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DOD Current and Planned Software Modernization Efforts

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Abstract

To respond to evolving threats, DOD must develop and deliver software-based weapon and IT systems quickly. In April 2023, GAO published a report examining the extent to which DOD implemented software modernization recommendations from the Defense Science Board and Defensive Innovation Board and positioned itself to pursue future software modernization reforms. In large part, these recommendations—and DOD's planned and ongoing efforts—focused on providing innovative software-based capabilities to the warfighter by tailoring DOD's traditional processes, such as streamlining acquisition processes, employing digital transformation, piloting novel funding approaches, and providing just in time training. Drawing on recent GAO work, this presentation will focus on DOD's efforts to date to modernize how it develops and acquires software and will also offer observations on DOD's planned software modernization efforts and GAO's recommendations to improve DOD's ability to implement them.

Keywords: Software, modernization, acquisition

Background

For years, commercial companies have recognized the value of software for providing new capabilities to consumers. According to the DSB and DIB, the commercial industry has developed leading practices that foster quicker, more cost effective software development, which allows for the speedier delivery of new capability to users and consumers.

DOD has also recognized software as an increasingly critical element for meeting weapon systems' requirements. However, 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 systems. Other recent studies, such as the 2018 DSB and 2019 DIB reports, also found deficiencies in software development and acquisition practices within DOD, such as outdated acquisition processes and delays in delivering software to users.

Agile Software Development

Modern approaches to software delivery rely extensively on Agile development. Agile development is a flexible, iterative way of developing software that delivers working capabilities to users earlier than traditional DOD software development processes, known as the waterfall approach. In most instances, adopting Agile methods involves new behaviors and a different mindset, which is a major shift in how an organization operates. For example, Agile practices call for the integration of planning, design, development, and testing into an iterative life cycle to deliver software early and often, ranging from every few days to every 60 to 90 days. The frequent iterations are intended to effectively measure progress toward delivery of the full suite of capabilities, reduce technical and programmatic risk, and be responsive to feedback from stakeholders and users.

In contrast, under the waterfall approach traditionally used by DOD, requirements are established in advance of development, and software is usually delivered as a single completed program at the end of the development cycle. Software development occurs without continual user involvement or feedback, and programs may not be able to modify

requirements without cost increases and schedule delays. This software development approach mirrored the development of a DOD hardware system. Figure 1 compares Agile and waterfall approaches for developing software.

Agile Iterations

Waterfall Phases
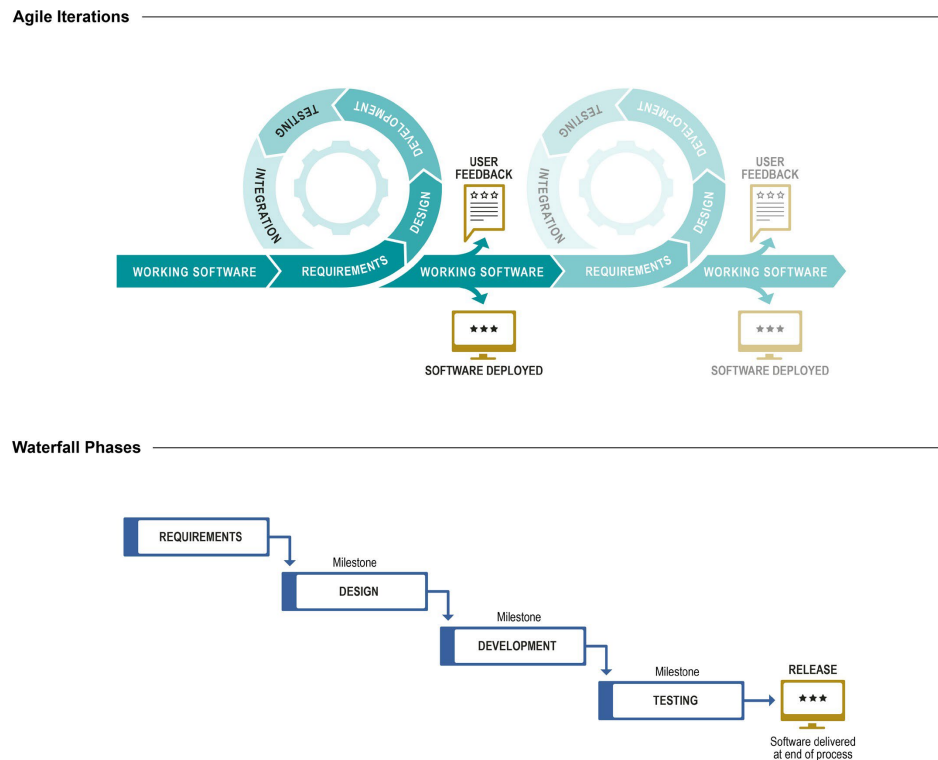
Source: GAO analysis of Department of Defense and U.S. Citizenship and Immigration Services Information. | GAO-23-105611

Figure 1. Comparison of Agile and Waterfall Frameworks for Developing Software

There are numerous frameworks available for Agile programs to use, such as Development, Security, and Operations (DevSecOps), an iterative software development methodology that combines development, security, and operations as key elements in delivering useful capability to the user of the software. These frameworks provide a basic structure to guide projects. Agile, as a concept, is not prescriptive but rather an umbrella term for a variety of iterative software approaches. Each framework is unique and may have its own terminology for processes and artifacts (documents, data, or other information describing what was planned or completed). According to GAO's Agile Assessment Guide, when implementing Agile in the federal environment, both government and contractor staff should work together to define the Agile terms and processes to be used for particular programs. The frameworks are not mutually exclusive and can be combined.

DOD's Software Factory Ecosystem

DOD's software factory ecosystem is a collection of tools and processes that support activities throughout the DevSecOps life cycle. Software factories use cloud-based computing to assemble a set of software tools enabling developers, users, and management to work together on a daily tempo. As shown in figure 2, these tools and processes support continuous iterative development through three key phases: planning, development, and operations, with security emphasized throughout each.
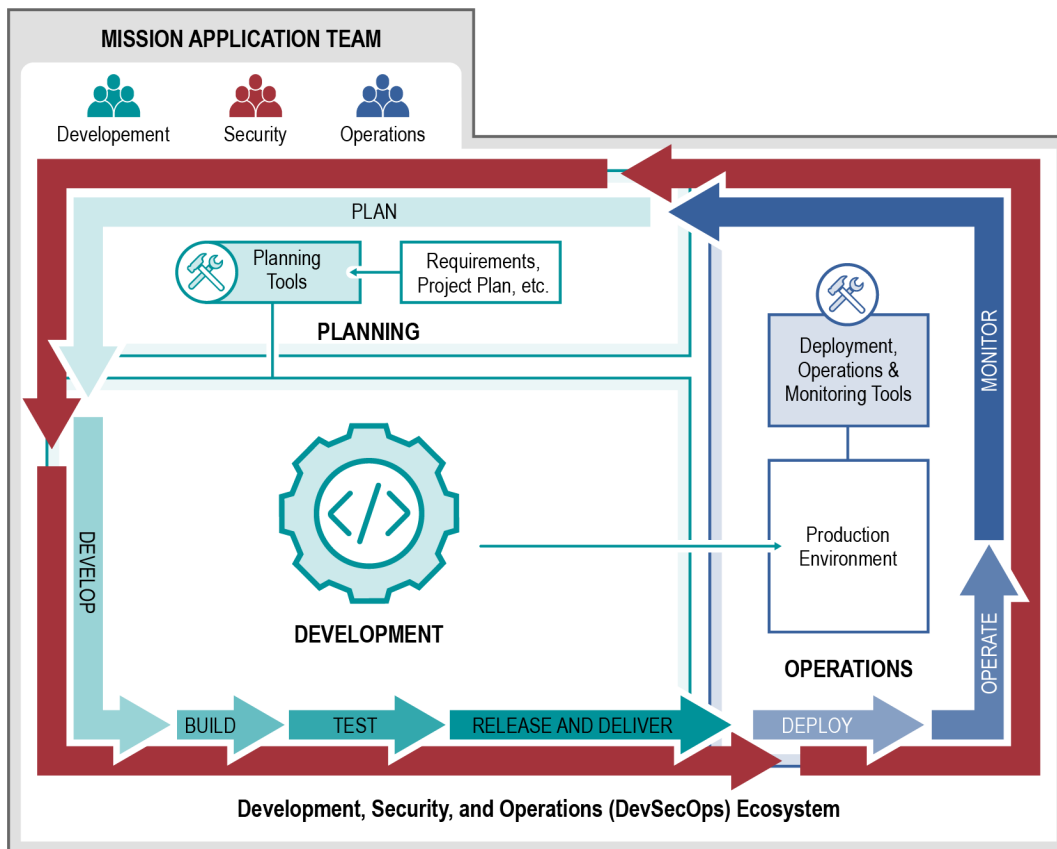
Source: GAO analysis of Department of Defense information. | GAO-23-105611

Figure 2. The Department of Defense's Software Factory Ecosystem

- **Planning.** This phase involves activities that help projects manage time, cost, quality, risk and other issues, such as system design, project plan creation, risk analysis, and business requirements gathering.
- **Development.** This phase contains multiple work streams, equipped with tools and workflows to automate activities with minimal human intervention to produce software applications.
- **Operations.** In this phase, software is deployed to the end user. Among other things, operations and security monitoring are performed during this time.

In February 2018, the DSB stated that software factories are a crucial part of iterative development practices, as they allow programs to identify errors and obtain user feedback continuously.

DOD's Adaptive Acquisition Framework and Software Acquisition Pathway

In January 2020, DOD reissued and updated its acquisition policies, emphasizing speed and agility in the acquisition process. The updated instruction established the Adaptive Acquisition Framework, comprised of six acquisition pathways, each tailored to the characteristics and risk profile of the capability being acquired. These six acquisition pathways are intended to, among other things, deliver solutions to the end user in a timely manner (see fig. 3).
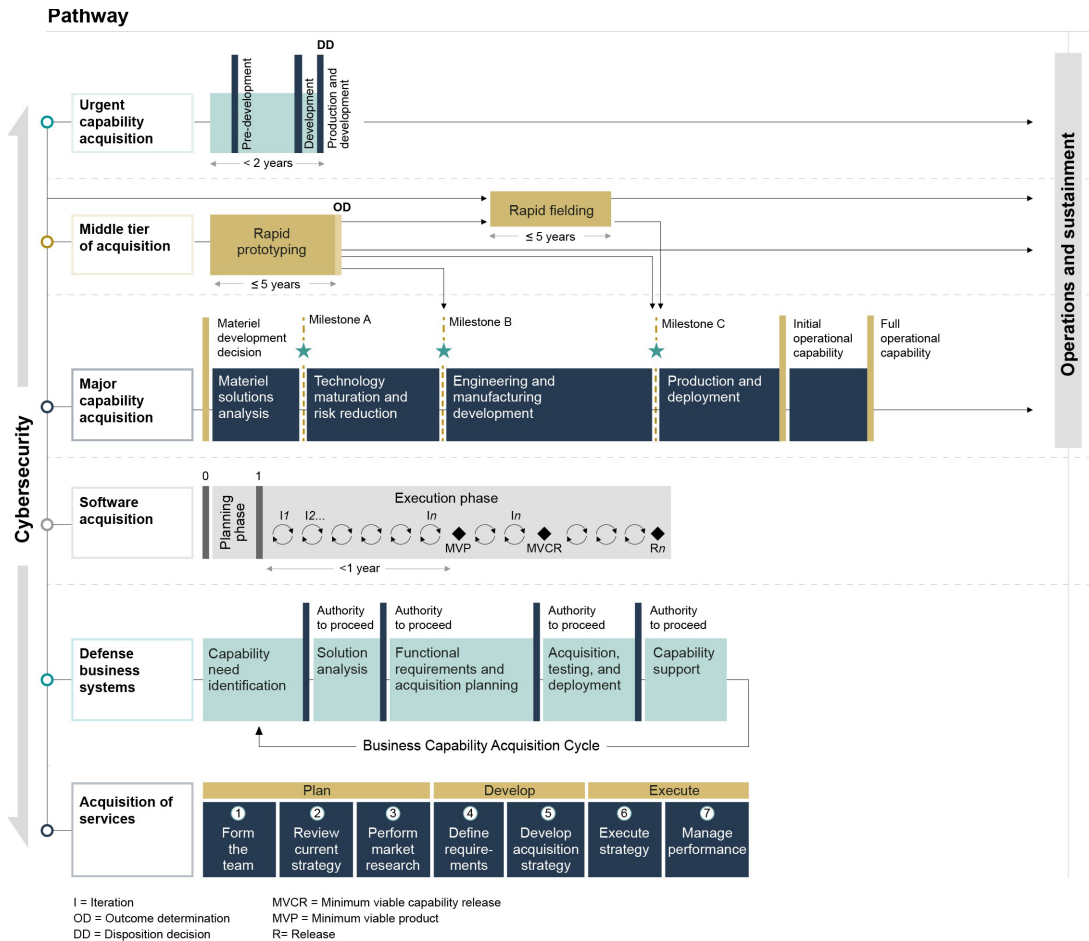
Pathway

I = Iteration
OD = Outcome determination
DD = Disposition decision

MVCR = Minimum viable capability release
MVP = Minimum viable product
R= Release

Source: GAO analysis of Department of Defense (DOD) data. I GAO-23-105611

Figure 3. DOD's Adaptive Acquisition Framework

One of these pathways, the software acquisition pathway, is intended to provide for the efficient and effective acquisition, development, integration, and timely delivery of secure software. Section 800 of the NDAA for Fiscal Year 2020 mandated that DOD develop this pathway. The pathway establishes a framework for software acquisition and development investment decisions that addresses tradeoffs between capabilities, affordability, risk tolerance, and other considerations. It has two phases: planning and execution (see fig. 4).
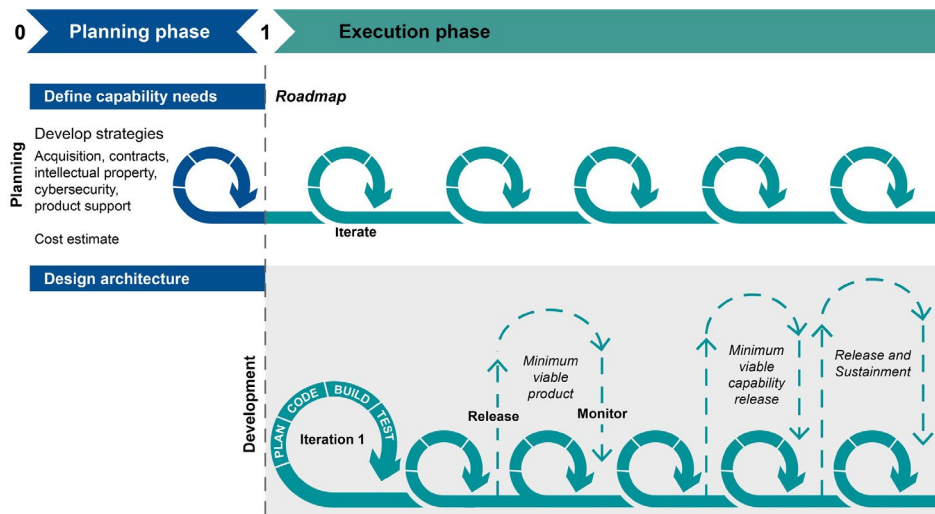
Figure 4. The Department of Defense's Software Acquisition Pathway

Using this pathway, small cross-functional teams—users, testers, software developers, and cybersecurity experts—are expected to be able to deliver software rapidly and iteratively to meet user needs. DOD policy encourages program officials to frequently engage with users and deliver new capabilities to operations at least annually. The instruction implemented recommendations we made in 2019 that DOD ensure its software development guidance provides specific, required direction on the timing, frequency, and documentation of user involvement and feedback. Further, in March 2022, we reported that the instruction generally reflected key product development principles used by leading companies.

While the software acquisition pathway offers a number of potential ways to improve DOD's ability to benefit from modern software development approaches, our recent work also shows that DOD is still determining how it will conduct oversight of the pathway. For example, we reported in June 2021 that DOD had yet to collect the data and develop tools it needed to oversee the programs using the pathway.

In September 2021, DOD stated that it had established a software acquisition pathway data collection strategy and shared it with component headquarters and relevant program offices. In addition, DOD stated that it plans to prepare a semiannual reporting template and collect trial submissions from early pathway programs to gain insights, implement suggestions, and improve the template.

Entities Involved in Software Modernization Efforts

The Under Secretary of Defense for Acquisition and Sustainment (USD(A&S)), the Under Secretary of Defense for Research and Engineering (USD(R&E)), and the DOD Chief Information Officer (CIO) are responsible for leading the coordination of software modernization activities, specifically through the Software Modernization Senior Steering Group (SSG). Among other things, the Software Modernization SSG is intended to promote the adoption of modern software development practices across the department and remove barriers to adoption.

Many other offices within OSD—including Cost Assessment and Program Evaluation (CAPE), and the Director, Operational Test and Evaluation (DOT&E)—as well as Joint Staff, and the military departments also have responsibilities for executing or overseeing certain

aspects of software modernization. These organizations are also represented on the Software Modernization SSG, among others.

Examples of selected responsibilities of these offices related to software modernization include:

- USD(A&S) establishes software acquisition and sustainment policies, such as DOD's software acquisition pathway instruction.
- USD(R&E) establishes policies and advises on all aspects of defense research and engineering and technology development, such as advancing and enabling the rapid transition of software-developed capabilities to acquisition programs of record through research and development and science and technology initiatives.
- DOD CIO develops strategy and policy on the operation of DOD information technology, information systems, and cybersecurity, such as co-leading the development of DOD's Software Modernization Strategy.
- DOT&E establishes DOD testing policies, including DOD Instruction 5000.89, Test and Evaluation, which outlines testing guidance for software acquisition pathway programs.
- CAPE establishes policy on cost estimation and analysis, including DOD Instruction 5000.73, Cost Analysis Guidance and Procedures, which outlines cost estimation guidance for software acquisition pathway programs.
- Joint Staff develops supplemental guidance for requirements validation and reviews software programs for joint requirements.
- Military departments implement DOD software acquisition policy and, acting through the decision authority, oversee software acquisition pathway programs. In addition, military departments develop supplemental software policies and manage their software workforce.

DSB and DIB Software Modernization Recommendations

Established in 1956, the DSB serves as the Federal Advisory Committee chartered to provide DOD leadership with independent advice and recommendations on science, technology, and acquisition processes, among other things. The DSB is comprised of former senior military and government officials as well as leaders from academia and industry.

In February 2018, a DSB task force concluded that DOD can, and should, leverage commercial software development leading practices to its advantage, including on its weapon systems. The DSB study made seven recommendations to DOD. We reported previously that DOD was taking steps to address some of these recommendations. Table 1 provides a list of the seven DSB recommendation topics and the specific recommended actions.

Table 1: GAO Summary of February 2018 DSB Software Modernization Recommendations

Recommendation	Recommended actions
Software factory[a]	- Establish a common list of source selection criteria for evaluating software factories for use throughout the department - Require contractors to demonstrate at least a pass-fail ability to construct a software factory - Review and update source selection criteria every 5 years

Continuous iterative development[b]	• Adopt continuous iterative development best practices for software, including security, throughout the acquisition life cycle • Identify minimum viable product approaches • Delegate acquisition authority to program managers • Require all programs entering system development (Milestone B) to implement iterative processes for acquisition category I, II, and III programs • Identify best practices and incorporate into regular program reviews
Adoption of risk reduction metrics for new programs	• Allow multiple vendors to begin work. After a vendor has demonstrated that work can be done, a down-select should happen. Retain several vendors through development to reduce risk, as feasible • Modernize cost and schedule estimates and measurements and contract with the defense industrial base for work breakdown schedule data to include, among others, staff, cost, and productivity • Build a program-appropriate framework for status estimation
Current and legacy programs in development, production, and sustainment	• Plan for ongoing programs to transition to a software factory and continuous iterative development processes • Require prime contractors for ongoing programs to transition to a hybrid model (i.e., hybrid approach between iterative software development and waterfall) and incorporate continuous iterative development processes into long-term sustainment plans • Make the business case for whether to transition the legacy programs for which development is complete • Provide a quarterly status update on the transition plan for programs to the Under Secretary of Defense for Acquisition and Sustainment • Brief best practices and lessons learned across the military departments from programs that have transitioned successfully to modern software development practices

Workforce	• Develop a workforce that is competent and familiar with current software development techniques
	   • Military departments should acquire or access a small cadre of software systems architects with a deep understanding of iterative development
	   • Services acquisition commands should use this cadre early in the acquisition process to formulate acquisition strategy, develop source selection criteria, and evaluate progress
	• Develop a training curriculum, including software acquisition training, to train this cadre and ensure the program managers of software-intensive programs are knowledgeable about software
	• Direct the Defense Acquisition University to establish curricula addressing modern software practices
	• Brief the Under Secretary of Defense for Acquisition and Sustainment at least annually to demonstrate contractors' progress on adopting modern software practices
	• Hire and train a cadre of modern software acquisition experts from across the military services
	• Create an iterative development integrated product team with associated training

Software sustainment	• Direct that requests for proposals and contractor selection criteria include elements of the software framework supporting the software factory, including code and document repositories and software tools • Require contractors to provide documentation, such as test files and coding, to DOD • Consider selection of contractors based on the ability of DOD to reconstitute a contractor's software framework and rebuild binaries, re-run tests, procedures, and tools against delivered software and documentation
Independent verification and validation for machine learning	• Establish research and experimentation programs around the practical use of machine learning in defense systems with efficient testing, independent verification and validation, and cybersecurity resiliency and hardening as the primary focus points • Establish a machine learning and autonomy data repository and exchange to collect and share necessary data from and for the deployment of machine learning and autonomy • Create and establish a methodology and best practices for the construction, validation, and deployment of machine learning systems

Source: GAO analysis of Defense Science Board (DSB) information. | GAO-23-105611

DIB Recommendations

Established in 2016 under the Federal Advisory Committee Act, the DIB provides independent recommendations to the Secretary of Defense and other senior DOD leaders on emerging technologies and innovative approaches for DOD to adopt. Topics addressed by the DIB include digital modernization, software, and artificial intelligence. The DIB is comprised of national security leaders, including from academia and the private sector.

When necessary, DOD may establish subcommittees and task forces through which the DIB provides recommendations, such as the subcommittee established to examine DOD's software acquisition and development practices. The DIB reports to the Secretary of Defense and the Deputy Secretary of Defense, who may act upon the DIB's recommendations.

In May 2019, the DIB released a report that emphasized the need for DOD to deploy software quickly, focus on continuous improvement throughout the software life cycle, and develop a workforce to follow modern software development practices. The DIB study made 10 primary recommendations to address statutory, regulatory, and cultural hurdles DIB identified that DOD faces in modernizing its approach to software (see table 2).

Table 2: GAO Summary of May 2019 DIB Software Modernization Recommendations

Recommendation	Recommended actions
New acquisition pathway	Establish one or more new acquisition pathways for software that prioritize continuous integration and delivery of working software in a secure manner, with continuous oversight from automated analytics
New appropriation category	Create a new appropriation category for software capability delivery that allows software to be funded as a single budget item, with no separation between research, development, test and evaluation, production, and sustainment
Security considerations	Make security a first-order consideration for all software-intensive systems
Software features	Shift from the use of rigid lists of requirements for software programs to desired features and required characteristics to avoid requirements creep, overly ambitious requirements, and program delays
Digital infrastructure	Establish and maintain digital infrastructure within the Department of Defense (DOD) and the military departments that enables rapid deployment of secure software to the field, and incentivize its use by contractors
Automated testing and evaluation	Create, implement, support, and use fully automatable approaches to testing and evaluation, including security
Authorization to operate (ATO)a reciprocity	Create a mechanism for ATO reciprocity within and between programs, the military departments, and other DOD agencies to enable sharing of software platforms, components, and infrastructure, and rapid integration of capabilities
Source code access	Require access to source code, software frameworks, and development toolchains—with appropriate intellectual property rights—for DOD-specific code, enabling full security testing and rebuilding of binaries from source
Organization of development groups	Create software development units in each military department consisting of military and civilian personnel who develop and deploy software to the field using DevSecOps practicesb
Acquisition workforce and training	Expand the use of training programs for leadership and program managers that provide insight into modern software development and the authorities available to enable rapid acquisition of software

Source: GAO analysis of Defense Innovation Board (DIB) information. | GAO-23-105611

DOD's Efforts to Date At Least Partially Implement All DSB and DIB Recommendations

DOD has taken many steps to facilitate programs' ability to modernize software development and acquisition in recent years, which at least partially implemented all 17 DSB and DIB recommendations. DOD, however, has not implemented all recommended actions. DOD officials told us that, while they are not required to implement these actions because the DSB and DIB are federal advisory boards, they expect they may implement some of them through future software modernization efforts. These officials told us that, in other cases, they have determined that implementing the recommended actions would be impractical.

DOD Has Partially Implemented Most DSB and DIB Recommendations

As shown in table 3, DOD has taken steps that partially address each of the DSB's seven recommendations but has not implemented all specific recommended actions for any of the recommendations.

Table 3: GAO Analysis of DOD Implementation of DSB Software Modernization Recommendations

GAO summary of DSB recommendations	Implementation of specifications
Evaluate software factories in source selection	◐
Adopt continuous iterative development best practices	◐
Adopt risk reduction metrics for new programs	◐
Transition current and legacy programs in development, production, and sustainment to continuous iterative development	◐
Begin workforce hiring and upskilling	◐
Review software sustainment documentation in source selection	◐
Independently verify and validate for machine learning	◐

Legend: ◐ = partially implemented.

Source: GAO analysis of Defense Science Board (DSB) report, Department of Defense (DOD) documents, and interviews with DOD officials. | GAO-23-105611

The following examples highlight actions taken by DOD that align with the DSB's recommendations as well as specific recommended actions DOD has not implemented.

Evaluate software factories in source selection. The DSB recommended several actions related to software factories, such as (1) establishing a common list of source selection criteria for evaluating software factories for use throughout DOD and (2) requiring that contractors demonstrate at least a pass-fail ability to construct a software factory to be considered minimally viable for a proposal. DOD has taken steps to address the recommended actions, but has not fully addressed them. For example, in August 2019, DOD published the Enterprise DevSecOps Reference Design, which establishes guidance for program managers on the DevSecOps ecosystem and life cycle, and applications. The reference design includes some guidance to assess agency and vendor software factories. However, use of the guidance is not required and the guidance does not address whether it should be used as criteria during source selection.

Transition current and legacy programs in development, production, and sustainment to continuous iterative development. The DSB recommended several actions related to transitioning programs to continuous iterative development. These include having ongoing development programs plan to transition to a software factory and continuous iterative development and briefing best practices and lessons learned across the military

departments. DOD has taken steps to address the recommended actions. For example, DOD established policies and guidance related to continuous iterative development for programs within the software acquisition pathway, including a process for new and legacy programs to enter the pathway. DOD has also provided opportunities for programs to provide feedback and lessons learned about the adoption of modern software development practices. For instance, in February 2020, DOD published the Agile Software Acquisition Guidebook. The guidebook covers topics that programs should consider when transitioning to Agile practices as well as iterative development lessons learned from DOD's Agile pilots.

However, DOD has not implemented some of the specific recommended actions. For example, DOD officials stated that they do not intend to direct prime contractors to transition to a hybrid model and adopt continuous iterative development within current contracts, as recommended by the DSB. Officials noted, however, that they agree with the intent of the recommendation and that contractors who propose modern practices for future programs will likely be more competitive than contractors proposing a legacy model.

Begin workforce hiring and upskilling. The DSB recommended several actions related to workforce hiring and upskilling, such as establishing training curricula on modern software practices as well as acquiring and maintaining a small cadre of software systems architects with a deep understanding of iterative development. DOD has taken steps to address the recommended actions. For example, the Office of the USD(A&S) collaborated with the Defense Acquisition University (DAU) to establish training in Agile and DevSecOps methods for DOD software development and acquisition staff, including DOD leadership. In addition, the military departments have also expanded or are planning to expand training opportunities on software intensive systems and practices. For example, the Air Force Institute of Technology provides DevSecOps courses for leadership, including program managers. However, additional work remains for DOD to implement all of the specific recommended actions.

Defense Innovation Board

DOD has taken steps that fully or substantially implement four of the DIB's 10 recommendations and partially implement the remaining six recommendations (see table 4).

Table 4: GAO Analysis of DOD Implementation of DIB Software Modernization Recommendations

GAO summary of DIB recommendations	Implementation of specifications
Create a new acquisition pathway for software	●
Create a new appropriation category for software	●[a]
Prioritize security considerations	●
Shift from system requirements to software features	◐
Use digital infrastructure to enable rapid deployment	◐
Use automated testing and evaluation approaches	◐
Create Authorization to Operate reciprocity between programs, services, and DOD agencies[b]	◐
Use source code access to enable security testing	◐
Use organic development groups to develop and deploy software	◐
Provide acquisition workforce training for leadership and program managers	●

Legend: ● = fully or substantially implemented; ◐ = partially implemented.

Source: GAO analysis of Defense Innovation Board (DIB) report, Department of Defense (DOD) documents, and interviews with DOD officials. | GAO-23-105611

The following examples highlight actions taken by DOD that align with DIB's recommendations as well as specific recommended actions DOD has not implemented.

Create a new acquisition pathway for software. The DIB recommended that DOD establish one or more new acquisition pathways for software that prioritize continuous integration and delivery of working software in a secure manner, with continuous oversight from automated analytics. DOD has addressed the recommendation. For example, in response to a legislative requirement, DOD established a pathway for the timely acquisition of software capabilities by using an iterative approach to software development. DOD's policy for the software acquisition pathway provides opportunities for new and existing programs to join the pathway but does not require its use. Each program following the pathway must develop and track a set of metrics—using automated tools to the maximum extent practicable—to assess and manage, among other things, the performance, progress, speed, and quality of the software development, and the ability to meet users' needs. As of March 2023, there were 49 programs using the pathway.

Create a new appropriation category for software. The DIB recommended the creation of a new appropriation category for software capability delivery that allows software to be funded as a single budget item that could be used for the purposes of research, development, test, and evaluation (RDT&E), production, and sustainment. DOD has substantially addressed the recommendation. In December 2020, the Consolidated Appropriations Act of 2021 established the Software and Digital Technology Pilot Program. The Office of the USD(A&S), in collaboration with the Under Secretary of Defense (Comptroller) (USD(C)), engaged Congress to establish the pilot. The act provides for certain programs to use RDT&E funding appropriated in that act for procurement and sustainment activities. Traditionally, software development programs have funded RDT&E, procurement, and sustainment activities through distinct appropriation categories. This pilot is intended to provide additional funding flexibility for software programs, particularly those using modern software development methods, such as iterative testing.

DOD does not plan for the pilot to be a permanent solution to software funding issues. Rather, DOD views the pilot as an opportunity to test whether the use of a single appropriation category enables modern software development practices. DOD intends to use the pilot for several years and work with Congress to implement a long-term solution based on lessons learned from the pilot. The pilot originally included eight programs. In May 2022, DOD officials told us that Congress has not approved recent requests to include additional pilot programs. However, DOD continues to collect data on the pilot programs to understand the effect of this funding mechanism on software development programs. As explained in the Joint Explanatory Statement accompanying the Consolidated Appropriations Act, 2023, the Secretary of Defense is encouraged to refrain from submitting additional pilot programs in future budget submissions until DOD has demonstrated its ability to collect data on performance improvements resulting from the pilot program.

Use digital infrastructure to enable rapid deployment. The DIB recommended that DOD establish and maintain digital infrastructure within DOD and the military departments that enables rapid deployment of secure software to the field and incentivize its use by contractors. DOD has taken action to address the recommendation but has not fully implemented it.

DOD issued policy and guidance related to establishing and operating digital infrastructure, such as networks and software factories. For example, DOD's September 2019 Enterprise DevSecOps Reference Design provides programs with modern software development techniques that consider security and operations throughout, such as

automated, iterative testing that begins earlier in the process. In addition, this guidance encourages programs to use software factories. DOD has also issued guidance related to the department's cloud infrastructure, intended to provide users and systems with secure internet access to and from unclassified cloud environments. According to DOD officials, each military department has established a cloud environment.

However, additional work remains related to establishing and maintaining digital infrastructure, as outlined in DOD's key strategy documents. For example, while not yet achieved, DOD's February 2022 Software Modernization Strategy establishes several goals:

- accelerating the DOD enterprise cloud environment;
- transitioning from disparate cloud efforts to an integrated cloud portfolio;
- establishing a DOD-wide software factory ecosystem;
- leveraging established software factories; and
- scaling the services across the department.

DOD Plans to Implement Some but Not All Remaining Recommended Actions

Officials from the Office of the USD(A&S) stated that they have addressed the intent of the recommendations from the DSB and DIB reports and do not plan to implement all of the specific recommended actions. According to DOD officials, the department is not required to implement specific actions recommended in the reports because DSB and DIB are federal advisory committees.

DOD officials told us that department-wide actions over the last several years have focused on encouraging—rather than requiring—programs to adopt modern software development and acquisition practices. Officials explained that this approach mitigates challenges with implementing the DSB and DIB recommendations that arose, in part, because older programs were less able to automate security and testing in a way that aligned with modern software development methods.

DOD officials told us they still plan to implement some specific recommended actions through their planned future software modernization efforts. For example, DOD plans additional actions to address DSB's recommendation that the military departments acquire or access a small cadre of software development professionals with a deep understanding of iterative development processes and practices.

According to officials from the Office of the USD(A&S), further planning to implement this part of the recommendation is underway in response to a provision in the NDAA for Fiscal Year 2022.

In other cases, DOD officials told us they chose not to implement the actions for specific reasons, such as the recommended actions being impractical. For example, they noted that DOD does not plan to fully implement the DSB's recommendation on transitioning programs to continuous iterative development. Specifically, DSB recommended that prime contractors—within contract constraints—transition from waterfall to a more iterative software development approach, using a hybrid approach, if necessary, and incorporate iterative development into a long- term sustainment plan. Officials from the Office of the USD(A&S) stated that they do not intend to direct contractors to take these actions because it is unrealistic to do so for a large number of contracts. These officials added that programs can make assessments of individual contracts once they have an understanding of modern software development practices.

DOD's software modernization efforts are still underway, and, moving forward, DOD is focused on continuing efforts in the areas DSB and DIB emphasized. DOD officials stated that, as the department continues its software modernization efforts, they expect that

additional actions recommended by DSB and DIB will be implemented. However, these officials also noted that certain steps recommended by DIB may become outdated as time passes and technology changes.

DOD Is Not Fully Positioned to Implement Future Software Modernization Efforts

DOD has outlined planned actions to continue its software modernization efforts across the department but has yet to incorporate certain key practices our prior work shows could help DOD implement these actions successfully. While DOD's planning incorporated some elements of most of the practices we assessed, we identified gaps in the implementation of several of them.

DOD Plans Outline Transformational Future Software Modernization Efforts

The perspectives of acquisition and T&E decision-makers—*IDSK stakeholders*—form the basis for the IDSK RA viewpoints and corresponding views. A viewpoint as stated in the *Software, Systems, and Enterprise—Architecture Description ISO Standard* (ISO/IEC/IEEE, 2022) establishes the conventions for creating, interpreting, presenting, and analyzing a view to a DOD senior leadership has repeatedly emphasized the importance of ongoing software modernization efforts and the need for the department to take further actions. In a February 2022 memorandum approving the DOD Software Modernization Strategy, the Deputy Secretary of Defense stated that achieving faster delivery of software capabilities requires the combined focus of DOD senior leadership and significant changes in policies, technologies, processes, and workforce.

DOD has detailed its plans for future software modernization efforts in three key department-wide strategies.

- Digital Modernization Strategy. Published in July 2019, this strategy supports implementation of the 2018 National Defense Strategy lines of effort involving cloud, artificial intelligence, command, control and communications, as well as cybersecurity.

- Software Modernization Strategy. Published in February 2022, this strategy is one of a set of sub-strategies of the Digital Modernization Strategy. The strategy provides a framework of technologies, approaches, and processes that must be addressed to modernize software delivery, such as adoption of DevSecOps, process and policy transformation, and workforce.

- Software Science and Technology Strategy. Published in November 2021 in response to a requirement in the NDAA for Fiscal Year 2020, this strategy is intended to guide strategic thinking within DOD to advance and enable the rapid transition of software- developed capabilities to acquisition programs through research and development and science and technology initiatives. According to an official from the Office of the USD(R&E), the goals of this strategy align with the Software Modernization Strategy, but the Software Science and Technology Strategy is focused on the research and development of critical technologies while the Software Modernization Strategy aims to achieve faster delivery of software capabilities in support of DOD priorities.

Together, these strategies document the breadth of DOD's future software modernization efforts. Each plan includes a discussion of the department's vision and goals relevant to the scope of the plan (see fig. 5).

DOD Digital Modernization Strategy	DOD Software Science and Technology Strategy	DOD Software Modernization Strategy
JULY 2019	NOV. 2021	FEB. 2022
Vision Deliver a more secure, coordinated, seamless, transparent, and cost-effective IT architecture that transforms data into actionable information and ensures dependable mission execution in the face of a persistent cyber threat.	**Vision** Deliver resilient software capabilities at the speed of relevance. For instance, modernize development approaches to deliver secure, resilient software capabilities within hours or days rather than months or years.	**Vision** Deliver resilient software capability at the speed of relevance. Resilience implies software that is high-quality to produce a portfolio of software capabilities enabled by DOD processes.
Goals (1) innovate for competitive advantage; (2) optimize for efficiencies and improved capability; (3) evolve cybersecurity for an agile and resilient defense posture; and (4) cultivate talent for a ready digital workforce.	**Goals** (1) incorporate engineering and software development earlier in the acquisition life cycle; (2) adopt an integrated framework of shared resources; (3) transform the software workforce; and (4) align software science and technology with acquisition.	**Goals** (1) accelerate the DOD enterprise cloud environment; (2) establish a department-wide software factory ecosystem; and (3) transform processes to enable resilience and speed.
Intent Provide a roadmap to support the implementation of National Defense Strategy priorities.	**Intent** Address statutory requirements to, among other things, outline a plan to advance and enable the rapid transition of software-developed capabilities to acquisition programs through research and development and science and technology initiatives.	**Intent** Establish a path to deliver resilient software capability quickly. This strategy addresses aspects of the Digital Modernization Strategy.

Source: GAO analysis of DOD documentation | GAO-23-105611

Figure 5: Visions, Goals, and Intent of the Department of Defense's (DOD) Key Software Modernization Strategies

The plans further define each goal through objectives or focus areas. For example:

- To achieve its goal of establishing a department-wide software factory ecosystem, DOD outlines five key objectives in its Software Modernization Strategy, such as advancing DevSecOps through enterprise providers and accelerating software deployment with continuous authorization.

- To achieve its goal of transforming the software workforce, DOD outlines five focus areas in its Software Science and Technology Strategy—training and investing in data science, artificial intelligence, machine learning, and software engineering as well as cultivating a software engineering workforce.

According to DOD, these future software modernization efforts are expected to require sustained effort to fully implement. For example, DOD's Software Modernization Strategy states that software modernization is a continuous journey where success requires action and a shift in mindset and culture. In addition, Office of the USD(A&S) and DOT&E officials said that it will take time to develop and encourage the adoption of Agile software practices across the department and establish supporting infrastructure, such as training the software development, acquisition, and cybersecurity workforce in modern software methods.

DOD Has Yet to Fully Implement Key Practices to Facilitate Future Software Modernization Plans

In its preparation to implement future software modernization efforts, DOD fully or substantially followed two of six, partially followed three, and has yet to implement one of six selected practices that our prior work shows can help agencies implement transformative changes. While DOD incorporated some elements of these four practices, we found gaps in the implementation of each.

DOD has substantially followed key practices related to involving employees and key stakeholders, and employee engagement.

Involving employees and key stakeholders. DOD took steps or developed plans to involve Congress, key stakeholders, such as the private sector, and employees in developing software modernization reforms. Our prior work shows that involving employees and key stakeholders helps facilitate goals, incorporate insights, and increase acceptance of transformation change. Examples of DOD's related efforts include:

- Software acquisition pathway. DOD has continuously involved employees in developing and refining aspects of the software acquisition pathway. OSD established a working group that collaborates with the military departments and other DOD organizations to shape policies and guidance related to the implementation of the pathway, according to officials from the Office of the USD(A&S). Additionally, the Office of the USD(A&S) continues to iteratively deploy guidance to aid programs transitioning to the pathway, including regularly updating policy and guidance and resources for the software acquisition pathway on DOD's Adaptive Acquisition Framework website. Officials from the Office of the USD(A&S) noted that these resources incorporate lessons learned and are intended to aid the software workforce in effectively delivering and acquiring software through the pathway. They added that they also consult directly with programs considering the pathway and plan to continue to do so as the pathway evolves.
- Software and Digital Technology Pilot Program. In December 2020, the Consolidated Appropriations Act of 2021 established the Software and Digital Technology Pilot program. The Office of the USD(A&S), in collaboration with the Office of the USD(C), engaged Congress to help establish the pilot program. Office of the USD(C) officials told us they proposed the single appropriation category to Congress after receiving initial support from within DOD. They noted that they continue to engage with Congress regarding proposals to expand the pilot, which began in fiscal year 2021. However, Congress has yet to approve any additional programs to date. DOD intends to execute the pilot for several years and subsequently work with Congress to implement a long-term funding solution.
- Ignite initiatives. According to officials from the Office of the USD(A&S), they established initiatives—which DOD refers to as ignite initiatives—with a goal of transforming functions such as requirements, cost estimating, and test and evaluation processes for software. The officials said that these initiatives include representatives from Joint Staff, OSD, and the military departments to provide input on policies, processes, and culture to enable modern software delivery.

DOD has also involved industry stakeholders in developing reforms. For example, DOD collaborated with industry to develop the Continuous Iterative Development Measurement Framework, which is a comprehensive set of metrics to evaluate vendor software factories.

DOD also has plans to involve additional stakeholders in future reforms, such as by partnering with industry to improve contracting processes and ensure access to enterprise cloud services. Two of DOD's key strategies establish goals and objectives related to working with industry, such as on cloud capabilities. For example, the Digital Modernization Strategy states that DOD will partner with industry to securely deliver cloud capabilities in alignment with mission requirements to achieve its goals. Further, the Software Modernization Strategy notes that DOD must partner with industry to improve contracting processes for cloud services, including a range of enterprise contracts that leverages existing acquisition success while avoiding duplication.

Employee engagement. DOD has taken several actions to sustain and strengthen employee engagement for its future software modernization reforms, such as educating

employees, conducting targeted outreach, and forming working groups. Our past work emphasizes the importance of this step because people define the organization's culture and drive its performance. Examples of DOD's efforts to engage employees include:

- DOD has communicated with employees on software modernization reform efforts. For example, the Office of the USD(A&S) performed outreach to and developed guidance for individual program offices to facilitate their transition to modern software approaches. OSD offices also offered training, such as through conferences and webinars, to educate the workforce on modern software approaches and why and how DOD needs to fundamentally transform the way it develops and acquires software.
- DOD and the military departments encourage participation in software communities of practice to share best practices and lessons learned on modern software approaches.
- According to an official from the Office of the USD(R&E), the office continuously engages with software factory stakeholders, such as the Office of the USD(A&S), DOD CIO, and software acquisition programs, at formal presentations and forums to understand what support software factories need from OSD organizations. These discussions include working with programs to help eliminate barriers for software factories.
- The Software Modernization SSG established an Action Officer Working Group that includes representatives from across DOD organizations and the military departments to help coordinate future software modernization initiatives.

DOD Developed Outcome- Oriented Goals but Has Yet to Establish Performance Measures

DOD has partially followed a key practice related to establishing goals and outcomes. Our past work has found that agencies should establish clear outcome-oriented goals to help identify what they are trying to achieve with their reform efforts and should establish performance measures to assess the extent to which they are meeting their goals. DOD's key department-wide strategies for software modernization establish clear outcome-oriented goals and objectives that align with DOD's mission and strategic plans, such as the National Defense Strategy. For example:

- DOD's Digital Modernization Strategy outlines a goal to preserve and expand the U.S. military's competitive advantage against adversaries. This goal depends on the United States' ability to deliver technology faster, a theme throughout the 2018 National Defense Strategy. Specifically, the National Defense Strategy notes that continuously delivering performance with affordability and speed is a defense objective.
- DOD's Software Modernization and Science and Technology strategies state that software modernization requires the department to transform its software workforce to adopt the appropriate technical skills, such as equipping software engineers, developers, and testers with modern tool sets, processes, and capabilities. These efforts align with cultivating workforce talent, as discussed in the 2018 National Defense Strategy. Specifically, the National Defense Strategy notes that cultivating a lethal force relies on the ability of warfighters and others in DOD's workforce to integrate new capabilities, adapt warfighting approaches, and change business practices to achieve mission success. The Software Modernization Strategy states that DOD's workforce must understand its role in delivering software, streamline processes, push for automation, and better leverage technology.

However, DOD has yet to establish performance measures to assess progress toward its goals. According to DOD officials, the department is developing implementation plans that are expected to include performance measures. Specifically, officials told us the Software Modernization Strategy implementation plan will include performance measures to assess progress against priority tasks, which track to outcome-oriented goals. DOD officials noted in November 2022 that the Software Modernization Strategy implementation plan is in draft and is expected to be published in the second quarter of fiscal year 2023. The Software Science and Technology Strategy states that its implementation plan will, among other things, establish and define metrics for outcome- oriented goals. According to DOD officials, the Software Science and Technology Strategy implementation plan is being drafted, with an estimated publication date in the first or second quarter of calendar year 2023.

While its plans to include performance measures in implementation plans are a positive step, DOD has yet to identify the steps it will take to develop effective measures. We have previously identified key attributes of successful performance measures, such as linkage to an agency's goals, which help organizations track the progress they are making and assess whether performance is meeting expectations (see appendix VI). DOD's key strategies do not establish any guidelines for the characteristics of performance measures to be developed. DOD officials noted they had yet to determine the particular measures they would use to assess progress against outcome-oriented goals because the plan is still in draft. As DOD finalizes implementation plans for its future software modernization efforts, ensuring that key attributes of successful performance measures are included, as appropriate, will help guarantee that DOD is well positioned to assess progress against outcome-oriented goals. In turn, the ability to assess progress will help DOD course correct, if necessary, to reach the desired software modernization outcomes.

DOD Established an Implementation Team but Has Yet to Fully Identify Resources or Responsibilities

DOD has partially followed a key practice related to leadership focus and attention. Our prior work shows that providing leadership for transformational reforms includes several things, such as establishing a dedicated implementation team with sufficient resources, designating leaders responsible for implementation, and holding those leaders accountable. DOD has established an implementation team but has yet to identify the resources needed to lead DOD's software modernization efforts or fully determine how it will hold department leaders engaged in these efforts accountable.

Dedicated implementation team with capacity to manage reforms. DOD has established a dedicated implementation team to manage its software modernization reform process. The Software Modernization SSG is the main governance body that oversees and leads the implementation of software modernization reforms across DOD, including activities supporting the Software Modernization Strategy.

While DOD officials told us that individual working groups are assessing the requirements to execute key areas of the Software Modernization Strategy, DOD has yet to take steps to determine whether the Software Modernization SSG as a whole will have the capacity and resources necessary to lead software modernization activities. The Software Modernization SSG relies on its members from OSD organizations, the Joint Staff, and the military departments to identify the resources each member organization is able to devote to support software modernization implementation. DOD officials noted that these entities must balance their own ongoing organizational commitments with available staffing and resources to support software reform efforts.

Identifying needed staffing and resources for DOD's dedicated implementation team could help DOD ensure that the Software Modernization SSG can effectively carry out its leadership role in implementing software modernization efforts.

Assigning leadership roles and responsibilities and holding leaders accountable. DOD's current planning documentation broadly assigns high-level leadership responsibility for implementing software modernization reforms. For example, DOD's Software Modernization SSG is tri-chaired by senior representatives from Offices of the USD(A&S), USD(R&E), and DOD CIO. These organizations are tasked with leading collaboration with other DOD organizations and the military departments as well as making decisions related to DOD's software modernization activities. Additional membership of the Software Modernization SSG includes representatives from across DOD, including DOT&E, CAPE, Joint Staff, and the military departments. These organizations and departments are to provide representation in all efforts pertaining to modern software development and delivery.

DOD's Software Modernization Strategy states that software modernization requires a cohesive departmental effort that involves various DOD organizations. The strategy states that implementation success depends heavily on partnerships and collaboration across the department given the role and pervasiveness of software across mission capabilities and supporting infrastructure. Further, the Deputy Secretary of Defense's February 2022 memorandum approving the strategy stated that all offices and personnel are expected to provide the necessary support for software modernization.

However, DOD has yet to fully develop an approach to hold accountable the many leaders who will need to be involved in implementing software modernization reforms. This is in part because DOD has yet to fully identify in key documents what entities will be involved in executing software modernization efforts and what their specific responsibilities will entail. For example, DOD's current planning documentation, including the Software Modernization and Software Science and Technology strategies, do not address the specific responsibilities of OSD offices with leadership roles or of the military departments and other organizations involved in implementation.

According to DOD officials, once issued, the Software Modernization Strategy implementation plan will identify an Office of Primary Responsibility to support key lines of effort. For example, individual DOD organizations and military departments will be responsible for implementing modern software practices, such as cloud computing and DevSecOps, at the program- and component-levels. The Software Modernization SSG is expected to monitor the efforts of these organizations. Office of the USD(A&S) officials noted that software modernization at DOD relies heavily on the DOD organizations and military departments.

While assigning lead offices is an important step in implementation planning, this approach, as described by DOD, does not ensure that DOD will fully identify the specific roles and responsibilities of leaders involved in transformational software reforms. Until DOD fully identifies the roles and responsibilities for these leaders, DOD will likely be challenged to hold them accountable for implementation.

DOD Is Developing Implementation Plans but Has Yet to Identify Data Collection Methods for Monitoring Progress

DOD has yet to implement a key practice related to managing and monitoring implementation. Our prior work emphasizes the importance of developing an implementation plan with key milestones and deliverables and putting in place processes to collect the needed data and evidence to effectively measure the reforms' outcome-oriented goals. DOD is in the process of developing implementation plans for its key strategies, although these

plans have been delayed from their original planned release dates. Further, DOD has yet to describe how the department plans to collect the data necessary to measure progress in achieving strategic goals.

Developing implementation plans. According to DOD officials, the implementation plans they are developing for the Software Modernization and Software Science and Technology strategies are expected to include key milestones and deliverables to track implementation progress. For example, DOD officials told us that the Software Modernization Strategy implementation plan will include a governance structure to assess, reprioritize, and track progress toward goals, such as measurable deliverables and milestones per activity outlined in strategic goals.

However, DOD has yet to publish these plans and has already delayed its anticipated completion dates for the Software Modernization Strategy. The February 2022 approval memorandum from the Deputy Secretary of Defense for the Software Modernization Strategy directed the delivery of an implementation plan within 180 days, which would have been in August 2022. The planned completion date for this plan has now slipped to the second quarter of fiscal year 2023. According to a DOD official, delays in publishing the implementation plan are due to the need for additional time for internal coordination among DOD leadership to clear for publication. Further, DOD officials told us that the Software Science and Technology Strategy implementation plan is expected to be published after the Software Modernization Strategy implementation plan to, in part, ensure that the goals outlined in both plans align. Given the importance of these plans in helping to manage and monitor implementation, it is essential that DOD finalizes them in a timely manner.

Processes and data to measure effectiveness of reforms. DOD has yet to describe how the department plans to collect the data necessary to effectively assess its progress against performance measures. According to DOD officials, the department plans to collect data to measure performance and expects to analyze it in Advana—DOD's enterprise data platform. However, DOD officials have yet to fully identify the methods they plan to use to collect data across the department or specify how they plan to use the data collected, in part, because DOD's data collection efforts related to software modernization to date have focused on the software acquisition pathway.

DOD Instruction 5000.87, Operation of the Software Acquisition Pathway, requires pathway programs to report data to assess and manage program performance and progress, such as average lead time and value assessment rating. However, software acquisition pathway program metrics and reporting requirements apply to a selected group of programs out of many in the department that are developing or acquiring software. Further, the software acquisition pathway is one component of DOD's software modernization efforts outlined in department-wide software strategies and does not represent the breadth of planned software modernization efforts.

Developing implementation plans for the Software Modernization and the Software Science and Technology strategies and establishing processes to collect the necessary data and evidence will help DOD ensure it is well positioned to measure progress toward implementing its goals.

DOD Has Yet to Conduct Strategic Planning for Its Software Workforce

DOD has partially followed a key practice related to strategic workforce planning. Our prior work has found that agencies should complete this planning to ensure they have the needed resources and capacity to successfully execute reforms. DOD has taken initial steps to identify its software workforce, a crucial effort that must be completed prior to conducting

strategic workforce planning. However, it has yet to determine whether it has the needed workforce resources and capacity to successfully execute planned software modernization reforms.

According to DOD, a workforce skilled in modern software development practices is fundamental to carrying out software modernization efforts. DOD's Software Modernization Strategy states that modern software practices require a shift in DOD's workforce and that developing, training, and recruiting that workforce are critical elements of software modernization. Both DOD's Software Science and Technology and Digital Modernization strategies identify transforming DOD's software workforce as a key goal.

Identifying the software workforce. DOD is taking initial steps to identify the makeup of its current software workforce. According to officials from the Office of the USD(A&S), determining the composition of the software workforce, such as identifying DOD professionals that currently make up the software workforce and the additional roles that would be needed to successfully adopt department-wide reforms, has been a challenge. A 2020 RAND study noted that DOD lacks a workforce model that properly supports a software acquisition workforce, such as an official software career field or a system for identifying or tracking software professionals in the department. This study included a recommendation for the department to identify who is in the software acquisition workforce and presented options for DOD to track and manage this workforce.

In July 2021, the department established the Digital Talent Management Forum, which aims to identify and define key software engineering roles needed for modern software delivery, according to DOD officials. These officials noted that the forum is supporting DOD CIO's efforts to expand the DOD Cyber Workforce Framework to include software engineering and software testing roles in the framework's database.

An official from the Office of the Under Secretary of Defense for Personnel and Readiness explained that, through this effort, the department is working to collect data to identify software professionals across DOD's workforce, such as those performing software functions that may not be captured in a job title or occupational series. The official noted that identifying the software workforce is currently a challenge for DOD because software professionals work across many occupational series. Once DOD captures the data, officials expect it will provide department-wide information on the software workforce composition, expertise, and skill sets. DOD officials said this data capture effort is expected to take about 12 to 18 months. The resulting insight into the composition of its software workforce should help DOD determine what resources are needed to support software modernization reforms.

Conducting strategic workforce planning. While identifying the workforce is a critical step, it is only the first step in a longer process to ensure that DOD will have the workforce it needs to execute its software modernization reforms. Key principles for strategic workforce planning in our prior work state that this planning should address two critical needs:

1) aligning an organization's human capital program with its current and emerging mission and programmatic goals and 2) developing long-term strategies for acquiring, developing, and retaining staff to achieve programmatic goals. Figure 6 illustrates the strategic workforce planning process.

DOD has yet to determine how it will execute this broader strategic workforce planning process for its software modernization efforts. DOD officials acknowledged that data collection is only the first step in conducting workforce planning. They noted that once software workforce professionals are properly identified in personnel data, DOD can conduct a workforce capability assessment. However, officials noted that DOD is still in the early

stages of these identification efforts. Similarly, an Office of the Under Secretary of Defense for Personnel and Readiness official noted that DOD is currently focused on elements that must be in place before strategic workforce planning can begin, such as determining the critical skills and competencies the software acquisition workforce needs to achieve programmatic results.

Strategic workforce planning for software modernization efforts is likely to take a number of years and will need to involve the coordinated efforts of management, employees, and key stakeholders across DOD. Developing a department-wide strategic workforce plan for DOD's software workforce—including strategies tailored to address gaps in the critical skills and competencies—will help position DOD to execute next steps in this planning process and achieve future software modernization goals.

Conclusions

DOD has made numerous efforts to modernize its software acquisition and development approaches in recent years, but much work remains in this crucial area. DOD's recently issued software strategies include ambitious goals that are essential to moving from early adoption of modern software practices by selected programs to a lasting, department-wide transformation. Meeting these goals will improve DOD's ability to keep pace with strategic competitors, such as Russia and China.

As DOD begins to translate its goals into action, incorporating key change management practices identified in our past work will help senior leadership oversee continued progress towards software transformation. For example, taking action to develop meaningful performance measures, establish data collection strategies for measuring performance, and finalize implementation plans can help DOD track progress towards achieving and implementing software modernization goals. Moreover, establishing a sufficiently-resourced implementation team and delineating roles and responsibilities associated with software modernization efforts can help ensure that leaders have the resources they need to implement reforms and are held accountable for achieving them.

Further, building a workforce—with critical skills and competencies—that can implement these reforms is foundational to all of DOD's planned actions. Until DOD determines when and how it will conduct effective workforce planning for its software workforce, its ability to implement its planned actions and meaningfully transform its software acquisition practices as intended remains in question.

Recommendations for Executive Action

We are making the following seven recommendations to DOD:

The Secretary of Defense should ensure that, as the Software Modernization SSG and other relevant entities develop performance measures for future software modernization efforts, these measures incorporate GAO's key attributes of successful performance measures, to the extent appropriate, to track progress towards achieving agency goals. (Recommendation 1)

The Secretary of Defense should direct the USD(A&S), USD(R&E), and DOD CIO to identify the resources needed, such as staffing and funding, to lead DOD's software acquisition and development reform efforts, and to address any related deficiencies these officials identify. (Recommendation 2)

The Secretary of Defense should fully identify roles and responsibilities for leaders throughout the department for carrying out reforms included in key software strategies. (Recommendation 3)

The Secretary of Defense should ensure the USD(A&S), USD(R&E), and DOD CIO finalize an implementation plan that includes key milestones and deliverables to track progress on implementing the Software Modernization Strategy. (Recommendation 4)

The Secretary of Defense should ensure the USD(R&E) finalizes an implementation plan that includes key milestones and deliverables to track progress on implementing the Software Science and Technology Strategy. (Recommendation 5)

The Secretary of Defense should direct the USD(A&S), USD(R&E), and DOD CIO to establish processes to collect the data necessary to effectively measure progress against outcome-oriented goals related to software modernization efforts. (Recommendation 6)

The Secretary of Defense should ensure that, once the software workforce is identified, the USD(A&S), the Under Secretary of Defense for Personnel and Readiness, and other relevant entities, use that information to develop a department-wide strategic workforce plan that identifies strategies tailored to address gaps in the critical skills and competencies needed to achieve software modernization goals. (Recommendation 7)