

**Report of the  
OSD CBM<sup>+</sup> Action Group  
2010 Summer Study**



**Information on Conducting  
Business Case Analyses  
For  
Condition Based Maintenance Plus (CBM<sup>+</sup>)  
Initiatives**

**October 2010**

Office of the Secretary of Defense  
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## **Preface**

The Office of the Under Secretary of Defense (OSD) for Acquisition, Technology, and Logistics (AT&L), in collaboration with the Military Services, has developed this planning guidance to assist Service Acquisition and other Department of Defense (DoD) organizational components in developing Business Case Analyses (BCAs) for evaluating and assessing methodologies and approaches to implement effective Condition Based Maintenance Plus (CBM<sup>+</sup>) initiatives within DoD system acquisition and sustainment programs. This paper documents the results and findings of an OSD-sponsored Study Team review of CBM<sup>+</sup> related BCA efforts from within DoD, industry, and academia in conducting BCAs for CBM<sup>+</sup> capability/components. This paper provides a framework, general guidance, and essential factors that should be addressed to properly scope, define, and conduct a BCA for CBM<sup>+</sup> initiatives within any phase of the acquisition lifecycle. This paper is intended to supplement existing DoD and Service-specific guidance for developing BCAs related to CBM<sup>+</sup>.

A key objective for this paper is to outline a flexible and effective BCA approach that can be tailored and affordable in both time and cost to support program manager's implementation of CBM<sup>+</sup> policy in accordance with the OSD CBM<sup>+</sup> Guidebook, Reference A. This paper provides an overall CBM<sup>+</sup> BCA process, a common set of cost elements, measures of effectiveness, a notional BCA framework, and factors to consider when assessing and subsequently conducting a CBM<sup>+</sup> BCA. This paper should help shape an understanding of the areas that CBM<sup>+</sup> capabilities might benefit a program/system, in order to support a go/no-go decision and subsequent investment decisions with justifiable information.

## **General Guidance and Information**

CBM<sup>+</sup> 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<sup>+</sup> is maintenance performed based on evidence of need provided by Reliability Centered Maintenance (RCM) analysis and other enabling processes and technologies. CBM<sup>+</sup> uses a systems engineering approach to collect data, enable analysis, and support the decision-making processes for system acquisition, operations, and sustainment. In evaluating potential CBM<sup>+</sup> capabilities, whether they are technologies, maintenance processes, or information/data knowledge applications, a BCA needs to address these areas in a comprehensive and consistent manner, particularly when an incremental acquisition or fielding strategy is being considered.

Although the basic concept and purpose of BCAs are generally understood throughout DoD, many interpretations exist regarding assessment of CBM<sup>+</sup> capabilities to ensure appropriate and accurate considerations are given to CBM<sup>+</sup> capabilities, costs, and benefits. So, what is a BCA? A BCA is a decision support document that identifies alternatives and presents convincing business, economic, risk, and technical arguments for selection and implementation to achieve stated organizational objectives/imperatives. A BCA does not replace the judgment of a decision maker, but rather provides an analytic and uniform foundation upon which sound investment decisions can be made. The subject of a BCA may include any significant

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investment decision that leadership is contemplating. For example, a BCA may be used to substantiate the case to invest in a new weapons system, but not at the same level as a Capabilities Based Assessment; transform business operations; develop a web-based training curriculum; or retire an asset. In general, BCAs are designed to answer the following question: What are the likely financial and other business (non-financial) consequences if we execute this investment decision or this action? The possibility exists that any projected savings or cost reductions identified in the BCA could be viewed as an asset available for reallocation in the budgeting process.

In evaluating the potential application of a CBM<sup>+</sup> capability, it is important to understand the desired end state from a CBM<sup>+</sup> metrics perspective and key assumptions that may impact the system or CBM<sup>+</sup> capability. Figure 1 outlines a general approach to help define the need for a BCA, understand and define the problem, and define the desired end state. This approach focuses on As-Is system trends, evaluating Measures of Effectiveness (MOEs) and their cost drivers, key CBM<sup>+</sup> metrics, determining if CBM<sup>+</sup> is a viable solution and if so, what CBM<sup>+</sup> capabilities are applicable, and then defining feasible solutions. Appendix A – CBM<sup>+</sup> Scoping Questions provides some general questions and guidance that may relate to your CBM<sup>+</sup> initiative. Answers to these questions are provided as information and an approach to support CBM<sup>+</sup> implementation. As you plan your CBM<sup>+</sup> BCA, they may assist in framing your general approach and strategy and ensure your CBM<sup>+</sup> BCA is adequately defined and scoped to address key CBM<sup>+</sup> business areas.

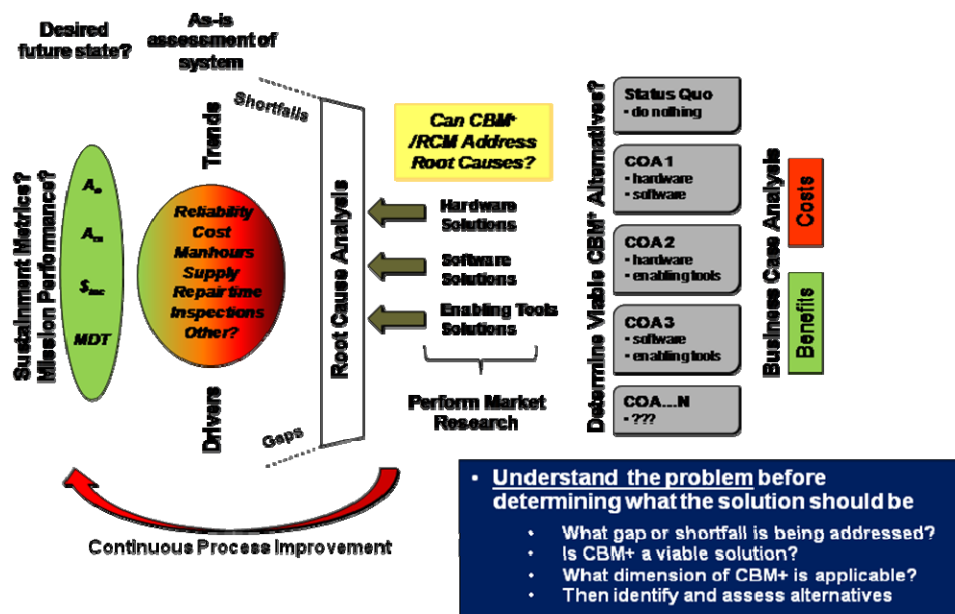


Figure 1 – Scoping a CBM<sup>+</sup> BCA

The National Defense Industrial Association (NDIA) final report of the Systems Enterprise Health Management (EHM) Technology Transition Study Report dated October 2009, Reference B,

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noted that “enabling technologies are not being transitioned and weapon systems are not realizing the value of the capability as quickly as they could, primarily due to inadequate implementation strategies. Properly evaluating enabling technologies with an objective of realizing the CBM<sup>+</sup> value more quickly can be accomplished with a common method and process for conducting CBM<sup>+</sup> BCAs.”

Figure 2, the basic CBM<sup>+</sup> infrastructure as described in the CBM<sup>+</sup> Guidebook, displays the areas that should be considered as building blocks in designing a new system or modification of existing systems, for overall CBM<sup>+</sup> implementation. Considering these areas enables incremental progression of levels of sophistication from foundational source data (e.g., systems/platform sensor data) through a full EHM capability. The levels of sophistication and relationship between CBM<sup>+</sup>, source data, RCM, and EHM should be considered in the systems engineering process and in conducting a CBM<sup>+</sup> BCA.

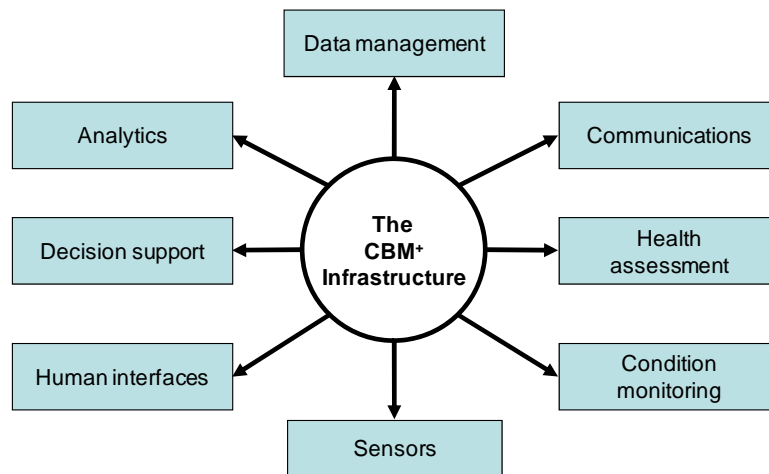


Figure 2 – CBM<sup>+</sup> Infrastructure

**CBM<sup>+</sup> BCA Framework.** Figure 3 illustrates a process intended to assist in defining assumptions and boundaries, describing the As-Is configuration of your current system, defining alternative CBM<sup>+</sup> courses of action (COAs) and then doing the risk assessment and sensitivity analysis to arrive at a recommended solution. Collaboration and/or interviews with the customers/stakeholders may be needed to ensure their needs, expectations, and projected outcomes are clearly understood. This includes identifying and applying appropriate CBM<sup>+</sup> cost and MOEs factors that should be considered in planning, conducting, and reporting results of CBM<sup>+</sup> BCAs. The specific cost elements, MOEs, and Return on Investment (ROI) will depend on variables associated with your specific system to include: the status of its life cycle, planned product improvements, planned CBM<sup>+</sup> increments/upgrades, as well as other external systems which interface with your system or are planned to be integrated within the life cycle of your system.

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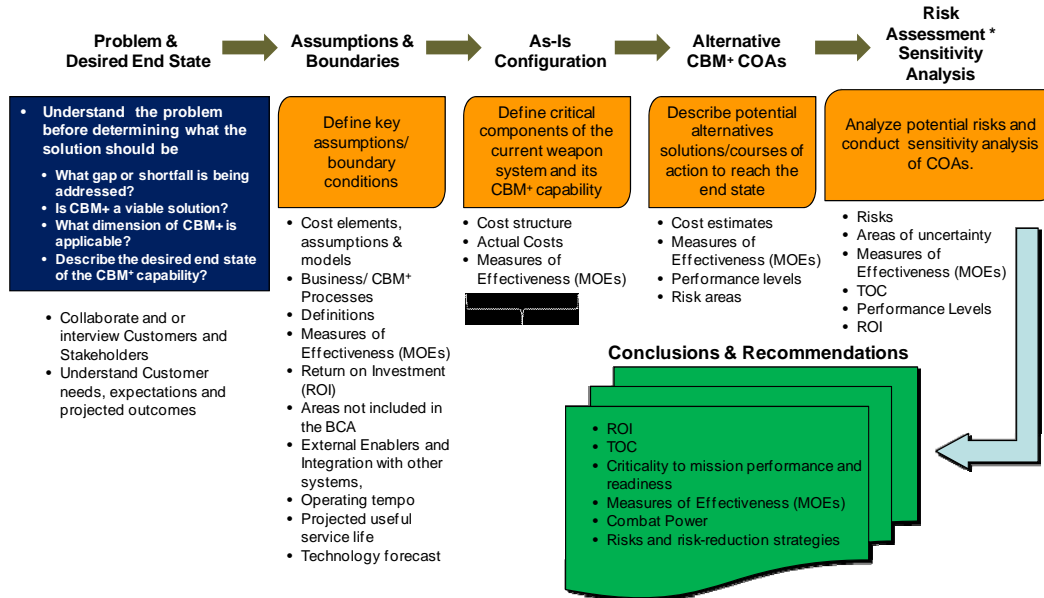


Figure 3 – CBM<sup>+</sup> BCA Process

The notional CBM<sup>+</sup> BCA framework described below and provided in Appendix B – CBM+ BCA Outline is based on CBM<sup>+</sup> related BCAs, the Defense Acquisition University (DAU) BCA Template, the Serialized Item Management (SIM) guide, and information obtained from the CBM<sup>+</sup> BCA community that participated in the study. Appendix C provides notional definitions from various CBM<sup>+</sup> and BCA references adapted for potential use in a CBM<sup>+</sup> BCA.

## I. Executive Summary

The Executive Summary should be clear and concise and present the case for or against the investment options, and demonstrate measureable benefits or detriments to the objectives and goals. This will answer the “so what?” The Executive Summary should also address the overall approach of the BCA; the recommended course of action; pros and cons; why it is the better choice from other considered alternatives, including the ROI (if any); the process that was followed to arrive at the conclusion (including weighting and scoring summary of the criteria along with a brief discussion of how quantitative and non-quantitative aspects were addressed, and summary results of the sensitivity analyses.); highlights of risk, uncertainties, and implementation considerations including resources required to support the recommendation.

## II. Boundaries and Assumptions

- a. **Goals and Vision.** This section should address your strategic objectives and why you are conducting a CBM<sup>+</sup> BCA and should clearly articulate an understanding of specific problems that the proposed CBM<sup>+</sup> capability is addressing. Include discussion of your business strategy including any phased or incremental CBM<sup>+</sup> implementation. The general approach outlined in Figure 1 and the scoping questions provided in Appendix A, are intended help understand the problem, your vision and projected end state to properly scope of your BCA.

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- b. **Context and Perspective.** Discuss specific CBM<sup>+</sup> attributes or performance measures for your CBM<sup>+</sup> implementation. Relate to specific CBM<sup>+</sup> business needs (e.g., need to predict equipment failures, need for greater accuracy in failure prediction, need to reduce the cost of ownership, need to optimize equipment performance (availability)) and metrics as defined in the CBM<sup>+</sup> Guidebook, Reference A. Consider any previous related BCA results that can assist in establishing a baseline for cost, MOEs, system performance, combat power, and/or mission impact.
- c. **CBM<sup>+</sup> Metrics.** The CBM<sup>+</sup> Guidebook, Reference A, outlines measureable objectives for maintenance in a CBM<sup>+</sup> environment and five relevant CBM<sup>+</sup> operating metrics: material availability, material reliability, ownership costs, and mean down time; and logistics footprint. OSD guidance for Performance Based Logistics (PBL) USD AT&L Ltr 16 Aug 2004 c and Life Cycle Sustainment (LCS), USD AT&L Ltr 10 Mar 2007, Reference D, also provides relevant metrics that can be used to support CBM<sup>+</sup> implementation. When defining metrics for your BCA, select a set of metrics, considering Systems Operational Effectiveness (SOEs) metrics, that fairly represent the potential costs and MOEs that you expect to be able to capture, or is available from existing data sources, monitor and properly evaluate with the BCA. Appendix C – CBM<sup>+</sup> Related Definitions/Descriptions contains definitions for metrics based on References A, C, and D. Other metrics may also be appropriate when considering predictive capabilities such as advanced diagnostics or prognostics that enable accurate and timely prediction of Remaining Useful Life (RUL). Potential MOEs for Prognostics Health Management (PHM) systems could include advanced warning of failures; increased availability through an extension of maintenance cycles and/or timely repair actions; lower life-cycle costs of equipment from reductions in inspection costs, downtime, inventory, and no-fault-found; or improved system qualification, design, and logistical support of fielded and future systems as noted in the Analysis of ROI for PHM applied to Electronic Systems, Reference E.
- d. **Key Assumptions.** Key assumptions constitute a critical element of the boundaries of the CBM<sup>+</sup> BCA. Not everything included in the analysis is known. CBM<sup>+</sup> BCAs, like any forecasting analysis, address future periods and conditions and as much as we utilize data to predict future conditions, any future datum or condition is subject to change from forces that could not be predicted when the analysis was conducted. Assumptions allow us to logically portray reasonable expectations of future circumstances. Tailoring the BCA to fit your case will require adjusting functional areas, weighting factors interfacing systems, sustainment/incremental capability improvements and service life considerations. Suggested areas to consider in defining assumptions should include: areas of integration with other systems; operating tempo; projected useful service life/remaining useful life; expected funding levels; basis for cost estimates; MOEs and related metrics (throughout the life cycle); technology forecast; CBM<sup>+</sup> related logistics processes; and areas not addressed in the BCA. Considering these areas will help to ensure the CBM<sup>+</sup> BCA is well scoped and defined. It is also important to understand how incremental CBM<sup>+</sup> capability improvements may impact ROI and ensure adequate assumptions are

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- defined regarding the impact of incremental improvements on ROI. These incremental improvements, as well as improvements to other systems, e.g., Global Combat Support System (GCSS), and maintenance processes, will make contributions to the CBM<sup>+</sup> ROI as they come online. Assumptions regarding timing and capability impact on the overall CBM<sup>+</sup> ROI should be clearly stated. The ROI contribution of other systems may be significantly greater than one depending on application, access, and use of CBM<sup>+</sup> data.
- e. **Cost Structure.** Clearly define the cost elements structure being applied for your BCA. Consider the OSD Cost Analysis Improvement Group (CAIG) Operations and Support Cost-Estimating Guide, Reference F, and clearly state any assumptions being made particularly in cases where other Service systems interfaces are planned or to be implemented. Be aware that differences exist among the military services' cost element structures and the OSD CAIG suggested cost element structure. These differences can affect the accuracy and completeness of Operating and Support (O&S) cost estimates. The October 2007 Guide provides suggested approaches and structures for preparing O&S cost estimates. The Defense Cost and Resource Center (DCARC) is a source for related reference material. Appendix D – CBM<sup>+</sup> Cost Elements Structure provides a suggested cost element structure that can be used in your CBM<sup>+</sup> BCA.
  - f. **External CBM<sup>+</sup> Enablers.** Identify any systems or interfaces that will impact your CBM<sup>+</sup> capability. In addition to making the proper assumptions regarding external systems interfaces and approaches for integrating and implementing those systems, it is also important to specifically define any parameters, protocols, and performance measures. Ensure that any external system that will impact incremental CBM<sup>+</sup> capabilities and implementation are clearly identified and defined to the maximum extent.
  - g. **Key Issues.** Identify specific key issues that should be addressed in the costs or benefits structure associated with costs or benefits that may be misunderstood and/or misapplied in CBM<sup>+</sup> BCA analyses, such as CBM<sup>+</sup> metrics; capability; and data/ management system to track results over the life cycle.
  - h. **Evaluation Criteria/Factors.** Define specific evaluation criteria related to the CBM<sup>+</sup> business needs, ROI, and MOEs.
- III. BCA Alternatives.** The scope of the CBM<sup>+</sup> alternatives being considered in terms of incremental capabilities is important to properly define the As-Is configuration and boundaries for each alternative being considered.
- a. **As-Is Configuration/Condition.** Define the As-Is CBM<sup>+</sup> configuration in terms of the existing CBM<sup>+</sup> capability itself, the platform/weapons system it supports or is integrated into, and the current system's CBM<sup>+</sup> performance measures/metrics. To the maximum extent possible, describe the As-Is configuration in terms of the CBM<sup>+</sup> functionality (fault detection, isolation, prediction, reporting, assessment, analysis, decision-support execution and recovery, both on and off-board); CBM<sup>+</sup> business needs; and operating metrics. Where incremental improvements have been



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implemented, provide any prior BCA, Economic Analysis (EA), or analytical data related to CBM<sup>+</sup> functionality, CBM<sup>+</sup> business needs, and metrics.

- b. **Description of Alternative Courses of Action (COAs).** Potential alternative CBM<sup>+</sup> solutions, whether a new system, an enhancement to fielded systems, or an entirely new concept, should be scoped based on an understanding of the program’s strategy and objectives as well as the desired end state from a CBM<sup>+</sup> metrics perspective. Define potential alternatives to the As-Is CBM<sup>+</sup> capability in terms of the projected end state of the CBM<sup>+</sup> capability as well as the platform/weapons system it supports or is integrated into. Ensure that incremental CBM<sup>+</sup> alternatives are properly defined and address as separate COAs based on the systems overall strategy and objectives. COA should be scoped to support the overall program objectives. Figure 4 provides an example of basic CBM<sup>+</sup> incremental capabilities.

<b>Example CBM<sup>+</sup> Increments or COAs</b>	
As-Is	Existing platform CBM <sup>+</sup> capability
Increment 1	Initial Sensor Capability
Increment 2	Increment 1 + Portable Maintenance Aid (PMA)
Increment 3	Increment 2 + Item Unique Identification (IUID)
Increment 4	Increment 3 + Health maintenance
Increment 5	Increment 4 + Decision Support (DS)
Increment 6	Increment 5 + Logistics and C2 Enterprise connectivity

*Figure 4– Example CBM<sup>+</sup> Increments or COAs*

- c. **Projected CBM<sup>+</sup> Cost Elements and MOEs.**
- i. **CBM<sup>+</sup> Cost Elements.** To the maximum extent possible, cost elements should be consistent with the respective Service guidelines, a work breakdown structure consistent with Mil-Std 881 for the respective weapons systems which the CBM<sup>+</sup> capability is being evaluated, and the OSD CAIG - Operating and Support Cost-Estimating Guide, Reference F.
- (1) A number of techniques may be employed to estimate the O&S costs of a weapon system. The suitability of a specific approach will depend to a large degree on the maturity of the program and the level of detail of the available data. Most O&S estimates are accomplished using a combination of one or more of five estimating techniques; parametric, analogy, engineering estimate, actual cost, or cost factors. Cost factors for a CBM<sup>+</sup> BCA must be tailored based on the weapon system(s) and CBM<sup>+</sup> capability(s) being considered using the OSD Cost-Estimating Guide, Reference F. Data normalization is a key requirement and should be thoroughly addressed in an appendix or annex to the CBM<sup>+</sup> BCA.
  - (2) The specific cost element structure should follow the general OSD and Service specific cost estimating guidance and be tailored to fit your CBM<sup>+</sup> capability. Below is a suggested framework which contains a minimum set of four cost element categories for a CBM<sup>+</sup> BCA that must be tailored to the

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respective system and Service requirements. Ensure that recurring, non-recurring, and infrastructural costs are addressed. Internal costs should reflect Government (military and civilian) and support contractor elements separately thereby enabling combining with external contractor costs when appropriate. A detailed set of suggested cost elements is provided at Appendix D.

- (a) Research and Development
  - (b) Investment
  - (c) Operation and Sustainment
  - (d) Disposal/System Replacement
- (3) Cost models. Various cost estimating tools are available and should be considered and tailored to fit your specific system and cost structure. Commonly used tools and a summary of their application are listed and provided in Figure 5.
- (a) Automated Cost Estimating Integrated Tools (ACEIT) supports estimates of Research and Development (R&D), procurement, and/or O&S costs. ACEIT integrates ACE (an automated costs estimating system with “documentation on-the-fly” capability and built-in methodology library including cost estimating relationships cost models, and additional estimating sources); a library of commercial and non-commercial cost models); RI\$K (a model which quantifies risk associated with a cost estimate) and CO\$TAT (a cost analysis statistical package).
  - (b) System Evaluation and Estimation of Resources - Software Estimating Model (SEER-SEM) is a software project estimation model built upon a mix of mathematics and statistics. It is a decision-support and process optimization tool that estimates cost, labor, staffing, schedule, reliability, and risk associated with all types of software development projects from mainframe commercial Information Technology (IT) business applications to real-time embedded aerospace systems.
  - (c) Crystal Ball (similar to @Risk estimating software) is a spreadsheet-based application suite for predictive modeling, forecasting, simulation, and optimization.
  - (d) Constructive Cost Model II (COCOMO II) is a model that allows one to estimate the cost, effort, and schedule when planning a new software development activity.

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	Cost Element				Cost Risk Analysis
	R&D	Investment	O&S	Disposal	
<b>Model &amp; Tools</b>					
ACE-IT	X	X	X	X	X
SEER-SEM/SEER-H	X	X			X
PRICE S&H	X	X	X		X
Crystal Ball					X
COCOMO II	X	X	X		X
Custom Cost Spreadsheet	X	X	X	X	X
<b>Data</b>					
Analogous Programs	X	X	X	X	X
Current Contracts	X	X	X		X
Engineering Estimates	X	X	X		X
Vendor Estimates	X	X	X		X
Program Office Est.	X	X	X	X	X
Gov't Planning Factors	X	X	X	X	X

Figure 5 – Summary of Common Cost Estimating Tools and Application

- ii. **Measures of Effectiveness.** MOEs should clearly answer the question, “What does this investment provide the customer, public, or organization?” It is important to understand how benefits will be measured to ensure that appropriate data and information is collected and folded into reasonable measures that support CBM<sup>+</sup> metrics and can be tied to time-phased changes in the system being evaluated. MOEs can be defined as an advantage, profit, or gain attained. They are commonly thought of as an investment return and should describe what the investment enables an agency to accomplish and how the mission is enhanced. Focusing on improved business outcomes rather than the technology is one of the best ways to ensure the expenditure of any resource furthers the agency’s mission. A general list of potential MOEs is provided below for use in tailoring your specific BCA. A more detailed breakdown of potential benefits and possible measures is provided in Appendix E – CBM<sup>+</sup> Measures of Effectiveness.
  1. Maintenance
    - a. Platform
    - b. Life Cycle Management
    - c. Operational/Unit/Squadron/Battalion/Fleet
  2. System Reliability
  3. Number of No Evidence of Failures (NEOF)
  4. Accuracy of failure prediction
  5. Equipment mean downtime (logistics responsiveness)
  6. Effectiveness of platform/system condition assessment
  7. Mission reliability
    - a. Mission abort rate

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- b. Combat power/platform/system availability
- 8. Safety
  - a. Number of avoided mishaps or maintenance risks
- 9. System design improvements
- 10. Maintenance facilities usage (all levels)
- 11. Troubleshooting and repair action
  - a. Accuracy and timeliness
- 12. Mean down time
- 13. Logistics decision process(es)
  - a. Supply chain impacts
  - b. Asset accountability and inventory control
  - c. Spare parts management
  - d. Warehouse management
- 14. Total Ownership Cost (TOC)
  - a. \$ per unit usage
  - b. Availability
  - c. Logistics Footprint
  - d. Maintenance

#### **IV. Return on Investment (ROI)**

The challenge of evaluating ROI, noted in the February 1999 Federal CIO Council Capital Planning and Information Technology (IT) Investment Committee report, is “it must be a standard, repeatable process, while containing a significant degree of flexibility. The process of assessing the total value of an investment informs decision-making, but this task can be difficult to perform without a clear agreement of the definition of terms, or paths to follow”. This is particularly true for CBM<sup>+</sup> due to the number of factors involved in defining the CBM<sup>+</sup> capabilities, interfaces, and MOEs to arrive at a reasonable projection for investment costs, benefits, and a realistic ROI.

Figure 6 illustrates three approaches to present the impact that incremental CBM<sup>+</sup> improvements may have on a system over the system’s life cycle. The series of charts shown in Figures 6A-6C are examples that demonstrate a benefit/dollar over time, an investment and TOC over time and the cumulative benefit over a system’s life cycle as incremental CBM<sup>+</sup> capabilities are implemented. Figure 6A depicts an incremental CBM<sup>+</sup> strategy and the cumulative benefits that would be realized with each increment. In this case, CBM<sup>+</sup> capabilities are built from increment 0, basic sensor capability through increment 5 which integrates Portable Maintenance Aid (PMA); Item Unique Identification (IUID); Health Management, Decision Support (DS) with the Logistics and Command and Control Enterprises. If your existing CBM<sup>+</sup> strategy is based on a robust or full CBM<sup>+</sup> capability, i.e., Increment 4 or Increment 5, the number and scope of increments may be significantly different. Incremental improvements in those cases

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maybe driven either by CBM<sup>+</sup> technology upgrades, external system capabilities or interfaces, new data requirements or analytical/decision support tools. The actual return on investment for the CBM<sup>+</sup> investment when leveraging external capabilities may produce a significantly greater ROI.

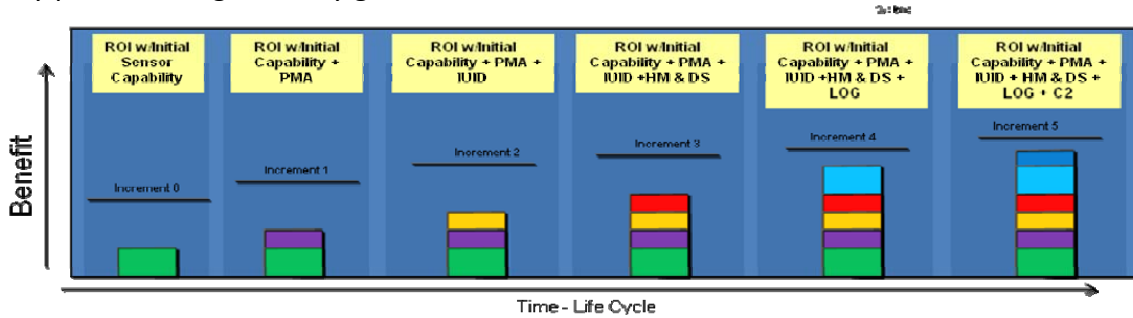


Figure 6A

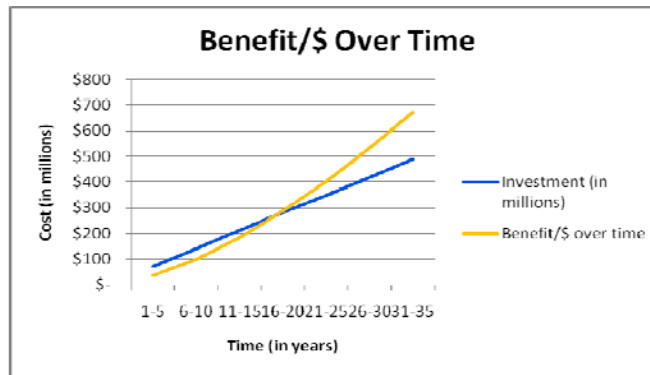


Figure 6B

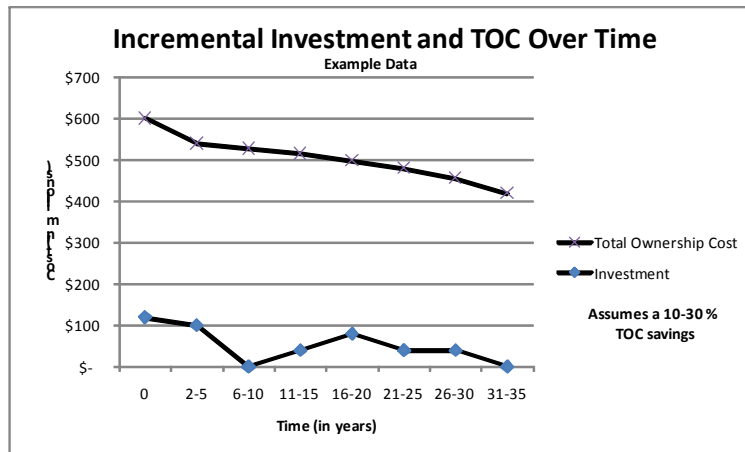


Figure 6C

*Figure 6 – Notional CBM<sup>+</sup> Investment and ROI Chart Examples*

Figure 6B depicts “notional” investment and the total benefits associated with CBM<sup>+</sup>. Figure 6C presents a summary of a projected phased/incremental investment strategy and the impact on TOC assuming a 10-30 percent TOC savings is achieved over the

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phasing periods. Recognizing these will vary, this example provides one approach to represent incremental ROI/benefits.

### **V. Risk Assessment**

Conduct risk analysis in accordance with The DoD Acquisition Risk Management Guide. Your CBM<sup>+</sup> BCA risk analysis should include any areas or processes that may significantly affect your program and provide an assessment of their likelihood and potential impact. For each alternative, identify risks that could adversely affect it, and assess the possibility that the initiative can be successful; specify a risk-reduction strategy for each risk; and identify key parameters and conditions that impact the investment decision. Present potential contingent actions that could mitigate the uncertainty. Identify how such uncertainties impact the analysis and investment decision.

### **VI. Comparison and Sensitivity Analysis**

Compare the alternatives and rank according to net present value, risk, ROI, or primary measures/factors such as risks and areas of uncertainty, technical maturity, level of integration risk, and funding. A sensitivity analysis can answer “What if the assumptions change?” It involves evaluating the variability of an alternative’s cost, benefit, and risk with respect to a change in specific factors. The objective is to determine which factors have the greatest impact (positive or negative) on the evaluation of the alternative.

### **VII. Conclusions**

Conclusions should state results in positive terms, focusing on the most convincing elements of your analysis that support your recommendations. Provide a ranking of alternatives based on the critical MOEs.

- a. Conclusions should state your case succinctly, but completely, and draw upon supporting evidence and analysis from the previous sections. Organize conclusions around ROI, TOC, critical MOEs, combat power, and, to the maximum extent possible, CBM<sup>+</sup> business needs.
- b. Conclusions should demonstrate that you did a thorough job of collecting data, applied the proper methods to assess quantitative criteria, properly assessed risks and mitigation strategies, and correctly considered subjective or qualitative criteria—all of which clearly lead to the best-value alternative.
- c. Clarify and explain any surprising or unexpected results—anything from the analysis that could be misinterpreted. In other words, be sure to tie up any “loose ends” from previous BCA sections.

### **VIII. Recommendations**

Recommendations should leave no doubt in the reader’s mind that the CBM<sup>+</sup> BCA was conducted objectively and based on unbiased and supportable conclusions. They should provide the best-value recommended alternative among all feasible alternatives that were evaluated based on:

- a. ROI

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- b. TOC
- c. Criticality to mission performance and readiness – combat power
- d. Fulfillment of user's requests and objectives – MOEs
- e. Support of DoD's strategic objectives

Provide recommended implementation approach to include metrics to measure initiative's progress, risks of implementing the recommended alternative, and recommended risk-reduction strategies.

**CBM<sup>+</sup> BCA Extracts.** Appendix G – CBM+ BCA Reference Extracts is a compilation of extracts from various CBM<sup>+</sup> BCAs that may be of value in planning, conducting, and reporting your CBM<sup>+</sup> BCA.

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### Appendix A – CBM<sup>+</sup> Scoping Questions

As you define your CBM<sup>+</sup> BCA, below are some general questions may relate to your CBM<sup>+</sup> initiative. Answers to these questions are provided as information, an approach to support CBM<sup>+</sup> implementation, and used to ensure your CBM<sup>+</sup> BCA is adequately defined the scoped.

- 1. What is the projected impact on system/component level replacement frequency?** *A CBM<sup>+</sup> capability can provide the source data and analytical capability to determine projected Remaining Useful Life (RUL), repair/replace decisions, maintenance task frequency, etc. In defining the scope of the BCA ensure that any Reliability Centered Maintenance (RCM) and diagnostic/trending data is used to define assumptions and establish a system/component maintenance/replacement MOEs baseline from which the overall CBM<sup>+</sup> capability cost and benefit can be assessed.*
- 2. Are there any contract alternatives (strategies) that will impact cost and schedule?** *Ensure that any known or pending contracts that may impact implementing a CBM<sup>+</sup> capability or that may benefit from a CBM<sup>+</sup> capability are considered when defining the scope of the CBM<sup>+</sup> BCA. The impact on and from related CBM<sup>+</sup> contracts should be addressed in the risk assessment and sensitivity analysis portion of the CBM<sup>+</sup> BCA.*
- 3. What cost, schedule, and performance risk is projected based on proposed technology for procurement, implementation, and sustainment?** *The CBM<sup>+</sup> BCA should provide a conclusion and recommendation regarding the level of technology maturity and risk associated with the technology, including a sensitivity analysis regarding cost, schedule, and performance.*
- 4. What maintenance tasks or functions can be eliminated or reduced?** *The CBM<sup>+</sup> BCA should identify potential functions, tasks, or systems/components (both hardware and software) that will be impacted by a CBM<sup>+</sup>. The level of detail that the CBM<sup>+</sup> BCA can generate will be based on the existing system, whether an RCM analysis has been done, and what level of maintenance data is available. To the maximum extent possible identify the proposed capability in terms of the CBM<sup>+</sup> functionality areas of fault detection, isolation, prediction, reporting, assessment, analysis, decision-support execution, and recovery, both on and off-board.*
- 5. How can data analysis and decision making be automated to reduce support costs?** *Ensure that your specific logistic or maintenance process(es) which will utilize an analytical CBM<sup>+</sup> tools/capabilities, such as trending, diagnostics and/or prognostics, are defined and that any potential CBM<sup>+</sup> tasks, functions, and measures of effectiveness/metrics that will be affected by those tools are understood.*
- 6. What data needs to be collected to measure the costs/benefits of the CBM<sup>+</sup>?** *Early Planning for the data collection will be necessary and should examine each element and metric as to the source of data and what factors will bear on its accuracy. While*



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collection of all elements is beneficial, those response elements that are discriminators should be the focus of the CBM<sup>+</sup> metrics planning approach. This is best accomplished by engaging the User community in that discussion as early as possible in the acquisition life cycle.

- 7. What are the data sources and limitations for the data that needs to be collected?** *The authoritative source for each data element needs to be established and a determination of whether the data is available should be established early in the CBM<sup>+</sup> BCA planning process.*
- 8. Does the CBM<sup>+</sup> initiative improve our ability (schedule/cost/technical) to modify/improve current systems or design new systems?** *Identify any "system" specific capability that the proposed CBM<sup>+</sup> capability will help improve for the existing system or for projected future increments. Identify specific incremental capabilities and external systems interfaces that the CBM<sup>+</sup> enhances, such as connectivity to near real time/real time weapon system health.*
- 9. What is the TOC impact?** *If you are conducting a CBM<sup>+</sup> BCA with a primarily focus on reducing TOC, ensure that you identify the specific elements of TOC within the CBM<sup>+</sup> BCA assumptions and MOEs. Also, properly define any analysis factors for the risk and sensitivity analysis to ensure conclusions and recommendations are fairly and comprehensively reached.*
- 10. What is the projected ROI?** *Ensure that you define ROI as well as an accurate estimate of the exiting sunk cost of your existing CBM<sup>+</sup> capability. Consider the overall life cycle of your system to properly scope the proposed CBM<sup>+</sup> capability and define any incremental increases planned over the system's life cycle. Also recognize that other interfacing or connected systems may make a significant ROI contribution greater depending on the application, access, and use of CBM<sup>+</sup> data.*
- 11. What is the impact on the following areas?** *A CBM<sup>+</sup> capability can provide the source data and analytical capability to determine projected RUL, repair/replace decisions, maintenance task frequency, etc. In defining the scope of the BCA ensure that any RCM and diagnostic/trending data is used to define assumptions and establish a system/component maintenance/replacement MOEs baseline from which the overall CBM<sup>+</sup> capability cost and benefit can be assessed. For each of the following areas identify specific MOEs and metrics that are appropriate to the proposed CBM<sup>+</sup> capability: Maintenance Planning; Manpower and Personnel; Supply Support; Support Equipment; Computer Resources Support; Facilities; Packaging, Handling, Storage, and Transportation; Design Interface; and Disposal.*
- 12. What is the impact on total life cycle cost, including disposal?** *The CBM<sup>+</sup> BCA cost element structure should ensure that the desired costs and levels of detail are defined and analyzed to support the proposed CBM<sup>+</sup> capability. Cost drivers should be clearly*

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defined and will vary depending on the CBM<sup>+</sup> capability. Hardware and software costs are primary elements regardless of the life cycle phase and will vary in scope depending on the CBM<sup>+</sup> capability being considered (e.g., sensors, diagnostics, prognostics, etc.). Appendices B and C of this information paper provide a suggested cost element structure and definitions, as well as related references for use in defining your cost element structure.

- 13. How will fuel conservation be affected?** *If the primary CBM<sup>+</sup> capability is focused on energy conservation or fuel management, your CBM<sup>+</sup> capability should be evaluated considering areas such as: fuel sensors/monitoring; real time fuel status; accuracy of fuel data; data transfer; fuel supply management; and system interfaces. The CBM<sup>+</sup> BCA should identify the potential change to fuel usage and fuel management at all levels of the operational and logistics chain. Also consider possible operational benefits for improved fuel management, distribution, manning impacts, and system performance Impacts.*
- 14. What is the software maintenance strategy and projected software sustainment cost?** *Identify your proposed software maintenance strategy and planned refresh frequency. Identify any existing sunk cost in terms of existing 24/7 support and cost of facilities and server infrastructure required to maintain the 24/7 capability. Ensure recurring and non recurring costs are adequately defined within the cost element structure.*
- 15. Are there incremental performance levels?** *Identify the planned CBM<sup>+</sup> capability acquisition strategy and define how it will fit with the acquisition strategy of weapon system it supports. Define the CBM<sup>+</sup> increments as clearly as possible and ensure boundaries and interfaces with existing logistics, Command and Control, and/or weapons systems are adequately described in relationship to the CBM<sup>+</sup> MOEs and metrics.*
- 16. What changes will be required for operator and maintenance personnel? And systems?** *Identify known impacts to the CBM<sup>+</sup> capability, and its parent system, to ensure that the appropriate qualitative as well as quantitative MOEs are included. These should include defined impacts to the system's operation and maintenance, policy, changes to tactics, techniques and procedures and personnel.*
- 17. How will the repair/replace decision be affected?** *When the BCA is focused on a specific system/sub-system or component, ensure that the scope, cost elements, and MOEs are tailored accordingly. Utilize existing RCM, cost and historical data, projected RUL estimates, any phased CBM<sup>+</sup> capability increments, and planned system/sub-system or component enhancements, wherever possible.*

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18. **Will the system/equipment modernization plan be affected and if so how?** *Identify those system/sub-system and/or components where the projected CBM<sup>+</sup> capability will have a direct or indirect affect on a planned modernization improvement.*
19. **How will the CBM<sup>+</sup> capability impact integration with other DoD systems?** *The CBM<sup>+</sup> BCA should identify the specific systems for which the CBM<sup>+</sup> capability will have a direct interface or integration requirement. These areas should be clearly defined in the assumptions and include the type of interface (hardware or software), timing for the connection and all related investment and sunk costs associated with the integration. In cases where an interfacing system has been fielded, ensure that the investment costs are adequately addressed in assumptions to either include them in the analysis or if they are unknown, note that they are not included.*
20. **How will the CBM<sup>+</sup> capability impact service life margins?** *In cases where the primary purpose of the CBM<sup>+</sup> BCA is to determine the effect on a weapon system's service life, ensure that the system is properly defined and all RCM and historical data/information (e.g., Performance and failure data from Visibility and Management of Operating and Support Costs (VAMOSOC). VAMOSOC is utilized to define baseline MOEs and related costs.*
21. **What is the impact on Maintenance Down Time (MDT)?** *To adequately assess the impact of MDT, ensure the MDT of the existing system is defined, as well as the primary MDT drivers (e.g., Mean Time To Repair (MTTR), logistics downtime, etc.). The primary drivers should be key MOEs and analyzed in the sensitivity analysis.*
22. **How will this CBM<sup>+</sup> system/sub-system affect operator usability?** *Identify known impacts to the CBM<sup>+</sup> capability, and its parent system, to ensure that the appropriate qualitative as well as quantitative MOEs are included. These should include defined impacts to the system's operation and maintenance, policy, changes to tactics, techniques and procedures and personnel.*
23. **How will platform health monitoring affect system performance?** *In cases where the primary purpose of the CBM<sup>+</sup> BCA is to determine the effect of a health monitoring system, ensure that the system and mission performance MOEs, metrics and investment costs are adequately defined. To the extent possible utilized available historical data/information (e.g., Operational Availability, Mean Down Time, Material Availability, etc.). Select the factors that can be defined, measured, and evaluated within your CBM<sup>+</sup> BCA framework to ensure conclusions and recommendations are based on a fair comparison and sensitivity analysis.*
24. **Does the system provide any increased prognostic/diagnostic capability?** *Identify MOEs and metrics (related to failure prediction, RUL estimates, spare part management, warehouse management, etc.) that can be assessed in terms of timeliness, accuracy and relevance of prognostic and diagnostic analytical tools. Also,*

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*consider any risks associated with source data, data transfer, and systems processing data, as well as with the analytical tools themselves.*

- 25. What affect does the CBM<sup>+</sup> capability have available combat power, system readiness and availability?** *The CBM<sup>+</sup> BCA should clearly define combat power, operational availability, and material availability for the weapon system which the CBM<sup>+</sup> capability is being proposed and also address any unknowns or areas that could not be addressed in quantitative terms. Assumptions should include a defined set of mission reliability MOEs and explain how the unknown areas will be treated in the analysis. The CBM<sup>+</sup> BCA conclusions and recommendations should address the quantitative and qualitative costs and benefits as well as risks associated with expected unknown areas which have not been quantified.*
- 26. How will this initiative improve or enhance system and operator safety?** *Identify specific safety measure of effectiveness and metrics that are relevant to your system.*
- 27. How will your overall supply chain be impacted by the CBM<sup>+</sup> Initiative?** *Identify the supply system process(es) that may be affected and specific MOEs/metrics that can be used for the analysis. Utilize existing logistics and historical data/information (e.g., failure data from VAMOSOC) is utilized to define baseline MOEs and related costs.*
- 28. Will CBM<sup>+</sup> change the way you buy and provision parts?** *Identify the purchasing process (es) that may be affected and specific MOEs/metrics that can be used for the analysis. Utilize existing RCM and historical data/information (e.g., failure data from VAMOSOC) to define baseline MOEs and related costs.*
- 29. Can any service, DoD, Defense Logistics Agency (DLA), other infrastructure be reduced as a result of the proposed CBM<sup>+</sup> initiative?** *Identify processes, functions and staffing related to the existing and proposed CBM<sup>+</sup> capability and utilize any RCM, maintenance or logistics analyses that maybe available as a source to define an existing system baseline. Define specific MOEs (e.g., maintenance tasks, warehousing functions, inventory management, etc.) that can be reasonably analyzed.*
- 30. How will the various COAs or alternatives be executed (i.e., acquisition strategy) and what is the associated cost/risk of each course of action?** *Ensure that the ability to execute and implement alternatives have been addressed in the risk assessment and sensitivity analysis. Identify and define implementation related factors in the assumptions.*
- 31. What maintenance and acquisition processes will be affected and how will they be impacted in terms of data collection, transmission, and manpower costs associated with analysis and decision making?** *Identify and define functions, tasks, and related activities for maintenance, acquisition, and logistics processes (e.g., Total Life Cycle Systems Management, PBL, Focused Logistics, Joint Capabilities Integration, and*

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*Development System, Functional Needs Analysis, Functional Areas Analysis, etc.) that is affected by or provides information about the proposed CBM<sup>+</sup> capability.*

- 32. How will readiness, availability, ready for tasking, down time (parts or maintenance), and/or unscheduled down time be affected?** *Identify specific MOEs and metrics that are critical to support the customer expectations. Ensure that definitions are provided within assumptions and appropriate measures identified for analysis. Minimize the number of metrics being evaluated to ensure reasonable amount of effort is required to obtain and analyze data to arrive at fair and reasonable conclusions and recommendations. Impact should be assessed using the primary CBM<sup>+</sup> metrics - Operational availability, material readiness, total ownership cost, and mean downtime.*
- 33. What areas will this CBM<sup>+</sup> initiative result in cost avoidance?** *Consider measures that may offer direct or indirect cost avoidance such as: no evidence of failure, avoided mishaps, reduction in spares, reduced maintenance, warehouse storage/space.*
- 34. Will use of analytic techniques to predict failure or reduced performance levels affect scheduled maintenance and major replacement strategies?** *Identify specific analytical tools, their projected accuracy, and their specific implementation (incremental). Utilize existing analyses, RCM studies, and historical data/information (e.g., failure data from VAMOSOC) to establish a baseline for the analysis.*
- 35. How does this initiative improve the overall awareness of equipment condition at the tactical and strategic levels?** *Identify and define any potential systems interfaces, data exchange, decision processes, planned integration, and customer expectation in the key assumptions. Address incremental capability improvements that may impact the CBM<sup>+</sup> ROI as new increments become available or are integrated into the overall maintenance and logistics processes. Ensure that relevant CBM<sup>+</sup> functionality areas (fault detection, isolation, prediction, reporting, assessment, analysis, decision-support execution, and recovery, both on and off-board) at the operational/ tactical command and strategic levels are assessed and addressed in the conclusions and recommendations.*
- 36. How does this initiative increase the accuracy in failure prediction and situational awareness?** *Identify specific system/sub-system/component and existing performance levels (failure rate, etc.) that the CBM<sup>+</sup> capability is targeted to support. Define and analyze related the CBM<sup>+</sup> functionality areas of fault detection, isolation, prediction, reporting, assessment, analysis, decision-support execution and recovery, both on and off-board.*

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## **Appendix B – CBM<sup>+</sup> BCA Outline**

### **Conditional Based Maintenance Plus (CBM<sup>+</sup>) Business Case Analysis (BCA) Outline**

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- I. Executive Summary
- II. Boundaries and Assumptions
  - a. Goals and Vision
  - b. Context and Perspective
  - c. CBM<sup>+</sup> Metrics
  - d. Key Assumptions
  - e. Cost Structure
  - f. External CBM<sup>+</sup> Enablers
  - g. Key Issues
  - h. Evaluation Criteria/Factors
- III. Alternatives
  - a. As-Is Configuration/Condition
  - b. Description of Alternative Courses of Action
  - c. Projected Cost Elements and Measures of Effectiveness
    - i. Cost Elements
    - ii. Measures of Effectiveness
- IV. Return on Investment
- V. Risk Assessment
- VI. Comparison and Sensitivity Analysis
- VII. Conclusions
- VIII. Recommendations

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### **Appendix C – CBM<sup>+</sup> Related Definitions/Descriptions**



Copy of CBM + BCA  
Definitions -Workshee

Eight-page worksheet attached to Appendix C in printed copy.

**CBM+ BCA INFORMATION PAPER - DEFINITIONS/DESCRIPTIONS**  
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Term	Definition/Description	Reference
Business Case Analysis (BCA)	A business case analysis (BCA) is a decision support document that identifies alternatives and presents convincing business, economic, risk, and technical arguments for selection and implementation to achieve stated organizational objectives/imperatives. A BCA does not replace the judgment of a decision maker, but rather provides an analytic and uniform foundation upon which sound investment decisions can be made. The subject of a BCA may include any significant investment decision that leadership is contemplating. For example, a BCA may be used to substantiate the case to invest in a new weapons system; transform business operations; develop a web-based training curriculum; or retire an asset. In general, BCAs are designed to answer the following question: What are the likely financial and other business (non-financial) consequences if we execute this investment decision or this action?	Air Force Manual 65-510, Business Case Analysis Procedures, 22 September 2008; AFMC PBL-BCA Checklist 31 May 2007
Cost Benefit Analysis (CBA)	All Cost Benefit Analysis (CBA) provide decision makers with facts, data, and analysis required to make an informed decision. In its most basic form, the CBA is a tool to support resource informed decision making. There is no prescribed length to a CBA. All that is required is that it fully supports the recommendation. Therefore, quality is genuinely more important than quantity.	U.S. Army Cost Benefit Analysis Guide dated 12 January 2010
CBM+	Condition Based Maintenance Plus (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 based on evidence of need provided by Reliability Centered Maintenance (RCM) analysis and other enabling processes and technologies. CBM+ uses a systems engineering approach to collect data, enable analysis, and support the decision-making processes for system acquisition, sustainment, and operations.	DoDI 4151.22, Condition Based Maintenance Plus (CBM+) for Material Maintenance dated December 2, 2007
CBM+ Operating Metrics	At the highest level, there are four measurable objectives of a maintenance program: - Material availability—maximizing readiness and availability of weapon systems and equipment - Material reliability—improving reliability of weapon systems, equipment, and components - Ownership costs—reducing life-cycle ownership costs - Mean down time—reducing mean down time.	DoD Condition Based Maintenance Plus DoD Guidebook, May 2008
Economic Analysis (EA)	Economic analysis is a systematic approach to the problem of choosing the best method of allocating scarce resources to achieve a given objective. A sound economic analysis recognizes that there are alternative ways to meet a given objective and that each alternative requires certain resources and produces certain results	DoDI 7041.3 dated 7 November 1995
Time Based Metrics	Fraction of total systems available for operational use or, as defined in Sections 3.1.2.2 and 3.1.2.3 of RAM -C Cost Rationale Report, percentage of time a given system is available for operational use. Note the RAM-C manual does not address material availability for networking or information technology systems.	DoD Reliability, Maintainability, and Cost Rationale Report Manual dated 1 June 2009
Material availability		DoD Reliability, Maintainability, and Cost Rationale Report Manual dated 1 June 2009
Material reliability	The probability that the system will perform its intended function over a specified time period	DoD Reliability, Maintainability, and Cost Rationale Report Manual dated 1 June 2009
Ownership Costs	Owner cost as defined in para 3.2.4.3 of the RAM -C Cost Rationale Report 2.0 Unit Operations: 2.1.1 (only) Energy (fuel, petroleum, oil, lubricants (POL), electricity) Note: The fully burdened cost of fuel is to be included after the ongoing pilot programs have been completed and policy has been formalized. 3.0 Maintenance (all elements) 4.0 Sustaining Support (all elements except 4.1 System Specific Training) 5.0 Continuing System Improvements (all elements).	DoD Reliability, Maintainability, and Cost Rationale Report Manual dated 1 June 2009; Cost Analysis Improvement Group (CAIG) Operating and Support Cost-Estimating Guide (October 2007);
Mean Down Time	The average downtime for maintenance actions (includes MTTR, LDT, and ADT)	DoD Reliability, Maintainability, and Cost Rationale Report Manual dated 1 June 2009
ROI	A performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments. To calculate ROI, the benefit (return) of an investment is divided by the cost of the investment; the result is expressed as a percentage or a ratio.	Dr Edward Deegan, AFAMS Brief dated 20 Feb 2009; Investopedia.com



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Term	Definition/Description Cost Elements	Reference
<b>Research &amp; Development</b>	Consists of development costs incurred from the beginning of the conceptual phase through the end of the system development and demonstration phase, and potentially into low-rate initial production. Typically includes costs of concept refinement trade studies and advanced technology development; system design and integration; development, fabrication, assembly, and test of hardware and software for prototypes and/or engineering development models; system test and evaluation; system engineering and program management; peculiar and common support equipment, peculiar training equipment/initial training, technical publications/data, and initial spares and repair parts associated with prototypes and/or engineering development models.	OSD O&S Cost Estimating Guide (Oct 2007); Defense Acquisition Guidebook -DAU
Design	Consists of design costs for specific CBM+ technologies. Note: To maintain consistency, CBM+ design and development should be based on a broad architecture and an enterprise framework that is open to modification and can be easily adjusted. CBM+ designs at this phase of the life cycle should consider integrated, predictive, prognostics, and diagnostics (CBM+) technologies and maintenance approaches that minimize unscheduled repairs.	OSD O&S Cost Estimating Guide (Oct 2007); Defense Acquisition Guidebook -DAU
Development (include both hardware & software)	Consists of costs associated with development of a capability to include hardware, software and integration costs. Refer to DAU technology and manufacturing readiness definitions to determine the technology readiness level and scope of costs for design. Utilize any existing Life Cycle Cost Estimates to assist in defining development costs.	OSD O&S Cost Estimating Guide (Oct 2007); Defense Acquisition Guidebook -DAU
Prototype	Cost should include the CBM+ prototype technologies that provide the CBM+ initiatives.	OSD O&S Cost Estimating Guide (Oct 2007); Defense Acquisition Guidebook -DAU
Testing & Validation	Includes costs associated with testing and validation of both hardware and software required to field the proposed CBM+ capability.	OSD O&S Cost Estimating Guide (Oct 2007); Defense Acquisition Guidebook -DAU
Data Management	Data management consists of acquiring data (e.g., through sensors or other acquisition techniques), manipulating data into meaningful form (e.g., converting analog to digital data), storing data (electronically in digital form), transmitting data (through electronic means), accessing data as a basis for analysis, and providing data (information) to decision makers.	CBM Guidebook May, 2008
CBM+ Services Applications	Consists of the cost of application development, licensing, infrastructure (architecture, hardware, software and data management). Enterprise software often includes software applications similar to those found at the equipment level, but may include data repositories and the applications that use information from the databases generated by equipment software.	CBM Guidebook May, 2008
<b>Investment</b>	Consists of production and deployment costs incurred from the beginning of low-rate initial production through completion of deployment. Typically includes costs associated with producing and deploying the primary hardware; system engineering and program management; peculiar and common support equipment, peculiar training equipment/initial training, technical publications/data, and initial spares and repair parts associated with production assets; interim contractor support that is regarded as part of the system production and is included in the scope of the acquisition program baseline; and military construction	OSD O&S Cost Estimating Guide (Oct 2007); Defense Acquisition Guidebook -DAU
System acquisition	Consists of costs associated with the acquisition of the CBM+ capability to include procurement, documentation and program support necessary to field the capability. Refer to DoD 5000 and Service specific requirements for new acquisition and modernization of fielded assets	DAU - DoD 5000.2
Facilities and Infrastructure	Describe, quantitatively and qualitatively, facilities/infrastructure requirements to support the capability. Identify any funding, environmental, and space allocation constraints. If assets exist, describe differences in requirements or upgrades/additions needed.	OSD O&S Cost Estimating Guide (Oct 2007); Defense Acquisition Guidebook -DAU
Supply support	Fully describe the supply support costs associate with the acquisition of CBM+ technologies. Include the provisioning, organic or Contractor Logistics Support (CLS), Third Party Logistics provider (3PL), or Performance Based Logistics (PBL) type contracts, and any use of interim contractor supply support, testing support, etc.	OSD O&S Cost Estimating Guide (Oct 2007); Defense Acquisition Guidebook -DAU
Test equipment	Identify costs for support equipment necessary to support the CBM+ capability/technology.	OSD O&S Cost Estimating Guide (Oct 2007); Defense Acquisition Guidebook -DAU
Prognostics/diagnostics services	Identify costs of service level agreements, licensing and software development for new applications and services as well as for existing and/or proprietary diagnostic/prognostics software/algorithms.	OSD O&S Cost Estimating Guide (Oct 2007); Defense Acquisition Guidebook -DAU
Data Warehouse	A data warehouse is a computer database that collects, integrates, and stores an organization's computer data with the aim of maintaining and providing accurate and timely management information and supporting data analysis. The data may be distributed; that is, located at multiple organizational and locations.	CBM Guidebook May, 2008

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Term	Definition/Description Cost Elements	Reference
Training	Consists of costs associated with training material, software applications, facilities, software integration required to field the capability.	
Operation & Sustainment	Consists of sustainment costs incurred from the initial system deployment through the end of system operations. Includes all costs of operating, maintaining, and supporting a fielded system. Specifically, this consists of the costs (organic and contractor) of personnel, equipment, supplies, software, and services associated with operating, modifying, maintaining, supplying, training, and supporting a system in the DoD inventory. May include interim contractor support when it is outside the scope of the production program and the acquisition program baseline. O&S costs include costs directly and indirectly attributable to the system (i.e., costs that would not occur if the system did not exist), regardless of funding source or management control. Direct costs refer to the resources immediately associated with the system or its operating unit. Indirect costs refer to the resources that provide indirect support to the system's manpower or facilities. For example, the pay and allowances (reflected in composite standard rates) for a unit-level maintenance technician would be treated as a direct cost, but the (possibly allocated) cost of medical support for the same technician would be an indirect cost.	OSD O&S Cost Estimating Guide (Oct 2007); Defense Acquisition Guidebook -DAU
Unit Level Manpower	The unit-level manpower element includes the costs of all operator, maintenance, and other support manpower at operating units (or at maintenance and support units that are organizationally related and adjacent to the operating units). Unit-level manpower includes active and reserve military, government civilian, and contractor manpower costs. While the cost elements in this category make the distinction between operators, maintainers, and other unit-level manpower, that distinction may not apply to all situations. For example, in O&S cost estimates for Navy ships, the ship manpower is typically estimated and documented for the entire crew as a whole, and is not broken down into operators, maintainers, and other support.	OSD OS Cost Estimating Guide (Oct. 2007)
Operations Manpower	The costs of all military, civilian, and contractor manpower required to operate a system.	OSD OS Cost Estimating Guide (Oct. 2007)
Unit-Level Maintenance Manpower	The costs of all military, civilian, and contractor manpower that performs unit-level level maintenance on a primary system, associated support equipment, and unit-level training devices. This element includes the costs of organizational maintenance manpower (usually resident in the system operating unit) and unit-level intermediate maintenance personnel. The costs of intermediate-level maintenance personnel resident in a support organization that is not unit-level relative to the operating unit such as a Navy shore-based Intermediate Maintenance Activity, are included in element 3.2 (Intermediate Maintenance). For cases where individuals maintain more than one system, manpower costs should be allocated on a relative workload basis.	OSD OS Cost Estimating Guide (Oct. 2007)
Other Unit-Level Manpower	The cost of all military, civilian, and contractor manpower that performs administrative, security, logistics, safety, engineering, and other mission support functions at the unit level. These costs include only the costs of manpower positions that exist to wholly or predominately support the system whose costs are being estimated. For systems that deploy, these costs include the costs of manpower positions that routinely deploy to support the system.	OSD OS Cost Estimating Guide (Oct. 2007)
Unit Operations	Unit Operations includes the unit-level consumption of operating materials such as fuel, electricity, expendable stores, training munitions and other operating materials. Also included are any unit-funded support activities; training devices or simulator operations that uniquely support an operational unit; temporary additional duty/temporary duty (TAD/TDY) associated with the unit's normal concept of operations; and other unit funded services. Unit-funded service contracts for administrative equipment as well as unit-funded equipment and software leases are included in this portion of the estimate. Unit Operating costs provided through a system support contract should be separately identified from those provided organically.	OSD OS Cost Estimating Guide (Oct. 2007)
Operating Material	Energy (Fuel, Petroleum, Oil and Lubricants [POL], Electricity) These costs include cost of POL, propulsion fuel, and fuel additives used by systems in performing their normal peacetime missions. These costs also include the cost of field-generated electricity and commercial electricity necessary to support the operation of a system. Training Munitions and Expendable Stores These costs include the unit-level consumption of training munitions, rockets, missiles, and expendable stores in the course of normal peacetime training missions. Includes the cost of live and inert ammunition, bombs, rockets, training missiles, sonobuoys, and pyrotechnics expended in training and non-combat firings such as firepower demonstrations. This category also includes other expendable stores such as chaff, flares, fuel tanks, travel pods or other items that lose their identity in use and may be dropped from stock record accounts when issued or used. Cost. Other Operational Material This element includes operating material costs other than energy, training munitions, or expendable stores. The costs identified must be related to the system whose O&S requirements are being assessed. Illustrative examples include computer supplies, paper, diskettes, ribbons, charts, maps, and administrative supplies used for housekeeping, health and safety.	OSD OS Cost Estimating Guide (Oct. 2007)

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Term	Definition/Description Cost Elements	Reference
Support Services	<p>This includes unit-level costs for purchased support services. These services may vary greatly from one unit to another. They may include but are not limited to:</p> <ul style="list-style-type: none"> <li>• Un-reimbursed food services, rations, postal services (postage/box rental), laundry services.</li> <li>• Lease or rental of administrative, computational, or support equipment or software.</li> <li>• Lease costs of special facilities or land (e.g., for the storage of warheads and missiles)</li> <li>• Unit-funded service contracts for administrative, computational, or support equipment.</li> <li>• Communications services (e.g., data/voice links, dedicated lines, microwave channels), port services, and other unit-funded utilities not part of base operating support costs.</li> <li>• Transportation costs for moving equipment (e.g., communications equipment, combat vehicles, missiles) to and from test ranges or training areas</li> <li>• Transportation of personnel and material to remote operating sites for operations, maintenance, or support.</li> </ul>	OSD OS Cost Estimating Guide (Oct. 2007)
Temporary Duty	<p>Temporary additional duty or temporary duty (TAD/TDY) pay and allowances costs include unit personnel travel for training, administrative, or regularly scheduled training away from the unit's permanent operating location that are associated with a unit's concept of operations and support. TAD/TDY costs include military and commercial transportation charges, rental costs for passenger vehicles, mileage allowances, and subsistence expenses (e.g., per diem allowances and incidental travel expenses). Excludes temporary duty associated with contingencies or wartime operations.</p>	OSD OS Cost Estimating Guide (Oct. 2007)
Data warehouse - data/software management	<p>A data warehouse is a computer database that collects, integrates, and stores an organization's computer data with the aim of maintaining and providing accurate and timely management information and supporting data analysis. The data may be distributed; that is, located at multiple organizational and locations.</p>	OSD OS Cost Estimating Guide (Oct. 2007)
Facilities	<p>A real property entity consisting of one or more of the following: a building, a structure, a utility system, pavement and underlying land</p>	
Services (24/7)	<p>Activities associated with operating, modifying, maintaining, supplying, training, and supporting a system in the DoD inventory. This includes costs of contract labor, material, and assets used in providing maintenance services to a weapon system, subsystem, support equipment, training device, or simulator at the unit level. Equipment, material, supplies, and services adopted by a Military Service for use by its own forces and activities. These include standard military items, base operating support, and the supplies and services provided by a Military Service to support and sustain its own forces, including those assigned to the combatant commands. Items and services defined as Service-common by one Military Service are not necessarily Service-common for all other Military Services.</p>	OSD OS Cost Estimating Guide (Oct. 2007)
Maintenance (all elements, schedule and unscheduled)	<p>Maintenance includes the costs of labor (outside of the scope of unit-level) and materials at all levels of maintenance in support of the primary system, simulators, training devices, and associated support equipment. Where costs cannot be separately identified to distinct levels of maintenance, the category that represents the predominant costs should be used. Any maintenance costs provided through a system support contract should be separately identified within the appropriate cost element.</p>	OSD OS Cost Estimating Guide (Oct. 2007)
Organizational Maintenance	<p>Organizational maintenance includes the cost of materials and other costs used to maintain a primary system, training devices, simulators, and support equipment. Maintenance materials are broken into categories that may not be applicable in all services or for all types of systems. It is therefore acceptable to combine consumable and repair parts costs where a service's logistics system does not differentiate between them.</p>	OSD OS Cost Estimating Guide (Oct. 2007)
Intermediate Maintenance	<p>Intermediate maintenance includes the cost of labor and materials and other costs expended by intermediate level maintenance organization in support of a primary system, simulators, training devices, and associated support equipment. Where intermediate level maintenance activities cannot be separately identified from organizational level maintenance, the costs are often combined as either organizational or intermediate maintenance. Where organizational and intermediate maintenance material or labor costs are combined, the cost estimate should note that fact in the documentation to avoid an interpretation that a portion of the maintenance costs were omitted.</p>	OSD OS Cost Estimating Guide (Oct. 2007)
Depot Maintenance	<p>Depot maintenance includes the fully burdened cost of labor, material, and overhead incurred in performing major overhauls or other depot level maintenance on a system, its components, or other associated equipment at centralized repair depots, contractor repair facilities, or on site by depot teams.</p>	OSD OS Cost Estimating Guide (Oct. 2007)

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Term	Definition/Description Cost Elements	Reference
Energy (fuel, petroleum, oil, electricity, etc.)	These costs include cost of POL, propulsion fuel, and fuel additives used by systems in performing their normal peacetime missions. These costs also include the cost of field-generated electricity and commercial electricity necessary to support the operation of a system.	OSD OS Cost Estimating Guide (Oct. 2007)
Sustaining Support	This category includes support services provided by centrally managed support activities external to the units that own the operating systems. It is intended that costs included in this category represent costs that can be identified to a specific system and exclude costs that must be arbitrarily allocated. Where a single cost element includes multiple types of support, or where the support is provided by contractors, each should be separately identified in the cost estimate.	OSD OS Cost Estimating Guide (Oct. 2007)
Systems Specific Training	The cost of system-specific specialty training for individuals that need to be replaced due to attrition and normal rotation. Training costs should include the costs of instructors, training support personnel, training devices, course support costs, and course materials, as well as all the costs of trainees, per diem, and travel directly associated with the training.	OSD OS Cost Estimating Guide (Oct. 2007)
Support Equipment Replacement	The costs incurred to replace equipment that is needed to operate or support a primary system, subsystems, training systems, and other support equipment. The support equipment being replaced (e.g., tools and test sets) may be unique to the system or it may be common to a number of systems, in which case the costs must be allocated among the respective systems. Note: This element addresses replacement equipment only. The cost of initial support equipment procurement is normally regarded as an investment cost, and not as an O&S cost.	OSD OS Cost Estimating Guide (Oct. 2007)
Sustaining Engineering and Program Management	The labor, material, and overhead costs incurred in providing continued systems engineering and program management oversight to manage the program and to determine the integrity of a system, to maintain operational reliability, to approve design changes, and to ensure conformance with established specifications and standards. In the case of systems that are simultaneously in production and operations, the costs over and above the costs the acquisition program office incurs to oversee and manage acquisition phase activities are included in the O&S estimate. When a separate sustainment program management office is established or is separately identifiable from the acquisition support management office, the costs of the sustainment program management office will be included in the O&S estimate. Costs reported in this category may include, but are not limited to, government and/or contract engineering services, studies, and technical advice. Examples might include aircraft structural integrity monitoring or corrosion monitoring. Specific modifications to hardware or software are included in element 5.0, Continuing System Improvements. Sustaining support costs provided through a system support contract should be separately identified within the appropriate cost element, if possible.	OSD OS Cost Estimating Guide (Oct. 2007)
Other Sustaining Support	This element includes any significant sustaining support costs not otherwise accounted for. This cost element may be used to identify expenses such as those listed below, if they apply to the system for which the estimate is being made: <ul style="list-style-type: none"> <li>• Test and evaluation in support of deployed systems, such as range costs, test support, data reduction, and test reporting.</li> <li>• Air, sea, and land support not funded by the unit and provided by other activities to verify the proper operation of an electronic, communication, sensor, or other similar system.</li> <li>• Centrally provided technical assistance, such as Help Desks, that provide DoDwide or Service-wide support.</li> <li>• Communication services (e.g., data/voice links, dedicated lines, microwave channels), hardware, and software leases purchased on a DoD-wide or Service wide basis for direct system specific support of a system.</li> </ul>	OSD OS Cost Estimating Guide (Oct. 2007)
Indirect Support	Indirect support costs are those installation and personnel support costs that cannot be directly related to the units and personnel that operate and support the system being analyzed. O&S cost analyses should include marginal indirect costs. The intention is to include only the costs that would likely change if the action being analyzed (e.g., new system development, etc.) occurs. Indirect support costs are more relevant in situations when total DoD manpower would change or when installations are affected (i.e., expanded, contracted, opened, or closed). Indirect support costs may also be relevant in analyses involving a choice between government and contracted support. In these cases it is important to compare the government and contracted alternatives on a comparable basis, including the relevant indirect costs of all alternatives.	OSD OS Cost Estimating Guide (Oct. 2007)
Installation Support	Includes base operations support, facilities sustainment, restoration, and modernization; base communications; and other similar costs. Base operating support may include functions such as communications, supply operations, personnel services, installation security, base transportation, etc.	OSD OS Cost Estimating Guide (Oct. 2007)
Personnel Support	Includes the costs for the acquisition, initial training, and quality of life programs necessary to maintain a quality force. Indirect personnel support costs are frequently allocated to a system based on the number and type of system-specific individuals identified in the Unit Manpower portion of the O&S cost estimate.	OSD OS Cost Estimating Guide (Oct. 2007)
Personnel Admin - Acquisition and Overhead accounts	Includes costs for recruiting, examining and processing individuals into the military service and for advertising in support of recruiting activities	OSD OS Cost Estimating Guide (Oct. 2007)
Personnel Benefits	Includes costs for operation and maintenance of family housing child development centers, family centers, family advocacy programs, youth development programs, commissaries and DoD schools.	OSD OS Cost Estimating Guide (Oct. 2007)

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Term	Definition/Description Cost Elements	Reference
Medical	The costs for medical care for active duty personnel and their dependents. Includes provisions for patient care in regional defense facilities, station hospitals and medical clinics, and dental facilities as well as care in non-defense facilities. Also includes TRICARE and other health support activities.	OSD OS Cost Estimating Guide (Oct. 2007)
General Training and Education	The costs for general training and education not associated with a specific weapon or other system provided through central activities.	OSD OS Cost Estimating Guide (Oct. 2007)
Basic & Initial Skill Training	Includes the costs of recruit and initial skills training.	OSD OS Cost Estimating Guide (Oct. 2007)
Educational Activities	Includes the cost of professional military education; and academic education programs.	OSD OS Cost Estimating Guide (Oct. 2007)
Licenses	Authorization	OSD OS Cost Estimating Guide (Oct. 2007)
Technical Refresh	The periodic replacement of Commercial Off-The-Shelf (COTS) components; e.g. processors, displays, computer operating systems, commercially available software (CAS) within larger DoD systems to assure continued supportability of that system through an indefinite service life.	
Data warehouse	Includes the costs associated with a computer database that collects, integrates, and stores an organization's computer data with the aim of maintaining and providing accurate and timely management information and supporting data analysis. The data may be distributed; that is, located at multiple organizational and locations.	
Packaging, Handling, Storage, and Transportation:	Packaging, handling, storage, and transportation (PHS&T) encompasses the requirements, resources, processes, procedures, design considerations, and methods to ensure that all system equipment and support items are preserved, packaged, handled, stored, and transported properly. This element includes all special provisions, containers (reusable and disposable), and supplies necessary to support packaging, preservation, storage, handling, and/or transportation of prime mission equipment, test and support equipment, spares and repair parts, personnel, technical data, and mobile facilities. In essence, this element basically covers the initial distribution of products and the transportation of personnel and materials for maintenance purposes.	OSD OS Cost Estimating Guide (Oct. 2007)
Continuing System Improvements	This portion of the cost element structure includes the costs of hardware and software updates that occur after deployment of a system that improve a system's safety, reliability, maintainability, or performance characteristics to enable the system to meet its basic operational requirements throughout its life. These costs include government and contract labor, materials, and overhead costs. Costs should be separated into government and contractor costs within each cost element, if possible. The continuing system improvements portion of an O&S estimate does not include all changes to a system developed subsequent to the initial delivered configuration. System improvements identified as part of an incremental evolutionary acquisition strategy or pre-planned product improvement program that are included in the acquisition cost estimate are not included in this portion of an O&S cost estimate. Any improvement of sufficient dollar value that it would qualify as a distinct Major Defense Acquisition Programs (MDAP) in its own right normally would not be included in this portion of the O&S cost estimate.	OSD OS Cost Estimating Guide (Oct. 2007)
Hardware Modernizations	These costs include costs associated with modifying the defense system, support equipment, and training devices. All costs associated with developing, producing, and installing the modifications are included. When hardware modifications require changes in system or support software or technical documentation, these costs should be included with hardware modifications costs.	OSD OS Cost Estimating Guide (Oct. 2007)
Software Maintenance and Modifications	The labor, material, and overhead costs incurred after deployment in supporting the update, maintenance and modification, integration, and configuration management of software. Depot-level maintenance activities, government software centers, laboratories, or contractors may incur these costs. Includes any licensing costs for software not owned by the operating units. Includes operational, maintenance, support and diagnostic software programs for the primary system, support equipment, and training equipment. The respective costs of operating and maintaining the associated computer and peripheral equipment in the software support activity and the cost to conduct all testing of the software should also be included.	OSD OS Cost Estimating Guide (Oct. 2007)
<b>Disposal</b>	Consists of costs associated with demilitarization and disposal of a military system at the end of its useful life. These costs in some cases represent only a small fraction of a system's life-cycle cost and may not always be considered when preparing life-cycle cost estimates. However, it is important to consider demilitarization and disposal early in the life-cycle of a system because these costs can be significant, depending on the characteristics of the system. Costs associated with demilitarization and disposal may include disassembly, materials processing, decontamination, hardware, collection/storage/disposal of hazardous materials and/or waste, safety precautions, and transportation of the system to and from the disposal site. Systems may be given credit in the cost estimate for resource recovery and recycling considerations.	OSD OS Cost Estimating Guide (Oct. 2007)
System Removal	An element of a maintenance event. One of more tasks necessary to retain an item in or restore it to a specified condition.	
Environmental Protection	The practice of protecting the environment, on individual, organizational or governmental level, for the benefit of the natural environment and (or) humans.	



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Term	Definition/Description	Reference
<b>Maintenance</b>	CBM+ technologies have the potential to improve maintenance capabilities and business processes and enhance reliability analysis efforts; involves the integration of support elements to enable enhanced maintenance-centric logistics system response; and facilitates more accurate predictions of impending failures (based on condition data), resulting in dramatic savings.	OSD CBM+ Guidebook
Platform	Maintenance functions performed at the unit (e.g., ground vehicle, aircraft, ship, support system, sub-system or component) level. At the tactical level, CBM+ may mean new tools, test equipment, and embedded onboard diagnostics. These tools take advantage of current and emerging commercial and diagnostic technologies that translate system condition data (such as temperature, vibration, cycle-time) in combination with environmental factors (like desert, arctic, and high humidity) into proactive maintenance actions that are performed only when there is evidence of actual need. With CBM+, maintainers can convert weapon system or equipment condition data into proactive maintenance actions. Scheduled inspections are supplemented or replaced because maintainers will have analytical.	OSD CBM+ Guidebook
Life Cycle Management	Maintenance functions performed by the life cycle manager based on CBM+ information and data (unit and above history, trending, diagnostics, prognostics and logistic support) to manage and support the headquarters and operational command infrastructures. Implementing CBM+ technologies not only improves the ability to predict failures, maintenance planning but the benefits carry over into related areas, such as supply support, use of facilities and test equipment, skills management, and other logistics support elements. While some CBM+ features are installed at individual platform level, the benefits of CBM+ are most effectively achieved when an entire fleet is incorporated and the information is leveraged. At the strategic level, CBM+ identifies maintenance actions based on a near-real-time assessment of equipment status from diagnostic sensors and equipment. Data collected from embedded sensors, such as health and usage monitoring systems are then translated into predictive trends or metrics that anticipate when component failures will occur and identifies components that may require redesign or replacement to reduce high-failure rates. Common use of items and data among the Services on like systems will greatly reduce logistics footprints and costs.	OSD CBM+ Guidebook
Operational/Unit/Squadron/ Battalion/Fleet	A homogeneous military organization. To the commander at the operational level, CBM brings the ability to meet mission requirements and increase weapon system availability. CBM+ provides commanders, mission planners, and logistics providers with information that enables better maintenance decision making and mission assignment. CBM+ supports Focused Logistics by enhancing command situational awareness at the weapon system level.	
<b>System Reliability</b>	Reliability is the probability of an item to perform a required function under stated conditions for a specified period of time. System reliability is defined as the ability of a system to perform as designed in an operational environment over a prescribed period without failure. DoD's system reliability objective is to minimize the risk of failure within the defined availability, cost, schedule, weight, power, and volume constraints.	DoD RAM Guide
<b>Number of no evidence of failures (NEOF)</b>	False failure. NEOF's can be caused by changes in the operating environment, errors in diagnostic procedures, cumbersome test equipment, or the basic design of the system.	CBM+ 101 Briefing - OSD CBM+ Advisory Group
<b>Accuracy of failure prediction</b>	CBM+ uses modern maintenance tools, technologies, and processes to detect the early indications of a fault or impending failure based on real-time condition data.	OSD CBM+ Guidebook
<b>Equipment mean downtime (logistics responsiveness)</b>	CBM+ uses modern maintenance tools, technologies, and processes to detect the early indications of a fault or impending failure to allow time for maintenance and supply channels to react and minimize the impact on system operational readiness and life-cycle costs.	DUSD (Logistics and Material Readiness) Memorandum - Life Cycle Sustainment Outcome Metrics, dated 10 Mar 2007
<b>Effectiveness of Platform/system condition assessment</b>	A measure of the overall effectiveness of the CBM+ capability (EHM or VHM) as it relates to the platform or system defined for the system being evaluated. Such as number of false	
<b>Mission reliability</b>	The probability that an item can perform its stated function for a specified interval under stated conditions.	DUSD (Logistics and Material Readiness) Memorandum - Life Cycle Sustainment Outcome Metrics, dated 10 Mar 2007; USD (AT&L) Memorandum - Total Life Cycle Systems Management (TLCSM) Metrics dated 22 Nov 2005
Mission abort rate	Abort rate is the number of aborts divided by the number of sorties.	
Combat power/platform/system availability	See 108 (Availability)	
<b>Safety</b>	The condition of being protected against physical, occupational, and other types or consequences of damage, failure, error, accidents, harm, or any other event which could be considered non-desirable.	OSD CBM+ Guidebook
Number of avoided mishaps or maintenance risks	Number of mishaps or maintenance risks that can be attributed to replacement of component(s)/systems that prevented a failure from occurring.	
<b>System design improvements</b>	Those actions taken to enhance a system's performance, function, safety, reliability, maintainability, etc.	OSD OS Cost Estimating Guide (Oct. 2007); DODI 5000.2

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Term	Definition/Description	Reference
Maintenance facilities usage (all levels)	Application of CBM+ technologies could result in the reduction of the maintenance facilities at any level of maintenance. For the CBM+ BCA define facilities involved and the potential impact with the proposed CBM+ change.	OSD OS Cost Estimating Guide (Oct. 2007)
Troubleshooting and repair action Accurate and timeliness	An element of a maintenance event. One of more tasks necessary to retain an item in or restore it to a specified condition. Data Accuracy - Degree to which the data represents actual (true) value. Data Timeliness - Degree to which the data is available when needed or required.	OSD OS Cost Estimating Guide (Oct. 2007) OSD CBM+ Guidebook
Mean down time	Mean down time (MDT) is the average total time required to restore an asset to its full operational capabilities. MDT includes the time from reporting of an asset being down to the asset being given back to operations or production to operate.	DUSD (Logistics and Material Readiness) Memorandum - Life Cycle Sustainment Outcome Metrics, dated 10 Mar 2007
Logistics decision process (es)	Logistics process (es) that are potentially impacted by the proposed CBM+ capability. Includes any supply chain, asset and inventory control, spare parts management, warehouse management and logistics information management processes. Consider specific metrics or MOEs considered to be problem areas or desired end state condition.	USD (AT&L) Memorandum -Total Life Cycle Systems Management (TLCSM) Metrics dated 22 Nov 2005; DUSD (Logistics and Material Readiness) Memorandum - Life Cycle Sustainment Outcome Metrics, dated 10 Mar 2007
Supply chain impacts	Potential impacts that the proposed CBM+ capability will have on supply chain management such as asset visibility, number of contracts, backorder age, backorder rates, requisition response time, etc..	
Asset accountability and inventory control	Identify, track and manage inventory of weapon system components	
Spare parts management	Identify, track and manage spare parts to support operational requirements	
Warehouse management	Management information system (S) required to identify, track and management of stored and maintained weapons system/components	
Logistics Response Time	The period of time from logistics demand signal sent to satisfaction of that logistics demand. 'Logistics demand' refers to systems, components, or resources, including labor required for weapon system logistics support. Logistics response time as measured by the appropriate logistics process supporting the existing system. Consider specific metrics or MOEs considered to be problem areas or desired end state condition, such as class IX repair parts, requisition date, receipt date, total requisitions, etc....	USMC Performance Based Logistics (PBL) Guidebook; USD (AT&L) Memorandum -Total Life Cycle Systems Management (TLCSM) Metrics dated 22 Nov 2005
Total ownership cost (TOC)	Total ownership cost includes the elements of a program's life-cycle cost, as well as other related infrastructure or business processes costs not necessarily attributed to the program in the context of the defense acquisition system.	Defense Acquisition Guidebook; DUSD (Logistics and Material Readiness) Memorandum - Life Cycle Sustainment Outcome Metrics, dated 10 Mar 2007
\$ per unit usage	Cost per unit	USD (AT&L) Memorandum -Total Life Cycle Systems Management (TLCSM) Metrics dated 22 Nov 2005
Availability	Availability is a measure of the degree to which an item is in an operable state and can be committed at the start of a mission when the mission is called for at an unknown (random) point in time.	DoD RAM Guide; USD (AT&L) Memorandum -Total Life Cycle Systems Management (TLCSM) Metrics dated 22 Nov 2005
Logistics Footprint	The amount of personnel, spares, resources, and capabilities specifically designed and/or designated in support and physically present and occupying space at a deployed location. The Government/contractor size or 'presence' of logistics support required to deploy, sustain, and move a weapon system. Measurable elements include inventory/equipment, personnel, facilities, transportation assets, and real estate. The logistics footprint supporting the existing system and any specific metrics or MOEs considered to be problem areas or desired end state condition. Consider areas such as consumables, energy usage, support equipment, spares, etc....	USD (AT&L) Memorandum -Total Life Cycle Systems Management (TLCSM) Metrics dated 22 Nov 2005; USMC Performance Based Logistics (PBL) Guidebook
Maintenance	The act of maintaining or state of being maintained.	OSD CBM+ Guidebook; OSD OS Cost Estimating Guide (Oct. 2007)

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## Appendix D – CBM<sup>+</sup> Cost Elements Structure

Life Cycle Phases	New System	0-10 Yrs	10-25 Yrs	25+ Yr
<b>Development</b>				
Design				
Development (include both hardware & software)				
Prototype				
Testing & Validation				
Data Management				
CBM <sup>+</sup> Services Applications				
<b>Investment</b>				
System acquisition				
Facilities and Infrastructure				
Supply support				
Test equipment				
Prognostics/diagnostics services				
Data Warehouse				
Training				
<b>Operation &amp; Sustainment</b>				
Unit Level Manpower				
Operations				
Unit-Level Maintenance				
Other Unit-Level				
Unit Operations				
Operating Material				
Support Services				
Temporary Duty				
Data warehouse - data/software management				
Facilities				
Services (24/7)				
Maintenance (all elements; schedule and unscheduled)				
Organizational				
Intermediate				
Depot				
Energy (fuel, petroleum, oil, electricity, etc.. )				
Sustaining Support				
Systems Specific Training				
Support Equipment Replacement				
Sustaining Engineering and Program Management				
Other Sustaining Support				
Indirect Support				
Installation				
Personnel				
Personnel Admin - Acquisition and Overhead accounts				
Personnel Benefits				
Medical				
General Training and Education				
Basic & Initial Skill Training				
Educational Activities				
Licenses				
Technical Refresh				
Data warehouse				
Packaging, Handling, Storage, and Transportation:				
Training				
Continuing System Improvements				
Hardware Modernizations				
Software Maintenance and Modifications				
<b>Disposal</b>				
System Removal				
Environmental Protection				



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## Appendix E – CBM<sup>+</sup> Measures of Effectiveness

Potential Benefit Areas or Measures of Effectiveness / CBM+ Effects	Metric	1. Failure Prediction	2. Holistic View of Equipment Condition	3. Accuracy of Failure Prediction	4. Improve Reliability	5. Reduce MDT	7. Optimize Performance	Overall Benefit + or -
<b>Maintenance -</b>								
Platform	MTBF, Mean time Between Removal (MTBR) Mean time Between Critical Failure (MTBCF), R <sub>M</sub>	X	X				X	
Life Cycle Management	TOC (\$), Spares requirements, ECP requests,		X				X	
Operational/Squadron/Battalion/Fleet	TOC(\$), A <sub>0</sub> , MC, FMC		X				X	
<b>System Reliability</b>	R <sub>M</sub>				X		X	
<b>Number of no evidence of failures (NEOF)</b>	# NEOF	X		X				
<b>Accuracy of failure prediction</b>	Error Rate, R <sub>M</sub>	X		X				
<b>Effectiveness of Platform/system condition assessm</b>	R <sub>M</sub> , False alerts		X					
<b>Mission reliability</b>	A <sub>0</sub> , R <sub>M</sub> , MTBCF							
Mission abort rate	A <sub>0</sub> , A <sub>M</sub> , R <sub>M</sub>				X		X	
Combat power/platform/system availability	Qualitative, R <sub>M</sub> , A <sub>0</sub> , FMC, MC		X		X		X	
<b>Safety</b>								
Number of avoided mishaps or maintenance ri	#		X				X	
<b>System design improvements</b>	# ECPs, Qualitative		X					
<b>Maintenance facilities usage (all levels)</b>	Cost(\$)		X					
<b>Troubleshooting and repair action</b>	MTTR		X				X	
Accuracy and timeliness	Repair cycle time		X				X	
<b>Mean down time</b>	MDT, Mnhrs					X	X	
<b>Logistics decision process (es)</b>	Various		X					
Supply chain impacts	\$, Asset Visibility, Backorder Age, Backorder Rates, Requisition Response Rate, NMCS, # Contracts		X				X	
Asset accountability and inventory control	Asset Visibility, Backorder Age, Backorder Rates, Requisition Response Time, Parts Turnaround Time, Fill Rate		X				X	
Spare parts management	\$, Asset Visibility, Backorder Age, Backorder Rates, Requisition Response Time, Parts Turnaround Time, Fill Rate		X				X	
Warehouse management	Cost(\$)(Leased, Purchased)		X				X	
<b>Logistics Footprint</b>	\$, Spares		X					
<b>Logistics Response Time</b>	Class IX Repair Parts, Requisition Date, Total Requisitions		X					
<b>Total ownership cost (TOC)</b>	TOC (\$)		X				X	

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### Appendix F – References

CBM <sup>+</sup> BCA Study References	
A.	Condition Based Maintenance Plus DoD Guidebook - May 2008
B.	NDIA Final Report EHM Committee - EHM Technology Transition Study October 2009
C.	USD - ATL Letter - Performance Based Logistics (PBL) Business Case Analysis (BCA). Product Support Strategy BCA Guiding Principles - 23 Jan 2004
D.	USD Letter - Life Cycle Sustainment Outcome Metrics - 10 Mar 2007
E.	The Analysis of Return on Investment for PHM Applied to Electronic Systems - October 2008
F.	OSD Cost Analysis Improvement Group - Operating and Support Cost-Estimating Guide - October 2007
G.	Army Aviation Condition Based Maintenance Plus (CBM <sup>+</sup> ) Program - December 2009
Additional References	
	Air Force Manual 65-510, Business Case Analysis Procedures - 22 September 2008
	A Decision Support Model for Determining the Applicability of Prognostic Health Management (PHM) Approaches to Electronics Systems - January 2005
	Air Force Material Command PBL BCA Checklist - 31 May 2007
	Business Case Development Guide; EI Toolkit Guide Version 2.0 - November 2003
	Considerations for a Business Case Analysis for Serialized Item Management (SIM)
	DAU Business Case Project Template Document XXX, Version 1.0
	DON Memorandum for Distribution- 6 Nov 2007, DON Guide for Developing Performance Based Logistics Business Case Analyses (P07-006)
	DoD 5000.04-M-1, Cost and Software Data Reporting (CSDR) Manual - 18 April 2007
	DoD Instruction 7041.3 dated 7 November 1995 - Economic Analysis for Decision Making
	DoD Reliability, Maintainability, and Cost Rationale Report Manual - 22 June 2009
	DoDI 4151.22, Condition Based Maintenance Plus (CBM <sup>+</sup> ) for Material Maintenance dated December 2, 2007
	FY 2000 DoD Logistics Strategic Plan - Aug 1999
	MIL-STD-881A
	OMB Circular A-94 "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs"
	OMB Circular No. A-130
	PM LAV Embedded Platform Logistics System (EPLS) BCA - Feb 2010
	Recommended Performance Measurement Scorecard for Supply Chain Management - LMI - June 1999
	Risk Management Guide for DoD Acquisition, Sixth Edition, Version 1.0, August 2006
	Standard Operating Procedure for Cost Benefit Analysis Review Board - 13 May 2010
	U.S. Army Cost Benefit Analysis Guide Version 1.0 dated 12 January 2010 - Assistant Secretary of the Army Financial Management and Comptroller Memorandum - 1 Feb 2010
	USAF High Velocity Maintenance brief - Jun 2010
	USAF Live-Virtual-Constructive Brief - 20 Feb 2009
	USD - ATL Letter - Performance Based Logistics (PBL) Business Case Analysis (BCA). PBL BCA Criteria - 20 Mar 2004
	USD - ATL Letter - Performance Based Logistics (PBL): Purchasing using Performance Based Criteria - 16 Aug 2004
	USD Memorandum - Total Life Cycle Systems Management (TLCSM) Metrics - 22 Nov 2005
	USMC Performance Based Logistics Guide V 1.04 - 24 Jun 2010

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### Appendix G – CBM<sup>+</sup> BCA Reference Extracts

#### CBM<sup>+</sup> BCA Extracts

1. Cost Benefit Analysis for the Army Aviation Condition Based Maintenance Plus (CBM<sup>+</sup>) Program - December 2009
  - a. The most compelling and supportable benefits described in this Cost Benefit Analysis (CBA) are those associated with aviator safety and aviation combat power. Evidence from actual experience supports increased safety (known to have avoided Class A accidents), and the potential avoidance of numerous mishaps (9-12% reduction). Our CBM<sup>+</sup> program has coincided with improved readiness rates (3.7-10.3% higher Mission Capability (MC) than non-equipped aircraft), the ability to generate additional flying hours within the CBM-equipped fleet, and lower mission abort rates (7-31% depending on platform variant). The ability to use CBM equipment to record flight hours can reduce scheduled maintenance burden by 12-22% with corresponding savings from contractor labor and maintenance test flight hours. Finally, Army Aviation CBM<sup>+</sup> program is responsible for hundreds of small, nearly unquantifiable gains in terms of troubleshooting time, precautionary landings that did not happen, avoided unnecessary maintenance procedures, and more. All of these together represent substantial and real aid to the Aviation Soldier. (Executive Summary, page 6 of 79)
  - b. The Army Material Command (AMCOM) CBM<sup>+</sup> program requires a substantial investment in terms of hardware and analytical manpower. Simply installing CBM equipment on aircraft will not instantly result in benefits and savings. It takes several years of data collection and analysis to turn the data into information and begin changing long-established maintenance procedures that take advantage of the technology. Only in the long process to change those procedures can CBM<sup>+</sup> demonstrate its enduring effect. However, economic modeling, combined with evidence from analysis of fleet-wide readiness and maintenance data, reveals that CBM<sup>+</sup> will likely have long and meaningful impact on Army Aviation maintenance and the combat power of our rotary-wing fleet. (Executive Summary, page 7 of 79)
  - c. For this CBA, the following MOEs will be evaluated to facilitate the comparative evaluation of alternatives:
    - i. Non-Monetary MOEs
      1. Safety : % Avoidable Mishaps
      2. Combat Power: % MC, % Non-Mission Capable Maintenance (NMCM), Mission Aborts/Flight Hour
      3. Maintenance Man-hours Avoided (annually and per flight hour)
      4. Maintenance Test Flights (MTFs) Hours Avoided annually
      5. Number of Mandatory Time Between Overhauls (TBOs)/ Part Retirements Eliminated
      6. % No Evidence of Failure (NEOF) Improvement

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- ii. Monetary MOEs
  - 1. Reduction in Maintenance Man–Hours Costs for Inspections/Vibration Testing/Rotor track and Balance
  - 2. Reduction in Maintenance Test Flight Flying Hour Costs
  - 3. Reduction in Parts Replace On Condition vs. TBOs
  - 4. Reduction in Maintenance Man-Hours for Parts Replaced On Condition With CBM<sup>+</sup> vs. TBOs
  - 5. Reduction in Maintenance Man-Hours for Manual Logging of Flight Time vs. Digital Source Collectors (DSC) Automated Flight Time Generation
  - 6. Reductions in parts demand resulting from changes caused by difference between Manual Logging of Flight Time vs. DSC Automated Flight Time Generation
  - 7. Costs avoided by decreasing frequency of Maintenance Test Flights due to Manual Logging of Flight Time vs. DSC Automated Flight Time Generation
  - 8. Savings From Impact of CBM<sup>+</sup> on Aviation Mishaps  
(Paragraph IV. Measures of Effectiveness, Pages 20 – 21 of 79)
- d. The AMCOM CBM<sup>+</sup> program is pursuing software development that will allow automation, and thus elimination, of these checks. In addition, the same software will allow us to eliminate the need for annual max-power checks on the engines. This MTF maneuver is a rather risky event, and eliminating it will be an added safety boon to the maintenance test pilot community. (Paragraph IV.4.g.viii, page 39 of 79)
- e. In terms of streamline orders of high priority aviation spare parts, highly accurate prognostics on CBM-monitored parts allow maintainers to predict when the part will fail or be replaced at scheduled maintenance and thus preorder to minimize aircraft downtime. In turn, this reduces stress on the supply system eliminating the need for high priority Class IX requisitions such as Aircraft-On-Ground (AOG) status. (Paragraph IV.4.i.ii, page 40 of 79)
- f. CBM<sup>+</sup> will improve the ability to conduct Battle Damage Assessment and Repair (BDAR). After an aircraft suffers combat- or accident-related damage, it is often difficult to conduct accurate and complete BDAR on the system. Anecdotally, CBM technologies have improved a unit's ability to understand the extent of damage, reduce testing/ inspection/troubleshooting time, and then allow faster repair of the aircraft for return to mission-capable status. (Paragraph IV.4.j.ii, page 40 of 79)
- g. Financially, CBM<sup>+</sup> will pay for itself with an estimated 1.2 Benefit to Investment Ratio (BIR) over a 10 year operating period once all aircraft are DSC equipped and major CBM<sup>+</sup> investments are executed. (Paragraph VII. Conclusions, page 51 of 79)
- h. Reductions in Parts demand resulting from changes caused by difference between Manual Logging of Flight Time vs. DSC Automated Flight Time Generation
- i. Costs avoided by decreasing frequency of Maintenance Test Flights due to Manual Logging of Flight Time vs. DSC Automated Flight Time Generation

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- j. Savings From Impact of CBM<sup>+</sup> on Aviation Mishaps
- 2. A Decision Support Model for Determining the Application of Prognostics Health Management (PHM) Approaches to Electronic Systems – Peter Sandborn, CALCE, Department of Mechanical Engineering., University of Maryland. (Proc. Reliability and Maintainability Symposium (RAMS) Arlington VA Jan 2005).
  - a. The paper presents a model that enables the determination of when scheduled maintenance makes sense, and how to optimally interpret PHM results for electronic systems.
  - b. “Although many applicable models for single and multi-unit maintenance planning have appeared, the majority of the models assume that monitoring information is perfect (without uncertainty) and complete (all units are monitored the same), i.e., maintenance planning can be performed with perfect knowledge as to the state of each unit. For many types of systems, and especially electronic systems these are not good assumptions and maintenance planning, if possible at all becomes an exercise in decision making under uncertainty with sparse data.”
- 3. The Considerations for a Business Case Analysis (BCA) supporting DoDI 4151.19, Serialized Item Management (SIM) was used as an example for this CBM<sup>+</sup> BCA information paper.
- 4. Department of the Navy (DON) Memorandum for Distribution- 6 Nov 2007, DON Guide for Developing Performance Based Logistics Business Case Analyses (P07-006) provides amplifying guidance and information in development of Performance Based Logistics (PBL) BCAs.
- 5. NDIA Final Report of the EHM Committee – October 2009
- 6. US Air Force Material Command PBL Checklist dated 31 May 2007
- 7. U.S. Army Standard Operating Procedure for Cost Benefit Analysis Review Board dated 13 May 2010. In accordance with a 30 December 2009 HQDA Memorandum, the Army has implemented a standard operating procedure for conducting and reviewing BCAs. This procedure defines the responsibilities, a process flowchart, a BCA checklist, and specific formats for BCA reports to the DASA (Cost and Economics).
- 8. U.S. Army Cost Benefit Analysis Guide Version 1.0 dated 12 January 2010 - Assistant Secretary of the Army Financial Management and Comptroller Memorandum dated 1 February 2010. This guide provides general guidance for planning and conducting Cost Benefit Analyses.
- 9. USAF High Velocity Maintenance brief - Jun 2010. Outlines a maintenance concept that improves “How Mx is Done” by applying standard high velocity maintenance processes, synchronized to optimize flow time; provide pre-planned support; Point of Use tasking and mechanic centric focus to increase velocity.