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Report to Congressional Committees

July 2023

DEFENSE SOFTWARE ACQUISITIONS

Changes to Requirements, Oversight, and Tools Needed for Weapon Programs

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GAO-23-105867

GAO Highlights

Highlights of GAO-23-105867, a report to congressional committees

July 2023

DEFENSE SOFTWARE ACQUISITIONS

Changes to Requirements, Oversight, and Tools Needed for Weapon Programs

Why GAO Did This Study

Congress included a provision in statute for GAO to examine DOD's software modernization efforts. This report assesses the extent to which DOD has (1) policy and guidance that establish requirements processes to support the use of Agile software development in weapon programs; (2) policy and guidance to provide direction for overseeing Agile software development in weapon programs; and (3) enabled program adoption of modern engineering tools for Agile.

GAO reviewed DOD's software acquisition and requirements policies and guidance, and GAO's leading practices in Agile and iterative development. GAO selected a nongeneralizable sample of five weapon programs based on their use of Agile, and other factors. GAO also interviewed relevant DOD officials, program officials, and user representatives.

What GAO Recommends

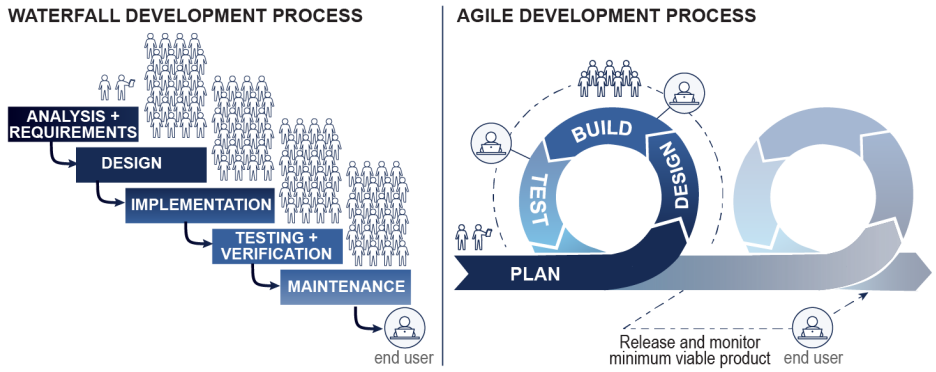
GAO is making three recommendations to DOD, including that for all programs using Agile for software development, DOD incorporate Agile principles into policies and guidance used for requirements processes as well as oversight; and that DOD establish an overarching plan—and identify resources—to enable the adoption of modern engineering tools across programs. DOD partially concurred with all three recommendations and identified some planned actions that would address elements of the recommendations. However, GAO noted additional steps DOD needs to take to fully address the recommendations.

View GAO-23-105867. For more information, contact Shelby S. Oakley at (202) 512-4841 or oakleys@gao.gov.

What GAO Found

The Department of Defense's (DOD) ability to respond to evolving threats is increasingly determined by its ability to rapidly develop and deploy software. Efforts to modernize DOD's software acquisition include a transition to Agile development principles from a traditional waterfall approach. Agile is intended to deliver working software to users in less than a year and add capability iteratively based on user needs. In contrast, the waterfall approach could take over 10 years to deliver software and involves greater risk.

Comparison of Waterfall and Agile Methods for Developing Software



Source: GAO analysis of Department of Defense information and other sources; GAO (icons). | GAO-23-105867

In 2020, DOD established six acquisition pathways—or sets of policy and guidance—that are tailored to the type of capabilities being acquired. DOD requires programs on its software pathway to use requirements processes tailored to support Agile development. For example, software pathway programs are to use streamlined requirements documents and develop user agreements, which help ensure programs iteratively develop software aligned with user needs. However, DOD requirements processes used by weapon programs developing software on a different pathway generally do not incorporate Agile principles. By not incorporating Agile principles into requirements processes, these programs risk developing capabilities that may not reflect changing user needs or threats.

DOD developed policies and guidance for oversight of programs on the software pathway, including using metrics and value assessments that measure Agile development outcomes. However, DOD has not issued corresponding policies or guidance for weapon programs using Agile software development on other pathways. As a result, programs on other acquisition pathways, such as those developing new aircraft or ships, may not be positioned to conduct effective oversight of iteratively delivered software capabilities.

The iterative and fast-paced nature of Agile relies on the use of modern engineering tools to help identify needs, develop capabilities, and understand outcomes. DOD, however, has not developed a plan or identified resources to enable the adoption of modern engineering tools across all programs. The absence of a plan prevents DOD from fully realizing the benefits of Agile.

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Abbreviations

AAF	Adaptive Acquisition Framework
ACAT	Acquisition Category
CDD	Capability Development Document
CNS	Capability Needs Statement
DD	Disposition Decision
DevSecOps	Development, Security, and Operations
DOD	Department of Defense
I	Iteration
MTC2	Maritime Tactical Command and Control
MVCR	Minimum Viable Capability Release
MVP	Minimum Viable Product
OD	Outcome Determination
OSD	Office of the Secretary of Defense
R	Release
Space C2	Space Command and Control
SW-ICD	Software Initial Capabilities Document
USD(A&S)	Under Secretary of Defense for Acquisition and Sustainment
USD(R&E)	Under Secretary of Defense for Research and Engineering

U.S. GOVERNMENT ACCOUNTABILITY OFFICE
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Congressional Committees

The Department of Defense's (DOD) capacity to respond to evolving threats and compete with strategic challengers, such as China and Russia, is increasingly determined by its ability to rapidly develop and deploy weapon systems, many with complex software. We have found that DOD has made efforts to modernize its software development and acquisition approaches over the past several years, such as by advocating for the increased use of Agile software development and by establishing a software acquisition pathway.[1] However, DOD has faced challenges—acknowledged by senior leadership—in modernizing its software development approach and addressing workforce shortfalls.[2]

Our recent work identified key principles used by leading companies to ensure product development success for both hardware and software. These principles include adopting an iterative design approach and collecting customer feedback to inform improvements—both key tenets of Agile software development.[3] Furthermore, in our June 2022 review of 59 current DOD acquisition programs, we found limited progress in implementing software development practices recommended by the Defense Science Board in 2018.[4] Such practices include providing training in modern software development approaches for program managers and staff.

[1]For the purposes of this report, we refer to DOD's efforts to modernize its software development and acquisition approaches as software modernization efforts. Additionally, we refer to steps DOD has taken to implement software development using Agile, which also include steps to implement iterative development methodologies, such as Development Security and Operations (DevSecOps).

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

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

[4]GAO, *Weapon Systems Annual Assessment: Challenges to Fielding Capabilities Faster Persist*, GAO-22-105230 (Washington, D.C.: June 8, 2022).

Section 838 of the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 includes a provision for us to examine DOD's software modernization efforts.[5] This report assesses the extent to which DOD has (1) policy and guidance that establish requirements processes to support the use of an Agile software development approach in weapon programs, (2) policy and guidance to provide direction for overseeing Agile software development approaches in weapon programs, and (3) enabled weapon program adoption of modern engineering tools for Agile.

To address our first two objectives, we collected and analyzed DOD policy and guidance on weapon system acquisition requirements, oversight, acquisition pathways, and Agile software development. We also collected and analyzed requirements, oversight, and other related documents from selected programs using Agile for software development. In addition, we reviewed GAO's Agile Assessment Guide as well as our relevant prior work on leading practices in iterative development and compared them to DOD policy and guidance.[6] We also interviewed Office of the Secretary of Defense (OSD) and military department officials responsible for requirements processes, as well as OSD and military department acquisition officials. To gain further contextual information, we attended several DOD-run community of practice events that had been cited by officials as a primary means of sharing information on software acquisition modernization across the department.

For illustrative examples, we selected a nongeneralizable sample of five weapon programs. Program information was collected during our 2022 DOD annual assessment of weapon systems as well as interviews with DOD acquisition officials.[7] We then selected five programs ensuring they met four criteria including (1) at least one program from each military department; (2) programs that reported using modern iterative software development processes, i.e., Agile, and reflected the use of different acquisition pathways; (3) programs with a high level of complexity—

[5]William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116-283, § 838 (2021). We previously addressed additional topics included in § 838 in GAO-22-105230; *DOD Software Acquisition: Status of and Challenges Related to Reform Efforts*, GAO-21-105298 (Washington, D.C.: Sept. 30, 2021); and *Software Acquisition: Additional Actions Needed to Help DOD Implement Future Modernization Efforts,* GAO-23-105611 (Washington, D.C.: Apr. 5, 2023).

[6]GAO, *Agile Assessment Guide: Best Practices for Agile Adoption and Implementation*, GAO-20-590G (Washington, D.C.: Sept. 28, 2020); and GAO-22-104513.

[7]GAO-22-105230.

defined as multiple software products, multiple development teams, or significant integration with external systems; and (4) programs that have delivered software to users or to an operationally representative environment if embedded software. Selected programs are described in table 1. For each program, we reviewed requirements and planning documents, acquisition strategies, metrics, and briefings, and spoke with program officials and user representatives.

Table 1: Reported Acquisition Approaches of Selected Weapon Programs

Program	Military department	Current acquisition approach[a]	Previous acquisition approach[a]
Air Operations Center	Air Force	Software acquisition	Middle tier of acquisition
Space Command and Control (Space C2)	Air Force	Not applicable[b]	Not applicable
Global Command and Control System Maritime	Navy	Major capability acquisition	Not applicable
Maritime Tactical Command and Control	Navy	Software acquisition	Major capability acquisition
Integrated Air and Missile Defense Battle Command System	Army	Software acquisition	Major capability acquisition

Source: GAO analysis of selected program documentation. | GAO-23-105867

[a]For the purposes of this table, major capability acquisition programs include major defense acquisition programs; other programs categorized as acquisition category (ACAT) I; major systems, usually categorized as ACAT II; automated information systems; and other capabilities. In some cases the programs were initiated prior to the Adaptive Acquisition Framework, and in those cases "Major capability acquisition pathway" indicates the program began under a prior iteration of Department of Defense Instruction 5000.02.

[b]Space C2 was established as a Development, Security, and Operations (DevSecOps) Pathfinder in 2019 and is not using one of the six pathways of the Adaptive Acquisition Framework. Space C2 officials are planning to transition the program to the software pathway.

To address our third objective, we collected and reviewed DOD and military department strategies for implementation of modern engineering tools and digital engineering; OSD guidance for mission, systems, and software engineering; and engineering policy and guidance for programs. We reviewed GAO's Agile Assessment Guide, prior engineering-related work on leading practices in assessing iterative development, and standards for internal control. We also interviewed senior military department engineering officials cognizant of tool implementation as well as officials from the selected programs.

We conducted this performance audit from March 2022 to July 2023 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

Our recent work has highlighted that DOD's software development practices have not kept up with leading industry practices even as software has become increasingly vital to DOD weapon systems.[8] The Defense Science Board and Defense Innovation Board issued reports, in 2018 and 2019, respectively, that also found deficiencies in software development and acquisition practices within DOD, such as outdated acquisition processes and challenges with rapidly delivering software to users.[9] These two reports made 17 recommendations for DOD to help address these deficiencies. Our recent report found that DOD has implemented four of these recommendations and partially implemented the remaining 13.[10] In this report, we also made seven recommendations to help DOD better position itself to implement its future software modernization plans. Problems in software acquisition can result in DOD weapon programs delivering needed capabilities late, over budget, or not at all.

Modern Iterative Software Development Approaches that Use Agile Principles

Modern approaches to software delivery rely extensively on using Agile development principles. Agile refers to a flexible, iterative way of developing software that delivers early and frequent working capabilities to users.[11] Agile integrates planning, design, development, and testing with delivery using small cross-functional teams to accomplish the work. Frequent iterative delivery of software is intended to allow programs to effectively measure progress toward delivery of an evolving suite of

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

[9]Defense Innovation Board, *Software Is Never Done: Refactoring the Acquisition Code for Competitive Advantage* (Washington, D.C.: May 3, 2019). Defense Science Board, *Design and Acquisition of Software for Defense Systems* (Washington, D.C.: Feb. 14, 2018).

[10]GAO-23-105611.

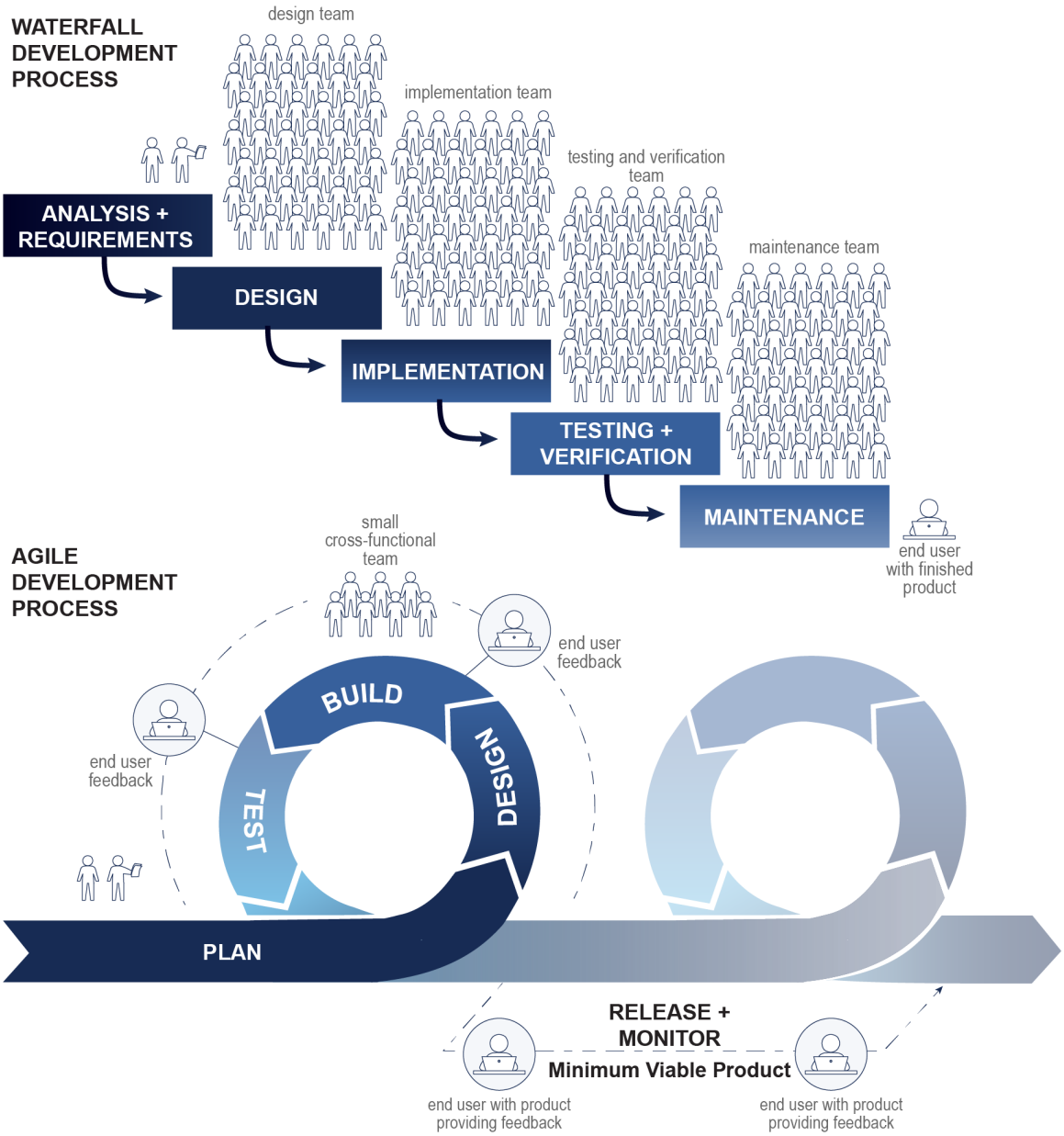
[11]Throughout this report, the use of the term Agile refers to Agile development of software and the principles associated with that development.

capabilities, reduce technical and programmatic risk, and be responsive to feedback from stakeholders and users.

Using this approach, programs have multiple levels of considerations, from strategic objectives—the overarching vision that represents the high-level needs of the organization—to lower level detailed requirements that address individual user needs and are largely solicited during development. Development, Security, and Operations (DevSecOps) is among the many modern iterative software development approaches that use Agile principles.

Agile differs from the way DOD has historically developed software, where requirements were solidified prior to development and software was delivered as a single completed program at the end of the development cycle. This approach is referred to as waterfall development. Traditional waterfall software development occurred without regular user involvement and feedback, or the ability to easily modify requirements and adjust for programmatic and technical challenges or opportunities—including new technologies. Traditional waterfall software development mirrored the development of a hardware system with a linear sequential process and large teams of developers. In DOD, this could mean that over a decade would pass between identification of system requirements and capability reaching the hands of users. Figure 1 compares waterfall and Agile methods for developing software.

Figure 1: Comparison of Waterfall and Agile Methods for Developing Software



Source: GAO analysis of Department of Defense information and other sources; GAO (icons). | GAO-23-105867

Modern Engineering Tools and Agile

Agile software development efforts and their comparatively fast-paced development cycles rely on the use of modern engineering tools. These tools support an integrated digital approach to engineering. For the purposes of this report, these tools include those needed to support modern engineering practices in mission, systems, and software engineering and development, as well as other engineering disciplines. The Under Secretary of Defense for Research and Engineering (USD(R&E)) issued a Systems Engineering Guidebook in February 2022. This guidebook provides guidance and recommended best practices for all defense acquisition programs planning and executing systems engineering activities.[12] It describes several practices related to Agile implementation, including how the use of automated tools for designing capabilities within a digital engineering ecosystem can accelerate engineering activities and reduce the time to develop and field systems. In addition to DOD engineering guidance, our Agile Assessment Guide identifies the importance of using modern engineering tools to enable Agile software development.[13] We have also recently reported that the use of such tools and digital engineering practices are a leading practice among innovative companies.[14] These tools support various activities, including modeling and simulation, software development, program management, version control, testing, continuous integration, and others.

Engineering Disciplines to Support Identifying Requirements and Outcomes

USD(R&E) defined three engineering disciplines that we address in this report:

1. Mission engineering—a discipline focused on understanding the mission, including performance measures, capability gaps, and impact of new capabilities.

[12]Office of the Under Secretary of Defense for Research and Engineering, *Systems Engineering Guidebook* (Washington, D.C.: Feb. 11, 2022).

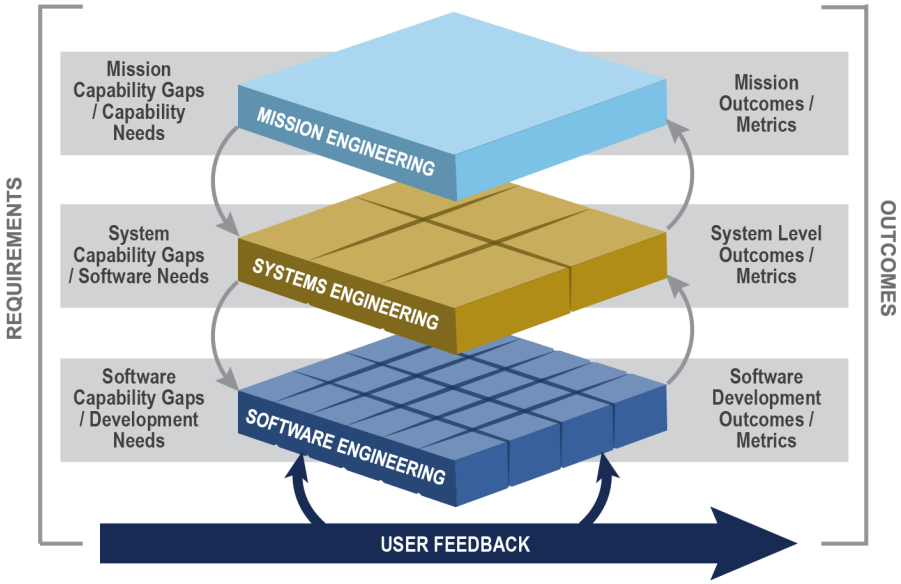
[13]GAO-20-590G.

[14]GAO-22-104513.

2. Systems engineering—a discipline focused on identifying the most efficient technical means to deliver a capability and understand how a subsystem, such as software, contributes to that capability.
3. Software engineering—a discipline focused on processes for software and system architecture, design, and development.

These disciplines integrate to help DOD identify gaps in mission capabilities and document capability needs, identify the optimal systems development effort to meet the need, and then address the need with software changes on that system. Likewise, the expected mission and system outcomes associated with software development activities can be identified to aid in assessing their value. Figure 2 below shows how these three engineering disciplines integrate to support identifying requirements and outcomes.

Figure 2: Role of Engineering Disciplines in Requirements and Outcomes



Source: GAO analysis of Department of Defense data. | GAO-23-105867

Text for Figure 2: Role of Engineering Disciplines in Requirements and Outcomes

	Requirements	Outcomes
Mission Engineering,	Mission Capability Gaps / Capability Needs	Mission Outcomes / Metrics
Systems Engineering	System Capability Gaps / Software Needs	System Level Outcomes / Metrics

	Requirements	Outcomes
Software Engineering	Software Capability Gaps / Development Needs	Software Development Outcomes / Metrics

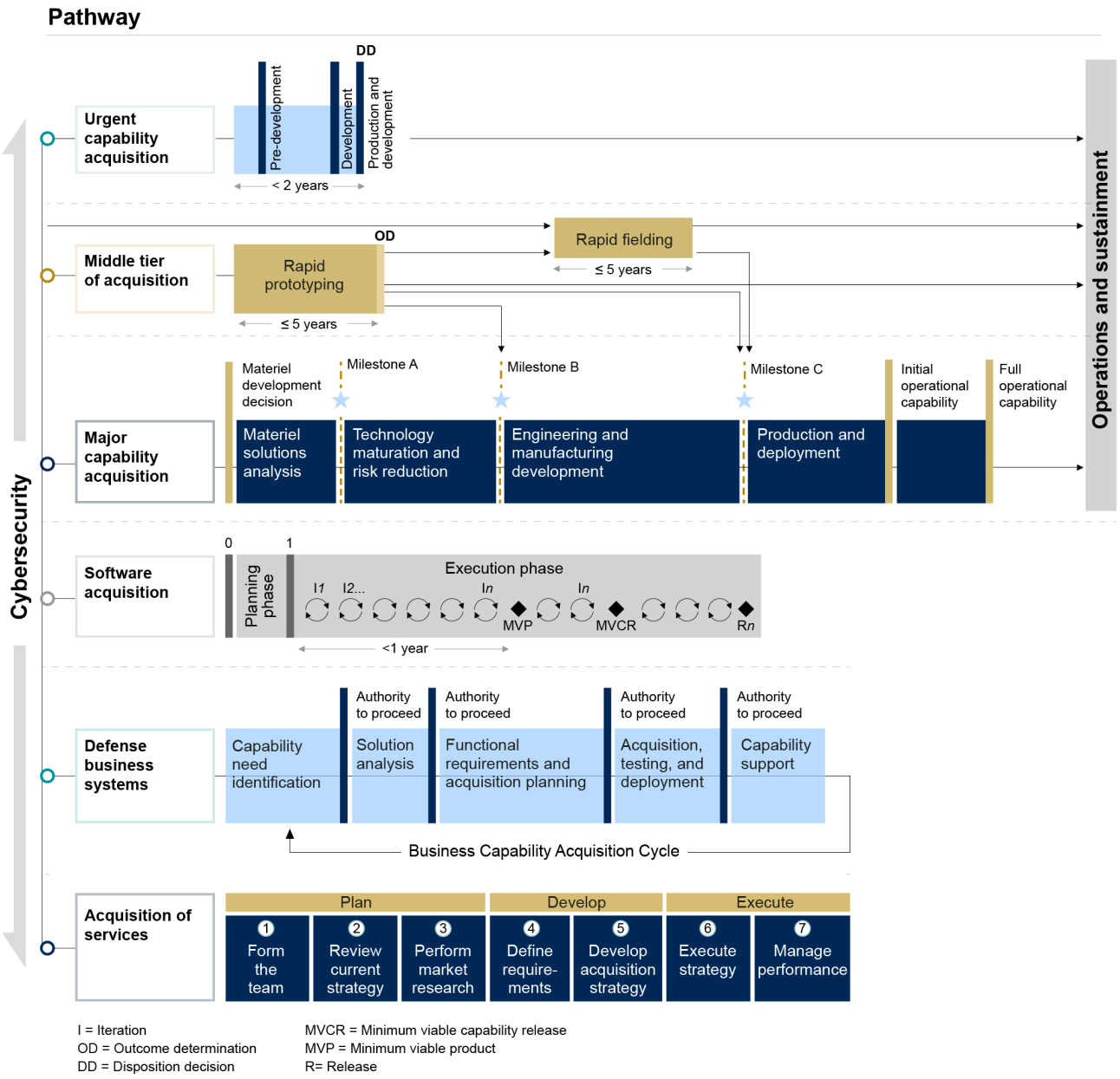
Source: GAO analysis of Department of Defense data. | GAO-23-105867

Adaptive Acquisition Framework

In January 2020, DOD Instruction 5000.02 established the Adaptive Acquisition Framework (AAF), which is intended to help enable flexible and responsive acquisitions.[15] The AAF emphasizes several principles that include simplifying acquisition policy, tailoring acquisition approaches, and conducting data-driven analysis. The AAF is comprised of six acquisition pathways, each tailored to the characteristics of the capability being acquired. DOD issued policy documents to address each of these six acquisition pathways as well as additional functional policy documents in areas such as engineering and test and evaluation. Figure 3 illustrates the AAF and each pathway.

[15]Department of Defense, *The Defense Acquisition System*, DOD Directive 5000.01 (Sept. 9, 2020); and *Operation of the Adaptive Acquisition Framework*, DOD Instruction 5000.02 (Jan. 23, 2020).

Figure 3: The Department of Defense's Adaptive Acquisition Framework



Source: GAO analysis of Department of Defense data. | GAO-23-105867

Text for Figure 3: The Department of Defense's Adaptive Acquisition Framework (Cybersecurity)

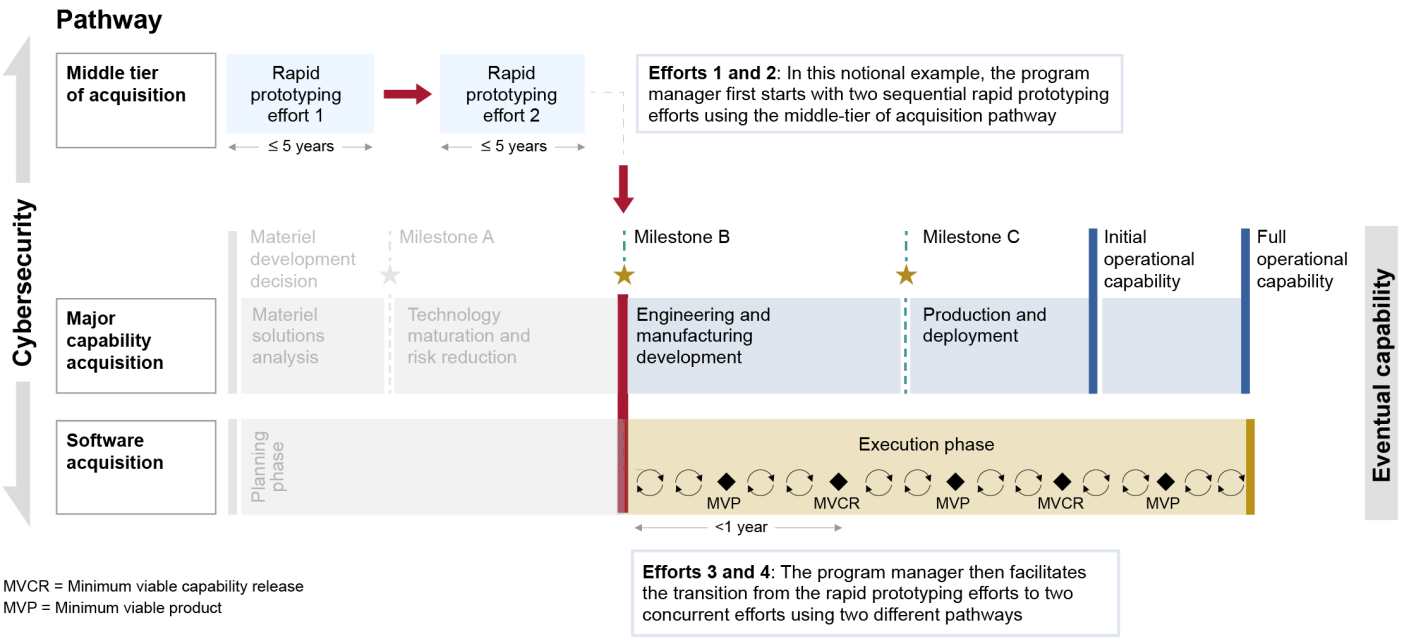
Pathway	Framework
Urgent capability acquisition (Operations and sustainment)	Pre-development
	Development
	Disposition decision
	Production and development
	Less than 2 years
Middle tier of acquisition (Operations and sustainment)	Rapid prototyping, Outcome determination (Less than or equal to 5 years)
	Rapid fielding (Less than or equal to 5 years)
Major capability acquisition (Operations and sustainment)	Materiel development decision
	Materiel solutions analysis
	Milestone A
	Technology maturation and risk reduction
	Milestone B
	Engineering and manufacturing development
	Milestone C
	Production and deployment
	Initial operational capability
	Full operational capability
Software acquisition	Planning phase (0 to 1 year)
	Execution phase
	Iterations (Less than a year)
	Minimum viable product
	Iterations
	Minimum viable capability release
	Iterations
	Release
Defense business systems	Business Capability Acquisition Cycle
	Capability need identification
	Authority to proceed, Solution analysis
	Authority to proceed, Functional requirements and acquisition planning
	Authority to proceed, Acquisition, testing, and deployment
	Authority to proceed, Capability support

Pathway	Framework
Acquisition of services	Plan
	Form the team
	Review current strategy
	Perform market research
	Develop
	Define requirements
	Develop acquisition strategy
	Execute
	Execute strategy
	Manage performance

Source: GAO analysis of Department of Defense data. I GAO-23-105867

Programs with approval from the appropriate decision authority may leverage a combination of acquisition pathways to provide value not otherwise available through use of a single pathway. Program managers can also tailor, combine, and transition between pathways based on program goals and risk associated with the weapon system being acquired. Figure 4 shows how a program could use multiple efforts within a single pathway and multiple pathways to achieve eventual capability.

Figure 4: Notional Example of How Programs Can Use Multiple Efforts and Pathways in the Adaptive Acquisition Framework



Source: GAO analysis of Department of Defense data. | GAO-23-105867

Text for Figure 4: Notional Example of How Programs Can Use Multiple Efforts and Pathways in the Adaptive Acquisition Framework (Cybersecurity)

Pathway	Framework	Notes
Middle tier of acquisition	Rapid prototyping effort 1 (Less than or equal to 5 years) Rapid prototyping effort 2 (Less than or equal to 5 years)	Efforts 1 and 2: In this notional example, the program manager first starts with two sequential rapid prototyping efforts using the middle-tier of acquisition pathway
Major capability acquisition	Materiel development decision Materiel solutions analysis Milestone A Technology maturation and risk reduction Milestone B Engineering and manufacturing development Milestone C Production and deployment Initial operational capability Full operational capability	Eventual capability Efforts 3 and 4: The program manager then facilitates the transition from the rapid prototyping efforts to two concurrent efforts using two different pathways

Pathway	Framework	Notes
Software acquisition	Planning phase	
	Milestone B	
	Execution phase	
	Iterations, Minimum viable product, Iterations, Minimum viable capability release (Less than a year)	
	Iterations, Minimum viable product, Iterations, Minimum viable capability release, Iterations, Minimum viable product, Iterations	

Source: GAO analysis of Department of Defense data. I GAO-23-105867

Four of these six pathways address weapon system programs: (1) urgent capability acquisition; (2) middle tier of acquisition; (3) major capability acquisition; and (4) software acquisition. Table 2 describes the purpose and anticipated duration associated with each pathway.

Table 2: Key Characteristics of Adaptive Acquisition Framework Pathways for Weapon System Programs

Acquisition pathway	Purpose	Duration
Urgent capability	To field capabilities to fulfill urgent existing and/or emerging operational needs or quick reactions.	<2 Years
Middle tier	To rapidly develop fieldable prototypes within an acquisition program to demonstrate new capabilities and/or rapidly field production quantities of systems with proven technologies that require minimal development.	≤5 Years
Major capability	To acquire and modernize unique programs that provide enduring capability.	Unspecified
Software	To facilitate rapid and iterative delivery of software capabilities to the user.	<1-year increments

Source: GAO analysis of Department of Defense Instruction 5000.02. | GAO-23-105867

These pathways also have specific guidance regarding the type and frequency of review for requirements documents that programs must use. For example, as part of the major capability pathway, programs must use a Capability Development Document (CDD), which is created prior to development. A CDD identifies a specific proposed materiel solution—such as a new or upgraded weapon system—and the capability requirements against which the usefulness of that system will be measured.

The Software Acquisition Pathway

The software acquisition pathway is intended to facilitate rapid and iterative delivery of software capability, including software-intensive systems, to users.[16] The associated instruction implemented recommendations we made in 2019 that DOD ensure its software development guidance provides specific direction on the timing, frequency, and documentation of user involvement and feedback.[17] The pathway instruction requires program officials to frequently engage with users and to deliver new capabilities to operations at least annually.[18] The pathway involves the use of small cross-functional teams, such as users, testers, software developers, and cybersecurity experts, to deliver software rapidly and iteratively to meet user needs. It is intended to

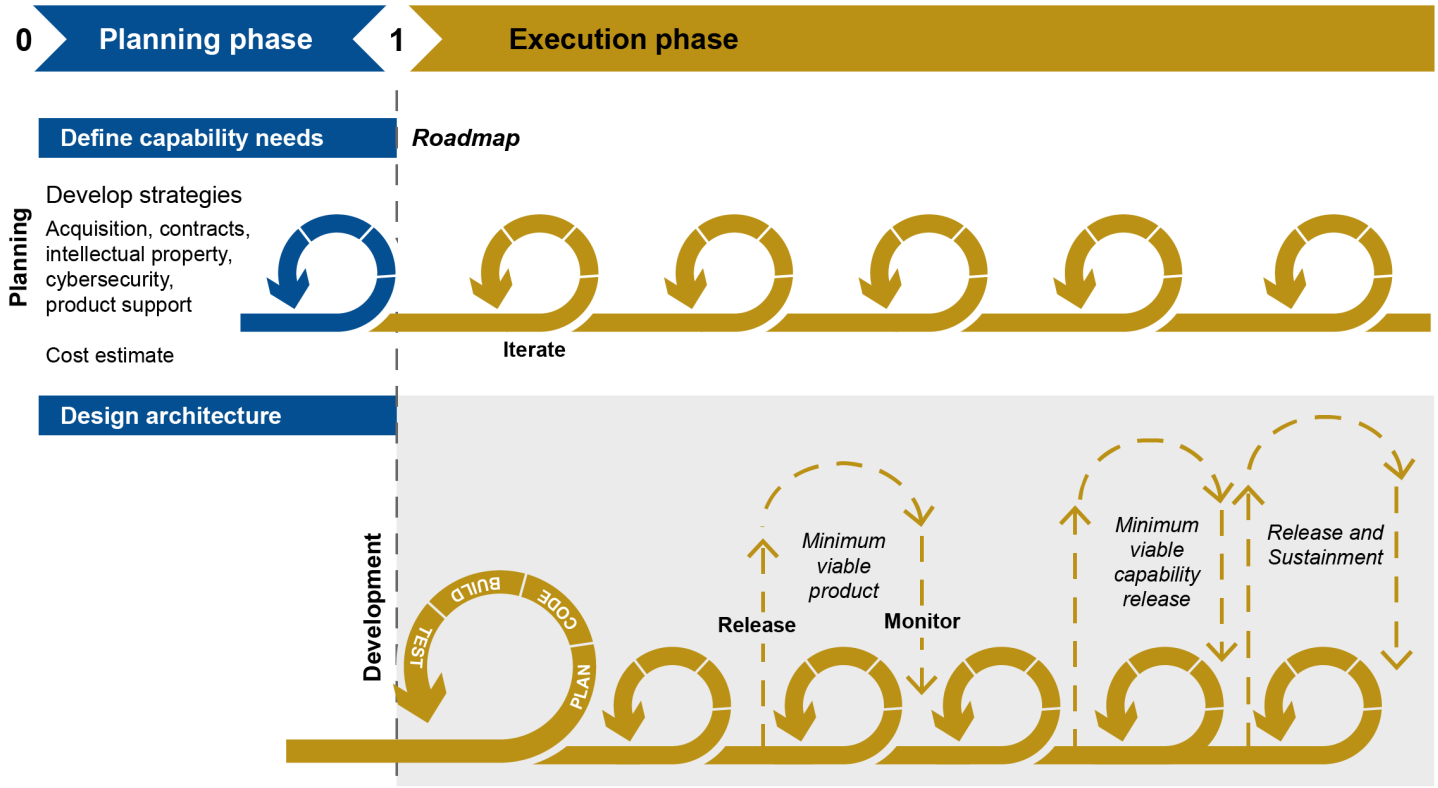
[16]Department of Defense, Office of the Under Secretary of Defense for Acquisition and Sustainment, *Operation of the Software Acquisition Pathway*, DOD Instruction 5000.87 (Oct. 2, 2020).

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

[18]For embedded software on systems that DOD has yet to operationally accept, software must be delivered to an operationally representative environment at least annually.

enable DOD to deploy software quickly and adopt Agile principles such as continuous iterative development, among other things. The software pathway has two phases: planning and execution (see fig. 5).

Figure 5: The Department of Defense's Software Acquisition Pathway



Source: GAO analysis of relevant Department of Defense instructions. | GAO-23-105867

Text for Figure 5: The Department of Defense's Software Acquisition Pathway

Planning phase	Execution phase
Define capability needs	Roadmap
Planning	Iterate
Develop strategies	
Acquisition, contracts, intellectual property, cybersecurity, product support	
Cost estimate	

Planning phase	Execution phase
Design architecture	**Development**
	Plan, Code, Build, Test
	Release
	Minimum viable product
	Monitor
	Minimum viable capability release
	Release and Sustainment

Source: GAO analysis of relevant Department of Defense instructions. | GAO-23-105867

Pathway policy and guidance also identifies new roles and responsibilities for program stakeholders from both the acquisition and operational communities. See table 3.

Table 3: Selected Software Acquisition Pathway Roles

Role	Definition
Decision authority	The official responsible for oversight and key decisions of programs. The official designates a program manager and supports this person in tailoring and streamlining processes, reviews, and decisions to enable speed of capability delivery. The official may be the Defense Acquisition Executive, Component Acquisition Executive, Program Executive Officer, or other official designated by the Component Acquisition Executive.
End user/user community	Those who will ultimately use the software solution. Users convey operational concepts, requirements, and needs; participate in continuous testing activities; and provide feedback on developed capabilities.
Sponsor	The individual or organization that identifies and advocates for needed end-user capabilities and associated resource commitments. The sponsor is responsible for identifying the needed capabilities to justify initiating a software acquisition.

Source: Department of Defense Instruction 5000.87. | GAO-23-105867

DOD reported that 49 programs were using the software acquisition pathway as of May 2023. Under Secretary of Defense for Acquisition and Sustainment (USD(A&S)) officials stated that the majority of these programs are weapon programs that transitioned to the software pathway from other pathways. However, the use of Agile is not limited to programs using the software pathway. Data collected as part of our 2023 weapon systems annual assessment showed that 44 of 52 programs reported using Agile or other modern software development approaches on other pathways.[19] These programs are developing or modernizing major capabilities including a strategic bomber, fighter aircraft, uncrewed surveillance aircraft, helicopters, Navy destroyers, and other types of capabilities.

DOD's Requirements Processes Are Not Tailored to Support All Weapon Programs Using Agile

DOD policy requires programs using the software pathway to use requirements processes tailored to support Agile software development, including streamlined documentation and continuous user engagement.

[19]GAO, *Weapon Systems Annual Assessment: Programs Are Not Consistently Implementing Practices that Can Help Accelerate Acquisitions*, GAO-23-106059 (Washington, D.C.: June 8, 2023). Data were collected on a total of 58 programs; however, five of these programs did not report their method for software development and one program is using the software pathway.

However, no similar policy exists for weapon programs using Agile but not on the software pathway.

DOD Developed Requirements Processes for Programs Using Agile on the Software Pathway

DOD developed streamlined requirements processes, including documents and user agreements, to support Agile development for programs using the software pathway. These documents are tailored to identify high-level needs while allowing for flexibility as detailed requirements evolve and to help ensure programs engage users during software development— traits generally consistent with leading practices.[20]

Software Pathway Requirements Documents

DOD's Capability Needs Statement (CNS) and Software Initial Capabilities Document (SW-ICD) outline prioritized requirements for programs on the software pathway. DOD Instruction 5000.87 requires software pathway programs to use CNSs.[21] Programs with joint equities—requirements applicable to multiple departments—must use a SW-ICD instead.[22] As described in DOD guidance, both the CNSs and SW-ICDs may serve as the software pathway requirements document and are intended to capture high-level needs for a program, while allowing speed and flexibility for software development. Additionally, policy states that the CNS or SW-ICD developed for each program will be concise documents—for example, the SW-ICD is expected to be under 10 pages. These documents are to focus on operational needs and effects, convey

[20]GAO-20-590G; and GAO-22-104513.

[21]Department of Defense, Office of the Under Secretary of Defense for Acquisition and Sustainment, *Operation of the Software Acquisition Pathway*, DOD Instruction 5000.87 (Oct. 2, 2020). DOD Instruction 5000.87 states that "Current acquisition programs with approved Joint Capability Integration and Development System documents that transition to the software acquisition pathway may continue to use them as the basis of requirements or develop a CNS to capture current, software-unique needs."

[22]Joint Chiefs of Staff, *Charter of the Joint Requirements Council and Implementation of the Joint Capabilities Integration and Development System*, CJCSI 5123.01I (Oct. 30, 2021). The general guidelines for joint equity programs include Combatant Command generated requirements; programs related to Joint All-Domain Command and Control; programs related to Nuclear Command Control and Communications; and any explicit joint or joint-service requirement.

priorities, and provide a framework for managing capability needs. USD(A&S) officials highlighted the need to keep software pathway requirements at a high level and flexible. This allows detailed requirements to be developed during iterative time-phased planning of capability and through regular user engagement.

The sponsor is to review CNSs at least annually, while the Office of the Chairman of the Joint Chief of Staff (Joint Staff) is to review the SW-ICD a year after validation and biennially thereafter. DOD guidance states that the CNS is to be approved at the lowest level practical whereas the SW-ICD is to be validated by the Joint Staff under an expedited time frame of 40 days.[23] USD(A&S) guidance also contains a number of considerations regarding requirements management. For example, programs using the software pathway should describe

- the current and planned requirements documents (e.g., CDD, CNS) that govern the acquisition;
- how the program will capture, prioritize, and integrate user feedback to shape requirements;
- how the program will avoid the risk of being constrained to predefined requirements that may not adequately reflect changing user needs, current operational environment, threats, or an evolving understanding of the system;
- how the program will manage and prioritize the work to be done based on factors such as user need, risk, cost, and time required; and
- how the program intends to manage software requirements, including considerations such as the level and timing of approvals.

Program officials using the software pathway described the benefits of the CNS for implementing Agile for software development.[24] Navy Maritime Tactical Command and Control (MTC2) program officials stated that the development and iteration of the CNS enabled them to develop initial capabilities and readjust priorities once those capabilities were delivered. These officials stated that this flexibility, in contrast with other

[23]Department of Defense, Office of the Under Secretary of Defense for Acquisition and Sustainment, *Operation of the Software Acquisition Pathway*, DOD Instruction 5000.87 (Oct. 2, 2020); *Manual for the Operation of the Joint Capabilities Integration and Development System, 2021* (Oct. 30, 2021). DOD also publishes and updates guidance for implementing the Software Acquisition Pathway at https://aaf.dau.edu/aaf/software/.

[24]No SW-ICD had been approved at the time of our review. However, we were able to review a draft SW-ICD.

requirements documents such as a CDD, enabled the program to better respond to the changing needs of the Navy fleet. They stated that a key component of this flexibility was the increased timeliness of approvals of revised CNSs as a result of that responsibility falling to relatively junior officials. Air Force Air Operations Center program officials explained that the CNS provided their programs similar benefits and highlighted how transitioning to a CNS allowed them to better plan for scaling their system across multiple locations. These officials explained that the locations they must deliver capabilities to all have different specific needs and that the program office, in cooperation with the sponsor, needs to be able to re-prioritize the delivery of capabilities to those locations based on current threats.

Software Pathway User Agreements

DOD policy also requires programs using the software pathway to create User Agreements.[25] The User Agreement is a commitment between the sponsor and program manager for continuous user involvement and assigns decision making authority in the development and delivery of software capability. It helps to ensure the user community is represented and engaged throughout software development by defining responsibilities and expectations for involvement and interaction of users and developers. This involvement helps ensure that detailed low-level requirements of users are considered during development. USD(A&S) officials explained that the User Agreement is a critical document because it helps DOD become more culturally agile. They noted that the User Agreement sets the expectation for regular user involvement during development, in contrast to the traditional approach of users helping to determine requirements and then having limited insight or contributions to development until delivery of a capability several years later.

Officials from programs we reviewed highlighted the value of the User Agreement and the importance of user involvement during Agile software development. While the CNS or SW-ICD generally identify high-level requirements, these officials pointed out that user involvement throughout development ensures consideration of lower-level requirements, such as interface design and other design choices. This helps ensure the program delivers useable software. These officials also described how establishing expectations for user involvement through a User Agreement helps to

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

mitigate risk for the program. They explained that operational users are often very busy and cannot be continuously available. However, with a User Agreement, both the program and users agree on expectations of involvement and the program can plan so it gathers and implements feedback as effectively as possible.

DOD Requirements Processes for Weapon Programs on Other Pathways Do Not Support Agile Software Development

Weapon programs not on the software pathway follow capability development requirements processes and use requirements documents that, without tailoring to incorporate Agile principles, do not support Agile software development. Similarly, these policies do not require user engagement.

Non-Software Pathway Program Requirements Lack Needed Flexibility

DOD's requirements processes for non-software pathway weapon programs using Agile do not offer the flexibility necessary to support Agile software development. Without tailoring, such as the use of a CNS, to incorporate Agile principles, the requirements documents and associated processes used by the programs may be incompatible with Agile software development because they establish detailed and prescriptive requirements years in advance of capability delivery. Additionally, changes to the documents usually require lengthy review and approval by high-level officials.

The lack of flexible requirements processes is a widespread issue, as many major capability acquisition programs report using Agile for software development, but are not using the software pathway. Data collected as part of our 2023 weapon systems annual assessment showed that 44 of 52 programs reported using Agile or other modern software development approaches while using other pathways.[26] Additionally, USD(A&S) officials told us that across DOD, regardless of pathway, they expect that programs use Agile methods for software development.

[26]GAO-23-106059.

However, such programs are constricted because the other pathways' policies do not require programs to develop requirements and acquisition planning documents to support Agile software development. For example, the CDD identifies detailed requirements for overall program completion, rather than high-level capability needs and priorities for iterative software development.[27] Additionally, review and validation timelines for CDDs are incompatible with Agile methods as they inhibit iterative development of requirements. For example, the baseline time frame for validation of CDDs at the Joint Requirements Oversight Council is 103 days, and we have found that the council struggled to meet this goal.[28] These review and approval processes mean that programs developing software while not following the software pathway have little incentive to revisit and, if necessary, update requirements documents such as CDDs.

Program officials we interviewed noted that both software pathway and other pathway requirements documents could work in conjunction to meet program needs. Specifically, most of the programs using the software pathway we reviewed that use a CNS for software requirements have also used a prior CDD or similar document as a guide for system requirements—with the CNS reflecting near-term needs and priorities. Officials from these programs also described the challenges they encountered when, for example, they only had a CDD and had yet to develop documents such as CNSs. Officials from Space Command and Control, a program that has not yet transitioned to the software pathway, explained that only having a CDD boxes them into developing specific solutions that make it difficult to incorporate evolving technology.

DOD and GAO have reported on the importance of flexible requirements documentation that is tailored to the needs of programs using Agile. For example, DOD's Agile Software Acquisition Guidebook describes the need for programs using Agile for software development to set an initial definition of capability needs, rather than a detailed, prescriptive

[27]DOD, *Manual for the Operation of the Joint Capabilities Integration and Development System, 2021* (Oct. 30, 2021).

[28]GAO, *Weapon System Requirements: Joint Staff Lacks Reliable Data on the Effectiveness of Its Revised Joint Approval Process,* GAO-22-104432 (Washington, D.C.: Oct. 21, 2021).

description of requirements.[29] The guidebook states that an initial description of a capability need should:

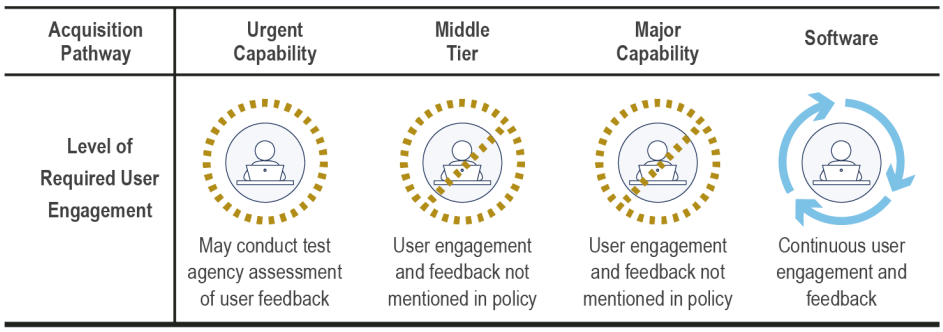
1. tailor the extent of documentation to the size, scope, and complexity of the operational need;
2. be focused on operational needs, key features, and interfaces, not detailed system specifications; and
3. convey high-level priorities, timelines, and operational constraints.

Additionally, according to our Agile Assessment Guide, programs using Agile should develop documentation that is flexible enough for detailed requirements to be refined over time while allowing management to mitigate risks.[30]

Non-Software Pathway Programs Not Required to Regularly Engage Users

Weapon programs using Agile for software development that are not using the software pathway are not required to engage users to inform detailed requirements and provide feedback during development. Figure 6 shows the user engagement requirements for each weapon system acquisition pathway.

Figure 6: User Engagement Requirements for Acquisition Pathways



Source: GAO analysis of Department of Defense data; GAO (icons). | GAO-23-105867

[29]Department of Defense, Office of the Under Secretary of Defense for Acquisition and Sustainment, *Agile Software Acquisition Guidebook* (Washington D.C.: Feb. 27, 2020).

[30]GAO-20-590G.

Text for Figure 6: User Engagement Requirements for Acquisition Pathways

Acquisition Pathway	Urgent Capability	Middle Tier	Major Capability	Software
Level of Required User Engagement	May conduct test agency assessment of user feedback	User engagement and feedback not mentioned in policy	User engagement and feedback not mentioned in policy	Continuous user engagement and feedback

Source: GAO analysis of Department of Defense data; GAO (icons). | GAO-23-105867

Officials from three of the programs we reviewed that transitioned to the software pathway from other pathways told us that, prior to their transition and creation of User Agreements, the programs struggled to set expectations and maintain regular user involvement in development. Additionally, USD(A&S) officials stated that operational users have historically not been expected to be regularly involved in development activities, so the move to Agile and heightened expectations of user involvement represent a cultural shift for the department that the User Agreement is intended to help address.

DOD has highlighted the importance of early and continuous user engagement when pursuing Agile development. For example, in its 2019 report to Congress on Agile software pilot programs, DOD identified the need for early and continuous user engagement in order to produce solutions that meet organization and user needs.[31] Pilot programs reported that their users had a higher level of participation than had previously been the case, and that design and development work benefited from this active engagement. Additionally, DOD's Agile Software Acquisition Guidebook states that user commitment and involvement is essential to building and delivering a successful Agile-based solution. If the Agile team is to deliver iteratively, then the users should be involved early and continuously in the planning, reviewing, and testing processes in alignment with the Agile team's delivery cadence.

Our leading practices for product development underscore the importance of user engagement. Specifically, we found that a policy requiring solicitation and incorporation of user feedback that extends to all DOD acquisition programs would better position them to understand user

[31]Department of Defense, *Report to Congress on Software Development Activity Completion Section 874 of the National Defense Authorization Act for Fiscal Year 2018 (P.L. 115-91)* (Washington, D.C.: Oct. 3, 2019).

needs and develop capabilities to meet those needs.[32] Additionally, our Agile Assessment Guide states that, if an acquisition strategy does not allow for interim delivery and product demonstrations, then the organization may lose opportunities to obtain information and face challenges when adjusting requirements to meet and adapt to customer needs.[33]

DOD has not incorporated Agile principles into its policies and guidance for programs using Agile to develop software on other pathways. This is despite the department's emphasis on the importance of user engagement for Agile and the challenges of attempting to use Agile methods to meet requirements solely defined by existing requirements documents. USD(A&S) officials we spoke with did not see a need to update policy for weapon programs using Agile but not on the software pathway. These officials stated that, with additional approvals, program managers could "tailor in" the regulatory information from the software pathway. While DOD does allow for tailoring of the acquisition pathways, a 2015 study commissioned by OSD identified a number of institutional obstacles that hindered program managers from tailoring their program documentation. The OSD report recommended that DOD develop an explicit framework to link program characteristics with tailoring options.[34] Furthermore, our 2023 annual assessment of weapon systems found programs developing software that were unaware of options to leverage the software pathway. For example, several were unaware of the option to use the pathway for their software development efforts.[35]

By not incorporating Agile principles into requirements policy and guidance for all programs using Agile for software development, DOD may not use processes and documents, such as the CNS and user agreements, that can support the timelines and flexibility needed for Agile software development and help encourage regular user engagement and feedback. As a result, these programs risk delivering capabilities that do

[32]GAO-22-104513.

[33]GAO-20-590G.

[34]McKernan, Megan, Jeffrey A. Drezner, and Jerry M. Sollinger, *Tailoring the Acquisition Process in the U.S. Department of Defense* (Santa Monica, CA: RAND Corporation, 2015).

[35]GAO-23-106059.

not reflect changing user needs, new technologies, or an evolving understanding of the system.

Existing Policies and Guidance Do Not Support DOD Oversight of Non-Software Pathway Weapon Programs Using Agile

DOD has taken steps to develop acquisition policies and guidance for programs on the software acquisition pathway that include oversight mechanisms such as the use of metrics and value assessments that measure Agile development outcomes. However, DOD has not included such details in corresponding policies or guidance for weapon programs that are using Agile development approaches but are on other acquisition pathways.

DOD Established Policy and Guidance to Facilitate Overseeing Agile Software Development for Programs on the Software Pathway

DOD established three primary means of oversight tailored to Agile development in its policies and guidance for the software pathway, including: (1) semi-annual software pathway insight reporting to DOD to support pathway improvements; (2) oversight metrics for use by program offices, program decision authorities, and other program stakeholders; and (3) annual assessments of delivered value conducted by the operational community. We found the guidance and metrics to be generally consistent with our previously identified best practices.[36]

Software pathway insight reporting: DOD's software pathway policies and guidance and associated military department policies require programs to report data semi-annually that provide insight into the operation of the pathway and support decisions regarding future pathway

[36]GAO-20-590G.

improvements.[37] While these data are not intended or used to inform program oversight, our work found that several of the tracked metrics could also be used by a program for its own oversight purposes, such as cycle time metrics and those related to the value delivered to users. USD(A&S) officials told us they are considering how to monitor pathway programs in the future, rather than just monitoring pathway implementation.

DOD also requires software pathway programs to report updates to programmatic information, including budgets, contract types, intellectual property strategy, and development approach. Programs must also report on various software metrics, such as average lead time and an assessment of value. Reporting is currently manual, but USD(A&S) officials told us that they plan to automate the process. USD(A&S) officials noted that in the reporting period from April through October 2022, all software pathway programs reported insight metrics. USD(A&S) officials told us they generally try to avoid imposing too many reporting burdens on programs using the software pathway.

Program oversight metrics: DOD requires programs using the software pathway to assess and manage software development and satisfaction of user needs using various metrics, and emphasizes the use of automated tools to the maximum extent practicable. DOD's guidance provides many examples of metrics that programs on the software pathway can use, such as delivered features and level of user satisfaction. The guidance also describes metrics that address process efficiency, software quality, software development progress, cyber security, cost, and assessed value of what has been delivered to customers. We compared this guidance with best practices for Agile adoption and implementation identified in our Agile Assessment Guide, such as ensuring metrics align with and prioritize organization-wide goals and objectives.[38] We found that DOD's

[37]Department of Defense, Office of the Under Secretary of Defense for Acquisition and Sustainment, *Operation of the Software Acquisition Pathway*, DOD Instruction 5000.87 (Oct. 2, 2020). DOD also publishes and updates guidance for implementing the Software Acquisition Pathway at https://aaf.dau.edu/aaf/software/. Department of the Navy, *Department of the Navy Implementation of the Defense Acquisition System and the Adaptive Acquisition Framework,* Secretary of the Navy Instruction 5000.2G (Apr. 8, 2022). Department of the Air Force, *Operation of the Software Acquisition Framework,* Air Force Instruction 63-150 (Aug. 11, 2021). Department of the Army, Office of the Assistant Secretary of the Army for Acquisition, Logistics and Technology, *Software Acquisition Pathway Policy* [memorandum] (Washington, D.C.: December 2021).

[38]GAO-20-590G.

guidance generally aligned with these practices. DOD also developed an Agile Metrics Guide for those DOD programs implementing Agile.[39] This guide addresses how metrics differ from those used with traditional development approaches, including the types of metrics that are available, their benefits, drawbacks, and potential uses.

Value assessments: At least annually, DOD Instruction 5000.87 requires user communities and sponsors of software pathway programs to complete outcome-based value assessments of mission improvements and efficiencies realized from delivered software capabilities. Program officials and other program stakeholders are required to use these assessments to make a determination of whether the outcomes are worth the investment, and the assessments can inform strategy updates and resourcing decisions. This practice is generally consistent with our prior work, which recommends that programs assess value expected versus value delivered.[40] DOD guidance suggests that programs document agreed upon time frames for assessments in the User Agreement.

Value assessments provide a means to identify if a program is delivering incremental value toward capabilities needed by users. According to DOD guidance, the program refines requirements by soliciting feedback from customers. Then, for each iteration, the program focuses on creating only that which provides value to the customer, who can provide immediate feedback on demonstrated capabilities. For example, Navy MTC2 program officials told us they received user feedback through site visits, product demonstrations, and discussions, including with users onboard ships using the software. These officials stated that they then made improvements to their system based on customer feedback regarding software usability issues. Navy program officials stated that this approach helped a deployed ship avoid experiencing the types of major software issues that arose frequently with prior versions of the software developed without user feedback and value assessment. As of March 2023, USD(A&S) officials told us that 11 software pathway programs have completed at least one value assessment. They noted that this relatively low number was a result of programs only recently starting to deliver capabilities under the software pathway.

[39]Department of Defense, *Agile Metrics Guide: Strategy Considerations and Sample Metrics for Agile Development Solutions*, Version 1.2 (Washington, D.C.: Nov. 11, 2020).

[40]GAO-20-590G.

DOD Does Not Provide Direction to Weapon Programs Using Other Pathways Regarding Oversight of Agile Software Development

DOD's acquisition policies and guidance governing weapon programs using Agile software development when following pathways other than the software pathway generally do not address oversight of Agile development such as using metrics, including outcome-based metrics, and value assessments to assess program outcomes.

Acquisition policies for programs on the major capability acquisition pathway generally reflect the longer periods between key events and decisions that traditionally exist in waterfall development programs, rather than the quick and continual iterations associated with Agile development. For example, programs on the major capability acquisition pathway must complete developmental testing and evaluation. This testing provides feedback to the program manager on the system's ability to achieve key performance parameters and attributes (i.e., metrics). However, this testing is completed toward the end of what is often a multi-year development effort, rather than at the end of short (less than 1 year) development cycles characteristic of the Agile approach.

Our review of DOD and military department policy found that the Navy has issued acquisition policies for other pathways that address Agile (see table 4).

Table 4: Discussion of Agile Development Oversight in DOD and Military Department Acquisition Policies

Policy document	Discussion of agile development oversight
DOD Instruction 5000.85, Major Capability Acquisition (November 2021)	No discussion relevant to metrics for Agile, value assessments, or Agile generally. Related Adaptive Acquisition Framework guidance also does not address these topics.
DOD Instruction 5000.80, Operation of the Middle Tier of Acquisition (December 2019)	No discussion relevant to metrics for Agile, value assessments, or Agile generally. Related Adaptive Acquisition Framework guidance also does not address these topics.
Air Force Instruction 63-101, Integrated Life Cycle Management (November 2021)	No discussion relevant to metrics for Agile, value assessments, or Agile generally.
Army Regulation 70-1 Research, Development, and Acquisition (August 2018)	No discussion relevant to metrics for Agile, value assessments, or Agile generally.
Navy Instruction 5000.2G, Implementation of the Defense Acquisition System (April 2022)	For programs that include software development or modification, the program manager shall support continuous software development, testing, and delivery upgrades as described in the DOD software pathway policy. The program manager shall implement Agile software approaches wherever feasible.

Source: GAO analysis of Department of Defense (DOD) and military department policies. | GAO-23-105867

USD(A&S) officials explained that they encourage weapon programs to use Agile and other iterative approaches for software development, but do not require them to do so. We previously reported that DOD acquisition policies partially implemented iterative approaches like Agile within most weapon programs.[41] USD(A&S) officials told us they do not currently plan to update these policies with new information regarding metrics for Agile or value assessments. As previously noted, while USD(A&S) officials stated that program managers could optionally tailor in the regulatory information from the software pathway to support the oversight of Agile, obstacles exist to such adoption.

Our prior work regarding best practices for Agile adoption and implementation recommends that programs use appropriate metrics, such as Agile metrics for technical and program management, as well as continuously assess value expected versus value delivered.[42] This gives the organization other measures of progress beyond traditional cost or schedule considerations. Outcome-based metrics track whether software development is achieving desired outcomes. Our prior work also found that without the use of outcome-based metrics and continually assessing the value of what was delivered against user needs, a program using Agile software development might deliver capabilities and features that are not essential to the customer and that could contribute to schedule and cost overruns. DOD has not incorporated oversight of Agile software development into acquisition policy and guidance for all programs using Agile. Without incorporating the oversight of Agile software development into acquisition policy and guidance for all programs, such as the use of metrics, including outcome-based metrics, and continually assessing the value of capability delivered to support iterative software development, acquisition officials may not be able to conduct effective oversight. This could result in greater risk of programs not meeting the needs of operational users in a timely and cost effective manner.

DOD Has Not Enabled the Adoption of Modern Engineering Tools Needed for Agile

DOD has not enabled the adoption of modern engineering tools—such as those used for mission, systems, and software engineering—across all

[41]GAO-22-104513.

[42]GAO-20-590G.

programs. The iterative and relatively fast-paced nature of Agile relies on the use of modern engineering tools to aid in efficiently identifying capability needs, developing a capability, and understanding outcomes. DOD has reported on the importance of the use of modern engineering tools for Agile software development and set the goal of their widespread use. For example, USD(R&E)'s 2018 Digital Engineering Strategy calls for the use of digital engineering tools and advocates for the establishment of a robust infrastructure.[43] Additionally, DOD's Agile pilot program completion report reinforces the importance of modern tools for Agile.[44] However, DOD has not issued an enterprise-wide plan or identified resources that would help support the adoption of modern engineering tools.

Implementing modern engineering tools involves an assortment of costs. These costs may include purchasing and acquiring licenses to use the tools, establishing required infrastructure to use the tools such as networks suitable for the transfer of large amounts of data, and training government and contractor staff to use the tools.[45] Senior Air Force officials responsible for overseeing implementation of modern engineering tools told us that while some large weapon programs are adopting these tools, the military departments have experienced particular challenges in getting smaller weapon programs to adopt the modern engineering tools necessary to efficiently support Agile. These officials explained that it is difficult for program offices to justify investing in and adopting these tools because of the high potential costs and uncertainty of benefits.

DOD officials also explained that many of the benefits of using modern engineering tools are realized or enhanced—and costs reduced—through widespread usage. For example, some programs have requirements that certain components be certified by another organization, such as for security reasons. Senior cybersecurity officials within the Air Force explained that the use of modern engineering tools across organizations could accelerate this process significantly. For instance, with an accurate

[43]Department of Defense, Office of the Under Secretary of Defense for Research and Engineering, *Digital Engineering Strategy* (Washington, D.C.: June 2018).

[44]Department of Defense, *Report to Congress on Software Development Activity Completion Section 874 of the National Defense Authorization Act for Fiscal Year 2018 (P.L. 115-91)* (Washington, D.C.: Oct. 3, 2019).

[45]Modern engineering tools often rely on infrastructure such as network connectivity and cloud environments.

digital model, certifying organizations could focus their reviews on just design changes rather than the entirety of a product when a change is made. Additionally, officials from the Air Force's Digital Transformation Office explained that the costs associated with implementing modern engineering tools—such as licensing—are minimized when tools are implemented collectively rather than individually. DOD's 2019 report to Congress on software development efforts echoed these observations, stating that the lack of existing enterprise solutions across DOD created a quandary for individual programs.[46]

Our review identified several areas of progress related to enabling program use of modern engineering tools. For example, Army officials noted that investment in a cloud environment and its mandated usage had created a more cost-effective option to support engineering for many Army programs. These officials also pointed to another effort within the Army to establish a software engineering platform to meet the needs of multiple aviation programs while reducing cost. Department officials reported that organizations within the Navy and Air Force have made progress in delivering modern engineering tools to multiple programs. However, officials associated with these efforts also acknowledged that additional opportunities existed to reduce costs and improve tool adoption. These officials stated that the development of an overarching plan and identification of resources would also help ensure the effectiveness and longevity of enterprise efforts.

While cost savings from efforts to reduce the total number of tools could be significant, senior engineering officials cautioned against assuming that a single solution across all programs would be practicable. For example, they noted that the engineering tools needed to develop a new cloud-based command and control system are very different from those required to upgrade an existing aircraft. These officials suggested a better approach would be for the military departments to minimize the number of individual program solutions where practicable, and instead invest in making a few solutions available that meet the needs of different types of programs.

Congress has taken steps to facilitate the adoption of modern engineering tools. For example, the James M. Inhofe National Defense Authorization

[46]Department of Defense, *Report to Congress on Software Development Activity Completion Section 874 of the National Defense Authorization Act for Fiscal Year 2018 (P.L. 115-91)* (Washington, D.C.: Oct. 3, 2019).

Act for Fiscal Year 2023 included a provision to support Air Force digital transformation efforts through additional procurement authorities, inclusion of a dedicated program element in budget materials, and a reporting requirement to include review of the market for engineering tools.[47]

Despite some progress, limited adoption of the modern engineering tools that underpin Agile software development could slow the pace of such efforts and require more staff and time to identify mission needs, track progress, and conduct testing. It could also impede timely trade-off and resourcing decisions. Over the longer term, Air Force officials told us that the slow adoption of modern engineering tools could make it harder for the government to retain engineers, if use of these tools lags behind the private sector. The limited adoption of modern engineering tools could ultimately hinder effective implementation of Agile development practices and negate many of their intended benefits.

Our prior work highlighted the importance of developing a plan to achieve organizational objectives, as well defining the desired outcomes and aligning the resources needed.[48] DOD defined its objectives for adopting modern engineering tools and the desired outcomes associated with their use, such as supporting fast-paced development approaches like Agile. However, DOD has yet to develop an overarching plan that identifies the resources necessary to achieve these outcomes across the department. Without developing an overarching plan and identifying the resources needed to adopt modern engineering tools across all programs, DOD risks sporadic adoption of these tools across the department, resulting in increased costs and reduced benefits.

Conclusions

DOD has taken steps to implement Agile principles for weapon system programs using the software acquisition pathway. These steps include the establishment of new requirements and user engagement processes, and program policies and guidance tailored to support oversight of Agile

[47]James M. Inhofe National Defense Authorization Act for Fiscal Year 2023, Pub. L. No. 117-263, § 153(a)-(d) (2022).

[48]GAO, *Government Performance Management: Key Considerations for Implementing Cross-Agency Priority Goals and Addressing GAO Recommendations*, GAO-21-104704 (Washington, D.C.: Sept. 28, 2021); and *Standards for Internal Control in the Federal Government,* GAO-14-704G (Washington, D.C.: Sept. 10, 2014).

software development. However, not all programs that claim to be incorporating Agile use the software pathway to do so. Many rely solely on the requirements processes and acquisition policies established for decades-old waterfall development practices. The ability of these programs to make the necessary shift in culture and use Agile to iteratively deliver working software capabilities to users will languish unless DOD and the military departments take steps to incorporate Agile principles across pathways. Such steps include implementing flexible and timely requirements processes such as a CNS, ensuring regular user involvement and feedback, using appropriate means of oversight such as outcome-based metrics, and regularly assessing the value of delivered capability. Additionally, across the department, the adoption of the modern engineering tools necessary to fully realize the benefits of Agile will be hindered absent an overarching plan—identifying associated resources—to enable their widespread adoption and use.

Recommendations for Executive Action

We are making three recommendations to DOD:

The Secretary of Defense should ensure that the Under Secretary of Defense for Acquisition and Sustainment and the Chairman of the Joint Chiefs of Staff collaborate to incorporate Agile principles into requirements policy and guidance for all programs using Agile for software development. This should include a Capability Needs Statement and User Agreement. (Recommendation 1)

The Secretary of Defense should ensure that the Under Secretary of Defense for Acquisition and Sustainment incorporate oversight of Agile development of software into acquisition policy and guidance for all programs using Agile. This should include use of metrics, including outcome-based metrics, and continually assessing the value of capability delivered to support iterative software development. (Recommendation 2)

The Secretary of Defense should ensure that the Under Secretary of Defense for Research and Engineering, with the input of the military departments, establishes an overarching plan—which identifies associated resources—to enable the adoption of modern engineering tools, across all programs. This should include (1) mission engineering, (2) systems engineering, and (3) software engineering. (Recommendation 3)

Agency Comments and Our Evaluation

We provided a draft of this product to the Department of Defense for comment. In its written comments, reproduced in appendix I, DOD partially concurred with our three recommendations.

DOD partially concurred with our first recommendation to incorporate Agile principles into requirements policy and guidance for all programs using Agile for software development. In its written comments, DOD agreed to clarify requirements policy to provide guidance on using an acquisition Capability Needs Statement (CNS) and User Agreement for development of software that is embedded within an already validated requirements document without needing additional requirements validation. We believe that this planned action, if implemented, would address our recommendation to incorporate Agile principles into requirements policy and guidance for this subset of programs.

However, DOD stated that for programs that are focused on software and have minimal hardware development, the Information Systems Initial Capabilities Document or Information Systems Capability Development Document (CDD) already provide a requirements process with delegated authority for rapid software development. While these processes may involve some streamlining, we note that USD(A&S) software pathway guidance states that the CNS captures high-level needs and provides greater speed and flexibility than the Information Systems Initial Capabilities Document. This guidance also illustrates how an existing software-centric program with an Information Systems Initial Capabilities Document or an Information System CDD can transition to a CNS to capture the scope of software needs going forward and provide the acquisition team with greater flexibility to meet current priority needs. Therefore, we continue to believe that the requirements processes for such programs would benefit from further incorporation of Agile principles.

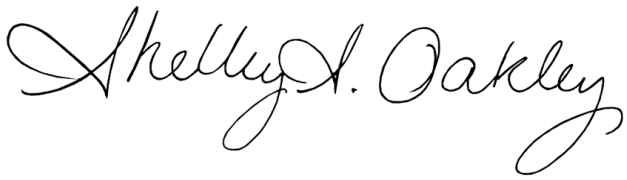
DOD partially concurred with our second recommendation to incorporate oversight of Agile development of software into acquisition policy and guidance for all programs using Agile. In its written comments, DOD agreed to consider changes within each acquisition pathway to amplify tailoring considerations for programs developing software, and it will address any necessary changes through standard processes for updating DOD policy. Current policy allows programs on other pathways to tailor in information from the software pathway to support the oversight of Agile. As we noted in the report, without an explicit framework linking program

characteristics with tailoring options, program managers will continue to face institutional obstacles when attempting to incorporate oversight approaches from the software pathway. In order to address this concern, DOD should ensure that all programs using Agile have policy and guidance that encourages the use of oversight approaches tailored to their program, to include using outcome-based metrics and continually assessing the value of capability delivered to support iterative software development.

DOD partially concurred with our third recommendation to establish an overarching plan—which identifies associated resources—to enable the adoption of modern engineering tools, across all programs. DOD agreed with the need for modern engineering tools across all programs and stated the department would develop an overarching plan in conjunction with the military departments, with USD(R&E) actively supporting implementation efforts through working groups and relevant policy and guidance development. However, DOD disagreed that a single overarching plan will address the issue and stated that such a plan cannot provide a single source of resources needed for implementation. Our recommendation provides DOD flexibility to assign responsibility for implementation and resourcing between USD(R&E) and the military departments as DOD deems appropriate. In addition, our recommendation encourages a department-wide approach to ensuring tool adoption across all programs in order to ensure their widespread use and full realization of their benefits.

We are sending copies of this report to the appropriate congressional committees and the Secretary of Defense. In addition, the report will be available at no charge on GAO's 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 II.



Shelby S. Oakley
Director, Contracting and National Security Acquisitions

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Appendix I: Department of Defense Comments

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE
3600 DEFENSE PENTAGON
WASHINGTON, DC 20301-3600

ACQUISITION

JUN 2 6 2023

Ms. Shelby Oakley
Contracting and National Security Acquisitions
U.S. Government Accountability Office
441 G St NW
Washington, DC 20548

Dear Ms. Oakley,

This is the Department of Defense (DoD) response to the Government Accountability Office (GAO) Draft Report, GAO-23-105867 "DEFENSE SOFTWARE ACQUISITIONS: Changes to Requirements, Oversights, and Tools Needed for Weapons Programs" dated May 26, 2023 (GAO Code 105867).

The Department is committed to acquisition reform and continual improvement for all of our systems with software-defined capabilities. While DoD has made great strides to date, we understand that transformation is a long journey, and we will continue pushing to make even greater progress. We agree with GAO on the importance and scope of the challenges ahead.

The Department's response to each GAO recommendation is enclosed. The Software Modernization Senior Steering Group will lead the Department's collaborative work, addressing key aspects of the recommendations through the Department's Software Modernization Strategy and the associated implementation plan.

The Department appreciates the opportunity to review the Draft Report. My point of contact for this effort is Mr. Scott Smith, (571) 388-8978.

Sincerely,

Tanya M. Skeen
Performing the Duties of Assistant Secretary
of Defense for Acquisition

Enclosure:
As stated

GAO DRAFT REPORT DATED JULY 1, 2023
GAO-23-105867 (GAO CODE 105867)

"DEFENSE SOFTWARE ACQUISITIONS: CHANGES TO REQUIREMENTS, OVERSIGHT, AND TOOLS NEEDED FOR WEAPON PROGRAMS"

DoD RESPONSES TO THE GAO RECOMMENDATIONS

RECOMMENDATION 1: The Secretary of Defense should ensure that the Undersecretary of Defense for Acquisition & Sustainment and the Chairman of the Joint Chiefs of Staff collaborate to incorporate Agile principles into requirements policy and guidance for all programs using Agile for software development. This should include a Capability Needs Statement and User Agreement.

DoD RESPONSE: PARTIALLY CONCUR. Requirements policy will be clarified to provide guidance on using an acquisition Capability Needs Statement (CNS) and User Agreement for development of software that is embedded within an already validated requirements document without needing additional requirements validation. For standalone software development, the Software Initial Capabilities Document (ICD) provides the requirements validation process for use of Agile software development. For programs that are software focused with minimal hardware development, the Information Systems ICD or Information Systems Capability Development Document already provide a requirements process with delegated authority for rapid software development.

RECOMMENDATION 2: The Secretary of Defense should ensure that the Undersecretary of Defense for Acquisition & Sustainment Incorporate oversight of Agile development of software into acquisition policy and guidance for all programs implementing Agile. This should include use of metrics, including outcome-based metrics, and continually assessing the value of the capability delivered to support iterative software developed.

DoD RESPONSE: PARTIALLY CONCUR. The Department will consider whether changes are needed within the context of each pathway to amplify tailoring considerations for programs with software and then address any necessary changes through standard processes for updating DoD policy.

RECOMMENDATION 3: The Secretary of Defense should ensure that the Undersecretary of Defense for Research and Engineering, with the input of the military departments, establishes and overarching plan – which identifies associated resources – to enable the adoption of modern engineering tools, across all programs. This should include (1) mission engineering, (2) systems engineering, and (3) software engineering.

DoD RESPONSE: PARTIALLY CONCUR. The Department agrees that there is need of modern engineering tools across all programs including mission engineering, systems engineering and software engineering. However, the Department does not agree a single overarching plan will address the issue nor can it provide a single source of resources needed to implement. The realization of engineering tool modernization is in the scope of each Service.

The overarching plan will be developed in conjunction with the Services and R&E will actively support implementation efforts through working groups and relevant guidance and policy development.

Text for Appendix I: Department of Defense Comments

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE
ACQUISITION
3600 DEFENSE PENTAGON
WASHINGTON, DC 20301-3600

Ms. Shelby Oakley
Contracting and National Security Acquisitions
U.S. Government Accountability Office
441 G St NW
Washington, DC 20548

JUN 26 2023

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Performing the Duties of Assistant Secretary of Defense for Acquisition

Enclosure:

As stated

GAO DRAFT REPORT DATED JULY 1, 2023

GAO-23-105867 (GAO CODE 105867)

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Appendix II: GAO Contact and Staff Acknowledgments

GAO Contact

Shelby S. Oakley at (202) 512-4841 or oakleys@gao.gov.

Staff Acknowledgments

In addition to the contact named above, Robert Bullock, Assistant Director; Brian D. Fersch, Analyst-in-Charge; Walker Adams; Rebecca Gertler; and Sean Seales made key contributions to this report. Other contributors included Lorraine Ettaro; Stephanie Gustafson; Michael Holland; Tonya Humiston; Jennifer Leotta; Sally Newman; and Christine Pecora.

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