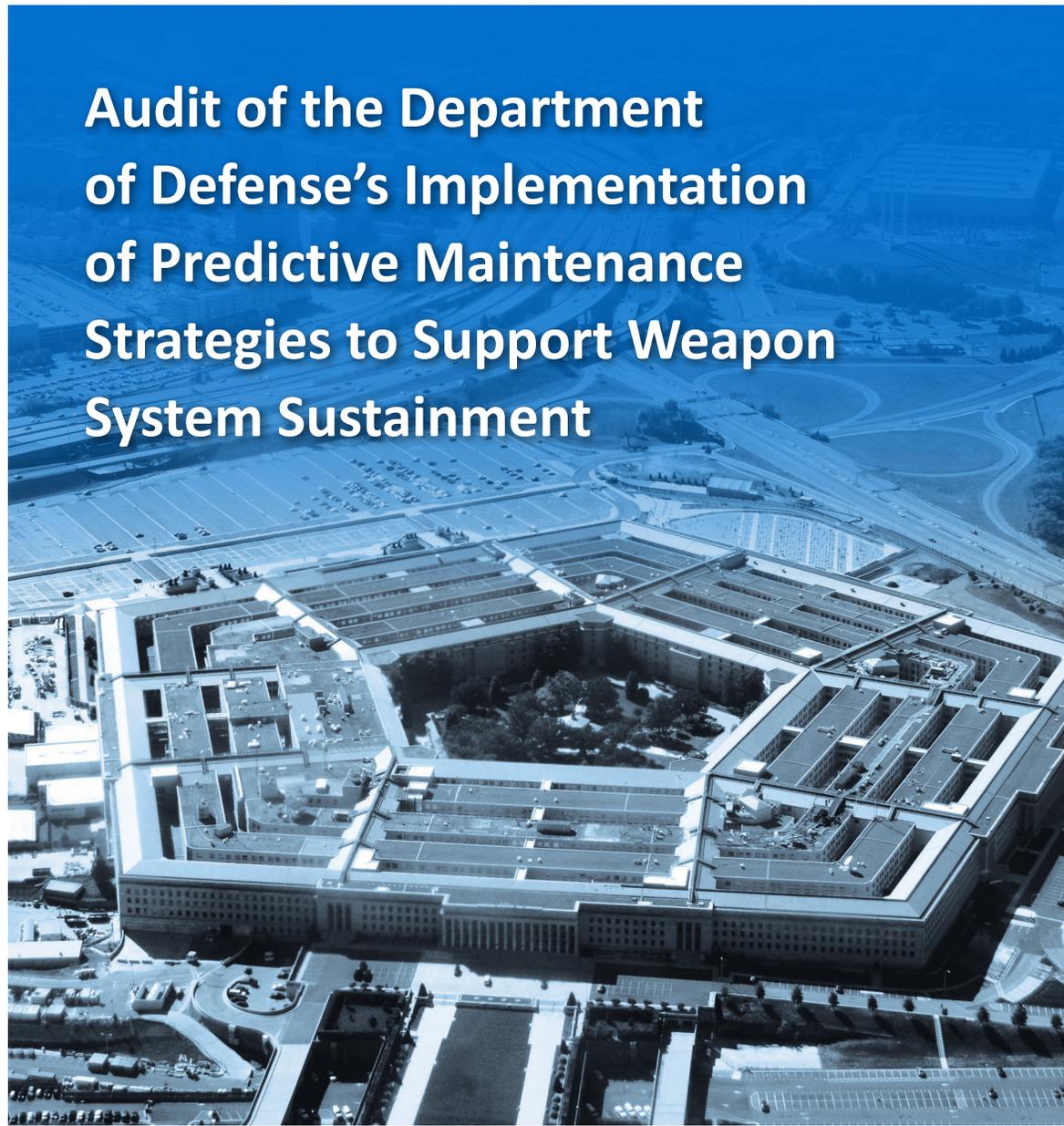




INSPECTOR GENERAL

U.S. Department of Defense

JUNE 13, 2022



Audit of the Department of Defense's Implementation of Predictive Maintenance Strategies to Support Weapon System Sustainment

INTEGRITY ★ INDEPENDENCE ★ EXCELLENCE





Results in Brief

Audit of the Department of Defense's Implementation of Predictive Maintenance Strategies to Support Weapon System Sustainment

June 13, 2022

Objective

The objective of this audit was to determine whether the DoD tracked, monitored, and shared lessons learned regarding impacts of predictive maintenance on weapon system sustainment. Our objective was also to determine whether select predictive maintenance strategies achieved cost and availability goals. However, during the planning phase, we identified that the Services had not fully implemented predictive maintenance strategies.¹ Therefore, we amended our objective to determine the extent that the DoD had implemented predictive maintenance in accordance with guidance.

Background

Materiel maintenance is the work required to keep the DoD's weapon systems and mission support assets in a mission-capable status, therefore ensuring the readiness and sustainability of the DoD's combat forces. Predictive maintenance is a technique used to predict the future failure of a component, so that the Services can plan to replace the component before it fails. Condition-Based Maintenance Plus (CBM+) is the overarching strategy of knowing the condition of parts to reduce or eliminate unscheduled maintenance.

DoD Instruction 4151.22, "Condition-Based Maintenance Plus for Materiel Maintenance," August 14, 2020, states that the DoD will use CBM+ as a primary strategy for

¹ Fully implemented predictive maintenance strategies for the purpose of this report means that parts or components are replaced regularly, based on predictive maintenance forecasts as part of the maintenance strategy and not as part of testing or a pilot program.

Background (cont'd)

achieving cost-effective weapon system life-cycle sustainment. The DoD Instruction requires CBM+ maintenance to be fully integrated in the Joint Capabilities Integration and Development System process for all new weapon systems, and requires the integration of CBM+ technologies and processes in current weapon systems where it is technically feasible, improves materiel availability, and is cost-effective to do so.²

Finding

The DoD has made progress toward implementation of predictive maintenance strategies but has not fully implemented predictive maintenance on any of its weapon systems. In addition, DoD officials did not:

- develop comprehensive strategic plans or policies,
- have full visibility of CBM+ and predictive maintenance projects, or
- develop training tailored to the appropriate levels in the life-cycle sustainment workforce necessary to implement predictive maintenance strategies.

The DoD also identified challenges to implementing predictive maintenance, such as transitioning from a run to failure maintenance culture to a predictive maintenance culture, lack of a standardized method to distinguish parts removed based on forecasts, lack of accurate and usable data and algorithms to make maintenance forecasts, and limited funding and resources.

The DoD's goal is that the Services will implement and execute CBM+ to reduce total life-cycle sustainment cost and minimize unscheduled maintenance. Therefore, the DoD could miss opportunities to decrease maintenance cost and increase weapon system availability if predictive maintenance strategies are not fully implemented across the Services, as appropriate.

² The Joint Capabilities Integration and Development System supports the Chairman of the Joint Chiefs of Staff and the Joint Requirements Oversight Council in identifying, assessing, and prioritizing joint military capability requirements.



Results in Brief

Audit of the Department of Defense's Implementation of Predictive Maintenance Strategies to Support Weapon System Sustainment

Recommendations

We recommend that the Deputy Assistant Secretary of Defense (Materiel Readiness), in coordination with the CBM+ focal points for the Services and other relevant stakeholders, develop and execute a mechanism to report and provide visibility of CBM+ and predictive maintenance projects and tools; and to standardize a method to distinguish parts removed due to predictive maintenance forecasts.

We recommend that the Deputy Assistant Secretary of Defense (Materiel Readiness) continue updating and distribute the DoD "Condition Based Maintenance Plus Guidebook" to reflect updated CBM+ guidance.

We recommend that the Air Force Deputy Chief of Staff for Logistics, Engineering, and Force Protection, and the Army Deputy Chief of Staff for Logistics:

- continue to develop clear and comprehensive guidance for their respective Services' implementation of CBM+ and predictive maintenance that aligns with DoD Instruction 4151.22; and
- develop and tailor training to the appropriate levels in the life-cycle sustainment workforce necessary to achieve effective CBM+ and predictive maintenance implementation.

We also recommend that the Army Deputy Chief of Staff for Logistics continue to develop and implement a clear and comprehensive strategic plan for scaling CBM+ and predictive maintenance across the Army enterprise.

We recommend that the Chief of Naval Operations update Office of the Chief of Naval Operations Instruction 4790.16B to detail the roles and responsibilities of stakeholders, based on guidance provided by DoD Instruction 4151.22.

We recommend that the Deputy Assistant Secretary of the Navy (Sustainment):

- develop and implement a clear and comprehensive strategic plan for scaling CBM+ and predictive maintenance across the Navy enterprise;
- develop and tailor training to the appropriate levels in the life-cycle sustainment workforce necessary to achieve effective CBM+ and predictive maintenance implementation; and
- designate a CBM+ focal point to oversee CBM+ and predictive maintenance implementation across the Department of Navy.

Management Comments and Our Response

The Deputy Assistant Secretary of Defense (Materiel Readiness); the Air Force Assistant Deputy Chief of Staff for Logistics, Engineering, and Force Protection, responding for the Deputy Chief of Staff for Logistics, Engineering, and Force Protection; the Director of Maintenance Policy and Programs, responding for the Army Deputy Chief of Staff for Logistics; and the Director, Fleet Readiness Division, responding for the Chief of Naval Operations, agreed with our recommendations and provided comments and corrective actions to address the recommendations. Therefore, those recommendations are resolved and open. We will close the recommendations once we verify that the agreed-upon actions are complete.

The Deputy Assistant Secretary of the Navy (Sustainment) CBM+ Functional Lead, responding for the Deputy Assistant Secretary of the Navy (Sustainment), agreed and provided comments that addressed the specifics of the recommendations to develop and implement a strategic plan for scaling CBM+ and predictive maintenance and to designate a CBM+ focal point.



Results in Brief

Audit of the Department of Defense's Implementation of Predictive Maintenance Strategies to Support Weapon System Sustainment

Contents (cont'd)

Therefore, these recommendations are resolved and open. We will close these recommendations once we verify that the agreed-upon actions are complete.

The CBM+ Functional Lead disagreed with the training development recommendation, stating that current training resources exist and are already required for practitioners. Comments from the CBM+ Functional Lead did not address the specifics of the training development recommendation. Therefore, the recommendation is unresolved.

We acknowledge that the Naval Air Systems Command, Naval Sea Systems Command, and Marine Corps have varying levels and comprehensiveness of CBM+

training available. However, Systems Command and Marine Corps personnel acknowledged that comprehensive curriculums are still being developed, or that currently available training is not always required. We request that the Deputy Assistant Secretary of the Navy (Sustainment) reconsider this recommendation and assess the availability and adequacy of CBM+ and predictive maintenance training across the Department of the Navy, and develop and tailor additional training, as appropriate.

Please see the Recommendations Table on the next page for the status of recommendations.

Recommendations Table

Management	Recommendations Unresolved	Recommendations Resolved	Recommendations Closed
Chief of Naval Operations	None	5	None
Deputy Assistant Secretary of the Navy (Sustainment)	6.c	6.a, 6.b	None
Deputy Assistant Secretary of Defense (Materiel Readiness)	None	1.a, 1.b, 2	None
Army Deputy Chief of Staff for Logistics	None	4.a, 4.b, 4.c	None
Air Force Deputy Chief of Staff for Logistics, Engineering and Force Protection	None	3.a, 3.b	None

Please provide Management Comments by July 12, 2022.

Note: The following categories are used to describe agency management’s comments to individual recommendations.

- **Unresolved** – Management has not agreed to implement the recommendation or has not proposed actions that will address the recommendation.
- **Resolved** – Management agreed to implement the recommendation or has proposed actions that will address the underlying finding that generated the recommendation.
- **Closed** – DoD OIG verified that the agreed upon corrective actions were implemented.



**INSPECTOR GENERAL
DEPARTMENT OF DEFENSE
4800 MARK CENTER DRIVE
ALEXANDRIA, VIRGINIA 22350-1500**

June 13, 2022

MEMORANDUM FOR DEPUTY ASSISTANT SECRETARY OF DEFENSE (MATERIEL READINESS)
AUDITOR GENERAL, DEPARTMENT OF THE NAVY
AUDITOR GENERAL, DEPARTMENT OF THE ARMY
AUDITOR GENERAL, DEPARTMENT OF THE AIR FORCE

SUBJECT: Audit of the Department of Defense's Implementation of Predictive Maintenance Strategies to Support Weapon System Sustainment (Report No. DODIG-2022-103)

This final report provides the results of the DoD Office of Inspector General's audit. We previously provided copies of the draft report and requested written comments on the recommendations. We considered management's comments on the draft report when preparing the final report. These comments are included in the report.

This report contains one recommendation that is considered unresolved because the Deputy Assistant Secretary of the Navy (Sustainment) CBM+ Functional Lead, responding for the Deputy Assistant Secretary of the Navy (Sustainment), did not agree with the recommendation. Therefore, as discussed in the Recommendations, Management Comments, and Our Response section of this report, the recommendation will remain open. We will track the unresolved recommendation until an agreement is reached on the actions that you will take to address the recommendation, and you have submitted adequate documentation showing that all agreed-upon actions are completed. DoD Instruction 7650.03 requires that recommendations be resolved promptly. Therefore, please provide us within 30 days your response concerning specific actions in progress or alternative corrective actions proposed on the recommendations. Send your response to audacs@dodig.mil.

Management officials agreed with 11 of the 12 recommendations presented in the report; therefore, we consider these recommendations resolved and open. As described in the Recommendations, Managements Comments, and Our Response section of this report, we will close the resolved recommendations when you provide us documentation and we verify that all agreed-upon actions to implement the recommendations are completed. Therefore, please provide us within 90 days your response concerning specific actions in process or completed on the recommendations. Send your response to followup@dodig.mil.

We appreciate the cooperation and assistance received during the audit. Please direct questions to me at [REDACTED]

A handwritten signature in black ink, appearing to read "T M Wimette".

Timothy M. Wimette
Deputy Assistant Inspector General for Audit
Acquisition, Contracting, and Sustainment

Contents

Introduction

Objective.....	1
Background.....	1
Review of Internal Controls.....	8

Finding. Progress Has Been Made, but Additional Work is Needed to Implement Predictive Maintenance

Predictive Maintenance and Condition-Based Maintenance Successes Reported.....	9
The DoD Has Made Some Progress in Updating CBM+ Guidance and Strategic Plans but More is Needed.....	12
The DoD Created a Community of Interest and Collaborated but Did Not Have Full Visibility.....	18
CBM+ and RCM Training Updated but Additional Training Needed.....	20
DoD Components Identified Challenges.....	21
Conclusion.....	23
Recommendations, Management Comments, and Our Response.....	24

Appendix

Scope and Methodology.....	32
Internal Control Assessment and Compliance.....	33
Use of Computer-Processed Data.....	34
Prior Coverage.....	34

Management Comments

Chief of Naval Operations Comments.....	35
Deputy Assistant Secretary of the Navy (Sustainment) Comments.....	36
Deputy Assistant Secretary of Defense (Materiel Readiness) Comments.....	38
Department of the Army Deputy Chief of Staff for Logistics Comments.....	41
Air Force Deputy Chief of Staff for Logistics, Engineering and Force Protection Comments.....	43

Acronyms and Abbreviations..... 44

Introduction

Objective

The objective of this audit was to determine whether the DoD tracked, monitored, and shared lessons learned regarding impacts of predictive maintenance on weapon system sustainment. Our objective was also to determine whether select predictive maintenance strategies achieved cost and availability goals. However, during the planning phase, we identified that the Services had not fully implemented predictive maintenance strategies.³ Therefore, we amended our objective to determine the extent that the DoD had implemented predictive maintenance in accordance with guidance. See the Appendix for our scope and methodology.

Background

Materiel Maintenance

Materiel maintenance is the work required to keep the DoD's weapon systems and mission support assets in a mission-capable status, therefore ensuring the readiness and sustainability of the DoD's combat forces. The two main categories of maintenance are reactive maintenance and proactive maintenance. Service personnel perform reactive maintenance for items expected to run to failure or those items that fail in an unplanned or unscheduled manner. Reactive maintenance of a repairable item is usually unscheduled in the sense that the failure occurred unpredictably and that maintenance restores an item to working condition after the failure has occurred.

Proactive maintenance is either preventive or predictive in nature, and the maintenance performed includes inspection, assessment, prognostic testing (predicting future failures), diagnostic testing (identifying current failures), servicing, and scheduled replacement or overhaul. Preventive maintenance is a technique where Service personnel base their maintenance actions and the replacement of components on calendar time, operating time, or some other periodic measurement. Intervals are determined based on engineering reliability and maintainability analyses, reliability-centered maintenance (RCM) analyses, and historic failure data. RCM is a process for determining maintenance requirements based on the analysis of the likely functional failures of components, equipment, subsystems, or systems having a significant impact on safety, operations, and

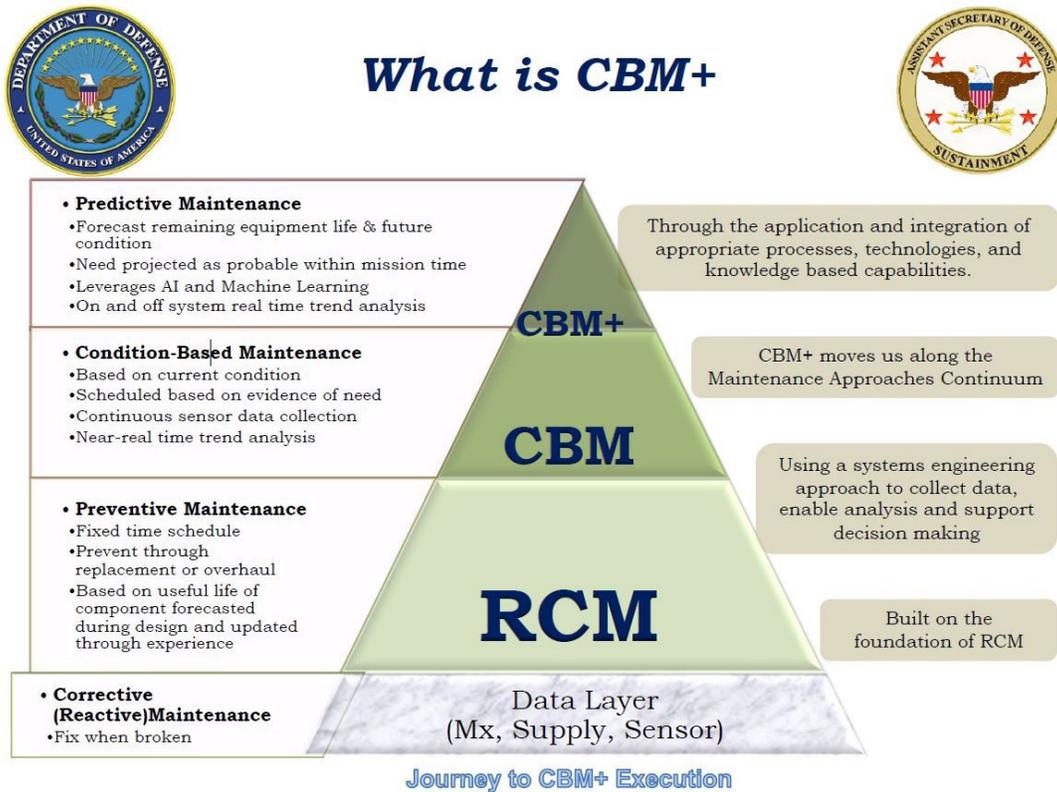
³ Fully implemented predictive maintenance strategies for the purpose of this report means that parts or components are replaced regularly based on predictive maintenance forecasts as part of the maintenance strategy, and not as part of testing or a pilot program.

life-cycle cost. The Services also use condition-based maintenance, which is maintenance performed based on the evidence of need. With condition-based maintenance, personnel monitor the condition of equipment to assess whether it will fail during some future period to take appropriate action to avoid the consequences of that failure. Condition-based maintenance employs real-time or approximate real-time assessments of data obtained from the equipment or external tests and measurements using either test equipment or actual inspection.

Condition-Based Maintenance Plus and Predictive Maintenance

Condition-based maintenance plus (CBM+) is the overarching strategy of knowing the condition of parts to reduce or eliminate unscheduled maintenance. At its core, CBM+ is maintenance performed based on evidence of need, integrating RCM analysis with enabling processes, technologies, and capabilities that enhance the readiness and maintenance effectiveness of DoD systems and components. CBM+ diminishes life-cycle costs by reducing unscheduled maintenance and enabling predictive maintenance. Predictive maintenance is a technique to predict the future failure point of a component, so that the Services can plan to replace the component at an optimal time before the component fails. Predictive maintenance differs from preventive maintenance in that predictive maintenance uses collected data to determine the condition of the component and forecasts the need for maintenance. Figure 1 shows the continuum of maintenance approaches from corrective (reactive) maintenance to predictive maintenance, and some key processes within each approach.

Figure 1. Journey to CBM+ Execution

**LEGEND**

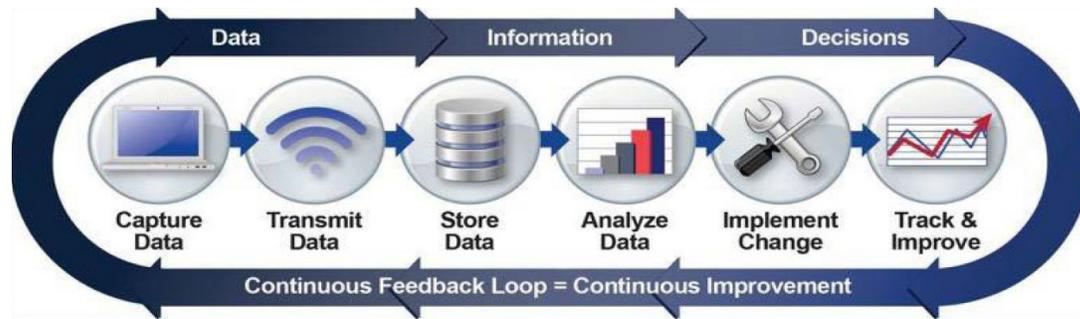
Mx Maintenance

Source: The Office of the Deputy Assistant Secretary of Defense (Materiel Readiness).

Six Functional Activities of CBM+

Six functional activities of CBM+ are necessary to create insight regarding materiel condition and to take appropriate steps to achieve weapon system sustainment goals. The functions begin with the capture of data. According to the Office of the Deputy Assistant Secretary of Defense (Materiel Readiness) (ODASD[MR]), the data may be derived from historical entries, manual inputs, or programmatic transfer from the asset itself. The data is then transmitted to storage where it can be retrieved and analyzed to determine, according to ODASD(MR) officials, the need for maintenance, adjustment of maintenance plans, modifications to predictive algorithms, reliability and maintainability improvements, and other possible improvement actions. Changes to programs are then implemented based on the analysis followed by the track and improve function. The functions are performed in a continuous cycle that, according to the ODASD(MR), when effectively implemented leads to continuous improvements in equipment availability and reliability. Figure 2 shows the six functional activities of CBM+.

Figure 2. Six Functional Activities of CBM+



Source: The Office of the Under Secretary of Defense for Acquisition and Sustainment.

CBM+ History

In 2002, the Deputy Under Secretary of Defense for Logistics and Materiel Readiness directed that a strategy be implemented to improve maintenance agility and responsiveness, increase operational availability, and reduce life-cycle total ownership costs. The DoD issued the first CBM+ policy memorandum in 2002 to set the path to establish broad-based CBM+ capabilities.⁴ In December 2007, the DoD issued DoD Instruction (DoDI) 4151.22, “Condition-Based Maintenance Plus (CBM+) for Materiel Maintenance,” which required the Military Departments and Defense agencies to include CBM+ in the selection of maintenance processes for all new weapon systems and implement CBM+ on current weapon systems when technically feasible and beneficial. After 19 years of DoD and Service-level guidance and policy development, each Service is in a different level of CBM+ implementation.

Roles and Responsibilities

Office of the Under Secretary of Defense for Acquisition and Sustainment

The Under Secretary of Defense for Acquisition and Sustainment reports to the Secretary of Defense on all matters pertaining to acquisition, logistics, and materiel readiness. The Assistant Secretary of Defense (Acquisition) provides oversight and policy direction for the Secretary, Deputy Secretary, and Under Secretary of Defense for Acquisition and Sustainment on matters relating to the DoD’s acquisition system, and is also responsible for the Defense Acquisition University (DAU). The Assistant Secretary of Defense (Sustainment) serves as the principal adviser to the Under Secretary of Defense for Acquisition and Sustainment on logistics and materiel readiness in the DoD. The Assistant

⁴ Deputy Under Secretary of Defense for Logistics and Materiel Readiness memorandum, “Condition Based Maintenance Plus,” November 25, 2002.

Secretary of Defense (Sustainment)'s responsibilities include monitoring and reviewing all logistics, maintenance, materiel readiness, and sustainment support programs within the DoD.

The Deputy Assistant Secretary of Defense (Materiel Readiness) (DASD[MR]) serves under the Office of the Assistant Secretary of Defense (Sustainment). The DASD(MR) is the principal adviser for policies and procedures for maintenance support of major weapon systems and military equipment. The DASD(MR) provides the functional expertise for centralized maintenance policy and management oversight for all weapon systems and military equipment maintenance programs and related resources within the DoD. Specifically for CBM+, the DASD(MR) develops policy, provides guidance, and monitors and reviews implementation and effectiveness of CBM+.

Joint Artificial Intelligence Center

The Joint Artificial Intelligence Center (JAIC) reported to the DoD Chief Information Officer and was established in 2018 to transform the DoD by accelerating the delivery and adoption of artificial intelligence. In 2019, the JAIC implemented two National Mission Initiatives on predictive maintenance and humanitarian assistance and disaster relief. The initiatives were artificial intelligence capability delivery projects focused on predictive maintenance and humanitarian assistance problems that cross the Services. The JAIC was the official focal point of the DoD Artificial Intelligence Strategy. A responsibility of the JAIC was to identify all logistics artificial intelligence efforts across the DoD, including predictive maintenance, and help the Services scale those efforts. However, effective February 1, 2022, the Office of the Chief Data and Artificial Intelligence Officer began serving as the successor organization to the JAIC, reporting directly to the Deputy Secretary of Defense.

Defense Innovation Unit

The Defense Innovation Unit (DIU) reports to the Under Secretary of Defense for Research and Engineering and was established in 2015 to accelerate the adoption of commercial technology to strengthen national security. The DIU partners with Military Departments, combatant commands, and Component organizations to rapidly prototype and deliver commercial solutions that address military challenges across the joint force. The DIU mission includes accelerating DoD adoption of commercial technology, transforming military capacity, and strengthening the national security innovation base. The DIU's work is focused around five technologies—artificial intelligence, autonomy, cyber, human systems, and space.

Air Force CBM+ Focal Points

The Air Force designated two focal points in its CBM+ Strategic Implementation Plan to oversee CBM+ implementation across the Air Force—the Aircraft Maintenance Division for the Directorate of Logistics, Headquarters Air Force; and the Air Force Life Cycle Management Center’s Rapid Sustainment Office (RSO). The Director of Logistics is responsible for, among other areas, providing strategic guidance; developing policy; and overseeing force development for logistics readiness, maintenance, and munitions. The Aircraft Maintenance Division, for the Directorate of Logistics, is ultimately responsible for CBM+ in the Air Force and provides strategic guidance used to guide the CBM+ program.

The RSO transforms the operations and sustainment enterprise by rapidly identifying, applying, and scaling technology essential to the operation and sustainment of the Air Force. The RSO’s focus areas include robotics and automation, advanced manufacturing, and CBM+. The RSO is responsible for CBM+ execution across the Air Force.

Army CBM+ Focal Points

The Army designated three CBM+ focal points that oversee CBM+ implementation, in addition to three subordinate commands that monitor CBM+ implementation for their respective commands. The three designated focal points for CBM+ are the Deputy Assistant Secretary of the Army (Sustainment); the Deputy Chief of Staff (DCS) for Logistics, Maintenance Directorate; and the Army Materiel Command (AMC). The Deputy Assistant Secretary of the Army (Sustainment) develops and oversees Army acquisition policies and life-cycle logistics policies and procedures for materiel development and total life-cycle management of weapon and support systems. In addition, according to Army officials, the Deputy Assistant Secretary of the Army (Sustainment) oversees the implementation of policy through reviews of life-cycle sustainment plans and operational sustainment reviews. Army officials also stated that the DCS for Logistics, Maintenance Directorate, monitors predictive maintenance and CBM+.

The AMC is the executive agent for planning, developing, deploying, and operating the CBM+ enterprise for the Army. The AMC develops and delivers materiel readiness solutions to ensure globally dominant land force capabilities. As the Army’s Lead Materiel Integrator, the AMC manages the global supply chain, synchronizing logistics and sustainment activities across the Army. According to Army officials, the AMC subordinate commands that monitor CBM+ are the Army Tank-Automotive and Armaments Command, Army Aviation and Missile Command, and Army Communications-Electronics Command.

Department of the Navy CBM+ Focal Points

The Assistant Secretary of the Navy (Research, Development, and Acquisition) serves as the Navy Acquisition Executive. The Assistant Secretary of the Navy (Research, Development, and Acquisition) has authority, responsibility, and accountability for all acquisition functions and programs. The Assistant Secretary of the Navy (Research, Development, and Acquisition) establishes policies and procedures and manages the Navy's research, development, and acquisition activities.

The Deputy Assistant Secretary of the Navy (Sustainment) (DASN[Sustainment]) is the principal adviser and coordinator for the Assistant Secretary of the Navy (Research, Development, and Acquisition) on matters pertaining to the Naval Sustainment System, policy, program assessments, affordability, supply chain management, and innovation.⁵ The role of the DASN(Sustainment) is to establish policy to ensure that Naval Sustainment System framework and best practices are tailorable, adaptable, and repeatable across Navy programs. In addition, the DASN(Sustainment) is responsible for reviewing program sustainment plans, performance, and resources. According to Navy officials, as of September 2021, the DASN(Sustainment) assumed the lead secretariat role providing oversight to the acceleration and implementation of CBM+ strategies across the Department of the Navy.

The Navy also designated two CBM+ focal points in the Naval Air Systems Command (NAVAIR) and the Naval Sea Systems Command (NAVSEA). Navy officials stated that the Navy relies on the program executive offices and system commands to implement and monitor CBM+ efforts. The program executive offices coordinate and promote common CBM+ technologies and provide recommendations for further development or improvement. System command leads for CBM+ advise on CBM+ initiatives, including identification of investment cost, readiness improvements, and potential savings.

The Marine Corps designated three CBM+ focal points—the Deputy Commandant for Installations and Logistics (DC I&L), the Marine Corps Systems Command, and the Program Executive Office Land Systems. The DC I&L acts on behalf of the Commandant in designated matters of logistics, policy, and management, and coordinates logistics actions with other agencies. The DC I&L serves as the Total Life Cycle Management Chair and leads CBM+ concept implementation for ground vehicles. The Marine Corps Systems Command ensures that personnel are trained and educated on CBM+. According to Marine Corps officials,

⁵ Naval Sustainment System is a combination of commercial best practices, process improvements, governance, and oversight to maximize efficiencies and effectiveness within available means.

the Marine Corps Systems Command and Program Executive Office Land Systems are the two separate acquisition commands that lead the design, development, production, fielding, and sustainment for all Marine Corps ground systems assigned to their portfolios.

Criteria

The DoD issued DoDI 4151.22, “Condition-Based Maintenance Plus for Materiel Maintenance,” August 14, 2020, DoD Manual 4151.22-M, “Reliability Centered Maintenance,” August 31, 2018, and DoD Directive 4151.18, “Maintenance of Military Materiel,” August 31, 2018, to aid the Services in their implementation and execution of CBM+. DoDI 4151.22 states that the DoD will use CBM+ as a primary strategy for achieving cost-effective weapon system life-cycle sustainment. The DoDI requires CBM+ maintenance concepts to be fully integrated in the Joint Capabilities Integration and Development System process for all new weapon systems, and the integration of CBM+ technologies and processes in current weapon systems where it is technically feasible, improves materiel availability, and is cost-effective to do so.⁶

Review of Internal Controls

DoDI 5010.40 requires DoD organizations to implement a comprehensive system of internal controls that provides reasonable assurance that programs are operating as intended and to evaluate the effectiveness of the controls.⁷ We identified internal control weaknesses related to the DoD’s use of predictive maintenance. Specifically, DoD officials did not develop comprehensive policies or strategic plans, did not have full visibility of CBM+ and predictive maintenance projects, and did not develop training tailored to the appropriate levels necessary to implement predictive maintenance strategies. We will provide a copy of the report to the senior official responsible for internal controls in the Office of the Under Secretary of Defense for Acquisition and Sustainment (OUSD[A&S]) and the Services.

⁶ The Joint Capabilities Integration and Development System supports the Chairman of the Joint Chiefs of Staff and the Joint Requirements Oversight Council in identifying, assessing, and prioritizing joint military capability requirements.

⁷ DoD Instruction 5010.40, “Managers’ Internal Control Program Procedures,” May 30, 2013, (Incorporating Change 1, June 30, 2020). Army officials stated that they have used this information to adjust the maintenance intervals.

Finding

Progress Has Been Made, but Additional Work is Needed to Implement Predictive Maintenance

The DoD has made progress toward implementation of predictive maintenance strategies but has not fully implemented predictive maintenance on any of its weapon systems.⁸ In addition, DoD officials did not:

- develop comprehensive strategic plans or policies,
- have full visibility of CBM+ and predictive maintenance projects, or
- develop training tailored to the appropriate levels in the life-cycle sustainment workforce necessary to implement predictive maintenance strategies.

In addition, DoD officials identified challenges to implementing predictive maintenance, such as transitioning from a run to failure maintenance culture to a predictive maintenance culture, lack of a standardized method to distinguish parts removed based on forecasts, lack of availability of accurate and usable data and algorithms to make predictive maintenance forecasts, and limited funding and resources. The DoD's goal is that the Services will implement and execute CBM+ to reduce total life-cycle sustainment cost and minimize unscheduled maintenance. Therefore, the DoD could miss opportunities to decrease maintenance cost and increase weapon system availability if predictive maintenance strategies are not fully implemented across the Services, as appropriate.

Predictive Maintenance and Condition-Based Maintenance Successes Reported

The Services reported various successes with predictive maintenance and condition-based maintenance. While the Services had not fully implemented predictive maintenance, they were replacing parts periodically based on forecasts, using software and health monitoring tools to improve condition-based maintenance (preventive), or improving predictive forecasts with pilot programs.⁹

⁸ Fully implemented predictive maintenance strategies for the purpose of this report means that parts or components are replaced regularly based on predictive maintenance forecasts as part of the maintenance strategy, and not as part of testing or a pilot program.

⁹ Examples of successes reported in this section of the report are not all inclusive of predictive maintenance and CBM+ efforts across the Services.

The Air Force reported successes with replacing parts periodically based on predictive maintenance forecasts. The Air Force used its CBM+ Toolkit, which had two dashboards tracking maintenance data for weapon systems.¹⁰ According to Air Force RSO personnel, the Air Force maintenance data fed into the enhanced Reliability-Centered Maintenance (eRCM) dashboard to track and forecast maintenance, and sensor data from platforms and components fed into the sensor-based algorithm dashboard. The Air Force used both dashboards to make predictive maintenance forecast decisions and produce monthly reports of how many parts or components personnel removed due to those forecasts. As of January 2022, the Air Force was tracking 16 platforms with its CBM+ Toolkit, including the KC-135 Stratotanker. An Air Force official stated that the Air Force plans to fully transition to a newly developed tool by July 2022 that would track eRCM and sensor-based algorithm forecasts in the same tool, and add more platforms. See Figure 3 for an example of the KC-135 Stratotanker.



Figure 3. KC-135 Stratotanker
Source: The Air Force.

The Army reported successes with condition-based maintenance and progress with predictive maintenance. For example, an Army official stated that the UH-60 Black Hawk platform was equipped with software that understands what the maintenance thresholds are and identifies whether a part is starting to see a negative trend so maintainers can replace that component. The Army official also stated that the Army used this information to improve the maintenance intervals of components. In addition, an Army official stated that the Army worked with the

¹⁰ A dashboard is a graphical report of various data relevant to a particular business or group.

JAIC on the UH-60 Black Hawk for predictive maintenance algorithm development to understand maintenance thresholds.¹¹ See Figure 4 for an example of the UH-60 Black Hawk.



Figure 4. UH-60 Black Hawk
Source: The Army.

The Department of the Navy reported successes with CBM+ implementation, specifically with health monitoring and digital modeling concepts. For example, a NAVAIR official stated that the F/A-18 Hornet used the Hornet Health Assessment and Readiness Tool that identified components experiencing degradation and flagged the part before failure, allowing maintainers to preventatively replace a part before the part failed.¹² Navy officials also stated that NAVSEA used a digital modeling concept to identify potential problems with a system. According to Navy officials, this concept allowed Navy maintainers to reduce the amount of manual inspections and saved hundreds of labor hours. See Figure 5 for an example of the F/A-18 Hornet.



Figure 5. F/A-18 Hornet
Source: The Defense Contract Management Agency.

¹¹ The UH-60 Black Hawk is the Army's utility tactical transport helicopter. It provides air assault, general support, aeromedical evacuation, command and control, and special operations support to combat, stability, and support operations.

¹² The F/A-18 Hornet is an all-weather, twin-engine, mid-wing, tactical aircraft and operates as a fighter escort, and provides fleet air defense and support.

In addition, the Marine Corps reported successes with CBM+ and a predictive maintenance pilot program. The Marine Corps worked with the Army on a contract for providing a prototype of predictive or condition-based maintenance software to improve DoD asset readiness. According to Marine Corps officials, they are working to add data sensors on the Medium Tactical Vehicle Replacement and Joint Light Tactical Vehicle. While speaking of the pilot program, a Marine Corps official added that the contract supports development of a dashboard, which will drive future CBM+ insights and maintenance events. In addition, the Marine Corps official stated that the Marine Corps worked with the contractor to validate predictive maintenance and historical data analysis on the Joint Light Tactical Vehicle and Medium Tactical Vehicle Replacement and planned to use lessons learned from these efforts to expand CBM+ and predictive maintenance throughout the Marine Corps.

The DoD Has Made Some Progress in Updating CBM+ Guidance and Strategic Plans but More is Needed

OUSD(A&S) officials provided more comprehensive CBM+ guidance by updating DoDI 4151.22 in August 2020. The Services differed in the amount of CBM+ and predictive maintenance requirements incorporated into their strategic plans and policies and did not always update their existing policies to align with the more comprehensive DoDI.

CBM+ Guidance Updated

OUSD(A&S) officials updated DoDI 4151.22, “Condition-Based Maintenance Plus for Materiel Maintenance,” in August 2020 to incorporate more comprehensive requirements and guidance for the implementation CBM+ enterprise wide. The CBM+ objective is to reduce unscheduled maintenance and enable predictive maintenance. The DoDI requires that the Military Departments incorporate CBM+ in appropriate policy and guidance. The updated DoDI also requires that the Military Services develop and issue a clear and comprehensive strategy, implementation guidance, and action plans necessary to execute and sustain CBM+. The updated Instruction requires the Services to maximize commonality when integrating CBM+ on similar platforms and components. In addition, the DoDI requires the Services to develop and tailor training to the appropriate levels necessary to achieve effective CBM+ execution.

The ODASD(MR) maintains the “CBM+ Guidebook,” issued in 2008, which provides details on implementing and executing CBM+. ODASD(MR) officials stated that since the release of the updated DoDI 4151.22 on August 14, 2020, they were reviewing and updating the Guidebook in 2021 to capture policy changes and other

improvements. However, as of January 2022, the Guidebook had not been reissued. The DASD(MR) should continue to review and update the “CBM+ Guidebook” to reflect updated DoD CBM+ and predictive maintenance guidance, and distribute the CBM+ Guidebook to responsible Military Service officials for inclusion into their respective policies and guidance.

The Air Force Developed a CBM+ Strategic Plan but Did Not Update CBM+ Policies

The Air Force developed a strategic plan to execute and sustain CBM+. However, the Air Force did not update the policies to include CBM+ execution characteristics or procedures that contribute to both the Service-level CBM+ strategy and the individual weapon systems CBM+ implementation as detailed in the DoDI.

The Air Force issued a strategic plan that provided direction, a structure for action, goals and objectives, roles and responsibilities, and a framework for CBM+ implementation. The Air Force issued the “CBM+ Strategic Implementation Plan” in April 2021 to move away from unscheduled maintenance concepts and adopt predictive, scheduled maintenance practices. The Air Force’s plan provides the conditions for each of the stages of CBM+ implementation, roles and responsibilities for CBM+ stakeholders, and a guide for selection and prioritization of weapon system and component roll out of CBM+ execution. In addition, the Air Force’s Implementation Plan discusses the predictive maintenance alert loop, which allows stakeholders to receive and act upon the results of eRCM analysis or sensor-based algorithms and modules.¹³

The Air Force also issued Service-wide policies for implementing CBM+ but did not provide comprehensive execution procedures in accordance with DoDI 4151.22. Specifically, Air Force Instruction 63-101/20-101 instructs project managers to include CBM+ for all new weapon systems and on existing weapon systems where technically feasible and beneficial.¹⁴ In addition, Air Force Instruction 21-101 states that the Air Force should discuss CBM+ in maintenance production meetings and identifies wing focal points for CBM+ programs. On October 1, 2021, the Air Force issued a guidance memorandum that updates and applies changes to Air Force Instruction 21-101.¹⁵ Those changes to the Instruction include defining CBM+ and requiring that a CBM+ team be assigned per weapon system. However, the Air Force did not update its policies to fully align with DoDI 4151.22, dated August 2020. The updated DoDI 4151.22 requires that the Military Departments

¹³ eRCM uses historical flight, maintenance, and supply records to provide full predictive analytic coverage across a wide variety and large number of components on the asset.

¹⁴ Air Force Instruction 63-101/20-101, “Integrated Life Cycle Management,” June 30, 2020.

¹⁵ Department of the Air Force Guidance Memorandum 2021-01, “Department of the Air Force Guidance Memorandum to Department of the Air Force Instruction 21-101, Aircraft and Equipment Maintenance Management,” October 1, 2021. Department of the Air Force Instruction 21-101, “Aircraft and Equipment Maintenance Management,” January 16, 2020.

incorporate CBM+ in appropriate policy and guidance, taking into consideration CBM+ execution characteristics and procedures detailed in the DoDI. For example, according to the DoDI procedures for incorporating CBM+ on legacy systems, the Services and program managers should pursue CBM+ through examination, evaluation, and implementation in accordance with the CBM+ Guidebook and using guides such as effect analyses and predictive reliability engineering methods.¹⁶ However, Air Force Instruction 21-101, which is the basic Air Force Instruction for guidance on managing weapon system and support equipment maintenance, does not incorporate CBM+ execution characteristics and procedures detailed in the DoDI, nor does it reference the DoDI or CBM+ Guidebook. Air Force officials stated that one of their initiatives includes identification and amendment of policies and directives to align with DoDI 4151.22, as necessary. The Air Force DCS for Logistics, Engineering, and Force Protection should continue to develop and implement Service-level instructions for CBM+ and predictive maintenance, ensuring to detail the roles and responsibilities of stakeholders, based on guidance provided by DoDI 4151.22.

The Army Developed a Strategic Plan but Did Not Update CBM+ Policies

Army officials developed a strategic action plan and implementation plan for CBM+; however, officials were developing a new strategic plan focused on predictive maintenance. In addition, although Army officials established CBM+ requirements, the Army did not update CBM+ policies in accordance with DoDI 4151.22.

Headquarters, Department of the Army, issued a strategic plan with Execution Order 032-19 that includes support for the Army's predictive maintenance overarching strategic vision.¹⁷ The Army established three stages of operation in Execution Order 032-19 that directed execution of the Army's CBM+ mission. However, according to Army officials, the Army decided to redirect the focus from CBM+ to predictive maintenance and artificial intelligence. In addition, the AMC issued the "Army Prognostics/Predictive Maintenance Implementation Plan" in August 2020. The Implementation Plan identified the Army's predictive maintenance lines of effort and responsible offices for predictive maintenance implementation across the Army. The lines of effort are data management, collection, transmission, storage, analysis, and exploitation.

¹⁶ DoDI 4151.22, "Condition-Based Maintenance Plus for Materiel Maintenance," August 14, 2020.

¹⁷ Headquarters, Department of the Army Execution Order 032-19, "Army Implementation and Execution of Condition Based Maintenance Plus (CBM+)," November 2018.

The Army's implementing policy for maintenance, Army Regulation 750-1, includes basic or general requirements to execute CBM+, but it does not provide comprehensive execution procedures in accordance with DoDI 4151.22.¹⁸ For example, the Regulation requires materiel developers to incorporate CBM+ technologies and concepts in the design, development, and improvement of equipment where it is feasible and cost-effective based upon a cost benefit analysis conducted by the program manager. However, the Army Regulation was not updated to incorporate CBM+ execution characteristics and procedures from the updated DoDI 4151.22. For example, according to the DoDI procedures for incorporating CBM+ on legacy systems, the Services and program managers should pursue CBM+ through examination, evaluation, and implementation in accordance with the CBM+ Guidebook and using guides such as effect analyses and predictive reliability engineering methods. However, the Army Regulation does not include details of these procedures or reference DoDI 4151.22 and the CBM+ Guidebook. In addition, the Army Regulation did not provide detailed CBM+ specific roles and responsibilities for identifying, planning, and executing CBM+ on individual platforms. Army officials stated that they developed a predictive maintenance Initial Capabilities Document that is awaiting signature and will update Army policy to advance Army predictive maintenance capability.¹⁹

The Army DCS for Logistics should continue to develop and implement a strategic plan for scaling CBM+ and predictive maintenance across the enterprise and should develop and implement clear and comprehensive implementation guidance for CBM+ and predictive maintenance, ensuring to detail the roles and responsibilities of stakeholders, based on guidance provided by DoDI 4151.22.

The Navy Did Not Develop a Strategic Plan or Update CBM+ Policies, but the Marine Corps Did Develop Comprehensive CBM+ Policies

The Navy did not develop a strategic action plan to execute and sustain CBM+ enterprise wide. In addition, the Navy did not update CBM+ policies in accordance with DoDI 4151.22. However, the Marine Corps did develop comprehensive CBM+ implementation policy.

The Navy did not develop a strategic action plan for CBM+ and predictive maintenance. According to DoDI 4151.22, the Services will develop and issue clear and comprehensive strategy, and action plans necessary to execute and sustain CBM+. However, the Deputy Assistant Secretary of the Navy (Sustainment)

¹⁸ Army Regulation 750-1, "Army Materiel Maintenance Policy," October 28, 2019.

¹⁹ The Initial Capabilities Document quantifies needed capability requirements and gaps associated with operational risks and propose remedies to close or mitigate those gaps.

DASN(Sustainment) did not develop or issue a strategic action plan to execute and sustain CBM+ across the Department of the Navy. In addition, while the other Services had designated CBM+ focal points at the Headquarters level, the Department of the Navy did not. The Navy relied on program executive offices, naval systems commands, and the Marine Corps to implement CBM+ and predictive maintenance without providing strategic guidance. However, in July 2021, the DASN(Sustainment) initiated action to collect information on CBM+ efforts, lessons learned, and barriers to acceleration of CBM+ from senior leaders across the program executive offices, naval systems commands, and the Marine Corps. According to officials from the Office of the DASN(Sustainment), as of September 2021, the DASN(Sustainment) assumed the lead secretariat role, providing oversight to the acceleration and implementation of CBM+ strategies across the Department of the Navy. According to the officials, the DASN(Sustainment) is overseeing pilot programs to understand CBM+ impacts and to determine how to proceed with CBM+ efforts across the Department of the Navy. The officials acknowledged that they had not yet designated a CBM+ focal point office to oversee CBM+ but the DASN(Sustainment) would be the lead until the conclusion of the pilot programs. Furthermore, the Navy did not develop enterprise-wide direction on CBM+ and predictive maintenance implementation. The DASN(Sustainment) should develop and implement a strategic plan for scaling CBM+ and predictive maintenance and designate a CBM+ focal point to oversee CBM+ and predictive maintenance implementation across the enterprise.

The Navy did not update CBM+ policies in accordance with DoDI 4151.22. The Office of the Chief of Naval Operations, NAVSEA, and NAVAIR issued policy and guidance for CBM+ implementation. The Chief of Naval Operations issued Chief of Naval Operations Instruction (OPNAVINST) 4790.16B, which established responsibilities for CBM and CBM+ implementation and integration for naval ships, expeditionary equipment, aircraft, and associated systems, equipment, and infrastructure.²⁰ OPNAVINST 4790.16B was last updated in 2015 and references a 2012 version of DoDI 4151.22. As a result, OPNAVINST 4790.16B does not incorporate guidance from the most recent version of DoDI 4151.22. For example, the updated DoDI 4151.22 requires the Services to develop and issue clear and comprehensive strategy, implementation guidance, and action plans necessary to execute and sustain CBM+. However, OPNAVINST 4790.16B does not include requirements for action plans necessary to execute and sustain CBM+. Furthermore, the roles and responsibilities in OPNAVINST 4790.16B do not reflect the Office of the Chief of Naval Operations reorganization and therefore do not ensure effective CBM+ execution. In addition to OPNAVINST 4790.16B,

²⁰ OPNAVINST 4790.16B, "Condition-Based Maintenance and Condition-Based Maintenance Plus Policy," October 1, 2015.

Naval Systems Commands issued additional CBM+ requirements. For example, on January 21, 2022, NAVSEA issued NAVSEA Instruction 4790.27B, which established and updated policy and responsibilities for integrating RCM, CBM, and CBM+ into the life-cycle maintenance processes for Navy ships.²¹ NAVAIR also issued CBM+ Standard Work Packages that serves as a basis for work description and standardization of CBM+ implementation. One Standard Work Package, “Condition Based Maintenance Plus High-Level Metrics,” provides NAVAIR officials guidance on the development and reporting of condition-based maintenance and CBM+ metrics to show the impact that CBM+ is having on the fleet. While the Navy established CBM+ requirements, the Navy did not update OPNAVINST 4790.16B to incorporate new DoDI 4151.22 requirements and clearly define CBM+ roles and responsibilities based on Office of the Chief of Naval Operations reorganization. The Chief of Naval Operations should update OPNAVINST 4790.16B, ensuring to detail the roles and responsibilities of stakeholders, based on guidance provided by DoDI 4151.22.

The Marine Corps developed comprehensive CBM+ implementation policy. On January 17, 2020, the Marine Corps issued Marine Corps Order (MCO) 4151.22, “Condition Based Maintenance Plus Order,” which directs the Marine Corps to implement CBM+ to integrate predictive maintenance capabilities. The MCO directs the Marine Corps to leverage people, processes, and technologies to integrate CBM+ and RCM in the Marine Corps maintenance program to increase operational availability and support personnel. MCO 4151.22 provided the overarching framework for CBM+ implementation and the roles and responsibilities of CBM+ stakeholders. For example, MCO 4151.22 states that the Deputy Commandant for Installations and Logistics (DC I&L) will lead execution for CBM+ concept implementation and ensure that the appropriate stakeholders adhere to the roles and responsibilities identified in the Order.²² In addition, the policy also states that the DC I&L is responsible for advocating for CBM+ doctrine development and training and education programs. MCO 4151.22 also contains a comprehensive “CBM+ Guidebook,” which explains the tenets of CBM+ and guides CBM+ project development and implementation.

In addition, the Commandant of the Marine Corps directed the Marine Corps to develop a foundation for CBM+ Service-wide with White Letter 2-20, “Achieving Condition Based Maintenance,” dated April 29, 2020. The White Letter establishes that the Deputy Commandant for Combat Development and Integration will integrate predictive maintenance actions across doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policy, with support

²¹ NAVSEA Instruction 4790.27B, “Condition-Based Maintenance Plus and Reliability-Centered Maintenance Policy for Ships, Ship Systems, and Equipment,” January 21, 2022.

²² MCO 4151.22, January 17, 2020.

from the DC I&L and subject matter experts across the Marine Corps. Additionally, the White Letter declares that the Marine Corps would establish baseline methods and processes for CBM+ execution and lay the foundation for scaling CBM+ to the entire Marine Corps.

The DoD Created a Community of Interest and Collaborated but Did Not Have Full Visibility

The ODASD(MR) monitored and supported the Services sharing similarities and lessons learned through a community of interest, and the Services collaborated on some predictive maintenance projects. However, the ODASD(MR) and the Services did not have visibility over all CBM+ and predictive maintenance efforts.

CBM+ Monitored Through a Community of Interest

The ODASD(MR) monitored CBM+ implementation and advocated and facilitated collaboration between the Services through working groups and summits. DoDI 4151.22 requires the Office of the Assistant Secretary of Defense (Sustainment) to monitor and review CBM+ implementation and oversee effectiveness across relevant DoD communities. The ODASD(MR) hosted and facilitated the monthly CBM+ Working Group to share lessons learned across the DoD. The CBM+ Working Group provided Service officials with information related to Service-specific CBM+ implementation and challenges, innovative commercial technologies, and potential resolutions for similar implementation issues. The CBM+ Working Group enabled the Services and the ODASD(MR) to collaborate on CBM+ execution. For example, the Working Group members discussed and collaborated on updating DAU CBM+ related courses, DoDI 4151.22, and the CBM+ Guidebook, and on establishing monthly CBM+ Forums to discuss CBM+ related topics with industry and academia. The Working Group also discussed CBM+ projects, such as the JAIC support of the H-60 platform, according to the minutes. In addition to these efforts, annual Senior Leader Summits provided senior leaders a platform to share CBM+ and predictive maintenance execution successes and strategies. For example, during the October 2019 CBM+ Senior Leader Summit, titled “Going Faster Toward Predictive Maintenance,” the ODASD(MR) and the Services discussed the Services’ CBM+ accomplishments and challenges, such as training, resourcing, and resistance to change across organizational levels.

The DoD Collaborated on Predictive Maintenance Efforts

In addition to attending and participating in the CBM+ Working Group and Senior Leader Summits, the Services collaborated with the DIU, JAIC, and each other on specific predictive maintenance projects. For example, an Air Force official stated that the Air Force worked with the DIU to obtain a contract with

a vendor to develop a CBM+ tool kit. The Air Force official stated that the contract was initially between the vendor and the DIU; however, the RSO contracted with the vendor after the initial contract with the DIU. The Air Force used the CBM+ Toolkit to track maintenance data and forecast when maintenance personnel should remove components and track the number of components removed based on those forecasts. In another example, an Army official stated that the Army collaborated with the JAIC on the UH-60 Black Hawk to collect data to help build algorithms to understand maintenance thresholds that would enable more accurate predictive maintenance forecasts. The Army official stated that the Army selected the UH-60 Black Hawk due to its commonality across the Services. In addition, the Army official stated that the Army collaborated with the JAIC on the Artificial Intelligence Task Force to advocate for predictive maintenance and CBM+, which had the potential to move across to other Services.

According to Service officials, the Services also collaborated on predictive maintenance matters. For example, the Army and Marine Corps worked with a contractor on a predictive maintenance software solution that leveraged historical records and data collected from the vehicle sensors to provide insights into vehicle health on the Army Bradley Fighting Vehicle and the Marine Corps M88 Hercules Armored Recovery Vehicle.²³ See Figures 6 and 7 for examples of both vehicles.



Figure 6. Army Bradley Fighting Vehicle
Source: The Army



Figure 7. M88 Hercules Recovery Vehicle
Source: Marine Corps Logistics Base Barstow.

More Visibility Needed to Enhance Oversight and Maximize Commonality

The ODASD(MR) and the Services did not always have visibility of CBM+ and predictive maintenance efforts across the DoD. The ODASD(MR) is responsible for monitoring and reviewing the implementation of CBM+ and overseeing its

²³ The Bradley Fighting Vehicle is a lightly armored, fully tracked transport vehicle that provides cross-country mobility, mounted firepower, and protection from artillery and small arms fire. The Hercules provides towing, winching, and hoisting to support battlefield recovery and evacuation operations for tanks and tracked combat vehicles.

effectiveness, and the Services are required to maximize commonality when integrating CBM+ technologies, processes, and procedures for similar platforms and components. However, an ODASD(MR) official stated that the ODASD(MR) relied on working groups and summits to receive regular updates for the CBM+ and predictive maintenance efforts of the Services due to a lack of resources to oversee all of the programs. The ODASD(MR) and the Services did not have a mechanism to share all efforts and achievements when integrating CBM+ technologies, processes, and procedures.

As a result, the ODASD(MR) and the Services may not have full visibility over all CBM+ efforts across the DoD, which could limit the ability to maximize commonalities and benefits of lessons learned between the Services when integrating CBM+ technologies, processes, and procedures, in accordance with DoDI 4151.22. Some DoD officials expressed that the DoD would benefit from having an online tool or exchange forum to share CBM+ and predictive maintenance projects, and the ODASD(MR) is working toward identifying an online platform to share information across the Services. The DASD(MR) and the Service-level CBM+ focal points should coordinate, develop, and execute a mechanism to report and provide visibility of CBM+ and predictive maintenance projects and tools.

CBM+ and RCM Training Updated but Additional Training Needed

DoDI 4151.22, updated in August 2020, established responsibilities for integrating CBM+ training at the Assistant Secretary of Defense (Acquisition) level and the Service level. The ODASD(MR) updated two DAU training courses. In addition, each of the Services created some RCM or CBM+ training.

The ODASD(MR) updated DAU courses LOG 0290, “Condition-Based Maintenance Plus (CBM+)” and LOG 0300, “Reliability Centered Maintenance,” in 2020, in accordance with DoDI 4151.22. According to the DoDI, the Assistant Secretary of Defense (Acquisition) must ensure that the DAU integrates CBM+ into training and education. The ODASD(MR) collaborated with the Services to update CBM+ training, which the DAU incorporated into its available course library. The DAU LOG 0290 course provides an overview and introduction to CBM+. The course discusses DoD maintenance, CBM+, CBM+ implementation, managing initiatives, and measuring success. The purpose of the DAU LOG 0300 course is to provide an RCM overview and introduction. The course explains the history and evolution of RCM and the RCM process.

DoDI 4151.22 also requires that the Services develop and tailor training to the appropriate levels necessary to achieve effective CBM+ execution. The DoDI further states that the life-cycle sustainment workforce must understand the principles of RCM, condition-based maintenance, and CBM+ for the continuous improvement of plans and processes that support sustainment of an item during all phases of the life cycle. Each of the Services established some RCM or CBM+ training. However, the Services did not have a comprehensive curriculum for CBM+ implementation and execution required for the appropriate levels necessary to achieve effective CBM+ execution, which was a new requirement in the updated DoDI 4151.22. Necessary levels include stakeholders in offices such as program management, engineering, supply chain, data management, and Service leadership. Comprehensive CBM+ curriculum for every stakeholder will ensure that all necessary levels possess an understanding of CBM+ in order to improve equipment availability or reduce sustainment costs. The Services acknowledged the need for required training at the appropriate levels necessary to achieve effective CBM+ execution. An ODASD(MR) official stated that training and education is one of the biggest factors in successful CBM+ implementation. Without training at all levels necessary, the Services may not be able to achieve effective CBM+ execution. The Services should develop and tailor training to the appropriate levels in the life-cycle sustainment workforce necessary to achieve effective CBM+ and predictive maintenance implementation Service-wide.

DoD Components Identified Challenges

The ODASD(MR) and Services identified challenges impacting the implementation of predictive maintenance across the Services. Examples of these challenges include transitioning from run to failure maintenance culture, lack of a standardized method to distinguish parts removed based on forecasts, lack of availability of accurate and usable data and algorithms to make predictive maintenance forecasts, and limited funding and technical expertise.

Maintenance Culture Transition

With CBM+ and predictive maintenance, the DoD is transitioning from the traditional DoD approach of reactive maintenance and replacing parts after they have failed to the use of predictive maintenance and replacing parts based on predictive forecasts. Service officials have acknowledged challenges with the maintenance culture shift, and senior leaders identified messaging and training as critical areas to address in order to expand predictive maintenance. For example, an Air Force official stated that moving from “fly to fail” to “fly to forecast” maintenance has been challenging. The Air Force official stated that maintainers were not always comfortable replacing a part based solely on computer data

when the part was still functioning properly. Air Force officials noted that they need to ensure that the user and maintainer understand why removal and failure thresholds are set where they are with predictive maintenance forecasts, and that training and policy are needed to assist in changing how they conduct maintenance. Army officials also acknowledged that there will need to be a cultural change across the Army to get buy-in for predictive maintenance and CBM+, noting reluctance from maintainers to replace a part that was forecasted to fail but was still working. Army officials stated they faced challenges with training predictive maintenance at the user level because they would be teaching “theory of operation” with so few systems currently having predictive maintenance capabilities.

In addition, the DoD did not have a universal supply condition code for parts that had not yet failed but were replaced due to predictive maintenance forecasts. Supply condition codes are used to classify materiel in terms of readiness for issue and use or to identify action underway to change the status of materiel. Because parts removed based on predictive forecasts have not yet failed, it is not apparent that the parts will likely soon fail. Therefore, it is important to have a code that specifically identifies the part’s condition. The ODASD(MR) acknowledged the challenge and planned to discuss solutions with an integrated product team with the Services and the Defense Logistics Agency. The DASD(MR) should coordinate with the Service-level CBM+ focal points and other relevant stakeholders to standardize a method to distinguish parts removed due to predictive maintenance forecasts.

Need for Accurate and Usable Data and Algorithms

Predictive maintenance uses data from embedded sensors or historical maintenance records that leverages artificial intelligence and machine learning to forecast the need for maintenance. An ODASD(MR) official stated that a lack of quality data is one of the main issues hindering predictive maintenance implementation. Air Force officials stated that incomplete data and inaccurate data along with lack of automated real time data capturing challenged their predictive maintenance efforts. An Army official discussed the enormous amounts of data needed to populate predictive tools, and the challenge of data storage and distribution to conduct meaningful analysis. The Army official added that artificial intelligence needs to improve to allow for around-the-clock data processing without needing human intervention. Marine Corps officials also stated that manually organizing and analyzing data was a source of lag time. Marine Corps officials stated that access to data was a challenge and that they continued to gather more data and refine algorithms to improve precision.

Need for Funding and Technical Expertise

DoD officials identified limited funding and technical expertise in the workforce as challenges to CBM+ and predictive maintenance implementation. In 2017, the Office of the Secretary of Defense chartered a study in conjunction with the Joint Staff to better understand the value of CBM+, assess implementation effectiveness, and identify and propagate best practices.²⁴ The study highlighted the substantive effort and funding needed to plan, implement, and sustain CBM+. The study also stated that sufficient funding is essential for the development, planning, implementation, and sustainment of any systemic effort like CBM+. The study added that the logistics and acquisition communities continued to address resourcing challenges and learned to prepare detailed business case analyses to inform decision makers of the near-term and far-term costs and benefits, such as the cost to incorporate sensors on systems and components and data warehousing for the data collected and benefit of increased weapon system availability. An ODASD(MR) official stated that personnel can be hesitant when they see a big price tag and no instant results, which was the case with predictive maintenance. The Air Force acknowledged resource challenges in its CBM+ Strategic Implementation Plan, issued in April 2021, which documented plans to roll out CBM+ in phases across individual weapon systems due to funding constraints. The Strategic Implementation Plan noted that more resourcing was needed to expand the analysis capability and fund component modifications. Service personnel stated that resources and changes in processes across the supply chain need to be addressed. Service personnel across the DoD also noted that a lack of appropriate workforce skillsets, such as data analysts to understand the data and algorithms used to make maintenance forecasts, hindered implementation of CBM+ and predictive maintenance strategies. A NAVSEA official further stated that the DoD is in competition with the private sector, which makes it more challenging to recruit and retain data analysts and other skilled workers.

Conclusion

The DoD has made progress toward implementation of predictive maintenance strategies to sustain its weapon systems, and continues to address issues regarding policies and training. However, the DoD needs to complete additional work to successfully achieve predictive maintenance goals. For example, the ODASD(MR) and the Services did not always have visibility over CBM+ and predictive maintenance efforts. In addition, the Services did not always have comprehensive strategic plans or policies necessary to execute and sustain CBM+ and therefore predictive maintenance, and did not develop and tailor training to achieve effective

²⁴ "Condition Based Maintenance Plus (CBM+), Achieving Effectiveness and Implementation Best Practices," July 2017.

CBM+ execution. The DoD also identified challenges to implementing predictive maintenance, such as transitioning maintenance culture and the need for accurate and usable data and algorithms, funding, and other resources.

CBM+ is designed to diminish life-cycle costs by reducing unscheduled maintenance and enabling predictive maintenance. Successful implementation of CBM+ is critical for improving weapon system availability and achieving cost savings across the DoD. The DoD could miss opportunities to decrease maintenance cost and increase weapon system availability if predictive maintenance strategies are not fully implemented across the Services, as appropriate.

Recommendations, Management Comments, and Our Response

Recommendation 1

We recommend that the Deputy Assistant Secretary of Defense (Materiel Readiness), in coordination with the Service-level condition-based maintenance plus focal points and other relevant stakeholders:

- a. **Develop and execute a mechanism to report and provide visibility of condition-based maintenance plus and predictive maintenance projects and tools.**

Deputy Assistant Secretary of Defense (Materiel Readiness) Comments

The DASD(MR) agreed with the recommendation, stating that the ODASD(MR) uses a variety of methods to share CBM+ projects and tools across the Services, such as working groups and forums. However, the DASD(MR) acknowledged that these efforts do not provide a mechanism to report and provide visibility of ongoing efforts for those that do not attend the meetings and forums. The DASD(MR) stated that a portfolio management system for projects, tools, and other information was established in March 2022, and is active and readily accessible across the DoD. Additionally, the DASD(MR) stated that the portfolio management system is expanding to improve reporting and visibility, with full benefits expected by June 30, 2022.

Our Response

Comments from the DASD(MR) addressed the specifics of the recommendation; therefore, the recommendation is resolved and open. We will close the recommendation once we verify that the portfolio management system provides visibility of CBM+ and predictive maintenance projects and tools across the DoD.

- b. **Standardize a method to distinguish parts removed due to predictive maintenance forecasts.**

Deputy Assistant Secretary of Defense (Materiel Readiness) Comments

The DASD(MR) agreed with the recommendation, stating that the ODASD(MR) is coordinating with the Services and considering how to best standardize a method to distinguish parts removed due to predictive maintenance forecasts. The DASD(MR) stated that the Navy, Air Force, and the Marine Corps agreed with the development of a new supply condition code and that coordination with the Army is in process. In addition, the DASD(MR) stated that a new DD Form 1575, "Materiel Condition Tag," is being established to identify those parts through the shipping process and repair cycle, and that the Navy submitted requirements to modify MIL-STD-129, Department of Defense Standard Practice, "Military Marking For Shipment And Storage," to develop the new condition tag. The DASD(MR) also stated that once the new supply condition code is approved, DoD Manual 4140.01, Volume 6, "DoD Supply Chain Materiel Management Procedures: Materiel Returns, Retention, and Disposition," will be updated to formalize definitions, processes, and procedures. The DASD(MR) estimated that these actions will be completed by December 1, 2022.

Our Response

Comments from the DASD(MR) addressed the specifics of the recommendation; therefore, the recommendation is resolved and open. We will close the recommendation once we verify the newly established supply condition code for parts removed due to predictive maintenance forecasts and receive the DD Form 1575, "Materiel Condition Tag," and the updated DoD Manual 4140.01, Volume 6 and verify that they incorporate the new supply condition code definitions, processes, and procedures.

Recommendation 2

We recommend that the Deputy Assistant Secretary of Defense (Materiel Readiness) continue to review and update the DoD "Condition Based Maintenance Plus (CBM+) Guidebook" to reflect updated condition-based maintenance plus and predictive maintenance guidance, and distribute the Guidebook to responsible Military Service officials for inclusion into respective Service-level policies and guidance.

Deputy Assistant Secretary of Defense (Materiel Readiness) Comments

The DASD(MR) agreed with the recommendation, stating that efforts are underway to update the CBM+ Guidebook. The DASD(MR) anticipates that the updates will be completed by September 30, 2022.

Our Response

Comments from the DASD(MR) addressed the specifics of the recommendation; therefore, the recommendation is resolved and open. We will close the recommendation once we receive the updated CBM+ Guidebook and verify that it reflects updated CBM+ and predictive maintenance guidance.

Recommendation 3

We recommend that the Air Force Deputy Chief of Staff for Logistics, Engineering, and Force Protection:

- a. **Continue to develop and implement clear and comprehensive implementation guidance for condition-based maintenance plus and predictive maintenance, ensuring to detail the roles and responsibilities of stakeholders, based on guidance provided by DoD Instruction 4151.22, "Condition-Based Maintenance Plus for Materiel Maintenance," August 14, 2020.**

Air Force Deputy Chief of Staff for Logistics, Engineering and Force Protection Comments

The Assistant DCS for Logistics, Engineering, and Force Protection, responding for the DCS for Logistics, Engineering, and Force Protection, agreed with the recommendation, stating that, during the annual review of the Air Force CBM+ Strategic Implementation Plan, the Air Force will incorporate any changes to DoDI 4151.22.

Our Response

Comments from the Assistant DCS addressed the specifics of the recommendation; therefore, the recommendation is resolved and open. We will close the recommendation once we receive the implementation guidance, directives, or instructions, as appropriate, which detail and clarify stakeholder roles and responsibilities for CBM+ and predictive maintenance, in accordance with DoDI 4151.22.

- b. Develop and tailor training to the appropriate levels necessary to achieve effective condition-based maintenance plus and predictive maintenance implementation.**

Air Force Deputy Chief of Staff for Logistics, Engineering and Force Protection Comments

The Assistant DCS for Logistics, Engineering, and Force Protection, responding for the DCS for Logistics, Engineering, and Force Protection, agreed with the recommendation, stating that the Air Force is working across the Office of Logistics, Engineering, and Force Protection; Air Force Life Cycle Management Center; Air Force Sustainment Center; and the respective Career Field Functionals to ensure CBM+ training is incorporated where applicable.

Our Response

Comments from the Assistant DCS addressed the specifics of the recommendation; therefore, the recommendation is resolved and open. We will close the recommendation once we receive documentation and verify that CBM+ and predictive maintenance training is available and tailored to the appropriate levels necessary to achieve effective implementation, as required by DoDI 4151.22.

Recommendation 4

We recommend that the Army Deputy Chief of Staff for Logistics:

- a. Continue to develop and implement a strategic plan for scaling condition-based maintenance plus and predictive maintenance across the enterprise.**

Department of the Army Deputy Chief of Staff for Logistics Comments

The Director of Maintenance Policy and Programs, responding for the Army DCS for Logistics, agreed with the recommendation, stating that the Army is currently in experimentation and technology demonstrations to further inform requirements development. The Director also stated that once requirements are defined, the Office of the DCS for Logistics will develop an overall strategic plan for scaling CBM+ and predictive maintenance across the enterprise. The Director did not provide an estimated date of completion but will provide updates to the DoD Office of Inspector General upon request.

Our Response

Comments from the Director addressed the specifics of the recommendation; therefore, the recommendation is resolved and open. We will close the recommendation once we receive the strategic plan and verify that it addresses scaling CBM+ and predictive maintenance across the Department of the Army.

- b. Develop and implement clear and comprehensive implementation guidance for condition-based maintenance plus and predictive maintenance, ensuring to detail the roles and responsibilities of stakeholders, based on guidance provided by DoD Instruction 4151.22, “Condition-Based Maintenance Plus for Materiel Maintenance,” August 14, 2020.**

Department of the Army Deputy Chief of Staff for Logistics Comments

The Director of Maintenance Policy and Programs, responding for the Army DCS for Logistics, agreed with the recommendation, stating that broad roles and responsibilities are well documented. However, the Director acknowledged the need to further detail and clarify stakeholder roles and responsibilities in accordance with DoD Instructions and stated that this need will be addressed in coordination with the strategic plan outlined in Recommendation 4.a. The Director will provide updates to the DoD Office of Inspector General on progress upon request.

Our Response

Comments from the Director addressed the specifics of the recommendation; therefore, the recommendation is resolved and open. We will close the recommendation once we receive the implementation guidance, directives, or instructions, as appropriate, and verify that they detail stakeholder roles and responsibilities for CBM+ and predictive maintenance, in accordance with DoD Instruction 4151.22.

- c. **Develop and tailor training to the appropriate levels necessary to achieve effective condition-based maintenance plus and predictive maintenance implementation.**

Department of the Army Deputy Chief of Staff for Logistics Comments

The Director of Maintenance Policy and Programs, responding for the Army DCS for Logistics, agreed with the recommendation, stating that training requirements and implications will be considered during the requirements development process. The Director will provide updates to the DoD Office of Inspector General upon request.

Our Response

Comments from the Director addressed the specifics of the recommendation; therefore, the recommendation is resolved and open. We will close the recommendation once we receive documentation and verify that CBM+ training is available and tailored to the appropriate levels necessary to achieve effective CBM+ and predictive maintenance implementation, as required by DoDI 4151.22.

Recommendation 5

We recommend that the Chief of Naval Operations update the Office of the Chief of Naval Operations Instruction 4790.16B, ensuring to detail the roles and responsibilities of stakeholders, based on guidance provided by DoD Instruction 4151.22, “Condition-Based Maintenance Plus for Materiel Maintenance,” August 14, 2020.

Chief of Naval Operations Comments

The Director, Fleet Readiness Division, Office of the Chief of Naval Operations, responding for the Chief of Naval Operations, agreed with our recommendation, stating that the Fleet Readiness Division will rewrite OPNAVINST 4790.16B, “Condition-Based Maintenance and Condition-Based Maintenance Plus Policy,” to incorporate the latest changes to the overarching DoD Instructions, with estimated completion in September 2022. Additionally, the Director stated that the Fleet Readiness Division has been working with the DASN(Sustainment) and Echelon II stakeholders to align the Navy’s predictive maintenance strategy during this process.

Our Response

Comments from the Director addressed the specifics of the recommendation; therefore, the recommendation is resolved and open. We will close the recommendation once we obtain the updated OPNAVINST 4790.16B and verify that it provides details and clarifies stakeholder roles and responsibilities for CBM+ and predictive maintenance, in accordance with DoDI 4151.22.

Recommendation 6

We recommend that the Deputy Assistant Secretary of the Navy (Sustainment):

- a. Develop and implement a strategic plan for scaling condition-based maintenance plus and predictive maintenance across the enterprise.**
- b. Designate a condition-based maintenance plus focal point to oversee condition-based maintenance plus and predictive maintenance implementation across the Department of the Navy.**

Deputy Assistant Secretary of the Navy (Sustainment) Comments

The DASN(Sustainment) CBM+ Functional Lead, responding for the DASN(Sustainment), agreed with the recommendations, stating that the DASN(Sustainment), in coordination with principal Operational Navy staff and Assistant Secretary of the Navy (Research, Development, and Acquisition) leadership, is managing a pilot project under the direction of the Vice Chief of Naval Operations. The CBM+ Functional Lead stated that the pilot program will expand and accelerate CBM+ implementation on two major weapon systems, and will eventually inform recommendations to Navy leadership on the proper governance, strategic scaling, and implementation methodologies to address Recommendations 6.a and 6.b. The CBM+ Functional Lead further stated that the DASN(Sustainment) is planning to conclude the pilot program in FY 2024.

Our Response

Comments from the CBM+ Functional Lead addressed the specifics of Recommendations 6.a and 6.b; therefore, the recommendations are resolved and open. We will close the recommendations once we verify that the DASN(Sustainment) has designated a Department of the Navy CBM+ focal point and developed a strategic plan to scale CBM+ and predictive maintenance across the enterprise.

- c. **Develop and tailor training to the appropriate levels necessary to achieve effective condition-based maintenance plus and predictive maintenance implementation.**

Deputy Assistant Secretary of the Navy (Sustainment) Comments

The DASN(Sustainment) CBM+ Functional Lead, responding for the DASN(Sustainment), disagreed with the recommendation. The CBM+ Functional Lead acknowledged that the DASN(Sustainment) should oversee the implementation of training. However, the CBM+ Functional Lead added that current training resources, such as DAU courses, exist and are already required for practitioners, such as Reliability and Engineering technical support communities.

Our Response

Comments from the CBM+ Functional Lead did not address the specifics of the recommendation; therefore, the recommendation is unresolved. DoDI 4151.22 requires the Military Services to develop and tailor training to the appropriate levels necessary to achieve effective CBM+ execution. The DoDI further states that the life-cycle sustainment workforce must understand the principles of reliability-centered maintenance (RCM), condition-based maintenance, and CBM+ for the continuous improvement of plans and processes that support sustainment of an item during all phases of the life cycle. We acknowledged in the report that all Services had some RCM or CBM+ training. Specifically for the Department of the Navy, we acknowledge that NAVAIR, NAVSEA, and the Marine Corps have varying levels and comprehensiveness of CBM+ training developed and offered to their sustainment workforces. However, personnel from the offices we interviewed within those systems commands and the Marine Corps acknowledged that comprehensive curriculums are still being developed, or that currently available training is not always required. Furthermore, while DAU courses provide foundational CBM+ training, they are not tailored. The CBM+ Functional Lead stated that one purpose of the Navy pilot program for expanding and accelerating condition-based maintenance practices is to inform recommendations to Navy leadership on proper governance, strategic scaling, and implementation methodologies. The pilot program could also inform recommendations for additional CBM+ and predictive maintenance training across the Department of the Navy. Therefore, we request that the DASN(Sustainment) reconsider this recommendation and assess the availability and adequacy of CBM+ and predictive maintenance training across the Department of the Navy, and develop and tailor additional training, as appropriate.

Appendix

Scope and Methodology

We conducted this performance audit from January 2021 through January 2022 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

The objective of this audit was to determine whether the DoD tracked, monitored, and shared lessons learned regarding impacts of predictive maintenance on weapon system sustainment. Our objective was also to determine whether select predictive maintenance strategies achieved cost and availability goals. However, during the planning phase, we identified that the Services had not fully implemented predictive maintenance techniques. Therefore, we amended our objective to determine the extent that the DoD had implemented predictive maintenance in accordance with guidance. To determine the progress that the DoD made with predictive maintenance, we interviewed officials from the following offices.

- Office of the Deputy Assistant Secretary of Defense (Materiel Readiness) (ODASD[MR])
- Joint Artificial Intelligence Center (JAIC)
- Defense Innovation Unit (DIU)
- Army Materiel Command (AMC)
- Air Force Rapid Sustainment Office (RSO)
- Navy Sea Systems Command (NAVSEA)
- Navy Air Systems Command (NAVAIR)
- Marine Corps Installation and Logistics

We also reviewed the following criteria to understand the assigned roles and responsibilities and guidance that the Services follow to plan and implement CBM+ and predictive maintenance.

- DoD Instruction (DoDI) 4151.22, “Condition-Based Maintenance Plus for Materiel Maintenance,” August 14, 2020
- DoD Manual 4151.22-M, “Reliability Centered Maintenance,” June 30, 2011 (Incorporating Change 1, August 31, 2018)
- DoD Directive 4151.18, “Maintenance of Military Materiel,” March 31, 2004 (Incorporating Change 1, August 31, 2018)

- Condition Based Maintenance Plus DoD Guidebook, May 2008
- Army Prognostics/Predictive Maintenance Implementation Plan, August 2020
- Army Regulation 750-1, “Army Materiel Maintenance Policy,” October 28, 2019
- Air Force Instruction 63-101/20-101, “Integrated Life Cycle Management,” June 30, 2020
- Air Force Instruction 21-101, “Aircraft and Equipment Maintenance Management,” January 16, 2020
- Air Force CBM+ Strategic Implementation Plan, April 2021
- Office of the Chief of Naval Operations Instruction (OPNAVINST) 4790.16B, “Condition-Based Maintenance and Condition-Based Maintenance Plus Policy,” October 1, 2015
- Headquarters, Department of the Army Execution Order 032-19, “Army Implementation and Execution of Condition Based Maintenance Plus (CBM+),” November 2018
- NAVAIR Sustainment Group Standard Work Package, SWP410-022, “Condition-Based Maintenance Plus (CBM+) Health-Ready Capability Levels,” February 22, 2021
- NAVAIR Sustainment Group Standard Work Package, SWPF410-026, “Condition Based Maintenance Plus (CBM+) High-Level Metrics,” February 22, 2021
- NAVSEA Instruction 4790.27A, “Reliability Centered Maintenance, Condition Based Maintenance and Condition Based Maintenance Plus Policy for Ships, Ship Systems, and Equipment,” May 30, 2013
- Marine Corps Order (MCO) 4151.22, “Condition Based Maintenance Plus Order,” January 17, 2020
- Commandant of the Marine Corps, White Letter 2-20, “Achieving Condition Based Maintenance,” April 29, 2020

In addition, we reviewed Service-level strategic plans and training programs related to CBM+ and predictive maintenance. Finally, we reviewed how the Services track CBM+ and predictive maintenance projects and the Services’ efforts to share lessons learned.

Internal Control Assessment and Compliance

We assessed internal controls and compliance with laws and regulations necessary to satisfy the audit objective. In particular, we reviewed the Office of the Secretary of Defense and Military Departments’ processes and controls governing the

progress in the implementation of CBM+ and predictive maintenance. However, because our review was limited to these internal control components and underlying principles, it may not have disclosed all internal control deficiencies that may have existed at the time of this audit.

Use of Computer-Processed Data

We did not use computer-processed data to perform this audit.

Prior Coverage

No prior coverage has been conducted on CBM+ or predictive maintenance during the last 5 years.

Management Comments

Chief of Naval Operations Comments



DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, DC 20350-2000

IN REPLY REFER TO
4790
Ser N83/22U142006
15 Apr 22

From: Director, Fleet Readiness Division, Office of the Chief of Naval Operations (OPNAV N83)
To: [REDACTED] Lead Auditor for Acquisition, Contracting, and Sustainment,
Department of Defense, Office of Inspector General

Subj: RESPONSE TO PREVENTIVE MAINTENANCE REPORT RECOMMENDATION

Ref: (a) Draft DoDIG Project No. D2021-D000AH-0080.000, "Audit of the Department of Defense's Implementation of Predictive Maintenance Strategies to Support Weapons System Sustainment"

1. Thank you for the opportunity to review reference (a), your draft report on predictive maintenance strategies. The Office of the Chief of Naval Operations concurs with Recommendation 5 and will rewrite OPNAVINST 4790.16B, "Condition-Based Maintenance and Condition-Based Maintenance Plus Policy," to incorporate the latest changes to the overarching Defense Department instructions.
2. The Fleet Readiness Division (OPNAV N83) has been working with select stakeholders to draft an updated version of the instruction for a larger enterprise review by September 2022. OPNAV N83 will work with the Deputy Assistant Secretary of the Navy for Sustainment and Echelon II stakeholders to align the Navy's predictive maintenance strategy during this process.
3. Upon review, our team did not identify any public release issues in the draft report.
4. My POC for this effort is [REDACTED]. Please contact us if you have any follow-on questions or concerns.

J. L. MOSER

Copy to:
Navy Inspector General

Deputy Assistant Secretary of the Navy (Sustainment) Comments

1 April 2022

Department of the Navy
Office of the Assistant Secretary
Research Development and Acquisition
1000 Navy Pentagon
Washington, DC 20350-1000

MEMORANDUM FOR OFFICE OF INSPECTOR GENERAL, DEPARTMENT OF DEFENSE AUDIT LEADERSHIP AND SUPPORT OPERATIONS

Subj: Deputy Assistant Secretary of the Navy, Sustainment Follow up to Department of
Defense Office of Inspector General's DRAFT report regarding Project No. D2021-
D000AH-0080.000 Recommendation #6

Ref: (a) DoD OIG Audit DRAFT Report "Audit of the Department of Defense's
Implementation of Predictive Maintenance Strategies to Support Weapon System
Sustainment" Project No. D2021-D000AH-0080.000

Encl: (1) Draft Report marked for CUI Identification

1. (U) DASN (Sustainment) concurs with Recommendation 6.a: The DoD OIG recommended that the Deputy Assistant Secretary of the Navy for Sustainment develop and implement a strategic plan for scaling condition-based maintenance plus and predictive maintenance across the enterprise.
2. (U) DASN (Sustainment) concurs with Recommendation 6.b: The DoD OIG recommended that the Deputy Assistant Secretary of the Navy for Sustainment designate a condition-based maintenance focal point to oversee condition-based maintenance plus and predictive maintenance implementation across the Department of the Navy.
3. (U) DASN (Sustainment) in coordination with principal OPNAV staff and ASN RD&A leadership is currently managing a pilot project under direction of the Vice Chief of Naval Operations to expand and accelerate the implementation of condition-based maintenance practices on two selected major weapons systems. One purpose of this pilot effort is to inform recommendations to senior Navy leadership on the proper governance and strategic scaling and implementation methodologies to address the recommendations found in 6.a and 6.b. DASN (Sustainment) is planning to conclude this project in FY24.
4. (U) DASN (Sustainment) does not concur with Recommendation 6.c: The DoD OIG recommended that the Deputy Assistant Secretary of the Navy for Sustainment develop and tailor training to the appropriate levels necessary to achieve effective condition-based maintenance plus and predictive maintenance implementation.
5. (U) DASN (Sustainment) should oversee the implementation of training required to achieve effective condition-based maintenance plus and predictive maintenance strategies. Current resources (e.g. DAU training) exist and are required for those technical support communities (e.g. Reliability and Engineering) that serve as practitioners.

Deputy Assistant Secretary of the Navy (Sustainment) Comments (cont'd)

6. (U) The DASN (Sustainment) POC for this matter is [REDACTED] who can be reached at [REDACTED].

DILLMASON.S
OLOMON. [REDACTED]

Major Mason Dill, USMC
DASN-S CBM+ Functional Lead

~~Controlled Unclassified
Information~~

~~Controlled by: Department of the Navy
Controlled by: DASN Sustainment
CUI Category: BASIC
Dissemination Control: FEDCON
POC: [REDACTED]~~

Deputy Assistant Secretary of Defense (Materiel Readiness) Comments



SUSTAINMENT

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE
3500 DEFENSE PENTAGON
WASHINGTON, DC 20301-3500

MEMORANDUM FOR DEPARTMENT OF DEFENSE INSPECTOR GENERAL

SUBJECT: Response to DoD IG Draft Report on Audit of the Department of Defense's Implementation of Predictive Maintenance Strategies to Support Weapon System Sustainment (Project No. D2021-D000AH-0080.000)

This is my response to the Department of Defense (DoD) Inspector General's (IG) draft report "Audit of the Department of Defense's Implementation of Predictive Maintenance Strategies to Support Weapon System Sustainment" (Project No. D2021-D000AH-0080.000).

My staff and I have reviewed the draft report and concur with the two recommendations directed to the Deputy Assistant Secretary of Defense (Materiel Readiness) and my office will take actions to implement both. My official written comments responding to these recommendations are attached.

My point of contact for this report is [REDACTED].

RAMDASS.VICKY [REDACTED]
SHASHINDERAJ [REDACTED]

Vic S. Ramdass, Ph.D
Deputy Assistant Secretary of Defense
(Materiel Readiness)

Attachment:
As stated

Deputy Assistant Secretary of Defense (Materiel Readiness) Comments (cont'd)

DOD IG DRAFT REPORT “AUDIT OF THE DEPARTMENT OF DEFENSE’S IMPLEMENTATION OF PREDICTIVE MAINTENANCE STRATEGIES TO SUPPORT WEAPON SYSTEM SUSTAINMENT” (PROJECT NO. D2021-D000AH-0080.000)

COMMENTS TO THE DoD IG RECOMMENDATIONS

RECOMMENDATION 1: We recommend that the Deputy Assistant Secretary of Defense (Materiel Readiness), in coordination with the Service-level condition-based maintenance plus focal points and other relevant stakeholders:

- a. Develop and execute a mechanism to report and provide visibility of condition-based maintenance plus and predictive maintenance projects and tools.
- b. Standardize a method to distinguish parts removed due to predictive maintenance forecasts.

DoD RESPONSE: Concur.

Recommendation 1.a: The Office of the Deputy Assistant Secretary of Defense (Materiel Readiness) (ODASD(MR)) uses a variety of methods to share and disseminate information on condition-based maintenance plus (CBM+) projects and tools across the Military Services; these methods include working groups, forums, symposiums, and summits. While beneficial, we acknowledge that these efforts do not provide a mechanism to report and provide visibility of ongoing efforts or allow those who are not present at or participating in these methods to garner the information provided. In March 2022 the DASD(MR) established a portfolio management system where projects, tools, and other information are readily accessible across the DoD. This portfolio system is active and being expanded to improve reporting and visibility for all stakeholders. The full efficacy of this system is expected by June 30, 2022.

Recommendation 1.b: The ODASD(MR), in collaboration with the Military Services, is considering how to best standardize a method to distinguish parts removed to due to predictive maintenance forecasts. The Navy, Air Force, and Marine Corps agree that the best approach is to develop a new supply condition code; coordination is underway with the Army. In addition to a new supply condition code, efforts are underway to establish a new DD Form 1575, Materiel Condition Tag, to uniquely identify such parts throughout the shipping process and repair cycle. The Navy submitted requirements to modify MIL-STD-129 and develop this new condition tag. Formalized definitions, processes, and procedures are also being drafted to be included in DoD Manual (DoDM) 4140.01 Volume 6 once the new supply condition code is approved. Estimate completion of these efforts is December 1, 2022.

RECOMMENDATION 2: We recommend that the Deputy Assistant Secretary of Defense (Materiel Readiness) continue to review and update the DoD “Condition Based Maintenance Plus (CBM+) Guidebook” to reflect updated condition-based maintenance plus and predictive maintenance guidance and distribute the Guidebook to responsible Military Service officials for inclusion into respective Service-level policies and guidance.

Deputy Assistant Secretary of Defense (Materiel Readiness) Comments (cont'd)

DoD RESPONSE: Concur.

Efforts are well underway to update the CBM⁺ Guidebook. We anticipate the updates will be completed by September 30, 2022.

Department of the Army Deputy Chief of Staff for Logistics Comments



DEPARTMENT OF THE ARMY
OFFICE OF THE DEPUTY CHIEF OF STAFF, G-4
500 ARMY PENTAGON
WASHINGTON, DC 20310-0500

DALO-MP-ZA

25 March 2022

MEMORANDUM THRU Office of the Deputy Chief of Staff, G-4 (DALO-ZA), 500 Army Pentagon, Washington, DC 20310-0500 **Concur** [REDACTED]

FOR The Department of Defense Office of the Inspector General, Alexandria, Virginia
[REDACTED]

SUBJECT: Audit of the Department of Defense's Implementation of Predictive Maintenance Strategies to Support Weapon System Sustainment (Project No. D2021-D000AH-0080.000)

1. The Headquarters Department of the Army Deputy Chief of Staff for Logistics (HQDA DCS G-4) concurs with the Office of the Department of Defense Inspectors General's recommendations listed in section 4.a, 4.b, and 4.c of the subject report.

2. DOD IG Recommendation 4.a: Continue to develop and implement a strategic plan for scaling condition-based maintenance plus and predictive maintenance across the enterprise.

a. HQDA DCS G-4 response: The Army concurs with this recommendation. Army is currently engaged in experimentation and technology demonstrations to further inform the formal requirements development process. Once requirements are defined we will develop an overall strategic plan for scaling across the enterprise in alignment with DOD policy. While there is no estimated completion date on the requirements development process, my staff will provide updates to your office on our progress no less than every six months and upon request from your office.

3. DOD IG Recommendation 4.b: Develop and implement clear and comprehensive implementation guidance for condition-based maintenance plus and predictive maintenance, ensuring to detail the roles and responsibilities of stakeholders, based on guidance provided by DoD Instruction 4151.22, "Condition-Based Maintenance Plus for Materiel Maintenance," August 14, 2020.

a. HQDA DCS G-4 response: The Army concurs with this recommendation. While broad roles and responsibilities regarding requirements development, acquisition, policy implementation, resourcing, and institutional training are well documented, I acknowledge the need to further detail and clarify stakeholder roles and responsibilities in accordance with DOD Instructions. This work will be completed in concert with the

Department of the Army Deputy Chief of Staff for Logistics Comments (cont'd)

DALO-MP-ZA

SUBJECT: Audit of the Department of Defense's Implementation of Predictive Maintenance Strategies to Support Weapon System Sustainment (Project No. D2021-D000AH-0080.000)

strategic plan outlined in Recommendation a; my staff will provide updates to your office on our progress no less than every six months and upon request from your office.

4. DOD IG Recommendation 4.c: Develop and tailor training to the appropriate levels necessary to achieve effective condition-based maintenance plus and predictive maintenance implementation.

a. HQDA DCS G-4 response: The Army concurs with this recommendation. Training requirements and implications will be considered throughout the requirements development process. While there is no estimated completion date on the requirements development process, my staff will provide updates to your office on our progress no less than every six months and upon request from your office.

5. My point of contact for this action is [REDACTED], she may be reached at [REDACTED]

MARSH.JAMES [REDACTED]

RICK MARSH
Director of Maintenance Policy & Programs

Air Force Deputy Chief of Staff for Logistics, Engineering and Force Protection Comments



**DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON, DC**

MEMORANDUM FOR DOD IG AUDIT TEAM

FROM: AF/A4

SUBJECT: AF/A4 Response to Draft Report: "Audit of the Department of Defense's Implementation of Predictive Maintenance Strategies to Support Weapon System Sustainment" (Project No. D2021-D000AH-0080.000)

1. I agree with the recommendations provided by the DoD IG Audit Team regarding your review of the Air Force's predictive maintenance strategies. Specifically, the team recommended:

A. The Air Force continue to develop clear and comprehensive guidance for implementation of condition-based maintenance plus and predictive maintenance that aligns with DoD Instruction 4151.22, which the Air Force will ensure during the annual review of our CBM+ Strategic Implementation plan incorporates the newest changes of DoDI 4141.22.

B. The Air Force develop and tailor training to the appropriate levels in the life-cycle sustainment workforce necessary to achieve effective condition-based maintenance plus and predictive maintenance implementation, which we are actively working across AF/A4, AFLCMC, AFSC, and the respective Career Field Functionals to ensure Air Force CBM+ training methods are incorporated where applicable.

2. Additionally, upon review the Air Force is comfortable with the release of data not already marked CUI. Further questions on this matter please contact [REDACTED] at [REDACTED].

FRI.DANIEL.A [REDACTED]

DANIEL A. FRI, SES
Assistant DCS/Logistics, Engineering &
Force Protection

1

Acronyms and Abbreviations

AMC	Army Materiel Command
CBM+	Condition-Based Maintenance Plus
DASD(MR)	Deputy Assistant Secretary of Defense (Materiel Readiness)
DASN (Sustainment)	Deputy Assistant Secretary of the Navy (Sustainment)
DAU	Defense Acquisition University
DC I&L	Deputy Commandant for Installations and Logistics
DCS	Deputy Chief of Staff
DIU	Defense Innovative Unit
eRCM	Enhanced Reliability-Centered Maintenance
JAIC	Joint Artificial Intelligence Center
MCO	Marine Corps Order
NAVAIR	Naval Air Systems Command
NAVSEA	Naval Sea Systems Command
ODASD(MR)	Office of the Deputy Assistant Secretary of Defense (Materiel Readiness)
OPNAVINST	Chief of Naval Operations Instruction
OUSD(A&S)	Office of the Under Secretary of Defense for Acquisition and Sustainment
RCM	Reliability-Centered Maintenance
RSO	Rapid Sustainment Office

Whistleblower Protection

U.S. DEPARTMENT OF DEFENSE

Whistleblower Protection safeguards DoD employees against retaliation for protected disclosures that expose possible fraud, waste, and abuse in Government programs. For more information, please visit the Whistleblower webpage at <http://www.dodig.mil/Components/Administrative-Investigations/Whistleblower-Reprisal-Investigations/Whistleblower-Reprisal/> or contact the Whistleblower Protection Coordinator at Whistleblowerprotectioncoordinator@dodig.mil

For more information about DoD OIG reports or activities, please contact us:

Congressional Liaison

703.604.8324

Media Contact

public.affairs@dodig.mil; 703.604.8324

DoD OIG Mailing Lists

www.dodig.mil/Mailing-Lists/

Twitter

www.twitter.com/DoD_IG

DoD Hotline

www.dodig.mil/hotline



DEPARTMENT OF DEFENSE | OFFICE OF INSPECTOR GENERAL

4800 Mark Center Drive
Alexandria, Virginia 22350-1500
www.dodig.mil
DoD Hotline 1.800.424.9098

