DoD Instruction 4151.22

Condition-Based Maintenance Plus for Materiel Maintenance

Originating Component:	Office of the Under Secretary of Defense for Acquisition and Sustainment
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Approved by:	Ellen M. Lord, Under Secretary of Defense for Acquisition and Sustainment

Purpose: In accordance with the authority in DoD Directive (DoDD) 5135.02 this issuance establishes policy, assigns responsibilities, and prescribes procedures for:

- Condition-based maintenance plus (CBM^+) as a proactive maintenance strategy for achieving cost-effective weapon system life cycle sustainment.
- Military Department and Defense Agency implementation of CBM^+ pursuant to DoDD 4151.18 and DoD Instruction (DoDI) 5000.02.

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SECTION 1: GENERAL ISSUANCE INFORMATION

1.1. APPLICABILITY.

a. This issuance applies to OSD, the Military Departments, the Office of the Chairman of the Joint Chiefs of Staff and the Joint Staff, the Combatant Commands, the Office of the Inspector General of the Department of Defense, the Defense Agencies, the DoD Field Activities, and all other organizational entities within the DoD.

b. This issuance does not apply to medical equipment and medical material.

1.2. POLICY.

The DoD will:

a. Use CBM^{+} as a readiness enabling capability and a primary strategy for achieving cost-effective weapon system life-cycle sustainment.

b. Require CBM^{+} maintenance concepts, enabling technologies, and processes to be fully integrated into the Joint Capabilities Integration and Development System process for all new weapon systems, equipment, and material programs when reliability centered maintenance (RCM) indicate CBM^{+} maintenance concepts, enabling technologies and processes will improve equipment availability or reduce sustainment costs over the life cycle.

c. Integrate CBM^{+} technologies and processes into current weapon systems, equipment, and materiel sustainment programs where it is technically feasible, improves materiel availability, and is cost-effective to do so.

d. Use serialized item management (SIM) in accordance with DoDI 4151.19 and item unique identification (IUID) in accordance with DoDI 8320.04 to enhance CBM^{+} data collection and analysis.

e. Adequately resource CBM^{+} throughout weapon systems, equipment, and materiel program life cycles.

SECTION 2: RESPONSIBILITIES

2.1. ASSESTANT SECRETARY OF DEFENSE FOR SUSTAINMENT.

Under the authority, direction, and control of the Under Secretary of Defense for Acquisition and Sustainment, the Assistant Secretary of Defense for Sustainment:

a. Develops policy and provides guidance for CBM$^+$ pursuant to DoDD 4151.18 and DoDI 5000.02.

b. Monitors and reviews the implementation of CBM$^+$ and oversees CBM$^+$ effectiveness across maintenance, acquisition, engineering, logistics, and industrial communities.

c. Ensures that SIM and IUID are integrated into CBM$^+$ implementations.

2.2. ASSISTANT SECRETARY OF DEFENSE FOR ACQUISITION.

Under the authority, direction, and control of the Under Secretary of Defense for Acquisition and Sustainment, the Assistant Secretary of Defense for Acquisition:

a. As part of program oversight responsibilities, requires that CBM$^+$ technologies and processes are fully integrated into the Joint Capabilities Integration and Development System process during program acquisition and technical planning.

b. Considers CBM$^+$ integration during program support reviews and other oversight reviews.

c. Ensures that the Defense Acquisition University integrates CBM$^+$ into training and education.

2.3. UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING.

The Under Secretary of Defense for Research and Engineering will advance CBM$^+$ by:

a. Supporting CBM$^+$ technologies through studies and analyses.

b. Reviewing CBM$^+$ technology development plans and projects to ensure that resources provided for CBM$^+$ produce capabilities that enable materiel condition analysis and predictive maintenance.

c. Resourcing CBM$^+$-focused science and technology programs, advanced component development, and prototypes programs to achieve CBM$^+$ capabilities.

2.4. SECRETARIES OF THE MILITARY DEPARTMENTS AND DIRECTORS OF THE DEFENSE AGENCIES.

The Secretaries of the Military Departments and the Directors of the Defense Agencies:

a. Incorporate CBM$^+$ in appropriate policy and guidance, taking into consideration the CBM$^+$ execution characteristics and procedures as detailed in Sections 3 and 4 of this issuance.

b. Develop and establish Military Service-wide requirements for implementing CBM$^+$.

c. Provide resources for CBM$^+$ requirements developed at Military Service and weapon systems levels.

d. Designate a focal point for CBM$^+$ efforts and establish a governance structure that includes all relevant stakeholders and coordinates Military Service-level execution of CBM$^+$ plans and programs.

e. Participate and collaborate in joint DoD CBM$^+$ activities, such as working groups, forums, and senior leader meetings.

f. Review and monitor programs for CBM$^+$ implementation and resultant outcomes including improvements to materiel availability and safety indices and reductions in sustainment cost and unscheduled maintenance.

g. Identify life-cycle sustainment challenges and implement CBM$^+$ solutions, as appropriate, to effectively address causes of reduced materiel availability and safety margins, increased sustainment costs, and unscheduled maintenance.

h. Maximize commonality to the greatest extent practicable when integrating CBM$^+$ technologies, processes, and procedures for similar platforms and components.

i. Require implementation of RCM in accordance with DoD 4151.22-M, and other appropriate reliability and maintainability (R&M) analyses, for the development of maintenance requirements, maintenance plans, and the continuous update of maintenance requirements and plans across the life cycle of materiel equipment.

j. Ensure CBM$^+$ is central to integrated logistics support programs and that associated automated information systems support CBM$^+$ objectives.

k. Require program managers to design, develop, demonstrate, deploy, and sustain equipment in accordance with DoD 4151.22-M, this issuance, and the CBM$^+$ DoD Guidebook to achieve required materiel readiness at best value.

l. Use SIM and IUID to optimize RCM and CBM$^+$ data analytics.

m. Ensure that appropriate life cycle item management data, including depot level data, is readily accessible by life-cycle managers, RCM analysts, and CBM$^+$ analysts.

SECTION 3: CBM+ IMPLEMENTATION AND EXECUTION

3.1. CBM+ OBJECTIVES.

The Military Services will implement and execute CBM+ in accordance with guidance provided in the CBM+ DoD Guidebook to:

a. Achieve materiel availability, reliability, safety, and life-cycle sustainment cost goals set by the program manager and owning Military Service.

b. Enhance maintenance efficiency and effectiveness through the development and operation of an information-based environment.

c. Enable proactive maintenance based on evidence of need and predictive maintenance.

d. Improve operational availability, equipment reliability, safety, and reduce total life-cycle sustainment cost.

e. Minimize unscheduled maintenance.

f. Inform fleet management decisions to enhance mission performance.

3.2. OVER-ARCHING CBM+ REQUIREMENTS.

Successful CBM+ implementation and execution requires understanding of the characteristics, detailed in Paragraphs 3.2.a. through 3.2.g., that contribute to both the Service-level CBM+ strategy and the individual weapon system CBM+ implementation. A continuous and disciplined RCM program, in accordance with the DoD 4151.22-M, along with other R&M analyses, in accordance with DoDI 5000.02T, forms the foundation for CBM+. The following tenets are necessary to achieve CBM+ goals:

a. Vision.

Life-cycle managers will accept and adopt CBM+ as the DoD strategy to sustain weapon system readiness in the most cost-effective manner. As maintenance requirements are the dominant driver of weapon system cost and availability, life-cycle managers, when informed by accurate condition information, will shift focus away from unscheduled, reactive tasks at time of failure to proactive, predictive efforts driven by accurate data and analysis-based decision-making.

b. Strategy, Planning, and Execution.

The Military Services will develop and issue clear and comprehensive strategy, implementation guidance, and action plans necessary to execute and sustain CBM+. The Military Services will provide direction, a structure for action, goals and objectives, roles and

responsibilities, and a framework for development, implementation, and execution of CBM$^+$ based on guidance provided in this policy and the CBM$^+$ DoD Guidebook.

c. Governance.

Military Service leadership, program managers, life-cycle managers, and CBM$^+$ practitioners will:

(1) Monitor the outcomes of CBM$^+$, such as materiel availability, reliability, and life-cycle costs against planned objectives.

(2) Use effective metrics management to establish a well-defined baseline for program execution, milestone tracking, resultant outcomes, and continuous improvement.

(3) Measure CBM$^+$ performance and outcomes to ensure effective implementation and execution and provide a basis for investment in CBM$^+$ enablers and processes.

(4) Review, measure, and report on CBM$^+$ plans, application, and execution to the appropriate Military Service and DoD stakeholder leadership on a routine basis.

(5) Coordinate CBM$^+$ implementation and execution with life-cycle management functional organizations responsible for providing critical system sustainment activities such as program management, engineering, supply chain, and data management.

(6) Use the data collected during CBM$^+$ execution to perform engineering analysis in order to inform changes to equipment configuration, technical instructions and manuals, and training.

(7) Use engineering analysis derived from CBM$^+$ data and analysis on legacy equipment to inform design and sustainment planning decisions regarding new equipment acquisitions.

d. Organization.

CBM$^+$ execution requires a comprehensive and systematic approach spanning multiple Military Service-level organizations, functional disciplines, and communities. Stakeholders such as program management, engineering, supply chain, and data management must understand and align their roles, responsibilities, and contributions to achieve successful CBM$^+$ outcomes. The Military Services and their leadership responsible for the implementation and execution of CBM$^+$ will meet regularly to assess application and outcome status and plan appropriate next steps towards the achievement of CBM$^+$ goals and objectives.

e. Resources.

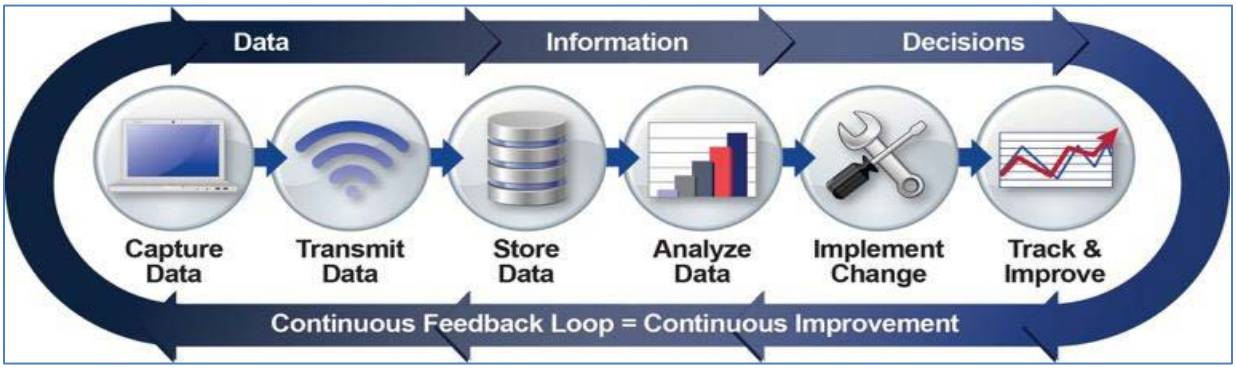
Based on comprehensive strategies, implementation guidance, and action plans referenced in Paragraph 3.2.b., the Military Services will provide personnel and funding resources necessary for implementation and execution of CBM$^+$. During independent logistics assessments and other appropriate program reviews, Military Service leadership and life-cycle managers will develop

and manage a continual process to evaluate CBM+ execution status and resource the necessary requirements to achieve CBM+ goals and objectives.

f. Technologies and Tools.

The Military Services will develop and integrate interoperable tools, technologies, and information infrastructures to facilitate CBM+ collaboration across multiple functional and organizational boundaries. To the greatest extent practicable, the Military Services will use common equipment and technologies to capture, store, and forward CBM+ data. CBM+ functional activities necessary to create insight regarding materiel condition and to take appropriate steps to achieve weapon system sustainment goals are detailed in the CBM+ DoD Guidebook and depicted in Figure 1. Organizations will plan for and execute these CBM+ functional activities.

Figure 1. Six Functional Activities of CBM+



g. Workforce.

The Military Services will develop and tailor training to the appropriate levels necessary to achieve effective CBM+ execution. 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.

h. SIM and IUID.

The Military Services and Defense Agencies will implement and use SIM and IUID as foundational elements necessary to achieve cost-effective materiel readiness goals and CBM+ objectives. SIM and IUID enable the discovery of life cycle item management data about individual components necessary for CBM+ execution.

SECTION 4: PROCEDURES

4.1. CBM+ DURING THE ACQUISITION PHASE.

From the earliest phases of an acquisition program through design, development, and delivery of a weapon system, the Military Services will require that program managers examine, evaluate, integrate, and incorporate capabilities that improve readiness, optimize sustainment resources, and reduce operation and support cost over the equipment's life cycle. To achieve CBM+ goals and desired outcomes, implementing organizations and programs will:

a. Include CBM+ in the development of mandatory sustainment key performance parameters and supporting key system attributes required for Acquisition Category I programs. Acquisition Category II and below programs will include CBM+ in the development of the sustainment key performance parameters or sponsor defined sustainment metrics, in accordance with the Joint Capabilities Integration and Development System Manual.

b. Measure CBM+ for over-arching outcomes using:

(1) The sustainment key performance parameters, materiel availability, and operational availability of weapon systems and equipment.

(2) The supporting key system attributes of reliability and operation and support cost.

(3) The ratio of scheduled to unscheduled maintenance.

c. Document CBM+ integration in the systems engineering plan and life cycle sustainment plan and assess the status of CBM+ implementation during acquisition and sustainment process reviews and evaluations.

d. Include members of the life-cycle sustainment community on planning teams early in the acquisition phase, during the development of the initial capabilities document, and throughout the materials solution analysis phase to capture CBM+ requirements. Additionally, to ensure that CBM+ is adequately considered, life-cycle managers will actively participate throughout the remainder of the acquisition process up to and including the production and deployment phase.

e. Develop action plans and milestones that support the established policies, strategies, and vision of CBM+ of the Military Service concerned.

f. Establish governance structures that include appropriate Service leadership, program managers, life-cycle managers, and other stakeholders to determine how CBM+ capabilities will be integrated into sustainment operations.

g. Establish a CBM+ approach that integrates condition-based maintenance and predictive maintenance and that optimizes material availability, minimizes unscheduled repairs, eliminates unnecessary maintenance, and employs the most cost-effective system health management processes based on DoD 4151.22-M compliant RCM principles and reliability analyses.

h. Optimize the use of original equipment manufacturer CBM$^+$ enabling technologies and capabilities to monitor and report the materiel condition of hardware and systems critical to readiness, safety, mission performance, and life-cycle cost when RCM and cost benefit analyses indicate improved equipment availability or sustainment cost reductions.

i. Acquire sufficient data rights to support CBM$^+$ objectives, when deemed appropriate by a thorough life-cycle cost analysis. If acquiring data rights is deemed cost-prohibitive, access to CBM$^+$ data will be negotiated during the acquisition phase. Data should be in a format that is interoperable with enterprise information technology architectures while conforming to non-proprietary, open industry standards that support data capture, integration, storage, and exchange across sustainment functional tiers and organizational levels. Accept data in proprietary formats only by exception.

j. Perform detailed analyses prior to making acquisition tradeoffs that could adversely affect the integration and implementation of CBM$^+$ capabilities and document the impacts of tradeoffs to readiness and sustainment costs across the life cycle.

k. Require that weapon systems' CBM$^+$ capabilities will operate independently to collect, store, and use condition data locally when there is low or no connectivity.

l. Ensure CBM$^+$ technologies adequately integrate with the existing information technology architectures and processes, and provide the ability to transmit, receive, and store data within the individual Services' information systems and joint level information systems.

m. Establish and maintain a Service-level or organizational capability that enables leadership, program managers, life-cycle managers, and other stakeholders across organizations and weapon system programs to analyze and act upon CBM$^+$ data to achieve weapon system readiness, safety, and life-cycle cost goals.

n. Integrate cybersecurity requirements, SIM, and IUID into CBM$^+$ implementations in accordance with DoD policy issuances.

o. Utilize CBM$^+$ data to validate warranty claim actions to the maximum extent possible.

4.2. CBM$^+$ FOR LEGACY SYSTEMS.

Many legacy weapon systems were developed and fielded without CBM$^+$ consideration. To improve materiel readiness and affordability for legacy systems, the Military Services and life-cycle managers will consider implementing and executing CBM$^+$ where cost-benefit analyses indicate improved equipment availability or sustainment cost reduction over the life cycle. To achieve CBM$^+$ policy objectives, Service-level organizations and life-cycle program managers will:

a. Optimize life-cycle logistics processes and minimize mean down time by providing timely condition information and precise failure mode identification based on both field and depot repair data to appropriate life-cycle managers, in order to:

(1) Expedite repair and support processes.

(2) Minimize unscheduled repairs and unnecessary scheduled maintenance.

(3) Reduce the logistics footprint.

(4) Enhance operational mission success.

b. Establish governance structures that include all relevant stakeholders to determine how CBM^+ capabilities will be integrated into sustainment operations.

c. Develop action plans and milestones for the integration and implementation of CBM^+ capabilities on legacy weapon systems when doing so is supported by life-cycle readiness and cost analyses.

d. Pursue CBM^+ through the examination, evaluation, and implementation of enabling technologies, tools, and process improvements from public and private sources in accordance with the CBM^+ DoD Guidebook. One or more of the following guides the decision to incorporate CBM^+:

(1) Failure modes and effects analyses and other R&M analyses.

(2) RCM analyses in accordance with DoD 4151.22-M.

(3) Predictive reliability engineering methods.

(4) Continuous process improvement initiatives in accordance with DoDD 5010.42.

(5) Technology assessments.

(6) Business case analyses in accordance with the CBM^+ DoD Guidebook, the DoD Product Support Business Case Analysis Guidebook, and the October 2010, Under Secretary of Defense for Acquisition, Technology, and Logistics Memorandum.

(7) Predictive materiel readiness modeling and simulation-based analyses.

e. Use existing empirical data to identify suitable weapon systems and components for implementing and integrating CBM^+ capabilities. The empirical data review must include the following:

(1) Evaluation of achieved weapon system materiel availability, safety, and life-cycle cost performance in relation to established program goals and objectives.

(2) Identification of the top weapon system sustainment degraders impacting readiness, cost, and the effective and efficient use of maintenance resources.

(3) Updated failure modes and effects analyses, RCM analyses, and other R&M analyses in accordance with DoD 4151.22-M.

(4) Evaluation of existing maintenance plans and maintenance tasks.

f. Comply with cybersecurity requirements in accordance with DoDI 8500.01, SIM in accordance with DoDI 4151.19, and IUID in accordance with DoDI 8320.04.

GLOSSARY

G.1. ACRONYMS.

ACRONYM	MEANING
CBM$^+$	condition-based maintenance plus
DoDD DoDI	DoD directive DoD instruction
IUID	item unique identification
SIM	serialized item management
R&M RCM	reliability and maintainability reliability centered maintenance

G.2. DEFINITIONS.

Unless otherwise noted, these terms and their definitions are for the purpose of this issuance.

TERM	DEFINITION
condition-based maintenance.	A maintenance practice based on monitoring the condition of equipment to assess whether it will fail during some future period in order 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. The objective of condition based maintenance is to perform maintenance based on the evidence of need while ensuring safety, reliability, availability, and reduced life-cycle cost.
CBM$^+$.	A collaborative DoD readiness initiative focused on the development and implementation of data analysis and sustainment technology capabilities to improve weapon system availability and achieve optimum costs across the enterprise. CBM$^+$ is the application and integration of appropriate processes, technologies, and knowledge-based capabilities to improve the reliability and maintenance

TERM	DEFINITION
	effectiveness of DoD systems and components. At its core, CBM$^+$ is maintenance performed based on evidence of need. CBM$^+$ is built upon RCM and condition based maintenance to enhance safety, increase maintenance efficiency, improve availability, and ensure environmental integrity. CBM$^+$ diminishes life-cycle costs by reducing unscheduled maintenance and enabling predictive maintenance. CBM$^+$ turns rich data into information about component, weapon system, and fleet conditions to more accurately forecast maintenance requirements and future weapon system readiness to drive process cost efficiencies and enterprise activity outcomes.
CBM$^+$ data.	At its core, CBM$^+$ is performing maintenance based on the evidence of need. That "evidence" is provided through the collection and aggregation of accurate data and analysis. This data includes life cycle item management data as well as environmental data and data from embedded sensors. CBM$^+$ data is captured from the equipment item in a variety of methods which may include physical inspection, capture of recorded maintenance and supply event data as well as real-time data collection from embedded sensors on military equipment.
CBM$^+$ tools and technologies.	The complement of tools and technologies used as enabling capabilities needed to execute CBM$^+$ strategies and plans. Examples of these tools and technologies include but are not limited to: embedded sensors, data aggregation and storage capabilities, automatic identification technologies, portable maintenance aids, integrated information systems, artificial intelligence and machine learning, and automated test equipment.
IUID.	The application and use of a unique item identifier as the global common data key in financial, property accountability, acquisition, and logistics (including supply and maintenance) automated information systems to enable asset accountability, valuation, life-cycle management, and counterfeit material risk reduction.
life cycle item management data.	Item-related data that supports product life-cycle management and spans an item's complete life cycle. It begins with initial design, specifications, manufacturing, and acquisition data that include use, supply, accountability, custody, ownership, valuation, sustainment cost, warranty, modification, configuration, reliability, availability,

TERM	DEFINITION
	maintainability, performance, and maintenance history data collected in various automated information systems. Relevant maintenance, logistics, and acquisition data supports analysis on specific populations and on each item throughout its life cycle.
predictive maintenance.	Predictive maintenance is a technique to predict the future failure point of a component, so that the component replacement can be planned at an optimal time before it fails. Predictive maintenance differs from preventive in that it uses collected data to determine the condition of the component and forecasts the need for maintenance.
preventive maintenance.	Preventive maintenance is a technique where maintenance actions and the replacement of components is based on calendar time, operating time, or some other periodic measurement. Intervals are determined based on engineering reliability and maintainability analyses, reliability centered maintenance and historic failure data.
RCM	A logical structured 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 life-cycle cost. RCM supports the failure-management strategy for any component, equipment, subsystem, or system based on its inherent reliability and operating context.
SIM	Programs and techniques that use life-cycle item management data to track the performance of uniquely identified items throughout their life cycle. The overarching goals of these programs and techniques is to enable managers to achieve optimum weapon system materiel availability at the best total ownership cost through effective and efficient life-cycle management practices.

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