CONDITION-BASED MAINTENANCE *PLUS*

A DoD Initiative

Condition-Based Maintenance **Plus** (CBM+)

- Condition-based maintenance enhanced by reliability analysis
- Routine predictive maintenance based on the evidence of need and forecasted by analyzing data collected through automated sensors and systems
- Promote improved weapon system and equipment performance
- Lead to more efficient maintenance, better readiness, and cost savings associated with smaller logistics footprints

CBM+ is an evolving set of maintenance capabilities focused on inserting technology into new and legacy systems that will improve supportability, lead to more efficient and effective business processes, and transform DoD's maintenance environment. CBM+ builds on the solid foundation of condition-based maintenance, but also includes a wide range of other maintenance and logistics considerations.

Preventive maintenance, as traditionally practiced, doesn't necessarily prevent catastrophic failures and the associated turmoil (e.g., high cost repairs or loss of equipment at inopportune times); nor has it effectively addressed high false alarm rates and the attendant costs. In a broad context, CBM+ ranges from addressing challenges (such as improving diagnostics and prognostics) to fostering new support concepts (such as anticipatory maintenance). Solid, accurate information can enable better decision-making that results in a smaller footprint for maintenance and logistics support packages. All of this can lead to more efficient operations, better use of limited resources, and improved equipment performance.

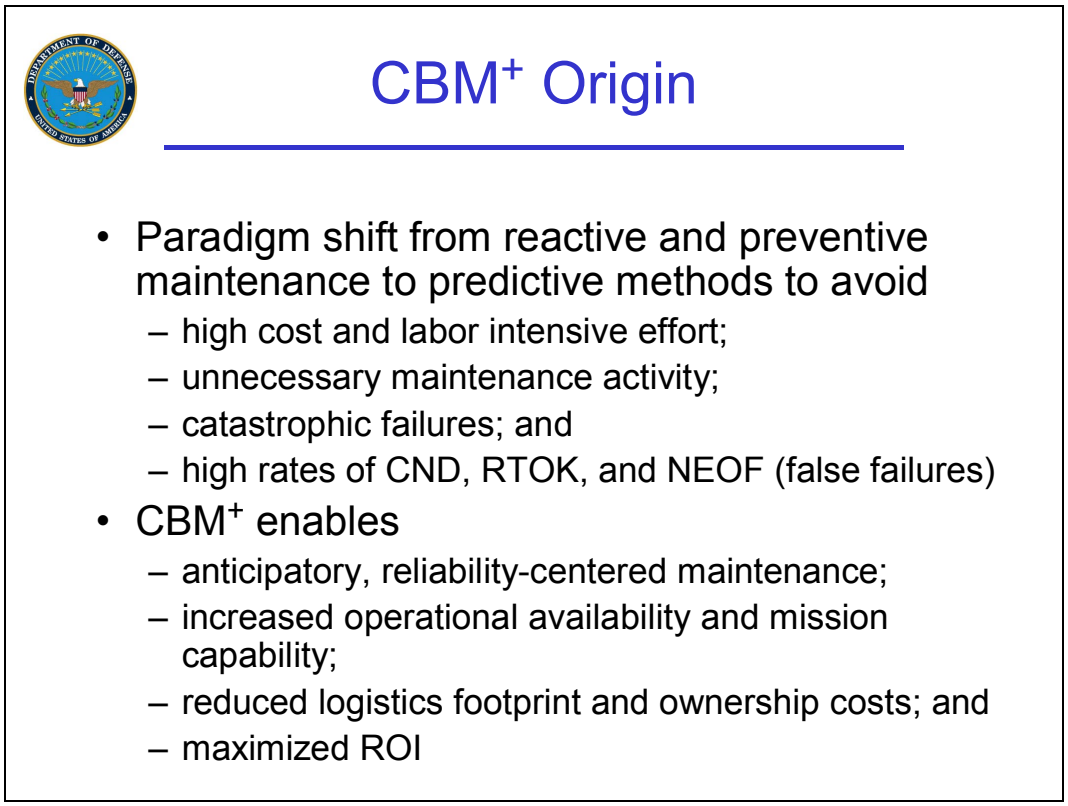
The challenge for the CBM+ initiative is to develop a solid basis of information, knowledge, and experience to help the military service and program leadership make necessary changes to existing programs and future acquisitions. With a clear understanding of the effects of CBM+, they can champion CBM+ insertion in the design phase; recognize opportunities to modify legacy systems when appropriate and cost effective; and better appreciate the readiness effects, logistics benefits, and return on investments (ROIs) to justify the cost of CBM+ implementation.

CBM+ Topics

- Origins
- Elements
- Guidance
- CBM+ Advisory Group
- Service Plans and Programs
- Related Efforts
- Future

This tutorial provides background and information on

- the origin of CBM+ (why it was developed and what is envisioned in DoD);
- components of CBM+, opportunities for application of technology, and the types of tools and processes that can be included in a program's maintenance plan;
- the guidance in place and the activity of the CBM+ Advisory Group;
- various programs that have already embraced CBM+ and other efforts from the commercial, academic and R&D communities; and
- the future of CBM+.



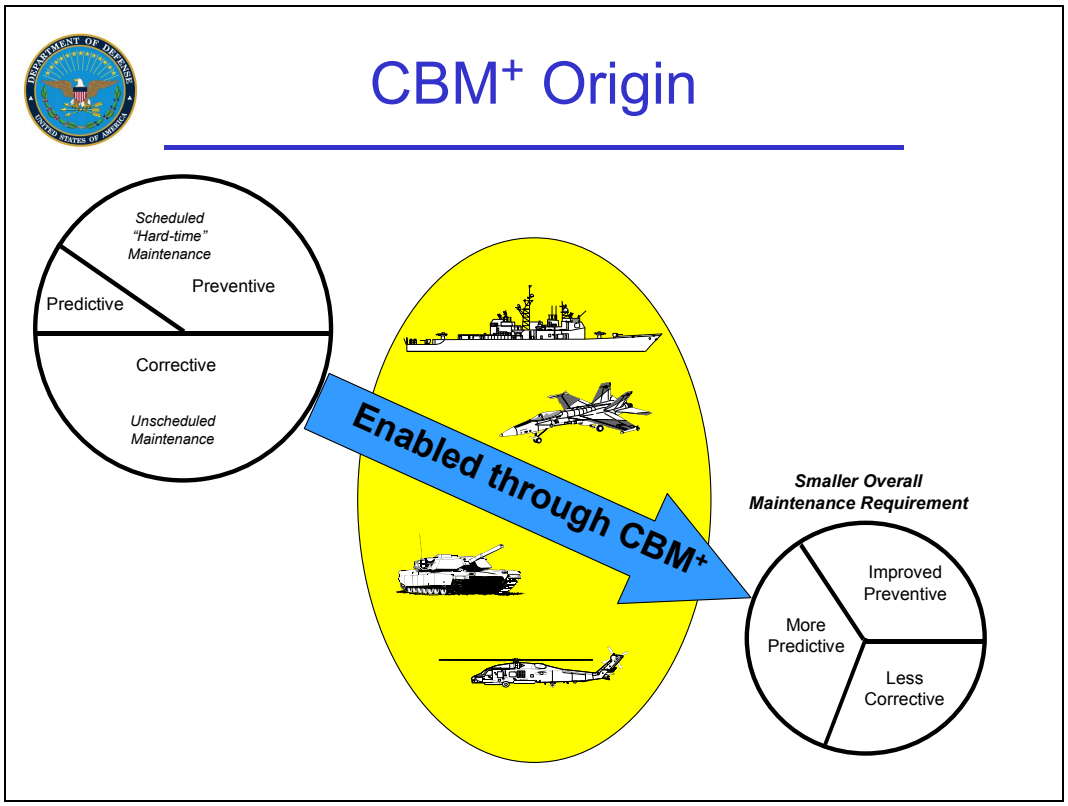
Note: CND = cannot duplicate; RTOK = retest okay; NEOF = no evidence of failure.

The 2001 Quadrennial Defense Review set a number of transformational objectives for the department. In response, an integrated Future Logistics Enterprise (FLE) plan was developed by the Deputy Under Secretary of Defense for Logistics and Materiel Readiness. Now termed the Force-centric Logistics Enterprise, FLE addresses the full range of DoD maintenance and supply responsibilities. It built upon the best commercial and DoD practices, embodying end-to-end customer (warfighter) service.

Two challenges drive FLE. Operationally, FLE is driven by such factors as availability of parts, high maintenance requirements, turnover of maintenance personnel, and a large maintenance or supply footprint. Its structural challenges include equipment design as well as disjointed acquisition and logistics processes. A set of FLE initiatives was developed comprising an integrated strategy to achieve logistics transformation. Among these FLE initiatives is CBM$^+$.

An integrated program team (IPT) consisting of members from all military services wrote the initial policy, charter, and plan of action and milestones (POA&M) for CBM$^+$. CBM$^+$ represents a shift to a proactive approach in maintenance planning and execution; it leverages the advancements that have been made in maintenance technologies and processes.

The requirement for efficient sustainment of mission capable weapon systems has never been greater. The expectations of the combatant commanders and the warfighters have never been higher. The foundation of CBM$^+$ is condition-based maintenance, but it affects a wide range of logistics features that translate into lower costs and improved availability.



CBM$^+$ represents a conscious effort to shift unscheduled corrective equipment maintenance to preventive and predictive approaches that schedule maintenance based upon the evidence of need. Using CBM$^+$ tools and technologies, maintainers can identify and respond to deteriorating equipment conditions more effectively, without having to wait for a failure. CBM$^+$ not only emphasizes a different approach, it also allows a net reduction in the amount of maintenance performed which affects all the associated logistics elements, including parts and other logistics footprint factors.

CBM$^+$ is all about determining the need for maintenance before operations are effected—and then being able to respond to that need quickly and effectively. Rather than a force multiplier, CBM$^+$ is a "maintainer multiplier." Maintainers are the key to the execution of equipment maintenance, and they need to be well trained, well equipped, well informed, and well supported. CBM$^+$ achieves this.

CBM+ Policy

- CBM+ policy key tenets
  - Need-driven, reliability centered maintenance
  - Embedded diagnostics and prognostics
  - Automated maintenance information generation
  - Analysis-based reliability and sustainability process improvements
  - Integrated information systems respond to equipment condition and tasking
  - Smaller maintenance and support footprints
  - Improved operational availability and performance

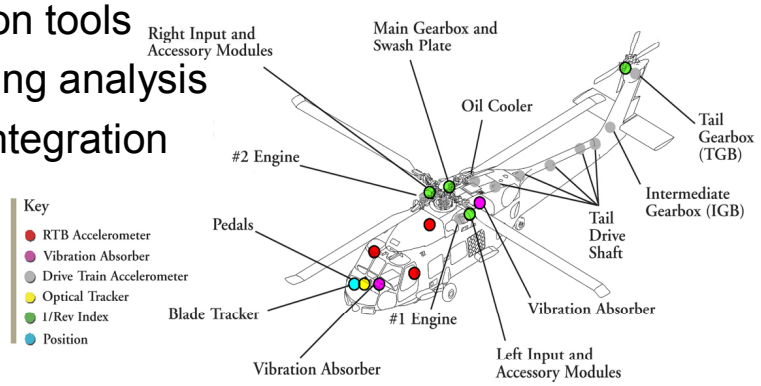
The policy for CBM+ was released in November 2002 by the Deputy Under Secretary of Defense for Logistics and Materiel Readiness. The primary policy elements have been and continue to be incorporated into other DoD and service guidance documents, including a POA&M, which acts as a basic guide for advisory group activities.

The range of technologies and practices included under the CBM+ umbrella is broad, making it difficult to focus on a core principle or a single goal. The universally accepted condition-based maintenance (CBM) concept, which encourages a need-driven approach to weapon system support, forms the main underpinning for CBM+. The "Plus" designation is intended to encompass the variety of equipment and maintenance process improvements that are possible through a more disciplined approach to maintenance planning, the development of sensor technologies, better maintenance information collection and analysis techniques, more capable and user friendly maintenance aids, the integration of maintenance and other logistics systems into an enterprise structure, as well as other advancements.

CBM+ Components

- CBM+ can include
  - Sensors and algorithms
  - Data collection techniques
  - Information tools
  - Engineering analysis
  - System integration

H-60 HUMS



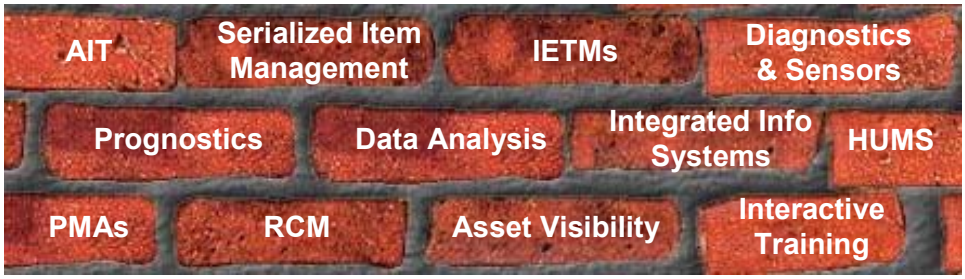
The following are examples of CBM+ "enabling" features:

- Sensors—on-board (embedded) or off-board (portable equipment interfaced to a platform), plus the software programs to facilitate analysis
- Data collection—on-system (data bus), at-system (organizational level) or off-system (intermediate and depot levels)
- Maintenance information systems network—both up-line reporting/recording and down-line support
- Information tools—interactive electronic technical manuals (IETMs), portable maintenance aids (PMA) and computers, automated identification technology (AIT), and serialized item management (SIM)
- Engineering analysis—reliability-centered maintenance (RCM) collected from specific and multiple weapon systems to identify trends and provide a dynamic maintenance plan
- System integration—linking logistics with maintenance through the increased capabilities of computer systems and connectivity tools to provide faster response and better materiel support.

The Helicopter Health Usage and Monitoring System (HUMS) is an example of the environment CBM+ is trying to establish. HUMS monitors a wide range of helicopter subsystems, creating a data-rich environment in which to build an anticipatory maintenance and logistics structure.

CBM+ Components

- CBM+ implements
  - –Practices, techniques, and technologies that improve maintenance capabilities and execution
    - in new systems during acquisition
    - in legacy systems *where applicable* and *cost effective*



CBM+ is built on a broad foundation of techniques and approaches. Capturing, analyzing, and acting on an expanding amount of information related to what's happening to equipment is crucial. CBM+ looks at adding and improving sensors, better use of the resulting data, software applications and algorithms that improve diagnosis of current symptoms, conditions and failures, and logical approaches to predict future failures. Asset management tools, SIM, and AIT will improve configuration management. AIT will make maintainers more efficient and provide accurate information across the board. IETMs will get better and more user friendly, and they will be integrated with training and evolve to become more effective job performance aids. Improved portable maintenance aids will replace paper-based technical data with electronic information that is easy to use. The individual maintainer remains the key to effective maintenance—CBM+ is focused on helping him or her become more effective and efficient by providing better tools and information, resulting in improved performance and readiness of our weapon systems.

The various portable maintenance aids (PMAs) being developed for wide use in DoD maintenance are examples of emerging technology or tools for CBM+. Generating and using information efficiently has always been a challenge. PMAs can help the maintainer in production management, technical data, communication, and even training. Emerging information systems promise to take advantage of the portability and on-site characteristics of many of these devices.

Among the fastest growing technologies within DoD, PMAs can best be defined as mobile computing devices that are used at the point of maintenance. In the DoD maintenance arena, this includes suitcase-size testers that diagnose weapon system faults and upload operational data, test measurement diagnostic equipment (TMDE) that fulfill multiple or single testing purposes, and lap-top or hand-held computers. A driving force behind the rapid growth in the use of these devices is the increase in digitization of our weapon systems and the associated technical data, often enabled by a secure, wireless environment. With growing memory and processing capabilities, PMAs will support streamlined maintenance business processes. To achieve real improvement in maintenance productivity with these aids, appropriate hardware and software need to be identified, effectively integrated with other tools and logistics processes, and supported through implementation by management. As part of CBM+, a variety of PMAs will come into use. The applications need to be logical, supportable, and optimized to meet the weapon system maintenance requirements.

CBM+ Awareness

- DoD Instruction 5000.2
- DoD Directive 4151.18
- Website *http://www.acq.osd.mil/log/mppr/*

Throughout DoDI 5000.2, CBM+ objectives are cited as program office requirements, including specific reference to affordable, integrated, embedded diagnostics and prognostics, serialized item management, AIT, and iterative technology refreshment.

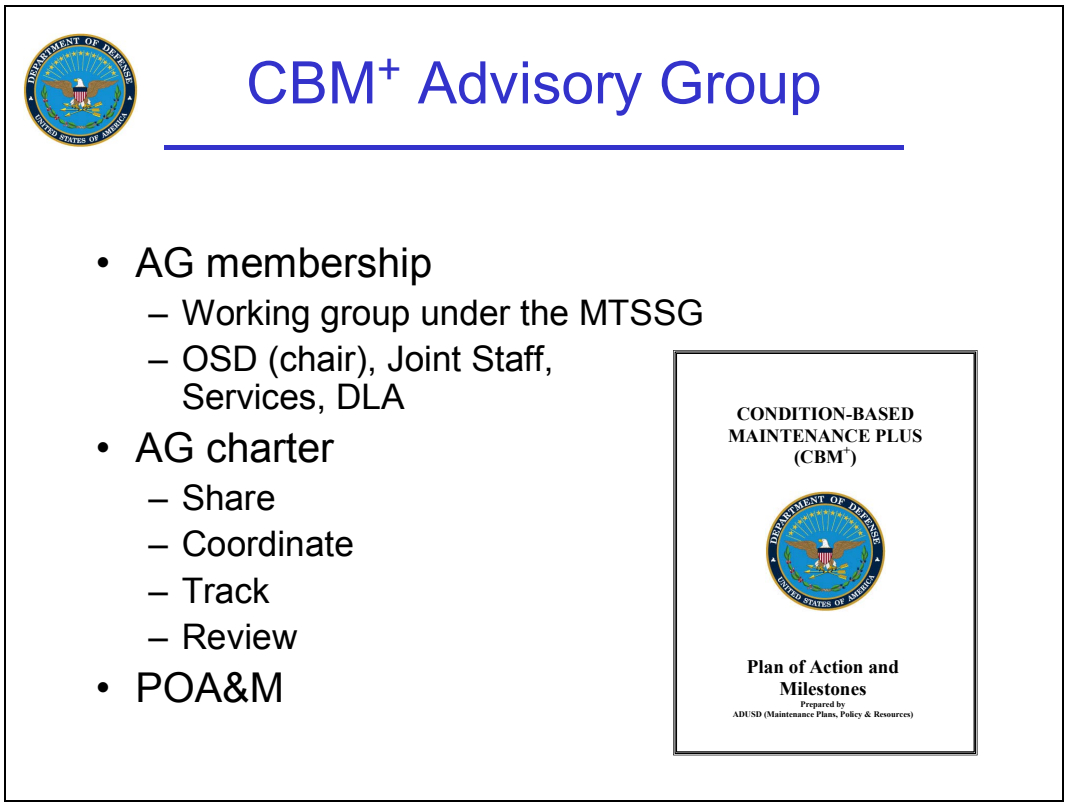
In DoDD 4151.18, CBM+ characteristics are mentioned in multiple examples. For example:

> Maintenance programs for military materiel shall utilize diagnostics, prognostics and health management techniques in embedded and off-equipment applications when feasible and cost-effective. Maintenance programs shall provide the organic maintenance workforce with the range of technological tools necessary to enhance the capabilities (e.g., interactive technical manuals, portable maintenance aids, and access to technical information), properly equip the workforce and provide adequate technical and managerial training.

The requirements to collect and analyze reliability data, take action on information, and other CBM+ activities are also cited.

The CBM+ website serves as the clearinghouse requirement stated in the original CBM+ charter. It is dynamic and continually refreshed. The website is populated with overarching policy documents, a copy of the CBM+ brochure, and links to government, academia, and industry condition-based maintenance websites and upcoming events. Each military service, the Joint Staff, and DLA also have an icon that links to their specific CBM+ information.

A CBM+ brochure has been distributed at a variety of forums and is available from OSD. OSD and the services are committed to providing revised documentation on a continuing basis.



The CBM+ Advisory Group, a sub-panel of the Maintenance Technology Senior Steering Group (MTSSG), is chaired by OSD and includes members from each of the services, the Joint Staff, and DLA. The panel receives direction from the MTSSG, and its main purpose is to implement CBM+ technology and practices throughout the DoD maintenance community by supporting each service's individual CBM+ plan. The advisory group's general tasking is to

- share information, successes, and failures (a clearinghouse function);
- provide a vehicle for pooling resources and coordinating efforts;
- track CBM+ implementation efforts in DoD and advise or share information across the military services;
- review government, academic, research and development, and industry opportunities to leverage their efforts.

A POA&M guides the advisory group activities and provides additional guidance for the services. The POA&M is revised periodically.

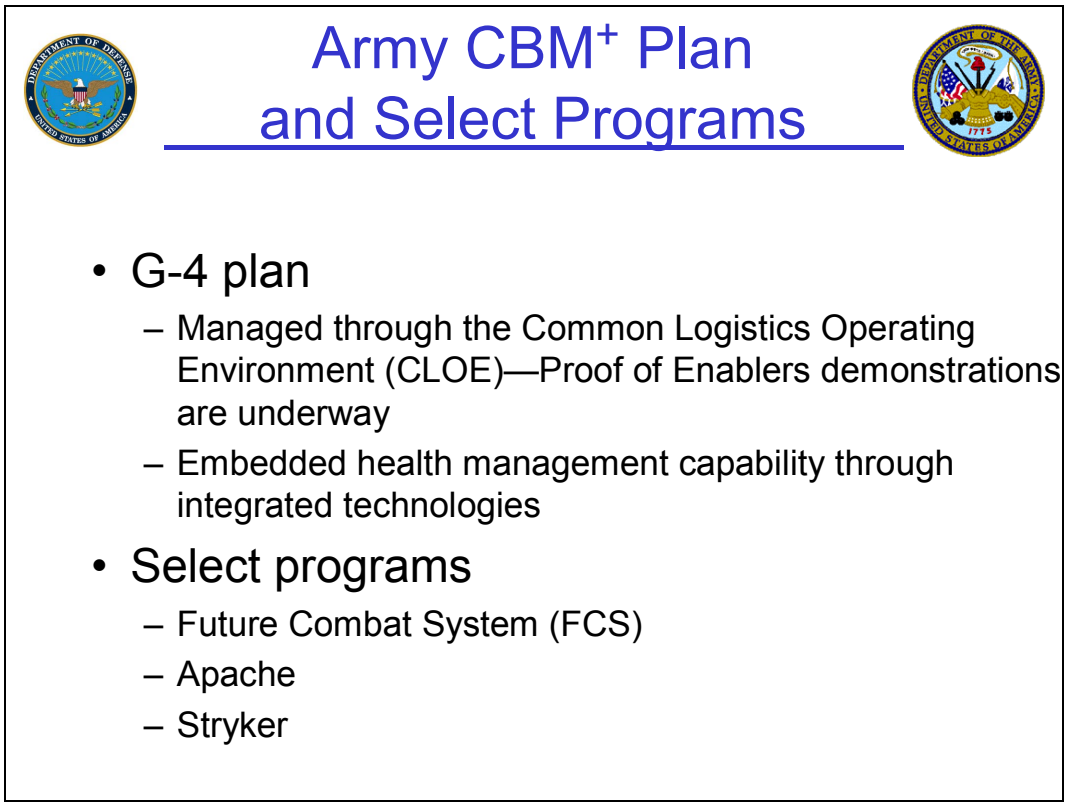
CBM+ Activity

- Establish DoD CBM+ Baseline
- Make web site the "go-to" Clearinghouse
- Leverage efforts for efficiency and effectiveness
- Investigate funding and training opportunities
- Identify contacts and related efforts
- Collect, compile, and coordinate experience

To help identify common ground for CBM+ development, a survey was conducted with select programs designated by each service. In the future, the survey will be expanded to other programs and appropriate commercial activities, as other CBM+ efforts are identified. The CBM+ baseline is a reference and a resource for programs and the services as they pursue CBM+ improvements. When specific CBM+ tools or technologies are identified, teaming between programs with similar efforts is encouraged to minimize costs, leverage the experience, and further progress their initiatives.

One of the harder parts of a program office's CBM+ process is financial (i.e., justifying the use of resources, calculating a return on their investment, and determining the effect on readiness). As progress is documented, the information is shared for others to use in support of their CBM+ efforts. Other funding resources are encouraged, such as efforts under the Advanced Concept Technology Demonstration (ACTD) and the Small Business Innovative Research (SBIR) programs.

The CBM+ Advisory Group performs a connecting function, promoting the flow of information and experience across programs consistent with the MTSSG's guidance. Results, discoveries, links, and references are posted on the unclassified and open-access CBM+ website.

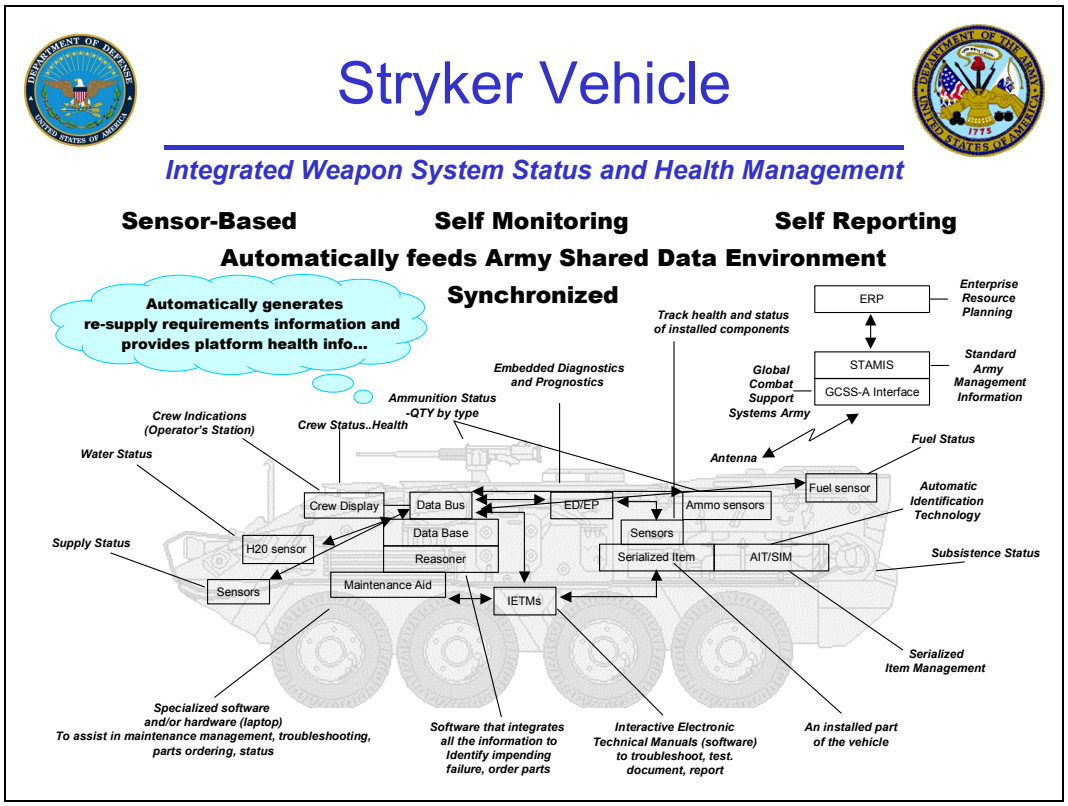


The Army is moving toward distribution-based maintenance operations, an Army two-level maintenance force structure that uses critical enablers to connect the maintainer to the enterprise information system. The starting point is the platform, which uses CBM+ from integrated capabilities (such as embedded diagnostics and prognostics, IETMs, AIT, automated log books, integrated data bus, and health management[1]).

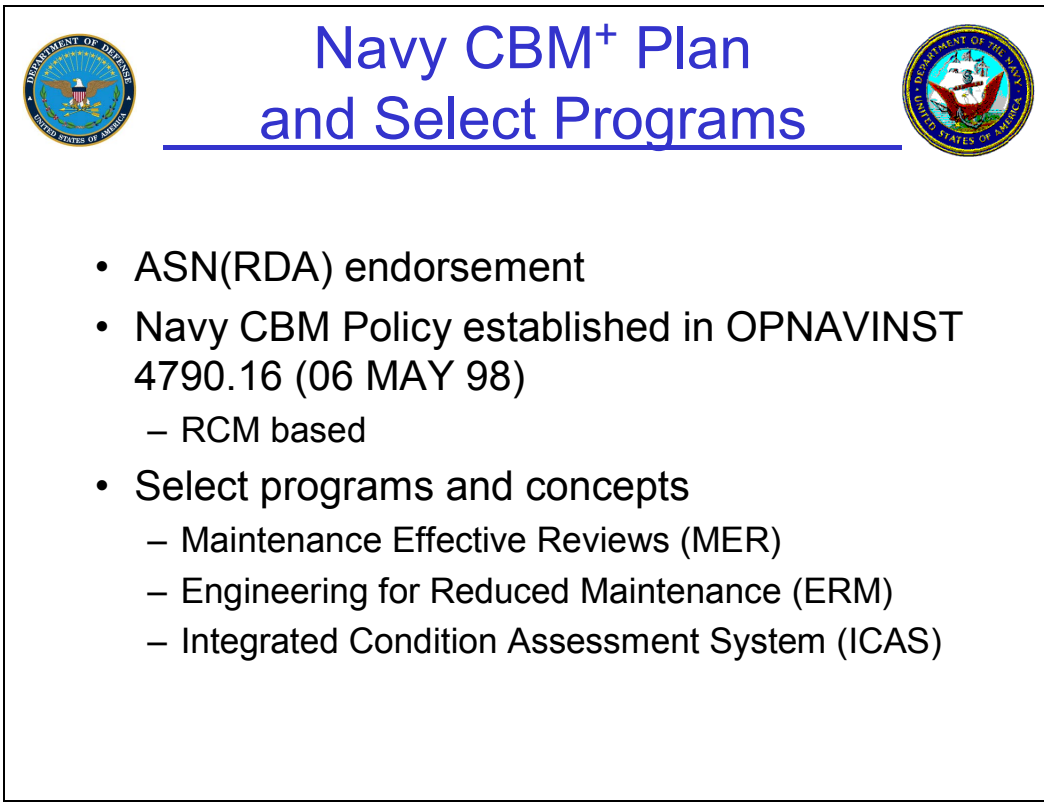
Policy documents (in revision) are the AR 750-1, *Army Materiel Management Policy,* and AR 750-43, *Test Measurement and Diagnostic Policy and Program*.

A Common Logistics Operating Environment (CLOE) Operational Architecture, version 1.0, was designed for Stryker. It will be expanded to FCS, aviation, and other classes of systems over time.

[1] These CBM+ initiatives are managed by the program (policy published in September 2003).



The Stryker's diagnostic and prognostic capabilities exemplify CBM^{+} tenets. For Stryker, the Army is identifying the kind of data needed, the sensors to provide the data, the collection and data transfer capabilities, and the supporting analytical infrastructure to make use of the data. Stryker will transmit data into a responsive, analytical logistics system. Trends and impending failures will be identified, and then anticipatory maintenance and logistics support will be scheduled. In this case, the Army plans to have many of these capabilities engineered and demonstrated in the next year, even though the supporting information systems may prove to be the long pole in the tent.

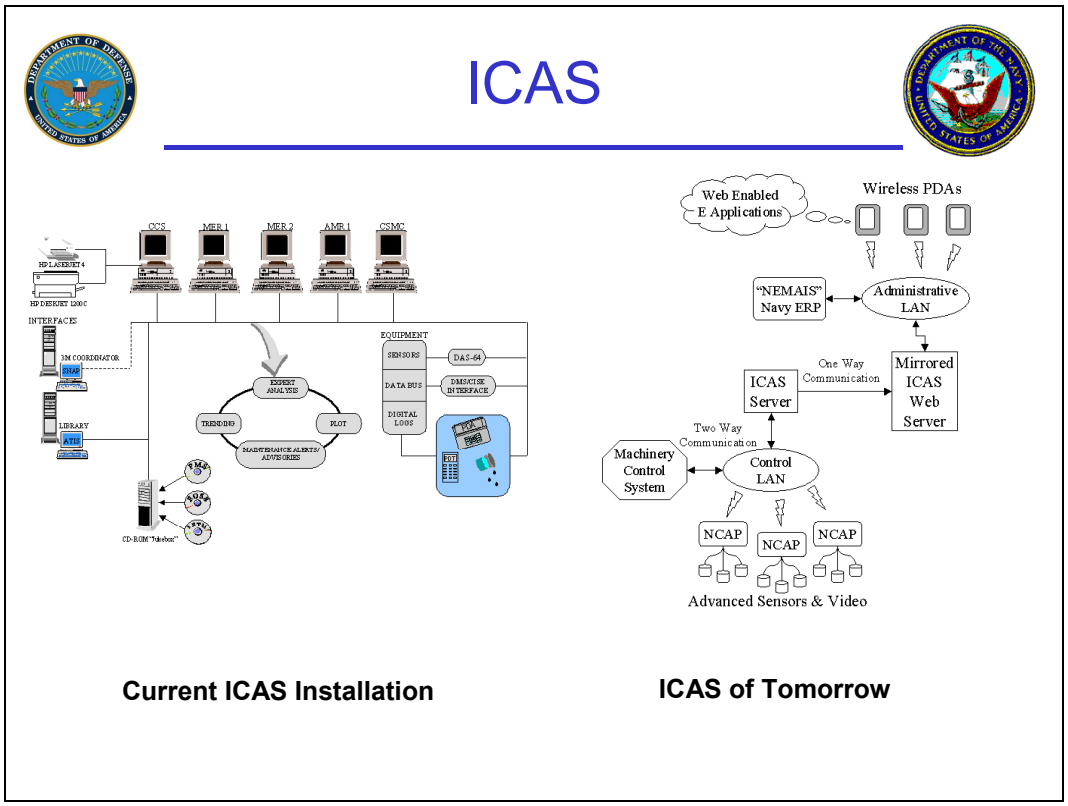


The Navy endorsed and distributed the original OSD policy. A CBM instruction already existed for Navy.

The Navy has used Maintenance Effectiveness Reviews (MER) to validate both the RCM applicability and RCM effectiveness of shipboard planned maintenance. The results include more than a 43 percent reduction in scheduled ship's force maintenance man-hours and attendant reductions in parts and consumables with no reduction in operability or reliability.

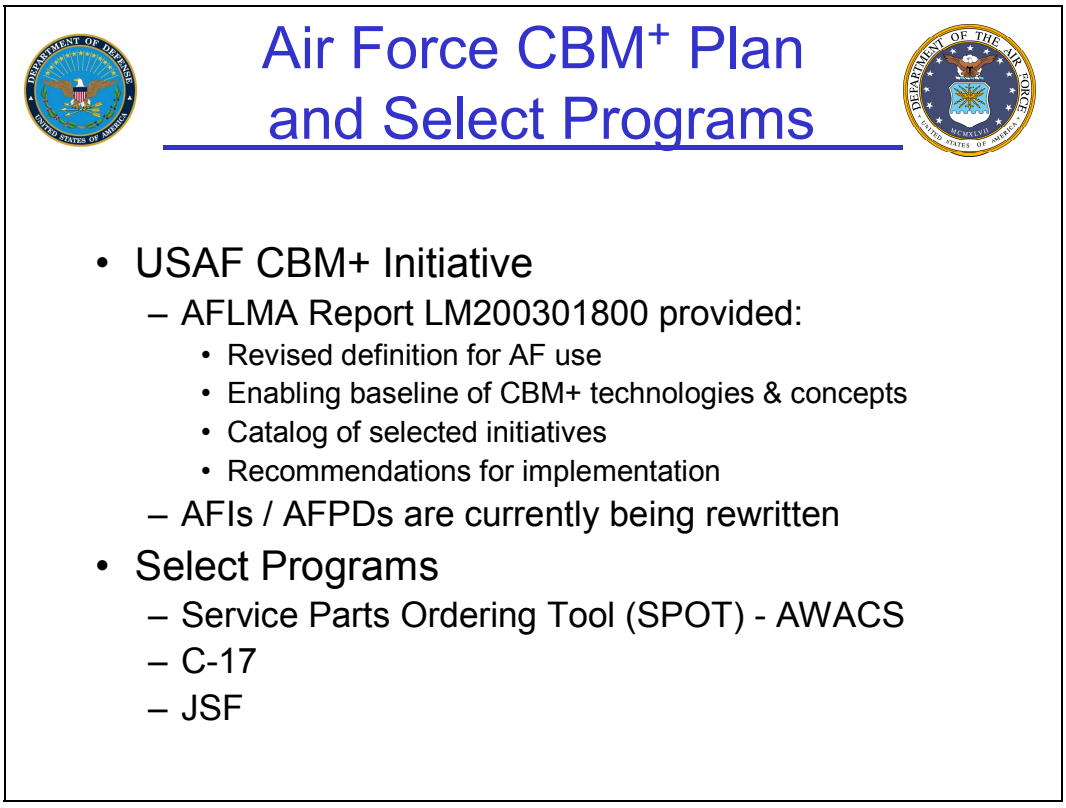
The Engineering for Reduced Maintenance (ERM) program evaluates existing systems including maintenance practices and implements advanced technology solutions such as advanced materials, coating systems, and configuration changes.

The Integrated Condition Assessment System (ICAS) uses COTS hardware and software for on-line automated machinery condition monitoring and assessment. ICAS is being evaluated to determine the potential for increases in component reliability while reducing watch stander requirements.



The Integrated Condition Assessment System (ICAS) is the Navy's ACAT IVM program of record for online automated machinery condition monitoring and assessment. ICAS is commercial off-the-shelf software, although the Navy holds government purpose license rights. ICAS gathers and processes real-time equipment data from system interfaces and machinery sensors, as well as periodic data from hand-held devices, for evaluating the operational condition of monitored equipment. As an implementing tool for CBM, ICAS compares live data against expected equipment operational data profiles, thus identifying abnormal conditions or performance degradation prior to a catastrophic failure.

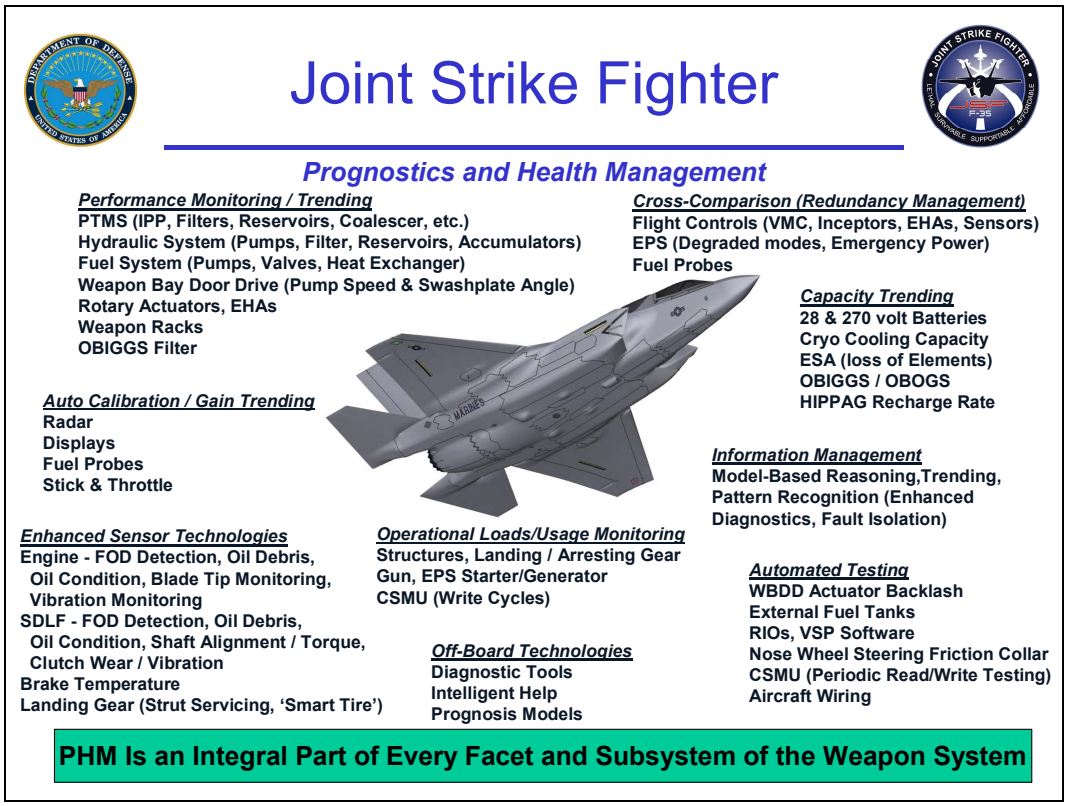
ICAS is currently installed on more than 100 ships across 12 classes throughout the fleet. It is a core technology for "Smart Ship" upgrades, and integral to both new construction and new ship design. A typical ICAS installation consists of four to five workstations (one in each major machinery compartment) connected by an active local area network (LAN). Each workstation accommodates a unique configuration data set that contains engineering information. ICAS converts uploaded data into useful information. It also contains links to other digital logistics products such as the Engineering Operational Sequencing System (EOSS), Planned Maintenance System (PMS), and ETMs. ICAS saves man-hours through the automation of performance monitoring and the software's automated diagnostic features. Efforts are underway to gather the collected data into a common database, the Maintenance Engineering Library Server (MELS). New technologies and proven business practices will be implemented as ICAS evolves, including commercially available electronic business applications, wireless networks and devices, enhanced diagnostics and prognostics capabilities, and integrated video and advanced sensors. ICAS should integrate with the Enterprise Maintenance Automated Information Service (NEMIAS), the Navy's ERP solution for ship and shore industrial activities.



The report from the Air Force Logistics Management Agency built upon DoD's CBM$^+$ definition to identify the importance of including CBM$^+$ considerations into the "total life-cycle support" of all weapon system (to include missiles). It has been submitted for posting on the CBM$^+$ website.

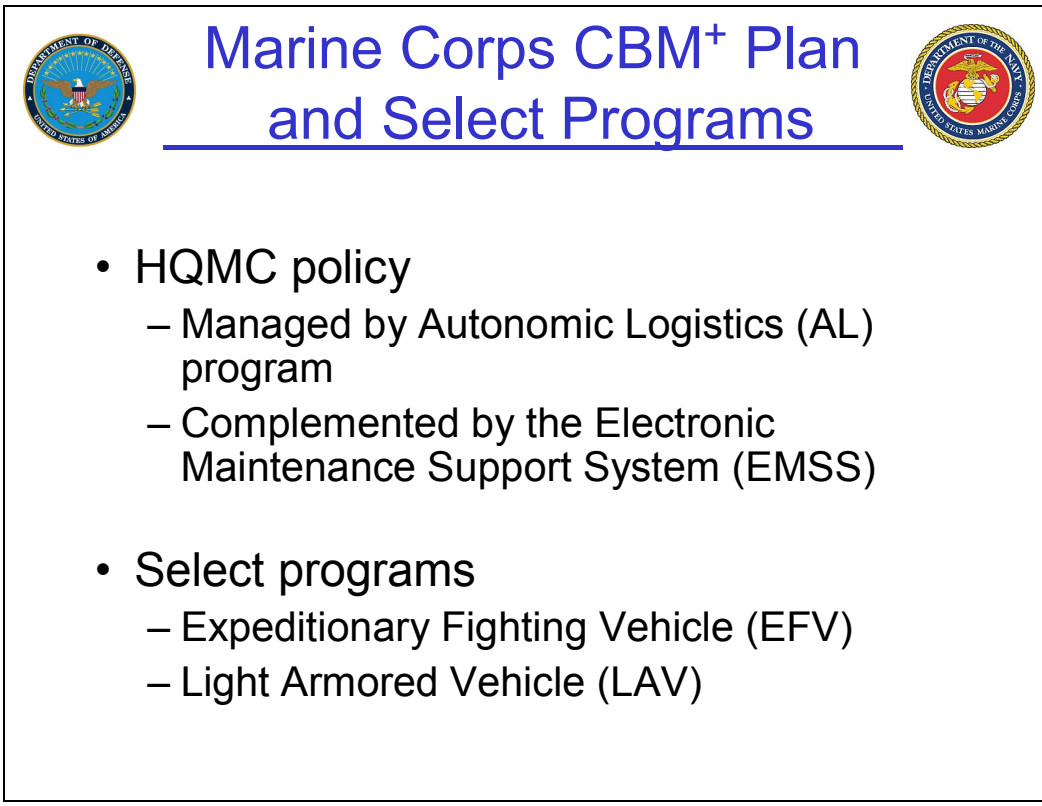
Air Force instructions and policy directives are being rewritten to reflect changes in DoDI 5000.2, *Operation of the Defense Acquisition System*, and to incorporate CBM$^+$ initiatives.

The Air Force C-17 program has a legacy CBM$^+$ opportunity, but the Joint Strike Fighter offers acquisition CBM$^+$ integration with two other services (Navy and Marine Corps) and several foreign partners. The Service Parts Ordering Tool (SPOT) program highlights process and procedures developed to enable improved logistics practices through connectivity between illustrated parts breakdown (IPB) manuals and the Core Automated Maintenance System (CAMS), which results in more efficient use of man-hours.



The JSF Autonomic Logistics (AL) System is a new and revolutionary supportability concept that will enable better utilization of the F-35 throughout the life of the platform—and at a lower cost than legacy aircraft. One of the key enablers of the AL concept is an advanced Prognostic and Health Management (PHM) system. The PHM system provides the data, information, and knowledge through a comprehensive set of capabilities that are applied to every major system and subsystem on the aircraft. PHM capabilities include the ability to do high-level automatic fault detection and fault isolation in real-time, in-flight, and on-board the aircraft with very low false alarm rates. Other facets of PHM include fault prediction or real prognostics on selected components, parts life usage tracking on life limited components, performance trending, fault filtering and reporting, and recommended actions to the pilot only when action is necessary. Information will be downloaded electronically before landing. Most maintenance actions and life-cycle decisions will be based on the assessment of an actual materiel condition.

The PHM architecture will provide data directly into the AL Information System. Stringent PHM requirements have been identified and placed on the JSF Air System to enable the JSF AL support concept. Prognostics represent the main challenges for the design and logistics teams.



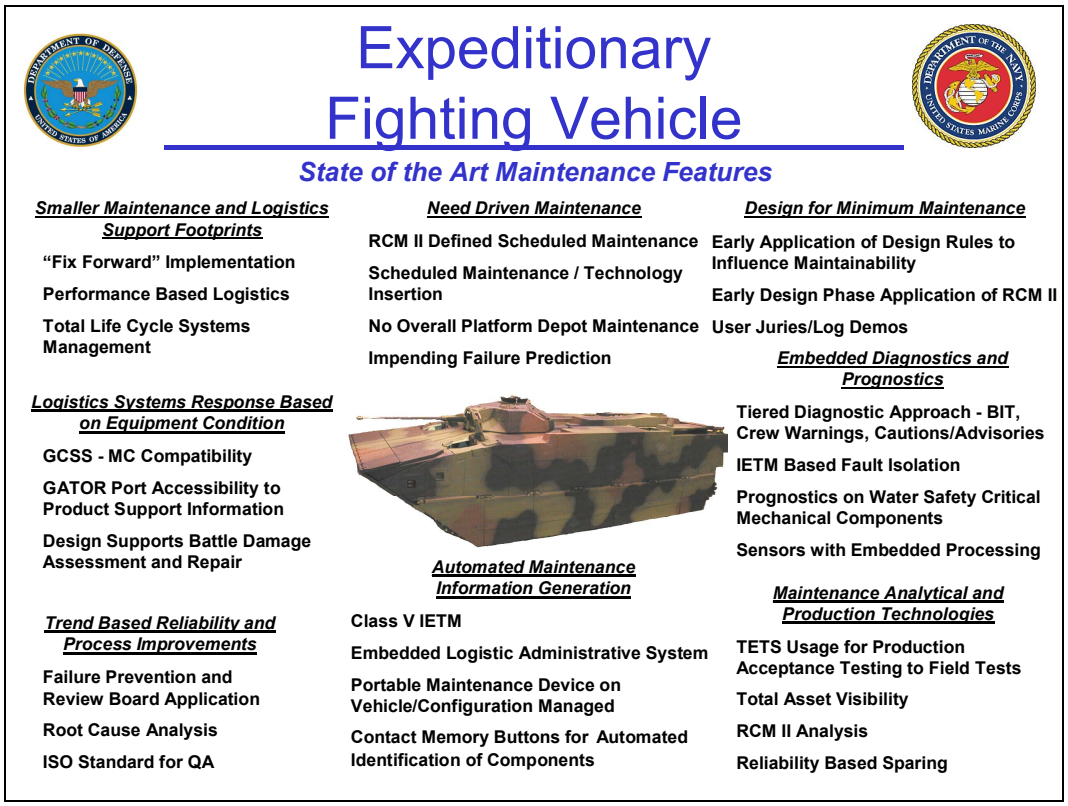
The Marine Corps is using the future program of record, Autonomic Logistics, to implement CBM$^+$ into its weapon systems. The AL approach goes beyond the prognostic and diagnostic elements of CBM$^+$ to include location and other logistic functions, such as fuel levels, ammunition levels, etc. Autonomic Logistics will affect all Marine Corps weapon systems. Its mission is to review all new programs for applicability for AL functions. In addition, AL periodically will review all legacy systems for application of AL functions. The Marine Corps anticipates changes and updates to sensors and other CBM$^+$ technology, plus future decreases in costs as technologies mature and provide additional opportunities for CBM$^+$ implement into weapon systems.

The Electronic Maintenance Support System (EMSS)[2] complements AL. Together, both programs enhance the maintenance efforts of the Marine Corps. EMSS will use the output of the prognostic and diagnostic processes from AL and feed the information into information systems (wearable computers, tablets, etc.) used by mechanics and technicians. EMSS uses integrated electronic technical manual functionality, and will have the ability to teach—as well as guide—the repairer about the defective component. Once the defect is determined and the repair parts are identified, the technician or mechanic will be able to use EMSS to order the required parts.

For the CBM$^+$ Select Programs initiative, the Marine Corps nominated the Expeditionary Fighting Vehicle (EFV)[3] and the Light Armored Vehicle (LAV) programs. Both programs have identified and are implementing CBM$^+$ into their platforms.

[2] EMSS will be fully compatible with GCSS-MC (Global Combat Support System–Marine Corps).

[3] Formerly known as the Advanced Amphibious Assault Vehicle

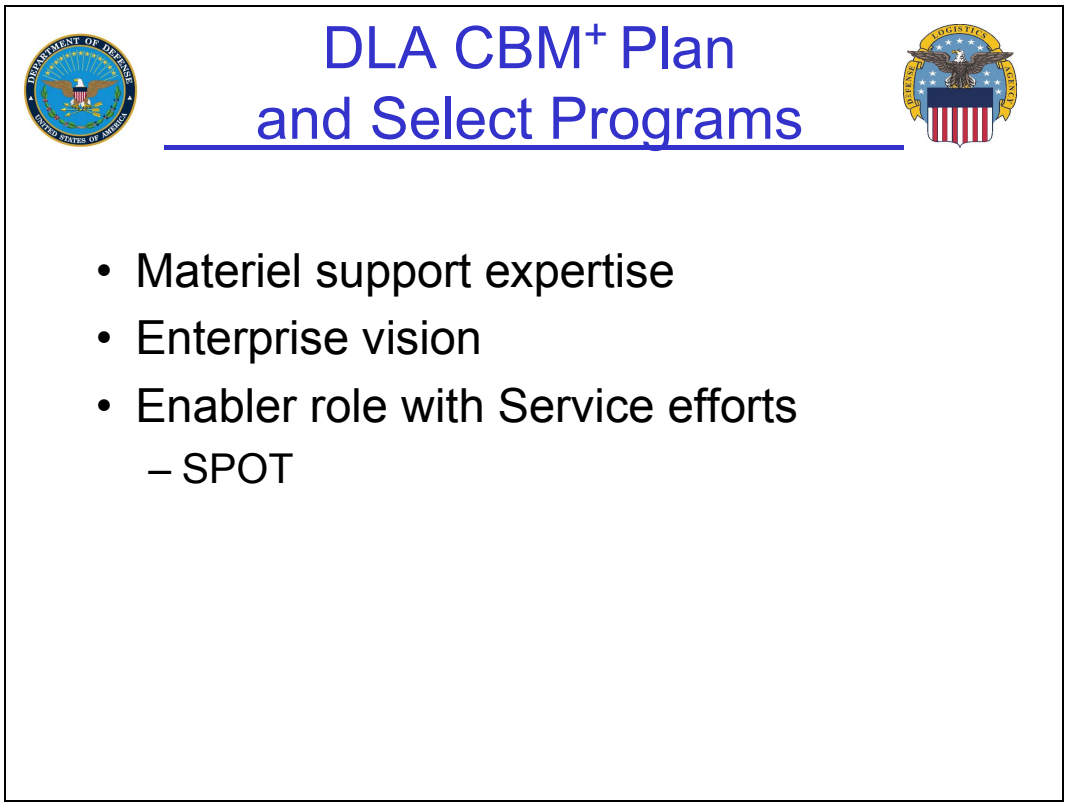


The maintenance concept of the EFV, as defined in the ORD, is to "fix as far forward as possible," with the intent of driving maintenance costs down but increasing vehicle availability. The EFV has a USMC 3-level maintenance concept, which works in concert with an emerging Logistics Enterprise Initiative maintenance strategy. The vehicle's design allows more maintenance at the organizational and intermediate levels. It is designed for maintainability by focusing on

- component accessibility,
- a robust diagnostics capability to efficiently and effectively locate the failed component,
- a RCM-based preventive maintenance schedule, and
- the prognostics monitoring of critical components where applicable) to predict failures in an "actionable" time period.

In addition, the simplicity of design keeps the required skill levels for maintenance personnel generally commensurate with Marines in assault amphibian battalions.

A scheduled maintenance, technology insertion (SM/TI) program is being developed to mitigate technological obsolescence and eliminate the requirement for major depot overhaul. All maintenance and technology upgrades will be accomplished as near to the owning unit as possible. As a result, the SM/TI program will realize significant cost savings in transportation, but still increase operational availability of EFV vehicles.



DLA fills a unique role in CBM$^+$. Lacking traditional program office activities, DLA does not have any programs for benchmarking, but it does have the opportunity to be "an enabler" of CBM$^+$ for others.

The supply functions and features often dictate the success or failure of new technologies and support options, most often with an emphasis on speed of delivery and reduced investment cost for support. DLA, as well as the services' inventory control points, need to be flexible enough to respond to any revised requirements process or practices that CBM$^+$ technologies may introduce. For example, prognostics may generate a requirement in advance of current failure-related generation, so DLA may need to prepare for the requirement with new justification.

DLA, as an organization, may need to modify current inventory and distribution parameters to comply with revised logistics footprint and supply response parameters. DLA can share their experience with other logistics initiatives, their enterprise-wide approach that will translate single solutions across DoD, and participate with the Services in the peculiar materiel support aspects of their CBM$^+$ programs.

The Air Force E-3 Sentry program is the platform for SPOT, a DLA Research and Development effort that has been transitioned to Air Force. SPOT envisions the use of IETMs by the maintainer to electronically generate an order into the supply system, eliminating the current manual steps. Through two interfaces, it links the IPB to SPOT, then links Spot to CAMS. SPOT is being expanded to cover other programs, including the Navy's Mine Warfare community.

CBM+ Related Efforts

- Defense Advanced Research Projects Agency (DARPA)
- Advanced Concept Technology Demonstrations (ACTD)
- Commercial Technologies for Maintenance Activities (CTMA)
- Academia
- Corrosion Control, Lean, and other maintenance-centric initiatives

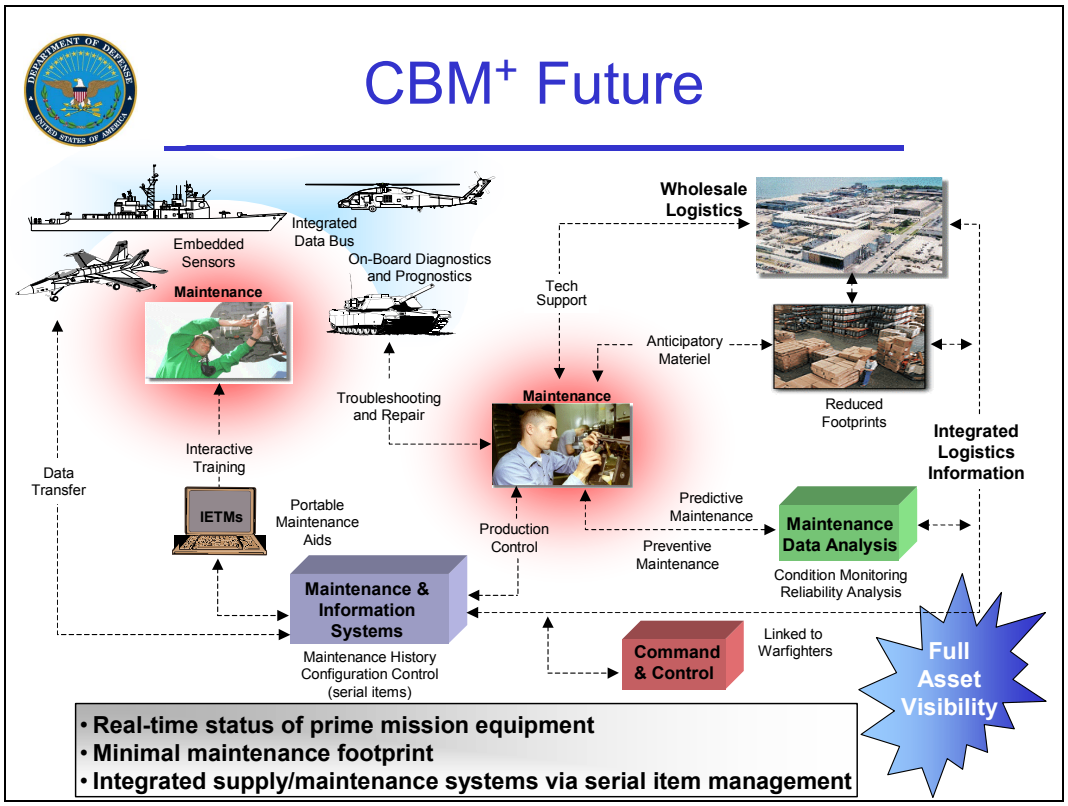
A number of DARPA projects involve CBM+ technologies, including a prognostics study, a material failure and defect growth study, and a developing project to research machines that sense their condition, share the information, and change configuration based on mission needs.

ACDT's team warfighters and the development community use mature or emerging technologies to evaluate solutions critical to military needs. The goal of the Joint Distance Support and Response ACTD project is to demonstrate the capability to transmit maintenance diagnostics from the field to a subject matter expert and return information to assist in the repair process.

The Light Armored Vehicle platform has a Commercial Technologies for Maintenance Activities (CTMA) project to test new predictive CBM methods, including diagnostic sensors, knowledge management, emote telematics, software, and others.

Georgia Tech Research Institute has extension courses and an electronic performance support system tested with the Navy's P-3 community. Rochester Institute of Technology is part of the LAV CTMA project and they established an Asset Health Management program. The Advanced Research Lab at Penn State worked on Systems Health Monitoring for the AAAV and LAV programs. Carnegie Mellon University developed wearable and handheld computers and studied team maintenance concepts, collaboration, and other maintenance applications for computers.

Studies in the corrosion control arena have highlighted technology, maintenance practices and material improvements that complement CBM+ efforts. Lean and other process management solutions implement changes in equipment maintenance plans. The CBM+ Advisory Group can help coordinate the integration of other DoD initiatives (e.g., AIT, RFID, and UID) within the CBM+ environment.



As envisioned, CBM+ will make DoD's logistics operations maintenance-centric. By improving both direct maintenance and supporting activities through CBM+, the preponderance of logistics resources can be brought together to enhance combat capability.

As CBM+ technologies are fielded on platforms and systems with advanced capabilities, DoD maintenance operations will be transformed with applications, techniques, and business processes to make future maintenance operations more effective. CBM+ concepts will link emerging maintenance and logistics requirements to the right resources in a timely and efficient manner. By providing maintainers with the necessary tools and information, CBM+ will optimize their ability to support the warfighter. The maintenance and logistics systems will be synchronized to deliver and sustain unprecedented combat capabilities that are inherent in current and future weapon systems. The individual maintainer remains the key to success—CBM+ provides the best information, training, tools, and logistics support possible.

One of the greatest technical challenges facing CBM+ is the development of prognostics as a routine element of DoD maintenance plans. It is consistently the most desired characteristic when talking to logistics managers and maintenance personnel. And it can bestow significant benefits in both improved readiness and cost savings.

CBM+ Summary

- CBM+ initiative envisions an integrated set of capabilities, technologies, and business processes
- As Service plans evolve and CBM+ efforts are implemented, OSD supports the development of technology, processes, tools and procedures to enable maintenance improvements
- CBM+ Goal - proactive maintenance based on evidence of need performed at an optimal time by maintainers with the
  - Right knowledge
  - Right tools and
  - Right support

Each military service is responsible for guiding the implementation of CBM+ in its programs and platforms. In addition to normal distribution within the service, general policy and specific CBM+-related program references will be posted on the CBM+ website for wider dissemination.

Although CBM+ is a "new requirement," it represents the continuing evolution of maintenance processes and procedures that are based upon improved capabilities in practices and techniques. Aside from CBM+ developments within DoD, maintenance technologies that belong under the umbrella of CBM+ include a wide variety of leading-edge commercial practices and products.

CBM+ efforts can be considered intuitively appropriate for application in a weapon system maintenance plan; more often, these efforts lack definitive metrics for the cost-benefit analysis that will support acquisition and implementation. Program managers must obtain the justification for limited resources. Therefore, it is important to capture the history of CBM+ technologies and features in military programs and the commercial sector to aide the transformation of DoD maintenance.