Department of Defense

INSTRUCTION

NUMBER 4151.22
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USD(AT&L)

SUBJECT: Condition Based Maintenance Plus (CBM^+) for Materiel Maintenance

References: See Enclosure 1

1. PURPOSE

Condition based maintenance plus (CBM^+) is the primary reliability driver in the total life-cycle systems management (TLCSM) supportability strategy of the Department of Defense. In concert with the other TLCSM enablers, such as continuous process improvement (CPI), cause and effect predictive modeling, and desired outcomes achieved through performance based logistics (PBL), CBM^+ strives to optimize key performance measures of materiel readiness - materiel availability, materiel reliability, mean downtime, and ownership costs. Under the authority in DoD Directive 5134.01 (Reference (a)), this Instruction establishes policy and guidance for the Military Departments and Defense Agencies for implementation of CBM^+ pursuant to DoD Directive 4151.18 and DoD Instruction 5000.2 (References (b) and (c)).

2. APPLICABILITY

a. This Instruction applies to the Office of the Secretary of Defense, the Military Departments, the Office of the Chairman of the Joint Chiefs of 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 in the Department of Defense (hereafter referred to collectively as the "DoD Components").

b. This Instruction applies to the Department of Defense and, through incorporation into contracts, to commercial maintenance operations for weapon systems, equipment, and materiel throughout all life-cycle phases.

3. DEFINITION

a. CBM^+ is the application and integration of appropriate processes, technologies, and knowledge based capabilities to improve the reliability and maintenance effectiveness of DoD systems and components. At its core, CBM^+ is maintenance performed on evidence of need provided by reliability centered maintenance (RCM) analysis and other enabling processes and

technologies characterized in Enclosure 2. CBM$^+$ uses a systems engineering approach to collect data, enable analysis, and support the decision-making processes for system acquisition, sustainment, and operations.

b. The CBM$^+$ strategy:

(1) Enhances maintenance efficiency and effectiveness and integrates all functional aspects of life cycle management processes, such as development, acquisition, distribution, supply chain management, and systems engineering.

(2) Establishes integrated, predictive maintenance approaches, which minimize unscheduled repairs, eliminate unnecessary maintenance, and employ the most cost-effective maintenance health management approaches.

(3) Implements an optimum mix of maintenance technologies (e.g., diagnostics and prognostics), RCM-based maintenance processes, and enablers (e.g., total asset visibility) within the integrated TLCSM framework.

(4) Enhances materiel availability by identifying the optimum opportunity to perform required maintenance, thereby increasing the number of assets in operational status.

(5) Improves materiel reliability through the disciplined analysis of failure data to develop modifications that will ensure equipment meets target performance standards within operational context.

(6) Minimizes mean downtime by providing real-time maintenance information and accurate technical data to technicians and logisticians that will expedite repair and support processes and return equipment to operational status.

(7) Reduces ownership costs by eliminating unnecessary maintenance activities and accurately positioning required assets for an effective logistics footprint in support of warfighting requirements.

c. Terms related to CBM$^+$ are defined in the Glossary.

4. POLICY

It is DoD policy that:

a. CBM$^+$ be included in the selection of maintenance concepts, technologies, and processes for all new weapon systems, equipment, and materiel programs based on readiness requirements, life-cycle cost goals, and RCM-based functional analysis.

b. CBM$^+$ be implemented into current weapon systems, equipment, and materiel sustainment programs where technically feasible and beneficial. This decision shall be based on any or all of the following:

(1) Results of reliability analyses, including RCM in accordance with Enclosure 3.

(2) Findings from CPI initiatives.

(3) Technology assessments.

(4) Business case analyses.

c. CBM$^+$ be pursued through the examination, evaluation, and implementation of enabling technologies, tools, and process improvements from both public and private sources.

d. CBM$^+$ technologies, processes, and enablers be incorporated as part of organic maintenance capabilities as well as, by incorporation into contracts, in commercially-supported systems or programs (e.g., PBL arrangements).

e. CBM$^+$ implementation be funded, including the research, development, test, and evaluation of new technologies and processes required to achieve desired maintenance outcomes.

f. CBM$^+$ outcomes be measured through the key performance indicators of materiel readiness – materiel availability, materiel reliability, mean downtime, and ownership costs.

5. RESPONSIBILITIES

a. Deputy Under Secretary of Defense (Logistics and Materiel Readiness) (DUSD(L&MR)). The DUSD(L&MR), under the Under Secretary of Defense for Acquisition, Technology and Logistics (USD(AT&L)), shall develop policy and provide guidance for CBM$^+$ pursuant References (b) and (c). DUSD(L&MR) shall monitor and review the implementation of these policies to ensure CBM$^+$ effectiveness across maintenance, engineering, logistics, and industrial communities.

b. Deputy Under Secretary of Defense (Acquisition and Technology) (DUSD(A&T)). The DUSD(A&T), under the USD(AT&L), shall, as part of program oversight responsibilities, ensure that CBM$^+$ technologies, processes, and enablers are integrated with program acquisition and technical planning. In addition, CBM$^+$ shall be a consideration during program support reviews and other oversight reviews that are conducted by the DUSD(A&T).

c. Director of Defense Research and Engineering (DDR&E). The DDR&E, under the USD(AT&L), shall assist in the advancement of CBM$^+$ by supporting identified critical technologies through studies and analyses, reviewing plans and projects to eliminate unpromising or unnecessarily duplicative programs, and guiding science and technology programs, advanced component development, and prototypes programs to achieve CBM$^+$ capabilities.

d. Secretaries of the Military Departments and Directors of the Defense Agencies. The Secretaries of the Military Departments and the Directors of the Defense Agencies shall:

(1) Incorporate the requirement for CBM$^+$ in the appropriate policy.

(2) Develop plans for implementing CBM$^+$.

(3) Designate a focal point for CBM$^+$ efforts and participate in joint DoD CBM$^+$ activity.

(4) Review and monitor programs for CBM$^+$ implementation and outcomes.

(5) Identify maintenance challenges and pursue CBM$^+$ solutions to sustain and maintain the inherent capabilities of new and fielded equipment.

(6) Integrate CBM$^+$ technologies, processes, and procedures for common systems and components.

(7) Ensure reliability analyses are implemented, including RCM in accordance with Enclosure 3.

(8) Ensure that logistics information systems effectively support CBM$^+$ objectives.

(9) Direct program managers to design, develop, demonstrate, deploy, and sustain equipment in accordance with CBM$^+$ guidance and procedures to achieve required materiel readiness at best cost.

6. RELEASABILITY. This DoD Publication is approved for public release. Copies may be obtained through the Internet from the DoD Issuances web site http://www.dtic.mil/whs/directives.

7. EFFECTIVE DATE

This Instruction is effective immediately.

John J. Young, Jr
Under Secretary of Defense
for Acquisition, Technology and Logistics

Enclosures
1. References
2. CBM$^+$ Examples and Characteristics
3. DoD RCM Process

Glossary

ENCLOSURE 1

REFERENCES

(a) DoD Directive 5134.01, "Under Secretary of Defense for Acquisition, Technology and Logistics (USD(AT&L))", December 9, 2005
(b) DoD Directive 4151.18, "Maintenance of Military Materiel," March 31, 2004
(c) DoD Instruction 5000.2, "Operation of the Defense Acquisition System," May 12, 2003
(d) "DoD Guide for Achieving Reliability, Availability, and Maintainability (RAM)," August 1, 2005[1]
(e) "The DoD Continuous Process Improvement (CPI) Transformation Guidebook," May 12, 2006[2]
(f) Defense Federal Acquisition Regulation Supplement 252.211, "Acquisition Streamlining"[3]
(g) "DoD Guide to Uniquely Identifying Items," Version 1.6, June 1, 2006[4]
(h) "Concept of Operations for IUID-Enabled Maintenance in Support of DoD Materiel Readiness," Revision 1, January 19, 2007[5]
(i) DoD Directive 5000.1, "The Defense Acquisition System," November 24, 2004
(j) "Performance Based Logistics: A Program Manager's Product Support Guide," March 2005[6]
(k) "Designing and Assessing Supportability in DoD Weapon Systems: A Guide to Increased Reliability and Reduced Logistics Footprint," November 1, 2004[7]
(l) "Systems Engineering Plan (SEP) Preparation Guide," Version 2.0, October 18, 2007[8]
(m) USD(AT&L) Memorandum "Policy Addendum for Systems Engineering," October 22, 2004[9]
(n) "Defense Acquisition Guidebook," as amended, December 20, 2004[10]

[1] This document is available at http://www.acq.osd.mil/sse/docs/RAM_Guide_080305.pdf
[2] This document is available at https://acc.dau.mil/CommunityBrowser.aspx?id=23504
[3] This document is available at http://www.acq.osd.mil/dpap/dars/dfarspgi/current/index.html
[4] This document is available at https://acc.dau.mil/CommunityBrowser.aspx?id=44323
[5] This document is available at https://acc.dau.mil/CommunityBrowser.aspx?id=143446&lang=en-US
[6] This document is available at https://acc.dau.mil/CommunityBrowser.aspx?id=32536
[7] This document is available at https://acc.dau.mil/CommunityBrowser.aspx?id=32566
[8] This document is available at https://acc.dau.mil/CommunityBrowser.aspx?id=19389
[9] This document is available at http://www.acq.osd.mil/sse/policy.html
[10] This document is available at http://akss.dau.mil/dag

ENCLOSURE 2

CBM+ EXAMPLES AND CHARACTERISTICS

A variety of advanced engineering, maintenance, and information system technologies as well as contemporary business processes support CBM+, which include, but are not limited to, the following characteristics and examples:

a. hardware. System health monitoring and management using embedded sensors; integrated data bus.

b. software. Decision support and analysis capabilities; on and off equipment; appropriate use of diagnostics and prognostics; automated maintenance information generation and retrieval.

c. design. Open system architecture; integration of maintenance and logistics information systems; interface with operational systems; designing systems that require minimum maintenance; enabling maintenance decisions based on equipment condition.

d. processes. RCM analysis; a balance of corrective, preventive, and predictive maintenance processes; trend-based reliability and process improvements; integrated information systems providing logistics system response; CPI; Serialized Item Management (SIM).

e. communications. Databases; off-board interactive communication links.

f. tools. Integrated electronic technical manuals (digitized data); automatic identification technology; item unique identification (IUID); portable maintenance aids; embedded database interactive training.

g. functionality. Low ambiguity fault detection, isolation and prediction; optimized maintenance requirements and reduced logistics support footprints; configuration management and asset visibility.

ENCLOSURE 3

DoD RCM PROCESS

1. BACKGROUND

a. As one of the key enablers of CBM^+ and the life-cycle sustainment of DoD weapons systems, RCM is conducted to ensure that effective maintenance processes are implemented. RCM provides a logical decision process for determining optimum maintenance approaches and establishes the evidence of need for both reactive and proactive maintenance tasks.

b. RCM analysis determines the optimum maintenance approaches that will achieve planned materiel readiness, which is measured by the life-cycle sustainment outcome metrics of materiel availability, materiel reliability, ownership cost, and mean downtime. RCM enables CBM^+ that implements improved maintenance technologies and processes. CPI analyzes performance and related processes on an ongoing basis, which is critical for RCM effectiveness across the life cycle. RCM, in turn, provides the means for accomplishing CPI of maintenance processes.

2. DEFINITION

a. RCM is a logical, structured process used to determine the optimal failure management strategies for any system based on system reliability characteristics and the intended operating context. RCM defines what must be done to a system to achieve the desired levels of safety, reliability, environmental soundness, and operational readiness, at best cost. RCM is to be applied continuously throughout the life cycle of any system.

b. RCM is based on the following precepts:

(1) The objective of maintenance is to preserve an item's function(s). RCM seeks to preserve a desired level of system or equipment functionality.

(2) The RCM process is a valuable life-cycle management tool and should be applied from design through disposal.

(3) RCM seeks to manage the consequences of failure, not to prevent all failures.

(4) RCM identifies the most technically appropriate and effective maintenance task and/or other logical actions

(5) RCM is driven by the following considerations, in order: safety (or a similarly critical consideration), the ability to complete the mission, and economic grounds.

(6) RCM acknowledges design limitations and the operational environment. At best, maintenance can sustain the inherent level of reliability within the operating context over the life of an item.

(7) RCM is a continuous process that requires sustainment throughout the life cycle. RCM uses design, operations, maintenance, logistics, and cost data, to improve operating capability, design, and maintenance.

3. IMPLEMENTATION

a. RCM planning is based on mission requirements, performance of the system or equipment, safety, environmental compliance, cost effectiveness, and operational and logistics impacts. Both tangible and intangible benefits apply to RCM. Tangible benefits could include return on investment, reduced work requirements, and improved readiness. Intangible benefits could include quality of life, morale, and war fighter confidence.

b. Effective RCM is rooted in Service level policy and guidance that will:

(1) Incorporate RCM throughout the total system life cycle, from requirements development through disposal.

(2) Establish and maintain reporting systems for RCM data collection and feedback to address failure management logistics considerations and readiness issues.

(3) Ensure that acquisition, operational, and support activities comply with RCM requirements.

(4) Designate lead(s) responsible for implementing RCM policies; monitoring the performance of RCM; and reporting the goals, status, and outcomes.

(5) Establish RCM training and certification processes.

(6) Ensure RCM training and certification requirements are reflected in the appropriate position descriptions.

(7) Ensure tools used to perform and document RCM analysis are available and maintained.

(8) Foster RCM activity with other Components.

c. A DoD-approved RCM process includes the following items in sequence:

(1) Functions. The desired capability of the system, how well it performs, and under what circumstances.

(2) Functional Failures. The failed state of the system (e.g., the system falls outside the desired performance parameters).

(3) Failure Modes. The specific condition causing a functional failure.

(4) Failure Effects. The description of what happens when each failure mode occurs, detailed enough to correctly evaluate the consequences of the failure.

(5) Failure Consequences. The description of how the loss of function matters (e.g., safety, environmental, mission, or economics).

(6) Maintenance Tasks and Intervals. The description of the applicable and effective tasks, if any, performed to predict, prevent, or find failures.

(a) A maintenance task is applicable when it prevents a functional failure or discovers a hidden functional failure.

(b) A maintenance task is considered effective when it reduces the risk of failure to an acceptable level. The consequences of failure must be used to determine task effectiveness.

(7) Other Logical Actions. Including, but not limited to, run-to-failure, engineering redesigns, and changes or additions to operating procedures or technical manuals.

GLOSSARY

DEFINITIONS

CBM. A maintenance strategy based on equipment operational experience derived from analysis. CBM includes maintenance processes and capabilities derived from real-time or approximate real-time assessments obtained from embedded sensors and/or external tests and measurements using either portable equipment or actual inspection. The objective of CBM is to perform maintenance based on the evidence of need while ensuring safety, reliability, availability, and reduced total ownership cost. CBM is further explained in the "DoD Guide for Achieving Reliability, Availability, and Maintainability (RAM)" (Reference (d)).

CPI. The Department of Defense's strategic approach for developing a culture of continuous improvement in the areas of reliability, process cycle times, costs in terms of less total resource consumption, quality, and productivity. In the Department of Defense, CPI comprises the application of a broad range of tools and methods, such as Lean, Six Sigma, and Theory of Constraints, as cited in "The DoD Continuous Process Improvement (CPI) Transformation Guidebook" (Reference (e)).

IUID. The DoD program that enables easy access to information about DoD possessions to allow the acquisition, repair, and deployment processes for items to be more efficient. IUID permanently identifies an individual item and is a mandatory requirement for all DoD solicitations issued on or after January 1, 2004 (DFARS 252.211 (Reference (f)) applies). (See also "DoD Guide to Uniquely Identifying Items" (Reference (g)) and "Concept of Operations for IUID-Enabled Maintenance in Support of DoD Material Readiness (Reference (h)).)

maintenance processes. Maintenance can be performed using a wide variety of approaches. Two main categories of maintenance – reactive and proactive – are provided to describe the range of options available.

reactive maintenance (i.e., corrective maintenance). Performed for items that are selected to run to failure or those items that fail in an unplanned or unscheduled manner. Run to failure is often the planned maintenance strategy for items that have little readiness or safety impact.

proactive maintenance. This type of maintenance can be considered as either preventive or predictive in nature, and the maintenance performed includes inspection, assessment, test, diagnostics, prognostics, servicing, and scheduled replacement/overhaul.

PBL. The purchase of support as an integrated, affordable, performance package designed to optimize system readiness and meet performance goals for a weapon system through long-term support arrangements with clear lines of authority and responsibility. Program managers are to develop and implement PBL strategies that optimize total system availability while minimizing cost and logistics footprint. PBL should include the best use of public and private sector capabilities through government and industry partnering initiatives (DoD Directive 5000.1 (Reference (i))). PBL is explained in detail in both "Performance Based Logistics: A Program

Manager's Support Guide," and "Designing and Assessing Supportability in DoD Weapon Systems: A Guide to Increased Reliability and Reduced Logistics Footprint" (References (j) and (k)).

RCM. A logical, structured process used to determine the optimal failure management strategies for any system, based upon system reliability characteristics and the intended operating context. RCM is further discussed in Enclosure 3 and additional guidance is provided in Reference (d).

systems engineering. The overarching process that a program team applies to transition from a stated capability to an operationally effective and suitable system. Systems Engineering encompasses the application of Systems Engineering processes across the acquisition life cycle (adapted to each life-cycle phase) and is intended to be the integrating mechanism for balanced solutions addressing capability needs, design considerations, and constraints, as well as limitations imposed by technology, budgets, and schedules. The Systems Engineering processes, aligned with the enterprise-wide sustainment strategy, are applied early on in concept definition and then continuously throughout the total life cycle. Expanded information on systems engineering is provided in Chapter 4 of the "Systems Engineering Plan (SEP) Preparation Guide" (Reference (l)), the USD(AT&L) memorandum of October 22, 2004 (Reference (m)), and Chapter 5 of the "Defense Acquisition Guidebook" (Reference (n)), which can all be found on the Defense Acquisition University (DAU) website.

TLCSM. The implementation, management, and oversight by the designated program manager of all activities associated with the acquisition, development, production, fielding, sustainment, and disposal of a DoD weapons system across its life cycle. The TLCSM approach to system development is optimized if it targets, as a major end state goal, operations and maintenance phase effectiveness and affordability. TLCSM is distinguished by the translation of force provider-specified levels of performance into deliverable capabilities that represent system readiness, availability, and logistics supportability. Reference (n) is the DoD reference for TLCSM.