leading Practices to Support Modernization Efforts*, [GAO-21-398](#) (Washington, D.C.: June 9, 2021).

Military Departments Have Yet to Fully Identify and Prioritize Investments Needed for MOSA Implementation

The military departments have yet to fully identify and prioritize necessary investments for MOSA implementation at the enterprise level. The NDAA for Fiscal Year 2017—enacted in December 2016—required the secretaries of the military departments to ensure necessary budgetary resources and engineering expertise for MOSA implementation.⁴¹ Acquisition officials at the Departments of the Air Force, Army, and Navy, however, stated they have yet to assess or align resources for MOSA implementation across their respective departments.

DOD and military department officials we spoke with described several categories of resources that facilitate MOSA implementation. These include repositories for MOSA data, access to open standards, subject matter expertise, and digital engineering tools. These officials stated that, in some instances, these activities have not been resourced to a degree needed to implement MOSA to the maximum extent practicable as required by statute:

- **Repositories for storing and accessing shared MOSA files.** The William M. (Mac) Thornberry NDAA for Fiscal Year 2021 required USD(A&S) to direct the appropriate DOD components to establish and maintain repositories for interfaces, syntax and properties, documentation, and other information.⁴² Making MOSA-related files accessible to acquisition officials working on other programs helps ensure reuse of open standards, decrease development time, and preserve information that will be essential to sustain systems designed using a MOSA.

Military department officials told us that development of these repositories is in process. Navy officials said they have created a repository containing standards that they believe meets the minimum requirements of the law, although, in their view, the language of the law is vague regarding what is required to be in the repository. Air Force officials told us that although they have established an initial minimal repository in response to the legal requirement, they have faced challenges due to limited available funding. In the future, they would like to expand its capabilities to enable new programs to search for pre-existing components with open standards to use as the building blocks of their early system designs. Army officials told us they created a repository in response to the law, but it is maintained by staff at different PEOs and they are in the process of determining what additional information will be added to it in the future. USD(R&E) officials told us that without military department-level efforts to establish common formats for MOSA-related digital files in these repositories, there is a risk that programs will not be able to access and use data they need for future modernizations.

- **Enterprise licenses for standards.** DOD officials told us the department is required in some cases to pay in order to gain access to commercially-developed open standards used on DOD weapon systems. OSD and military department acquisition officials stated there is currently no military department-level process for providing programs with access and licenses for using MOSA standards. They stated that providing

⁴¹See Pub. L. 114–328, §805(a) (2016) (codified as amended at 10 U.S.C. § 4403). 10 U.S.C. § 4403 requires secretaries of the military departments to coordinate on the development of major system interfaces and standards for use in major system platforms; ensure that sufficient systems engineering and development expertise and resources are available to support the use of MOSA in requirements development and acquisition program planning; ensure that necessary resources are provided to develop MOSA, associated major system interfaces, and systems integration; and issue related guidance, among other requirements.

⁴²William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116-283 (2021).

licenses at the military department level, rather than requiring programs to obtain separate licenses, would particularly benefit smaller programs, as a relatively larger portion of their funding would be needed to address licensing issues than for a larger program. Many open standards are developed by consortia of private companies and require a licensing fee to access these standards. These acquisition officials stated that in such cases, it is more efficient to pay the fee once at the enterprise level, rather than paying each time a program decides to implement a standard.

- **MOSA expertise.** Some offices within DOD have had difficulty funding positions for MOSA subject matter experts. For example, Air Force Materiel Command officials stated that they had requested funding to hire MOSA subject matter experts to provide direct assistance to programs regarding MOSA. They said the funding request was rejected for inclusion in DOD’s budget request when their request reached the OSD level. They stated that this was due to MOSA being a lower priority compared to other needs. Additionally, while offices such as USD(R&E) may serve as a source of expertise to help military departments implement MOSA effectively, USD(R&E) officials stated they do not have available staffing to review specific program-level MOSA efforts or provide substantial technical assistance at the program level. Furthermore, the Air Force’s proposed budget for fiscal year 2025 called for eliminating all future funding for Department of the Air Force Technical Architectures—in favor of other unstated Air Force priorities. Air Force budget documentation from March 2024 stated this effort was to shape the technical architecture of the entire Air Force and Space Force and foster modular architectures across programs. The documentation further noted that without these architectures, the Air Force would continue to acquire singular systems instead of modular, open system-of-systems capabilities.
- **Digital engineering tools.** The military departments have begun planning efforts to provide digital engineering tools needed for MOSA, such as model-based systems engineering software. DOD officials said model-based systems engineering helps programs document key MOSA decisions, use templates to easily implement consensus-based standards, and continuously evaluate the design process in real time.

Officials from all the military departments told us they each have at least one effort to facilitate MOSA using model-based systems engineering. However, these efforts are still underway, and funding for these tools is not universally available within DOD. For example, Navy officials told us that they can only procure digital design tools if program office funds are available. Additionally, military department officials stated that if programs use tools that are not common to the rest of DOD, then data generated by those tools are not useable by other programs, so they would prefer to use a common set of tools.

We previously reported in July 2023 that DOD officials stated many benefits of engineering tools are realized or enhanced and that costs—such as licensing—are reduced through widespread usage and implementing them collectively, rather than individually. We also reported that DOD had not enabled the adoption of modern engineering tools across all programs and recommended that DOD establish an overarching plan—which identifies associated resources—to do so. DOD officials estimated this plan would be finalized in December 2024.

Additionally, OSD and military department officials stated that not all MOSA efforts at the program level have adequate prioritization to receive funding, even when there is no technical barrier to implementing MOSA. As discussed earlier, military department secretaries are legally required to ensure necessary resources are provided to develop a MOSA.⁴³ Currently, acquisition programs individually request resources during the budget process. DOD officials stated that some programs, such as AARGM-ER, have faced difficulties in obtaining available funding, which is sometimes due to funds being devoted to higher priorities. These difficulties may occur particularly when there is no corresponding validated MOSA requirement that funding

⁴³10 U.S.C. § 4403.

decision-makers understand enables the delivery of new capabilities. Air Force Materiel Command officials also stated that officials at programs working with pre-existing systems have limited funds and must prioritize satisfying the requirements specified in capability requirements documents. While MOSA implementation may help reduce weapon systems costs in the longer term, USD(R&E) officials stated that program offices trying to field systems are focused on containing short-term costs more so than long-term costs.

In 2019, the military department secretaries indicated in a joint memorandum that MOSA is a warfighting imperative.⁴⁴ However, officials at all three military departments told us they have yet to develop department-level plans that identify their goals and prioritize resources for MOSA investments. The 2019 memorandum directed that MOSA standards be included in all requirements, programming, and development activities for future weapon system modification and new start development programs to the maximum extent practicable.

Furthermore, the 2022 National Defense Strategy also highlighted the importance of open systems to the nation's military needs.⁴⁵ The strategy noted how the existing DOD acquisition process was too slow and not incentivized to design open systems that can rapidly incorporate cutting-edge technologies. The National Defense Strategy noted that this situation creates problems such as obsolete equipment, poor interoperability, and cost ineffectiveness.

Currently, DOD pursues MOSA adoption through individual program efforts overseen on a program-by-program basis, rather than using enterprise-wide plans addressing MOSA as an organizational priority as called for by the joint memorandum and the National Defense Strategy. Our prior work on evidence-based policymaking highlighted the importance of government organizations developing a plan to achieve organizational objectives, as well as defining the desired outcomes and aligning the resources needed.⁴⁶ Until the military departments develop department-level plans that identify their goals and prioritize resources for MOSA investments, they will not be well-positioned to ensure that they are providing the necessary resources and engineering expertise required to implement MOSAs.

DOD Has Gaps in MOSA Policy, Regulations, and Guidance

DOD has updated some acquisition and engineering policies and is drafting statutorily required regulations and guidance at the OSD level to address MOSA. However, gaps in policy, regulations, and guidance remain at the OSD and military department level. First, DOD's policy for programs using the MTA pathway does not address how MOSA requirements apply to programs using this pathway. Second, drafting and issuance of required MOSA regulations and guidance at the OSD level is ongoing. Lastly, while the Army has developed detailed MOSA implementation guidance for its acquisition programs, the development of military department-level guidance has yet to be completed at the departments of the Air Force and Navy.

⁴⁴Office of the Secretary of the Navy, Office of the Secretary of the Army, and Office of the Secretary of the Air Force, Memorandum for Service Acquisition Executives and Program Executive Officers, *Modular Open Systems Approaches for our Weapon Systems is a Warfighting Imperative* (January 7, 2019)

⁴⁵2022 *National Defense Strategy of the United States of America* (Oct.. 27, 2022).

⁴⁶[GAO-23-105460](#).

OSD Policy for MTA Programs Does Not Address MOSA Implementation

USD(R&E), USD(A&S), and CAPE have updated engineering and acquisition policies to implement MOSA, including for the major capability acquisition pathway (used by MDAPs) and the software acquisition pathway.

- **Engineering of Defense Systems, DOD Instruction 5000.88 (Nov.18, 2020):** USD(R&E) engineering policy describes various requirements for programs where a MOSA is concerned. These include a policy requirement for major capability acquisition programs to address MOSA in systems engineering plans and to comply with statutory requirements for MOSA implementation to the maximum extent practicable.
- **Intellectual Property Acquisition and Licensing, DOD Instruction 5010.44 (Oct. 16, 2019):** USD(A&S) intellectual property policy requires military departments to ensure intellectual property deliverables and associated license rights are acquired and managed as necessary to support the use of modular open systems approaches in accordance with the law.
- **Major Capability Acquisition, DOD Instruction 5000.85 (Nov. 4, 2021):** USD(A&S) policy on major capability acquisitions states that program managers are responsible for evaluating and implementing a MOSA to the maximum extent feasible and cost effective. In general, the acquisition strategy must address MOSA and milestone decision authorities must ensure that, for programs implementing MOSA, their programs' development and production requests for proposal describe the MOSA.
- **Operation of the Software Acquisition Pathway, DOD Instruction 5000.87 (Oct. 2, 2020):** USD(A&S) policy on the software acquisition pathway requires programs using this pathway to use a MOSA as part of their use of modern, iterative software development approaches to support future capabilities.
- **Analysis of Alternatives, DOD Instruction 5000.84 (Aug. 4, 2020):** CAPE policy regarding how programs are to conduct an analysis of alternatives requires that consideration of the use of MOSA be included in the study guidance for these analyses.

However, these updates do not address how MOSA-related requirements apply to programs using the MTA pathway. The requirement to implement MOSA to the maximum extent practicable for MDAPs was included in the NDAA for Fiscal Year 2017. It was extended to all program types (including MTA programs) by the William M. (Mac) Thornberry NDAA for Fiscal Year 2021.

DOD has yet to provide pathway-specific policy for MTA programs on implementing MOSA to the maximum extent practicable.⁴⁷ Our prior work has shown that DOD is increasingly leveraging the MTA pathway to develop and field critical capabilities.⁴⁸ While DOD updated its instruction for MTA programs in November 2024, the updated policy does not specifically address MOSA. A USD(A&S) official told us in September 2024 that MOSA would not be addressed in the update because its inclusion was raised too late in the process. As an alternative, USD(A&S) plans to address MOSA in the Adaptive Acquisition Framework Document

⁴⁷DOD's *Engineering of Defense Systems Guidebook* addresses the benefits of using a MOSA for an MTA program. However, it does not provide the level of detail about MOSA implementation that is included for MDAPs in the major capability pathway instruction (DOD Instruction 5000.85) such as the specific program stages where MOSA should be considered and the specific types of documents that should address MOSA. Further, programs are not required to follow the guidebook.

⁴⁸GAO, *Weapon Systems Annual Assessment: DOD Is Not Yet Well-Positioned to Field Systems with Speed*, [GAO-24-106831](#) (Washington, D.C.: June 17, 2024).

Identification Tool hosted by the Defense Acquisition University, which it planned to establish in the updated instruction as having the same authority as the MTA pathway instruction.

The omission of pathway-specific policy for MTA programs on implementing MOSA risks creating confusion among MTA program officials regarding how best to plan for and implement MOSA at different events on this acquisition pathway. Until DOD issues acquisition policy requiring MOSA for MTA programs, DOD acquisition staff will not have sufficient information to consider and plan for the adoption of MOSA beginning early in the program's life cycle, comply with the statutory requirement for implementing MOSA to the maximum extent practicable, and achieve associated long-term benefits of a MOSA.

Issuance of Required MOSA Regulations and Guidance at the OSD Level Is Ongoing

Regulations

OSD is still in the process of finalizing defense acquisition regulations related to MOSA that are required by laws passed in 2011, 2016, and 2021.⁴⁹ Specifically, an October 2024 update on open cases for the Defense Federal Acquisition Regulation Supplement stated that a proposed rule to address all legal requirements from all three years was being drafted, with the draft expected to be completed in late February 2025.⁵⁰ USD(A&S) officials told us that while the process for making these regulatory changes began in 2012, the effort evolved over time as new legislation was passed and that the rulemaking for all three years has since been combined into a single case.

According to OSD officials, these regulatory changes are intended to help facilitate the procurement of licenses for data rights and other intellectual property by DOD acquisition programs implementing a MOSA. Data rights and intellectual property are critical to supporting implementation of a MOSA because they help ensure that DOD can share information needed to integrate new components or execute sustainment activities with contractors other than the original developer of the system. OSD officials told us that, in developing these regulations, they have been regularly engaging with industry. In public comments obtained by DOD as part of the rulemaking process for the draft regulations, DOD contractor industry group representatives raised several objections and offered suggestions to revise the proposed rules.⁵¹ Among these were concerns from industry that DOD had proposed requiring programs to acquire more data rights for the government than were necessary. Industry representatives also commented that some of the proposed rule's definitions could create confusion or were in conflict with definitions used elsewhere.

Our prior work has shown that on average, DOD took less than 2 years to implement acquisition-related NDAA provisions as final rules in the Defense Federal Acquisition Regulation Supplement, although regulatory

⁴⁹See National Defense Authorization Act for Fiscal Year 2012, Pub. L. No. 116-283, § 815 (2011); National Defense Authorization Act for Fiscal Year 2017, Pub. L. No. 114-328, § 809 (2016); William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116-283, § 804(a) (2021).

⁵⁰Modular Open Systems Approaches (DFARS Case 2021-D005).

⁵¹National Defense Industry Association, *NDIA Comments on Defense Federal Acquisition Regulation Supplement Modular Open Systems* (Feb. 20, 2024). Aerospace Industries Association, *DFARS Case 2021-D005: Modular Open Systems Approaches* (Feb. 15, 2024). Information Technology Industry Council, *DFARS Case 2021-D005: Modular Open Systems Approaches* (Feb. 15, 2024).

changes involving complex topics like intellectual property often take longer than DOD's standard process.⁵² As discussed in this prior work, DOD has adopted an enhanced public engagement model for data rights cases related to implementation of recommendations of the Section 813 Joint Government-Industry Advisory Panel to provide industry and the public additional opportunities to provide input early in the process.⁵³

DOD officials attributed these long time frames to the complex substance and history of the relevant statutes—specifically, statutory requirements that continued to evolve—and the 3-year regulatory freeze for numerous data rights cases within the scope of the Section 813 Advisory Panel that was agreed to by both industry and DOD. We are not making a recommendation relating to the status of these regulations because DOD is currently working draft regulations through the rulemaking process. Until DOD completes all required steps and finalizes these regulations, program offices may be challenged to fully implement a MOSA as described in legislation because they currently lack the regulatory tools that the regulations will provide.

OSD Guidance

OSD has issued some guidance related to engineering aspects of MOSA. For example, USD(R&E) issued engineering guides that describe a wide range of activities programs should take to prepare for implementation of MOSAs.⁵⁴ This guidance discusses how programs are to ensure their requirements support open systems, and ensure the system design accommodates open system architecture where feasible. Within USD(A&S), the Deputy Assistant Secretary of Defense for Product Support has also issued guidance calling for programs to assess the use of MOSAs as part of their long-term intellectual property strategy.⁵⁵ This guidance also cites the statutory requirements for MOSAs on DOD programs.

OSD is still in the process of developing certain other guidance required by law. The William M. (Mac) Thornberry NDAA for Fiscal Year 2021 required USD(A&S), in coordination with other officials, to issue guidance addressing MOSAs. Specifically, this guidance must cover how DOD programs doing prototyping, acquisition, or sustainment of new or existing weapon systems must address MOSAs in program documentation and weapon system contracts.⁵⁶ These legal requirements were to be fulfilled within 1 year of the law's enactment, by January 2022. We reported in June 2023 that DOD was working on the guidance responsive to this requirement.⁵⁷

⁵²GAO, *Defense Acquisitions: DOD Should Take Additional Actions to Improve How It Approaches Intellectual Property*, [GAO-22-104752](#) (Washington, D.C.: Nov. 30, 2021); and *Defense Acquisitions: DOD Needs to Improve How It Communicates the Status of Regulation Changes*, [GAO-19-489](#) (Washington, D.C.: July 11, 2019).

⁵³[GAO-19-489](#), and National Defense Authorization Act for Fiscal Year 2016, Pub. L. No. 114-92, § 813 (2015). The panel issued its final report, 2018 Report Government-Industry Advisory Panel on Technical Data Rights, in November 2018. The report examined long-standing tension points between government and industry regarding rights to technical data and made recommendations for legislative, regulatory, and policy changes.

⁵⁴*Engineering of Defense Systems Guidebook* (Feb. 2022); *Systems Engineering Guidebook* (Feb. 2022); *Defense Technical Risk Assessment Methodology, Criteria Volume* (May 2023); *Systems Engineering Plan Outline* (May 2023).

⁵⁵Department of Defense, *Product Support Manager Guidebook* (May 2022).

⁵⁶ William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116-283, § 804(a).

⁵⁷[GAO-23-106059](#).

However, updated guidance has not been issued as of October 2024. Officials from USD(R&E) told us that they still plan to fulfill the legal requirement for guidance in part through a guidebook they are developing in partnership with other OSD offices and the military departments. The draft guidebook we reviewed discussed the requirements of the law, including content related to the acquisition strategy, contract requirements, and the use of repositories for storing modular system interfaces. In August 2024, a USD(R&E) representative stated that the guidebook was undergoing additional revision and was expected to be released soon. A USD(A&S) representative added that changes to the terminology in laws regarding MOSA caused confusion that complicated the issuance of corresponding guidance and policies.⁵⁸ Until OSD completes and issues its MOSA guidance, program officials implementing a MOSA and military department officials responsible for issuing their own acquisition and engineering guidance on MOSAs will lack information regarding practices to help implement a MOSA.

Navy Lags behind Air Force and Army in Issuing Military Department MOSA Implementation Guidance

The Army and selected commands at the Air Force and Space Force have issued MOSA implementation guidance that provide additional detail about MOSA implementation, though not all Department of the Air Force acquisition programs are covered by this guidance. The Navy has yet to develop similar guidance, though its acquisition policy does address MOSA at a high level. Military department secretaries have statutory requirements to issue guidance on MOSA to address specific requirements of the law.⁵⁹ This guidance is to address MOSA content in acquisition program documentation, MOSA considerations at specific acquisition milestones, and other related topics.⁶⁰

- **Army.** The Army issued a service-wide MOSA guidebook, describing how its acquisition policies regarding MOSA should be implemented. The guidebook addresses a range of topics related to MOSA, including identifying MOSA objectives, developing a modular design, selecting open standards, and conducting MOSA assessments. The Army's service acquisition executive required PEOs to also develop their own MOSA guidebooks.
- **Air Force Materiel Command and Space Systems Command.** Air Force Materiel Command officials issued a MOSA guidebook, which was later adopted by the Space Force's Space Systems Command with some additional guidance for Space Force programs. However, Air Force and Space Force officials have not issued MOSA guidebooks that are applicable to all Air Force organizations outside the Air Force Materiel Command and Space Systems Command, such as the Space Development Agency and the Air Force's Rapid Capabilities Office. While other acquisition program staff could potentially decide to review

⁵⁸For example, the NDAA for Fiscal Year 2021 deleted the phrase "major system interface" and introduced the phrases "modular system" and "modular system interface." See Pub. L. 116-283, § 804(b)(1)(B) (2021) (codified at 10 U.S.C. § 4401(b)).

⁵⁹As noted earlier in the report, the Space Force is organized under the Department of the Air Force and as such is under the authority of the Secretary of the Air Force.

⁶⁰This requirement was codified at 10 U.S.C. § 4402, which requires military department secretaries to issue MOSA guidance implementing the requirements of that section, which included requirements for programs to include certain MOSA-related content in capability requirements documents, analyses of alternatives, acquisition strategies, requests for proposals, and Milestone Decision Authority certifications. The military department secretaries are further required by 10 U.S.C. § 4403 to issue guidance implementing the requirements of that section, which includes coordination regarding MOSA within and outside of their departments, and ensuring adequate expertise, budget, and training are available in relation to MOSA implementation.

and use the existing MOSA guidebooks issued within the Department of the Air Force from outside their organizations, they would not necessarily address any of the relevant local processes of their command.

- **Navy.** Navy acquisition officials told us they are also in the early stages of developing a MOSA implementation guidebook to supplement the Navy's acquisition policy. They stated that Navy staff implement MOSAs using the Navy's existing acquisition policy and engineering technical review processes. Officials from the office of the Navy's acquisition executive told us the Navy wanted to better understand the business incentives for MOSAs prior to developing guidance.

The military departments were statutorily required to address aspects of MOSA planning in their MOSA guidance. We reviewed the extent to which each military department addressed required MOSA aspects related to our reporting objectives in their guidance and found significant differences in how military department guidance addresses those legal requirements. The Army's guidance presents comprehensive information on statutory requirements and how to address them. The Air Force's guidance covers most topics but does not elaborate beyond citing the statutory requirements for a few topics. The information the Navy provides to programs is much more limited. While the Navy does not have a MOSA guidebook, its acquisition policy refers to some of the legal statutes regarding MOSA but does not fully address them and does not provide any department-specific information about implementation (see table 3).

Table 3: GAO Analysis of How Military Department Modular Open Systems Approach (MOSA) Guidance Addresses Selected Statutory Requirements for a MOSA

Requirement		Air Force ^a	Army	Navy ^b
10 U.S.C. § 4401	Requirement to implement a MOSA to the maximum extent practicable	Full	Full	Partial
10 U.S.C. § 4402	Capability documents describe evolving needs	Partial	Full	Partial
	Analysis of Alternatives includes MOSA considerations	Partial	Full	Partial
	Acquisition strategies incorporate a MOSA	Full	Full	Partial
	Requests for proposal describe the MOSA and include major system components	Full	Full	Partial
	Milestone Decision Authority determines at start of systems development that a MOSA is being used or else is not practicable	Full	Full	Partial
10 U.S.C. § 4403	Military departments must ensure necessary MOSA expertise is available	Full	Full	Not discussed
	Military departments must ensure necessary MOSA resources are available	Full	Full	Not discussed

Legend: Full = Provides specific guidance on MOSA. Partial = Cites law but provides no additional guidance

Source: GAO analysis of Air Force, Army, and Navy policy and guidance. | GAO-25-106931

Note: These statutory requirements were selected to reflect those related to planning for and resourcing implementation of a MOSA.

^aThe Space Force is organized under the Department of the Air Force and as such is under the authority of the Secretary of the Air Force.

^bThe Navy has not developed MOSA guidance. This table assesses the extent to which these requirements are addressed in the department's acquisition policy.

Limited or no discussion of certain requirements in Navy and Air Force MOSA guidance means that program officials may not be aware of all legal requirements regarding MOSA. There is also a risk that they will not know how to fully address the requirements through the processes unique to their military department. For example, the Navy's acquisition policy does not provide guidance that describes for Navy program staff the various roles of the different offices in integrating a MOSA onto Navy ships. This could further complicate the integration of new capabilities using a MOSA. Navy officials stated that subsystems on ships, like combat information or radar systems, may be modular and open, but that other program offices besides the one responsible for the ship are responsible for them. Similarly, Air Force and Space Force acquisition programs managed outside Air Force Materiel Command and Space Systems Command could experience similar challenges, and all programs within the Department of the Air Force may not be aware of the department's preferred approaches to considering MOSA in capability documents or Analyses of Alternatives.

Conclusions

Weapons systems that are not designed with modular components and open interfaces risk becoming increasingly obsolete and expensive to maintain as the pace of technological advancement accelerates and threats change. MOSAs offer DOD a chance to reduce risk from unanticipated technological change for its most expensive weapon systems by enabling rapid, affordable upgrades and sustainment. However, DOD's approach to planning for, coordinating, and resourcing MOSAs, along with incomplete policies, guidance, and regulations for MOSAs, hinder it from fully realizing these benefits.

DOD does not plan adequately for MOSAs in its programs and across military departments because it lacks effective processes for doing so. Specifically, DOD does not have a process for programs to assess costs and benefits of pursuing a MOSA, determine whether they have addressed key MOSA planning elements as

required by law, or coordinate MOSAs across programs. If DOD and the military departments develop these processes, they could ensure they are taking a long-term view of the program-level and portfolio-wide benefits they could achieve, such as fielding systems that are cheaper to sustain. Such processes would also help keep military department decision-makers informed about key planning decisions.

The military departments have also yet to fully identify or plan for the provision of necessary resources for MOSA implementation at the department level—such as licenses for open standards or digital engineering tools. Without confidence in funding, some supporting offices within the military departments might be challenged to fund, for example, positions for MOSA subject matter experts. Further, some acquisition programs cannot be assured they have the resources needed to implement a MOSA to the maximum extent practicable as required by law.

Additionally, DOD has yet to fully develop effective MOSA policies and guidance. DOD’s policy for programs using the MTA pathway does not address MOSA implementation, although the department uses the MTA pathway to acquire critical weapon capabilities. Further, while OSD has drafted statutorily required guidance to address MOSAs, these efforts have yet to be completed as OSD works through further internally directed revisions. Also, on the department level, the Army and selected Air Force and Space Force acquisition commands developed detailed MOSA guidance. However, the Air Force and Space Force guidance does not apply to all programs within these military services, nor does it provide detailed information on certain legal requirements. Further, the Navy has yet to issue MOSA guidance. These gaps in MOSA policies and guidance delay the cost and schedule savings that a MOSA can bring.

As it works to field cutting-edge weapon systems quickly, DOD can act on these issues to support implementation of cost-saving modular and open approaches to weapon system design that enhance its ability to deliver and sustain mission-critical capability to the warfighter.

Recommendations for Executive Action

We are making 14 recommendations to Department of Defense:

The Secretary of Defense should ensure the Under Secretaries of Defense for Acquisition and Sustainment and Research and Engineering, in coordination with the Director, Cost Assessment and Program Evaluation, develop a method for program offices to use when assessing the costs and benefits of pursuing a MOSA on weapon systems. (Recommendation 1)

The Secretary of the Air Force should ensure that the Assistant Secretary of the Air Force for Acquisition, Technology & Logistics and the Assistant Secretary of the Air Force for Space Acquisition and Integration identify steps needed during the review of relevant acquisition documentation to effectively determine whether programs have addressed key MOSA planning elements required by statute, policy, and guidance. (Recommendation 2)

The Secretary of the Army should ensure that the Assistant Secretary of the Army (Acquisition, Logistics and Technology) identifies steps needed during the review of relevant acquisition documentation to effectively determine whether programs have addressed key MOSA planning elements required by statute, policy, and guidance. (Recommendation 3)

The Secretary of the Navy should ensure that the Assistant Secretary of the Navy for Research, Development and Acquisition identifies steps needed during the review of relevant acquisition documentation to effectively determine whether programs have addressed key MOSA planning elements required by statute, policy, and guidance. (Recommendation 4)

The Secretary of the Air Force should ensure PEOs within the department establish a formal process for coordinating MOSAs across programs to enable portfolio-wide benefits. (Recommendation 5)

The Secretary of the Army should ensure PEOs within the department establish a formal process for coordinating MOSAs across programs to enable portfolio-wide benefits. (Recommendation 6)

The Secretary of the Navy should ensure PEOs within the department establish a formal process for coordinating MOSAs across programs to enable portfolio-wide benefits. (Recommendation 7)

The Secretary of the Air Force should identify the resources needed at the military department and program levels to implement a MOSA in all acquisition programs to the maximum extent practicable. (Recommendation 8)

The Secretary of the Army should identify the resources needed at the military department and program levels to implement a MOSA in all acquisition programs to the maximum extent practicable. (Recommendation 9)

The Secretary of the Navy should identify the resources needed at the military department and program levels to implement a MOSA in all acquisition programs to the maximum extent practicable. (Recommendation 10)

The Secretary of Defense should ensure that OSD policy governing the MTA pathway provides direction for DOD acquisition programs to implement a MOSA to the maximum extent practicable and addresses related statutory requirements. (Recommendation 11)

The Secretary of Defense should ensure that OSD guidance that fully addresses the statutory requirements to facilitate the implementation of a MOSA for any program prototyping, acquiring, or sustaining a new or existing weapon system is issued in an expedient manner. (Recommendation 12)

The Secretary of the Navy should ensure that department guidance for acquisition programs provides direction for Navy acquisition programs to implement a MOSA to the maximum extent practicable and addresses all statutory implementation requirements. (Recommendation 13)

The Secretary of the Air Force should ensure that department guidance related to MOSA covers all of the department's acquisition programs and provides appropriate information on MOSA considerations when developing capability documents and conducting analyses of alternatives. (Recommendation 14)

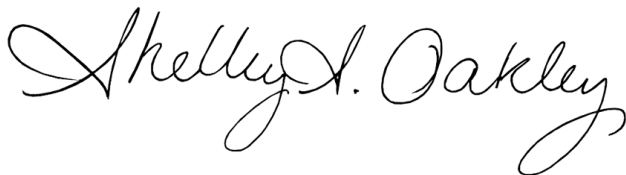
Agency Comments

We provided a draft of this product to DOD for comment. In its comments, reproduced in appendix IV, DOD concurred with our 14 recommendations and described planned actions to address them. DOD also provided technical comments, which we incorporated as appropriate.

DOD's planned actions to address our recommendations, if implemented effectively, should generally address the intent of our recommendations. Regarding our 13th recommendation, however, we do not believe that the steps outlined in DOD's written comments fully address our recommendation that the Navy ensure its guidance provides directions for acquisition programs to implement a MOSA to the maximum extent practicable and addresses all statutory MOSA requirements. DOD stated that the Navy will assess whether the current guidance addresses all statutory requirements and update the guidance if necessary. We did this assessment and found it does not. Specifically, the Navy's policy cited in this response does not provide any department-specific direction about how Navy programs should implement a MOSA and does not reference or discuss the requirements outlined in title 10, section 4403 of the U.S. Code. Until the Navy issues guidance addressing these issues, program managers are likely to be hampered in their ability to implement a MOSA to the maximum extent practicable.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Defense, the Secretary of the Army, the Secretary of the Navy, the Secretary of the Air Force, and other interested parties. In addition, the report is available at no charge on the GAO website at <https://www.gao.gov>.

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



Shelby S. Oakley
Director, Contracting and National Security Acquisitions

List of Committees

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

Chair
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Mike Rogers
Chairman

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

Chair
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Appendix I: Objectives, Scope, and Methodology

This report assesses (1) the extent to which selected acquisition programs reported implementing a modular open systems approach (MOSA) and the factors contributing to those decisions, including the use of cost-benefit analysis; (2) the extent to which the Department of Defense (DOD) has planned for MOSA implementation at the program and portfolio levels; (3) the extent to which the military departments have identified and invested in necessary resources to implement MOSAs; and (4) DOD's progress in developing MOSA policy, regulations, and guidance.

Program Selection

To select major defense acquisition programs (MDAP) for our review, we analyzed Selected Acquisition Reports from December 2021—the most recent year of reporting issued at the time we started our review. We selected the eight MDAPs that reported passing milestone A or B—entry to technology maturation and risk reduction or engineering and manufacturing development, respectively—after January 1, 2019. We selected this date to capture MDAPs that were subject to the National Defense Authorization Act (NDAA) for Fiscal Year 2017's mandate to implement MOSA to the maximum extent practicable if a program passed milestone A or B after that date. We also included one additional MDAP that began as an MTA program but transitioned to an MDAP in 2024. We excluded programs that had high levels of classification or ongoing litigation. We also reviewed these Selected Acquisition Reports for information on the type of system the program is developing, key schedule dates, and acquisition decisions.

To select middle tier of acquisition (MTA) programs for our review, we analyzed MTA program identification documents submitted as part of the President's Budget for Fiscal Year 2024. We selected up to three of the most recently initiated MTA programs for each armed service (Army, Air Force, Space Force, Navy, and Marine Corps), totaling 11 MTA programs. The Navy reported two programs, and the Marine Corps reported none. We selected these programs to capture the current state of the services' programs because these programs have a greater likelihood of responding to the latest requirements in MOSA legislation.

Assessment of the Extent to Which Selected Programs Report Implementing MOSA and Factors Affecting Those Decisions

To describe the extent to which selected programs report implementing MOSAs and the factors contributing to those decisions, we reviewed acquisition documentation relevant to MOSAs. This documentation included selected acquisition reports, acquisition strategies, systems engineering plans, requests for proposals, and contracts. We reviewed these documents for program information including descriptions of the systems being developed, acquisition pathways used, plans for designing the system and maturing its technologies and components, the government's requirements of the contractors to implement a MOSA, and compliance with statutory and policy requirements relating to MOSAs. We did not assess the program's technical compliance with the MOSA implementation status as described in their documentation.

We also reviewed information programs provided as part of questionnaires sent to programs assessed as part of our 2023 Weapon Systems Annual Assessment.¹ These questionnaires collected programs' responses on the extent to which they implement a MOSA, factors affecting their decisions, challenges encountered, and resources leveraged, among other things.

We also interviewed program officials and officials from acquisition commands, program executive offices, and other organizations involved in program oversight to determine the factors affecting their MOSA implementation decisions. We analyzed the information from these meetings to identify common and unique factors that contributed to programs' MOSA decisions.

To assess the extent to which programs informed their MOSA implementation decisions with a cost-benefit analysis, we requested written responses from our selected programs on whether they had conducted such an analysis, any documentation of the analysis, and explanations if an analysis was not conducted. To understand the policy governing these types of cost-benefit analyses, we reviewed policy and guidance such as GAO's *Cost Estimating Guide* and DOD policy and guidance related to MOSA.² We also interviewed officials from the offices of the Under Secretaries of Defense for Acquisition and Sustainment, and Research and Engineering and the Office of Cost Assessment and Program Evaluation to understand DOD's policies and guidance on cost-benefit analysis, as well as examples where programs realized benefits from implementing a MOSA. We also interviewed acquisition commands and program offices to understand what information was used to inform these decisions. We assessed this information against our prior work on evidence-based policymaking.³

Assessment of the Extent to Which DOD Planned for MOSA Implementation at the Program and Portfolio Levels

To assess the extent to which DOD acquisition programs are documenting key MOSA planning elements, we reviewed statutory requirements and DOD policy and guidance to identify key planning elements.⁴ For the 14 programs that reported implementing a MOSA, we assessed whether the acquisition strategy, request for proposals, and systems engineering plan addressed those planning elements.⁵ In cases where we identified that programs did not appear to have addressed the planning elements, we asked the service-level officials responsible for reviewing this documentation for explanations of the cause of the omission. To describe how program documents are reviewed for MOSA planning elements, we interviewed officials from the service acquisition executive offices in the military departments.

¹GAO, *Weapon Systems Annual Assessment: Programs Are Not Consistently Implementing Practices That Can Help Accelerate Acquisitions*, [GAO-23-106059](#) (Washington, D.C.: June 8, 2023).

²GAO, *Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Program Costs*, [GAO-20-195G](#) (Washington, D.C.: Mar. 12, 2020).

³GAO, *Evidence-Based Policymaking: Practices to Help Manage and Assess the Results of Federal Efforts*, [GAO-23-105460](#) (Washington, D.C.: July 12, 2023).

⁴The National Defense Authorization Act for Fiscal Year 2017 contained a provision requiring DOD to design and develop MDAPs with a MOSA to the maximum extent practicable. This provision applies to MDAPs receiving Milestone A or B approval after January 1, 2019. (See Pub. L. No. 114-328, § 805(a) (2016) (codified as amended at 10 U.S.C. § 4401)). The William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 expanded this requirement to include all defense programs. (See Pub. L. No. 116-283, § 804 (2021) (codified at 10 U.S.C. § 4401)).

⁵10 U.S.C. 4402 and Department of Defense, *Systems Engineering Plan (SEP) Outline Version 4.1*.

To assess the extent to which program executive offices (PEOs) coordinate their MOSA efforts within their portfolios of programs, we collected written responses from a subset of the chief engineers for the PEOs that are responsible for our selected programs. As part of these requests, we asked for copies of any policy or guidance documents that described these coordination processes and reviewed them for formal descriptions of MOSA coordination processes. We reviewed the PEOs' responses against standards for portfolio management developed by the Project Management Institute, Inc., to determine if PEOs were coordinating a MOSA across their programs to achieve portfolio-wide benefits.⁶ We also interviewed engineering and acquisition oversight officials in the offices of service acquisition executives to discuss how they oversee and coordinate a MOSA among the programs for which they are responsible.

Assessment of the Extent to Which the Military Departments Identified and Made Necessary Investments to Implement MOSA

To assess the extent to which the military departments have identified and invested in necessary resources to implement MOSA as required by statute, we reviewed the relevant statute to identify legal requirements for DOD to ensure available resources for MOSA.⁷ We reviewed military department MOSA guidebooks to identify any guidance relevant to the identification and prioritization of MOSA investments. We reviewed program documents such as acquisition strategies and systems engineering plans to understand whether programs reported using portfolio- and department-wide resources to implement their planned MOSAs. To describe current and potential enabling resources, we interviewed program, DOD component, and Office of the Secretary of Defense (OSD) officials.

We collected and reviewed DOD and military department documents for activities supporting MOSA, including program budget documents. We reviewed these documents for information on MOSA enabling investments, including how they were identified, the funding requested to obtain them, and whether they were ultimately funded. We collected information and documentation from service acquisition executive staff and PEO engineering leadership regarding processes used to oversee and implement MOSA. We also interviewed OSD, military department, and program officials responsible for acquisition programs, engineering, capability requirements, and product support. We compared the evidence we collected on the military departments' planning to our prior work on evidence-based policy making, specifically the practice related to planning to accomplish organizational objectives.⁸

⁶Project Management Institute, Inc., *The Standard for Portfolio Management*, 4th ed. (Newtown Square, PA: 2017). The PEOs we assessed for this analysis included the following: Air Force Bombers, Air Force Fighters, Air Force Strategic Systems, Army Aviation, Army Missiles and Space, Army Soldier, Navy Strategic Systems, Navy Unmanned Aviation and Strike Weapons, Navy Unmanned and Small Combatants, and Space Force Space Systems Command.

⁷See Pub. L. 114–328, §805(a)(1) (2016) (codified as amended at 10 U.S.C. § 4403). 10 U.S.C. § 4403 requires secretaries of the military departments to coordinate on the development of major system interfaces and standards for use in major system platforms; ensure that sufficient systems engineering and development expertise and resources are available to support the use of MOSA in requirements development and acquisition program planning; ensure that necessary resources are provided to develop MOSA, associated major system interfaces, and systems integration; and issue related guidance, among other requirements..

⁸GAO-23-105460.

Assessment of DOD's Progress Developing MOSA Policy, Regulations, and Guidance

We assessed the extent to which OSD has issued policies addressing requirements for acquisition programs to implement MOSA to the maximum extent practicable, in accordance with relevant laws. We reviewed DOD policies regarding weapon system acquisition requirements, oversight, acquisition pathways, and systems engineering to identify whether they addressed legal requirements to implement MOSA to the maximum extent practicable. We reviewed the status and contents of draft regulations required by law undergoing the rulemaking process regarding data rights and other topics related to MOSA. We identified what topics are planned to be addressed in these regulations once the rulemaking process has been completed. We reviewed the status and contents of a 2023 draft DOD MOSA guidance to identify what topics are planned to be addressed after its future issuance.

We assessed whether military departments issued guidance that addresses legal requirements, including addressing how MOSA is to be documented in acquisition program documentation, considerations regarding MOSA at acquisition milestones, and related topics. We conducted these assessments using three categories. "Provides specific guidance" indicates the guidance describes steps to take. "Cites law but provides no additional guidance" indicates the guidance does not describe specific steps to take on that subject but cites relevant law. "Not discussed" indicates there is no related content in the guidance.

We conducted this performance audit from June 2023 to January 2025 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: MOSA Legislation

In the National Defense Authorization Act (NDAA) for Fiscal Year 2017, Congress mandated that all MDAPs entering development after January 1, 2019 implement a MOSA to the maximum extent practicable.¹ The NDAA for Fiscal Year 2021 subsequently required that all other acquisition programs be developed and designed to implement a MOSA to the maximum extent practicable.² These and other relevant provisions are described in detail in table 4.

¹Pub. L. No. 114-328 (2016).

²Pub. L. No. 116-283 (2021).

Table 4: Selected Statutory Provisions That Pertain to a Modular Open Systems Approach

Section and title of provision	Brief description of provision
Provisions contained in the National Defense Authorization Act for Fiscal Year 2017	
Sec. 805. Modular Open System Approach in Development of Major Weapon Systems	<p>Requires major defense acquisition programs (MDAP) that receive Milestone A or Milestone B approval after January 1, 2019, to be designed and developed with a modular open system approach (MOSA) to the maximum extent practicable, and to document it as follows:</p> <ul style="list-style-type: none"> • Selected acquisition reports: Include a brief summary description of the key MOSA elements or a rationale for not using the approach. • Program capability document: Identifies and characterizes the extent to which requirements for system performance are likely to evolve over the program’s life cycle because of evolving technology, threat, or interoperability needs; and the minimum acceptable capability that is necessary for the MDAP’s initial operating capability for requirements that are expected to evolve. • Acquisition strategy: Differentiates between the major system platform and major system components being developed under the program, as well as major system components developed outside the program that will be integrated into the MDAP, and clearly describes the system’s integration approach that will be used, among other things. • Requests for proposals for the development or production phases: Describe the MOSA and the minimum set of major system components that must be included in the MDAP’s design. • Analysis of alternatives: Includes consideration of evolutionary acquisition, prototyping, and a MOSA. <p>Establishes the following definitions.</p> <ul style="list-style-type: none"> • Defines a major system platform as the highest-level structure of a major weapon system that is not physically mounted or installed onto a higher-level structure and on which a major system component can be physically mounted or installed. • Defines a major system component as a high-level subsystem or assembly, including hardware, software, or an integrated assembly of both, that can be mounted or installed on a major system platform through well-defined major system interfaces; and includes a subsystem or assembly that is likely to have additional capability requirements, is likely to change because of evolving technology or threat, is needed for interoperability, facilitates incremental deployment of capabilities, or is expected to be replaced by another major system component. • Defines a major system interface as a shared boundary between a major system platform and a major system component, between major system components, or between major system platforms, defined and characterized by certain attributes. • Defines a MOSA as an integrated business and technical strategy that, among other things, employs a modular design that uses major system interfaces between a major system platform and a major system component, between major system components, or between major system platforms; and is subject to verification to ensure that major system interfaces comply with widely supported, consensus-based standards if available and suitable. • Directs milestone decision authorities not to grant Milestone B approval without a written determination that either (a) a program using a MOSA has taken certain steps implementing a MOSA; or (b) the program is not using a MOSA, and a MOSA is not practicable for the program. • Directs the secretaries of the military departments to take certain steps related to the availability of major system interfaces and support for MOSA by, among other things, coordinating with certain government and private entities regarding the specification, identification, development, and maintenance of major system interfaces and standards for use in major system platforms, when practicable; ensures that major system interfaces incorporate both commercial standards and widely supported, consensus based standards that meet certain requirements; and ensures that adequate training in using a MOSA is provided to members of the requirements and acquisition workforce.

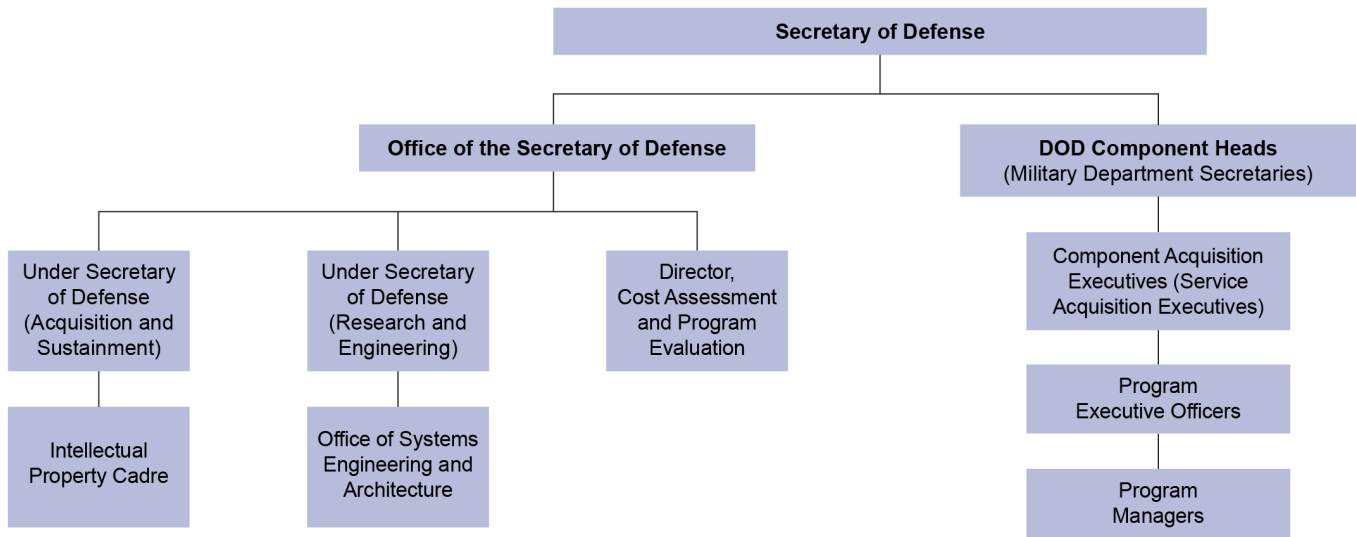
Section and title of provision	Brief description of provision
Provisions contained in the National Defense Authorization Act for Fiscal Year 2017	
Sec. 807. Cost, Schedule, and Performance of Major Defense Acquisition Programs	Among other things, requires that before funds are obligated for technology development, systems development, or production of an MDAP, the Secretary of Defense shall, by establishing certain goals, ensure that the milestone decision authority for the MDAP approves a program that will meet certain objectives related to affordability, program planning, and fielding. The goals to be established are goals for program cost targets, fielding targets, technology maturation, prototyping, and a MOSA to evolve system capabilities and improve interoperability.
Sec. 808. Transparency in Major Defense Acquisition Programs	Requires the Milestone Decision Authority to submit a report to the congressional defense committees no later than 15 days after granting Milestone A, Milestone B, and Milestone C approval. The Milestone B report must include, among other things, a statement of whether a MOSA is being used for the program.
Sec. 809. Amendments Relating to Technical Data Rights	Among other things, requires the Department of Defense (DOD) to prescribe regulations including a provision that the United States shall have government purpose rights in technical data pertaining to interfaces between an item or process and other items or processes, which are developed with mixed private and federal funds; and in technical data pertaining to the major system interface developed with mixed federal and private funding, or exclusively with private funding and used in a MOSA; unless the Secretary of Defense determines that negotiation of different rights in such technical data would be in the best interest of the United States. For major system interfaces developed exclusively at private expense for which the United States asserts government purpose rights, the Secretary must negotiate appropriate and reasonable compensation for the technical data.
Provisions contained in the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021	
Sec. 804. Implementation of Modular Open System Approaches	<p>Expands the statutory requirement first established in section 805 of the National Defense Authorization Act for Fiscal Year 2017 for MDAPs by requiring all other defense acquisition programs to be designed and developed, to the maximum extent practicable, with a modular open system approach to enable incremental development and enhance competition, innovation, and interoperability.</p> <p>Redefines a MOSA as an integrated business and technical strategy that, among other things, employs a modular design that uses modular system interfaces between major systems, major system components, and modular systems, and is subject to verification to ensure relevant modular system interfaces either (1) comply with, if available and suitable, widely supported and consensus-based standards; or (2) are delivered pursuant to certain statutory requirements.</p> <p>Requires the Under Secretary of Defense for Acquisition and Sustainment, in coordination with certain officials, to issue regulations and guidance applicable to certain entities which accomplish the following: (1) facilitate access to and use of modular system interfaces, (2) facilitate the implementation of MOSA across MDAPs and other relevant acquisition programs, and (3) advance DOD's efforts to generate diverse and recomposable kill chains. Among other things, the regulations and guidance must require each relevant DOD contract to include requirements for delivering modular system interfaces for modular systems deemed relevant, including certain requirements specified by law.</p> <p>Requires the Under Secretary of Defense for Acquisition and Sustainment to direct the Secretaries concerned and appropriate DOD components to establish and maintain repositories for interfaces, syntax and properties, documentation, and communication implementations delivered pursuant to certain statutory requirements.</p> <p>Requires the Under Secretary of Defense for Acquisition and Sustainment to establish and maintain a comprehensive index for interfaces, syntax and properties, documentation, and communication implementations delivered pursuant to certain statutory requirements and maintained in repositories: and, if practicable, establish and maintain an alternate reference repository for these resources.</p>

Source: GAO analysis of National Defense Authorization Act for Fiscal Year 2017, Pub. L. No. 114-328 (2016); William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116-283 (2021); and National Defense Authorization Act for Fiscal Year 2022, Pub. L. No. 117-81 (2021). | GAO-25-106931

Appendix III: Oversight Roles of Selected DOD Acquisition Organizations

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 and supervising all elements of the Department of Defense (DOD) related to acquisition and sustainment; providing capabilities to enable reporting and data analysis; conducting or approving independent cost estimates and cost analyses covering the life cycle of major defense acquisition programs (MDAP); and overseeing operational and live fire tests and evaluations. Figure 8 depicts the relationship between offices and officials with acquisition oversight responsibilities for the systems we reviewed.

Figure 8: Selected Department of Defense (DOD) Offices and Officials with Acquisition Oversight Roles



Source: GAO analysis of Department of Defense Information. | GAO-25-106931

At the military department level, the component acquisition executives, also referred to as the service acquisition executives, are responsible for implementing DOD acquisition policy within their respective departments and serve as the milestone decision authority for most MDAPs. Service acquisition executives at the military department level are also decision authorities for programs using the middle tier of acquisition (MTA) and software acquisition pathways, with some exceptions. Table 5 provides more detailed overviews of roles and responsibilities for DOD and military department officials in weapons systems acquisitions.

Table 5: 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))	<p>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.</p> <p>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 (MDAP). 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.</p>
Under Secretary of Defense for Research and Engineering (USD(R&E))	<p>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.</p> <p>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.</p>
Director, Cost Assessment and Program Evaluation (CAPE)	<p>Conducts or approves independent cost estimates, and cost analyses covering the life cycle of MDAPs, in support of milestone reviews, sustainment reviews, congressional certifications, and budget requests.</p> <p>CAPE also advises USD(A&S) on schedule, resource allocation, affordability, systems analysis, cost estimation, and the performance implications of proposed MTA programs; establishes policies and prescribes procedures for MTA cost data and cost estimates; and conducts an estimate of life-cycle costs for certain MTA programs.</p>
Intellectual Property Cadre	<p>An organization of intellectual property acquisition and licensing experts, responsible for DOD-wide implementation of intellectual property policy and guidance. The Cadre also advises and assists acquisition programs with intellectual property issues.</p>
Office of Systems Engineering and Architecture	<p>Develops systems engineering policy, guidance, standards, and best practice resources; manages DOD standards; facilitates engineering-related communities of practice (including the Modular Open Systems Working Group); and develops the defense engineering workforce.</p>

Appendix III: Oversight Roles of Selected DOD Acquisition Organizations

Entity	Responsibilities
Military departments	
Military Department Secretaries	Aligns the management of acquisition programs with the principal DOD processes to support affordable design, development, production and sustainment of mission effective capability and services, among other things.
Component Acquisition Executive (also referred to as the Service Acquisition Executive)	Implements DOD acquisition policy within their respective component. In the military departments, the officials delegated as Component Acquisition Executives are respectively: the Assistant Secretary of the Army for Acquisition, Logistics, and Technology; the Assistant Secretary of the Navy for Research, Development and Acquisition; and the Assistant Secretary of the Air Force for Acquisition, Technology, and Logistics. Component Acquisition Executives serve as the decision authority for many MDAPs and MTA programs.
Program Executive Officer	Balances the risk, cost, schedule, performance, interoperability, sustainability, and affordability of a portfolio of acquisition programs and delivers an integrated suite of mission effective capability to users.
Program Manager	Under the supervision of the Program Executive Officer and Component Acquisition Executive, plans acquisition programs, prepares programs for key decisions, and executes approved acquisition and production support strategies.

Source: GAO analysis of DOD information. | GAO-25-106931

Appendix IV: Comments from the Department of Defense

DEPUTY UNDER SECRETARY OF DEFENSE

3030 DEFENSE PENTAGON

WASHINGTON, DC 20301-3030

December 17, 2024
Ms. Shelby Oakley
Director, GAO Contracting and National Security Acquisitions
U.S. Government Accountability Office
441 G Street, NW
Washington DC 20548

Dear Ms. Shelby Oakley:

Enclosed is the Department of Defense response to the Government Accountability Office (GAO) Draft Report, GAO-25-106931, "WEAPON SYSTEMS ACQUISITION: DoD

Needs Better Planning to Attain Benefits of Modular Open Systems" dated October 7, 2024 (GAO Code 106931).

My point of contact is Ms. Nadine Geier, who can be reached at nadine.m.geier.civ@mail.mil and phone 571-372-3343.

Sincerely,

David A. Honey, PhD

Enclosure:

As stated

GAO DRAFT REPORT DATED OCTOBER 7, 2024 GAO-25-106931 (GAO CODE 106931)

"WEAPON SYSTEMS ACQUISITION: DoD Needs Better Planning to Attain Benefits of Modular Open Systems"

DEPARTMENT OF DEFENSE COMMENTS TO THE GAO RECOMMENDATIONS

RECOMMENDATION 1: The Government Accountability Office (GAO) recommends that the Secretary of Defense should ensure the Under Secretaries of Defense for Acquisition and Sustainment and Research and

Engineering, in coordination with the Director, Cost Assessment and Program Evaluation, develop a method for program offices to use when assessing the costs and benefits of pursuing a modular open systems approach (MOSA) on weapon systems. (Recommendation 1)

DoD RESPONSE: The Department of Defense (DoD) concurs with this recommendation. To address this recommendation, the Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E)) in coordination with the Under Secretary of Defense for Acquisition and Sustainment and the Director, Cost Assessment and Program Evaluation, is developing a MOSA Implementation Guidebook that includes recommendations to the Military Services on how to assess the costs and benefits of pursuing MOSA.

RECOMMENDATION 2: The GAO recommends that the Secretary of the Air Force should ensure that the Assistant Secretary of the Air Force for Acquisition, Technology & Logistics and the Assistant Secretary of the Air Force for Space Acquisition and Integration identify steps needed during the review of relevant acquisition documentation to effectively determine whether programs have addressed key MOSA planning elements required by statute, policy, and guidance. (Recommendation 2)

DoD RESPONSE: The DoD concurs with this recommendation. The U.S. Air Force will identify steps needed during the review of relevant acquisition documentation to effectively determine whether programs have addressed key MOSA planning elements required by statute, policy, and guidance. Mechanisms to address key MOSA planning elements are present in current guidance, including Department of the Air Force Instruction (DAFI) 163-101/20-101, Integrated Life Cycle Management; Department of the Air Force 2022 Digital Building Code; the U.S. Air Force Materiel Command MOSA Implementation Guidebook; and the Department of the Air Force Independent Technical Assessment Guidebook. The U.S. Air Force will review other relevant acquisition documents and make appropriate updates as necessary.

RECOMMENDATION 3: The GAO recommends that the Secretary of the Army should ensure that the Assistant Secretary of the Army (Acquisition, Logistics and Technology) identifies steps needed during the review of relevant acquisition documentation to effectively determine whether programs have addressed key MOSA planning elements required by statute, policy, and guidance. (Recommendation 3)

DoD RESPONSE: The DoD concurs with this recommendation. The U.S. Army will identify steps needed during the review of relevant acquisition documentation to effectively determine whether programs have addressed key MOSA planning elements required by statute, policy, and guidance. Mechanisms to address key MOSA planning elements are present in U.S. Army independent technical risk assessments (ITRAs) and MOSA Implementation Guidebooks. The

U.S. Army and the Assistant Secretary of the Army for Acquisition, Logistics, and Technology will review other relevant acquisition documents and make appropriate updates as necessary.

RECOMMENDATION 4: The GAO recommends that the Secretary of the Navy should ensure that the Assistant Secretary of the Navy for Research, Development and Acquisition identifies steps needed during the review of relevant acquisition documentation to effectively determine whether programs have addressed key MOSA planning elements required by statute, policy, and guidance. (Recommendation 4)

DoD RESPONSE: The DoD concurs with this recommendation. The U.S. Navy will identify steps needed during the review of relevant acquisition documentation to effectively determine whether programs have addressed key MOSA planning elements required by statute, policy, and guidance. Mechanisms to address

key MOSA planning elements are present in U.S. Navy ITRAs and acquisition gate review process. In addition, the U.S. Navy is developing a MOSA Implementation Guidebook that will provide guidance to programs implementing MOSAs. The

U.S. Navy will review other relevant acquisition documents and make appropriate updates as necessary.

RECOMMENDATION 5: The GAO recommends that the Secretary of the Air Force should ensure PEOs within the department establish a formal process for coordinating MOSAs across programs to enable portfolio-wide benefits. (Recommendation 5)

DoD RESPONSE: The DoD concurs with this recommendation. The U.S. Air Force will ensure PEOs within the Department establish a formal process for coordinating MOSAs across programs to enable portfolio-wide benefits. The U.S. Air Force will review and update DAFI 163-101/20-101, Integrated Life Cycle Management, and PEO-specific MOSA implementation guides as necessary.

RECOMMENDATION 6: The GAO recommends that the Secretary of the Army should ensure PEOs within the department establish a formal process for coordinating MOSAs across programs to enable portfolio-wide benefits. (Recommendation 6)

DoD RESPONSE: The DoD concurs with this recommendation. The U.S. Army will ensure PEOs within the U.S. Army establish a formal process for coordinating MOSAs across programs to enable portfolio-wide benefits. The U.S. Army will review relevant acquisition documents and make appropriate updates as necessary.

RECOMMENDATION 7: The GAO recommends that the Secretary of the Navy should ensure PEOs within the department establish a formal process for coordinating MOSAs across programs to enable portfolio-wide benefits. (Recommendation 7)

DoD RESPONSE: The DoD concurs with this recommendation. The U.S. Navy will ensure PEOs within the Department establish a formal process for coordinating MOSAs across programs to enable portfolio-wide benefits. The U.S. Navy will incorporate a formal process for coordinating MOSAs across programs into its MOSA Implementation Guidebook update and will review other relevant acquisition documents and make appropriate updates as necessary.

RECOMMENDATION 8: The GAO recommends that the Secretary of the Air Force should identify the resources needed at the military department and program levels to implement a MOSA in all acquisition programs to the maximum extent practicable. (Recommendation 8)

DoD RESPONSE: The DoD concurs with this recommendation. The U.S. Air Force will identify the resources needed at the Military Department and program levels to implement MOSAs in all acquisition programs to the maximum extent practicable. The U.S. Air Force established funding in a program element dedicated to identifying the resources needed at the Military Department and program levels to implement MOSAs in all acquisition programs to the maximum extent practicable. The U.S. Air Force will review its current efforts and make changes as necessary.

RECOMMENDATION 9: The GAO recommends that the Secretary of the Army should identify the resources needed at the military department and program levels to implement a MOSA in all acquisition programs to the maximum extent practicable. (Recommendation 9)

DoD RESPONSE: The DoD concurs with this recommendation. The U.S. Army will identify the resources needed at the Military Department and program levels to implement MOSAs in all acquisition programs to the maximum extent practicable. Once resource requirements are identified, the U.S. Army will document the process in its MOSA implementation guides to ensure the U.S. Army has an enduring process in place.

RECOMMENDATION 10: The GAO recommends that the Secretary of Navy should identify the resources needed at the military department and program levels to implement a MOSA in all acquisition programs to the maximum extent practicable. (Recommendation 10)

DoD RESPONSE: The DoD concurs with this recommendation. The U.S. Navy will identify the resources needed at the Military Department and program levels to implement MOSAs in all acquisition programs to the maximum extent practicable. Secretary of the Navy (SECNAV) Instruction 5000.2G, Department of the Navy Implementation of the Defense Acquisition System and the Adaptive Acquisition Framework, identifies resources needed at the Military Department and program levels to implement MOSAs. The forthcoming U.S. Navy MOSA Implementation Guidebook will provide additional details about the resources needed to implement MOSAs in all acquisition programs to the maximum extent practicable.

RECOMMENDATION 11: The GAO recommends that the Secretary of Defense should ensure that OSD policy governing the MTA pathway provides direction for DOD acquisition programs to implement a MOSA to the maximum extent practicable and addresses related statutory requirements. (Recommendation 11)

DoD RESPONSE: The DoD concurs with this recommendation. The OUSD(R&E) will ensure that Office of the Secretary of Defense (OSD) policy governing the Middle Tier Acquisition (MTA) pathway provides direction for DoD acquisition programs to implement a MOSA to the maximum extent practicable and addresses related statutory requirements. The OUSD(R&E) has already identified areas requiring updates in DoD Instruction 5000.80, Operation of the Middle Tier of Acquisition, which governs the MTA pathway, and plans to review other relevant acquisition documents and make appropriate updates as necessary.

RECOMMENDATION 12: The GAO recommends that the Secretary of Defense should ensure that OSD guidance fully addresses the statutory requirements to facilitate the implementation of a MOSA for any program prototyping, acquiring, or sustaining a new or existing weapon system is issued in an expedient manner. (Recommendation 12)

DoD RESPONSE: The DoD concurs with this recommendation. The OUSD(R&E) will ensure that OSD guidance fully addresses the statutory requirements to facilitate the implementation of a MOSA for any program prototyping, acquiring, or sustaining a new or existing weapon system and will ensure that the guidance is issued in an expedient manner. The OUSD(R&E) is developing a MOSA Implementation Guidebook that includes the latest statutory requirements to facilitate the implementation of MOSAs. To ensure continued compliance, the MOSA Implementation Guidebook will be updated annually to implement the latest statutory requirements and best practices.

RECOMMENDATION 13: The GAO recommends that the Secretary of the Navy should ensure that department guidance for acquisition programs provides direction for Navy acquisition programs to implement a

MOSA to the maximum extent practicable and addresses all statutory implementation requirements. (Recommendation 13)

DoD RESPONSE: The DoD concurs with this recommendation. The U.S. Navy will ensure that Department guidance for acquisition programs provides direction for Navy acquisition programs to implement a MOSA to the maximum extent practicable and addresses all statutory implementation requirements. SECNAV Instruction 5000.2G, Department of the Navy Implementation of the Defense Acquisition System and the Adaptive Acquisition Framework requires all programs to implement a MOSA to the maximum extent practicable. The U.S. Navy will assess whether the current version of this instruction addresses all statutory requirements and will update as necessary.

RECOMMENDATION 14: The GAO recommends that the Secretary of the Air Force should ensure that department guidance related to MOSA covers all of the department's acquisition programs and provides appropriate information on MOSA considerations when developing capability documents and conducting analyses of alternatives. (Recommendation 14)

DoD RESPONSE: The DoD concurs with this recommendation. The Department of the Air Force will ensure that Department guidance related to MOSA covers all the Department's acquisition programs and provides appropriate information on MOSA considerations when developing capability documents and conducting analyses of alternatives. The U.S. Air Force will review and update DAFI 163-101/20-101, Integrated Life Cycle Management, and all MOSA implementation guides to ensure they address all statutory requirements and will update them as necessary.

Appendix V: GAO Contact and Staff Acknowledgments

GAO Contact

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Staff Acknowledgments

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