Military Equipment Useful Life Study - Phase II

Final Report

Office of the Under Secretary of Defense
(Acquisition, Technology and Logistics),
Property and Equipment Policy Office

and

Office of the Under Secretary of Defense
(Comptroller),
Accounting and Finance Policy Office

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This report was prepared by:

Office of the Under Secretary of Defense (Acquisition, Technology and Logistics)
Property and Equipment Policy Office

Office of the Under Secretary of Defense (Comptroller)
Accounting and Finance Policy Office

KPMG LLP

Executive Summary

Department of Defense (DoD) military equipment continues to experience increased usage and fatigue due to combat and contingency operations. Higher than expected utilization rates and fatigue caused by operating environment and mission requirements are resulting in reduced service life expectancies for some of the Department's military equipment. This is leading to new and emerging requirements for capital planning and military equipment replacement and recapitalization.

The DoD continues to struggle with justifying billions of dollars in requested funding for military equipment programs impacted by changes in operational tempo (OPTEMPO). These challenges with justifying budget requests are due to the lack of sufficient quantitative detail to support the requests and a formal methodology for analyzing and assessing where a military equipment acquisition program is relative to its service life for determining future replacement or recapitalization requirements.

To address these challenges, DoD requires a standardized, repeatable, and supportable process to account for changes in OPTEMPO for the Department's military equipment impacted by changes in OPTEMPO. This will assist with justifying budget requests for military equipment replacement and recapitalization, as well as capital planning.

The Office of the Under Secretary of Defense (Acquisition, Technology and Logistics) (OUSD(AT&L)) Property and Equipment Policy Office and the Office of the Under Secretary of Defense (Comptroller) (OUSD(C)) Accounting and Finance Policy Office initiated Phase II of the Military Equipment Useful Life Study. The purpose of this study is to examine the impacts of OPTEMPO on the service lives of military equipment and develop a methodology and a process to apply that methodology to account for the impacts of military operational tempos on the Department's military equipment inventory, as an additional capital planning and budget justification tool.

The OPTEMPO methodology was developed during Phase II of this study to assist the Department in assessing requested funding for replacement and recapitalization. The methodology considers the effects of usage, fatigue, and losses on a program, thereby providing the Department with have a better estimation tool and a process for determining replacement and recapitalization requirements and justifying budget requests. The inputs to the methodology are standardized but allow for program-specific attributes to be considered, allowing the Department to use data metrics that most appropriately capture the activities within the programs that are resulting in a reduction of military equipment service lives.

The methodology is repeatable and scalable across multiple military equipment platforms where usage is an appropriate basis for assessing service life, including attack aircraft, airlift aircraft, rotary wing aircraft, combat vehicles, and tactical vehicles. For other platforms, such as satellites and sea craft, the methodology would not directly apply, as these programs are typically not significantly affected by changes in OPTEMPO since they are in constant use and their service lives are more appropriately measured on a time (years) basis.

Integration of quantitative OPTEMPO analysis into capital planning efforts will allow for more accurate assessments of the current operational age of a program and will ultimately provide decision-makers with the information needed to define and justify recapitalization and replacement requirements for a given program.

However, some obstacles exist that prevent the Department from implementing the methodology on all of the military equipment programs where the methodology applies. Some are systemic issues resulting in data accuracy problems due to source feeder system data issues, and some are issues that result in data not being captured in enterprise-wide systems due to the lack of policy instruction that require the Military Departments to collect and report usage data within their systems. These issues can be addressed by policy and management oversight. Still, the methodology can be immediately applied to many other programs (i.e., aircraft and combat vehicles) to assist the Department with emergent budgetary issues.

In order for the Department to realize the full benefits of the OPTEMPO methodology across all Military Departments for capital planning and budget justification efforts, several policy actions are recommended. Integrating these policy actions within the budgeting process will promote consistent and complete data reporting requirements across the Department and will facilitate the effective use and application of the OPTEMPO methodology for supporting budget requests and requirements for replacement and recapitalization of military equipment.

1. Policy directives must be published to require the Military Departments to include the OPTEMPO methodology within the existing budget exhibit documentation. Currently, a standardized process for determining military equipment aging and fatigue is not included within the budget formulation and justification process. Policy requirements should be included within the DoD Financial Management Regulation (FMR) that would require the Military Departments to include the OPTEMPO methodology within the budget justification narrative of the P-40 Budget Exhibit. In addition, language should be included within the FMR that allows for accelerated aging and accelerated depreciation of military equipment assets. By creating a supplemental 'OPTEMPO Effects' budget exhibit within the existing P-40 Budget Exhibit and by allowing for accelerated aging in financial reporting, which can be used to drive capital planning, the OPTEMPO methodology can be used for calculating the effects of changes in OPTEMPO over the life of a program and for determining future replacement requirements.
2. The Military Departments should consistently and accurately collect and report OPTEMPO data within their enterprise-wide systems. The data requirements include service life expectancy information, cumulative asset-level usage data, and fatigue data based on measurement capabilities or program estimates.

Given data availability and proper policy guidance, the OPTEMPO methodology is a valid estimation tool that would assist the Department by providing quantifiable management information to assess budget requests for military equipment replacement and recapitalization. The next steps for the Department are to consider and implement policy to ensure data availability and usability for supporting the use of the OPTEMPO methodology in the budget justification and capital planning processes.

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Introduction

Department of Defense (DoD) military equipment continues to experience increased usage and fatigue due to combat and contingency operations. Higher than expected utilization rates and fatigue caused by operating environment and mission requirements are resulting in reduced service life[1] expectancies for some of the Department's military equipment. This is leading to new and emerging requirements for capital planning and military equipment replacement and recapitalization.

The DoD continues to struggle with budget justification requests for military equipment replacement and recapitalization due to the lack of sufficient quantitative supporting detail to support the requests and a formal method/process for analyzing and assessing where a military equipment acquisition program is relative to its service life (program aging) for determining future replacement or recapitalization requirements. Without proper supporting detail and a standardized process for accounting for changes in operational tempos (OPTEMPO), the DoD will continue to struggle with preparing supportable budget requests and determining military equipment replacement requirements.

The Department must determine how to modify the initial estimated service lives of military equipment to account for changes in OPTEMPO due to combat and contingency operations and how to incorporate the results into the Programming, Planning, Budgeting, and Execution (PPBE) process. Therefore, the Office of the Under Secretary of Defense (Acquisition, Technology and Logistics) (OUSD(AT&L)) Property and Equipment Policy Office and the Office of the Under Secretary of Defense (Comptroller) (OUSD(C)) Accounting and Finance Policy Office initiated the Military Equipment Useful Life Study. The purpose of this study is to examine the impacts of OPTEMPO on the service lives of military equipment and develop a methodology and a process to apply that methodology to account for the effects of military operational tempos on the service lives of the Department's military equipment inventory, as an additional capital planning and budget justification tool.

In March 2007, Phase I of the Military Equipment Useful Life Study completed an analysis of the impacts of OPTEMPO on nine sample military equipment programs. The nine sample programs in scope for the study included Navy F/A-18, Air Force C-17, Army CH-47, Special Operations Command (SOCOM) MH-47, Army Abrams, Marine Corps Abrams, Army High Mobility Multipurpose Wheeled Vehicle (HMMWV), Marine Corps HMMWV, and SOCOM Ground Mobility Vehicle (GMV) programs. Phase I validated that as a result of Global War on Terrorism (GWOT) OPTEMPO, usage of military equipment has increased significantly and some military equipment is operating under harsh fatiguing conditions due to operating environment and mission requirements. Phase I also verified that DoD should develop a methodology that accounts for usage and fatigue in order to more accurately and effectively account for the impacts of OPTEMPO on the service lives of its military equipment.

Phase II of the Military Equipment Useful Life Study began in September 2007 and concluded in May 2008. The objective of the Phase II study was to develop a methodology to use as a planning and reporting tool to account for the impacts of OPTEMPO on military equipment service life estimates. The methodology is intended to provide an estimate of

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[1] The service life of a piece of military equipment is defined as the total amount of use that the equipment can expend before its capability is degraded to the point where it must be replaced or undergo a major depot-level, procurement-funded service life extension. Service life is a product of the engineering-based original design service life plus any SLEP/RECAP/Rebuild actions that result in additional capability or additional miles or hours.

program aging and consumption against program design service life expectancy, as a tool by which additional support for the justification of the Department's budget requests for military equipment replacement and recapitalization can be provided. Currently, budget exhibits do not require quantitative budget justification support based on changes in OPTEMPO, and the methodology is intended to fill this void in order to provide additional budget justification support for the Department, as well as to assist with capital planning efforts.

The Phase II study was segmented into four parts. The first segment focused on re-evaluating and validating the Phase I results for the nine sample programs and drafting an OPTEMPO methodology based on analysis of two sample programs, the Navy F/A-18 and Army Abrams programs, and additional research. Upon approval of the draft methodology during the Pre-Decisional Brief on December 14, 2007, the remaining segments were completed. The second segment focused on validating and completing the methodology for the remaining seven of the nine sample programs. The third segment focused on identifying the universe of military equipment programs that could be impacted by changes in OPTEMPO, where the methodology could be used to evaluate any changes in service life estimates based on OPTEMPO. The fourth segment focused on developing DoD Financial Management Regulation (FMR) policy guidance for the implementation of the methodology within the Department's budget justification process.

The four segments of the study were completed, resulting in a final validated methodology, an OPTEMPO universe that provides guidance for where the methodology could be used, and a DoD FMR Policy Paper that provides guidance for implementing the methodology. This report will discuss the approach to the study, the final methodology and illustrations of its application, where the methodology applies, and the findings and recommendations of the study.

Approach to Study

The approach to meeting the objective of the study, developing an OPTEMPO methodology that accounts for the impacts of OPTEMPO on the service lives of DoD military equipment, is discussed in this section. The approach included the following:

I. An extensive literature review effort and ongoing data collection.

II. The development of the methodology, including:

   a. Drafting a methodology based on in-depth analysis of two of the nine sample programs.

   b. Receiving approval of the draft methodology from the Under Secretary of Defense (Comptroller) (USD(C)) and Principal Deputy, USD(C).

III. The validation of the methodology, including:

   a. Assessing and validating the scalability and repeatability of the methodology on the remaining seven sample programs.

   b. Working with the Office of the Secretary of Defense (Comptroller/Program Budget) (OSD(C/PB)) and the Office of the Secretary of Defense (Program Analysis and Evaluation) (OSD(PA&E)) to apply the methodology to the budget justification process, to include the FY2009 Supplemental.

   c. Analyzing the applicability of the methodology across the Department's military equipment inventory.

These steps and related results are described below.

Data Collection and Research

Data collection and research were completed in order to obtain data and information to support the development of an OPTEMPO methodology that factors the impacts of usage and fatigue on the service lives of military equipment. Data collection and research efforts included meetings and teleconferences with select military equipment program management offices, discussions with DoD organizations and industry, and in-depth literature review.

<u>Meetings and Interviews with Military Equipment Program Management Offices</u>

A questionnaire was developed to facilitate data and information collection from the nine sample programs regarding engineering estimates for service life, usage data and systems where this data is recorded, fatigue factors and measurement capabilities, and the capital budgeting process, in an effort to solicit data and information to assist with the development of an OPTEMPO methodology. This questionnaire was distributed to representatives of the nine sample programs. Questionnaire responses were discussed and completed during follow-up meetings and teleconferences to discuss an approach for accounting for the impacts of OPTEMPO on the service lives of military equipment. Additionally, meetings or teleconferences were held with military equipment program management offices (PMO) and field sites beyond the nine sample programs to gain a broader understanding of the impacts of OPTEMPO on service life expectancies of military equipment.

In addition to obtaining information for use in a methodology, Phase I results were reviewed and validated through the review of these programs. It was confirmed that usage and fatigue are the primary drivers of military equipment service life degradation and should be factored in a methodology for evaluating service life based on changes in OPTEMPO.

The military programs with which these discussions were held include the following:

- Navy F/A-18 PMO; Patuxent River, MD
- Army CH-47 PMO; Huntsville, AL
- SOCOM MH-47 PMO; Orlando, FL
- Air Force C-17 PMO; Dayton, OH
- Army Abrams Main Battle Tank PMO; Warren, MI
- Army Anniston Depot; Anniston, AL
- Marine Corps Abrams Main Battle Tank PMO; Quantico, VA
- Army HMMWV PMO; Warren, MI
- Marine Corps HMMWV PMO; Quantico, VA
- SOCOM Ground Mobility Vehicle PMO; Orlando, FL
- Coast Guard Naval Engineering Support Unit; Honolulu, HI
- Navy Pacific Fleet; Honolulu, HI
- Navy P-3 Wing; Honolulu, HI
- Marine Corps Combat Services Group; Honolulu, HI
- Air Force Pacific Air Forces; Honolulu, HI
- Air Force 36th Wing; Guam

Detailed program characteristics and findings for the nine sample programs and from the Pacific commands are discussed later in this report within the methodology illustrations.

Discussions with DoD Organizations and Industry

Several discussions were held with DoD organizations to research the existence of military equipment aging models and the effects of OPTEMPO on military equipment service life estimates. The organizations listed below confirmed that a model or methodology does not exist that evaluates the service lives of military equipment based on changes in OPTEMPO. The following is a summary of the models and tools that are currently in place within the Department:

- OSD(C/PB) uses a date-driven model to age military equipment that does not factor both usage and fatigue.
- OSD(PA&E) uses a straight-line, date-driven model to age ground and sea systems. To age aircraft systems, a model based on usage in flight hours is used. These models do not address fatigue.
- OUSD(AT&L/Acquisition Resources and Analysis (ARA)) ages military equipment on a straight-line, years basis in the Capital Asset Management System – Military Equipment (CAMS-ME).
- OSD(Cost Analysis Improvement Group (CAIG)) has prepared a methodology to calculate the lifetime costs for thirty-four programs. Their methodology focused on useful life, straight-line by years per the DoD Operating and Support Cost-Estimate Guide, cost of the equipment, and the total systems in inventory. This methodology does not incorporate the impacts of OPTEMPO on service life.
- OUSD(AT&L/Logistics and Materiel Readiness (L&MR)) does not have a model or a methodology that addresses the service life of military equipment. The Honorable P. Jackson Bell, Deputy Under Secretary of Defense for Logistics and Materiel Readiness, agreed, when briefed on the methodology, that the methodology was a

correct approach for the Department to evaluate the impact of OPTEMPO on the service lives of military equipment as a budget justification and capital planning tool.

- Air Force(Secretary of the Air Force/Financial Management and Comptroller (SAF/FMC)) has a 'Cost of the Air Force' model that analyzes aircraft aging using flight hours. This model does not factor fatigue in a standardized manner.
- Army(G-8) is working to develop a model that factors in OPTEMPO, readiness rates, and maintenance requirements resulting from changes in OPTEMPO.
- Navy(Financial Management and Comptroller (FM&C)/FMO and Financial Management and Budget (FMB)) do not have a methodology that incorporates the impact of OPTEMPO on service life expectancies.

Further, conference calls were conducted with Federal Express and US Airways to research industry practices for aging their aircraft fleets. Neither have a model for determining the impact of OPTEMPO on aircraft service life, but Federal Express is currently evaluating a process to match physical usage of aircraft to the accounting depreciation, based on their auditor's recommendation and their internal capital planning initiatives.

Both companies consider usage when determining service life estimates for their fleets. According to Federal Express, aircraft utilization is based on flight cycles (takeoffs and landings), and representatives stated that it maintains a low utilization of aircraft and never worries about completely consuming the aircraft service life. US Airways uses cycles (landings) as the basis for determining service life of their aircraft. Based on usage trends, US Airways has assigned regional aircraft with a 25-year service life (more cycles) and national/international aircraft with a 30-year service life (less cycles).

Literature Review

An extensive literature review was completed to review a number of previous studies about DoD mission readiness, age and usage, fatigue, and service life of military equipment. The literature search and review confirmed that time is not a valid basis for measuring the service life of military equipment impacted by changes in OPTEMPO; instead, usage is a better measure for such programs. The literature reviewed also did not reveal any models or methodologies for evaluating service life based on changes in OPTEMPO, further emphasizing the need for such a model. Below is a summary of the significant findings from the literature reviewed.

- **Office of the Secretary of Defense (OSD); <u>Long-Term Equipment Repair Costs Report to Congress</u>, September 2006**. This report confirmed that expenditures related to recapitalization, rebuild, and RESET programs for various military equipment programs have increased since the beginning of GWOT due to increased usage and fatigue caused by harsh desert and combat conditions.

- **United States Government Accountability Office (GAO); <u>Defense Logistics, Army and Marine Corps Cannot Be Assured that Equipment Reset Strategies Will Sustain Equipment Availability While Meeting Ongoing Operational Requirements</u>, September 2007.** GAO highlighted in this report that military equipment is operating at a pace well in excess of that experienced during peacetime operations. The report states that a Marine Corps official stated that ground equipment and rotary wing aircraft are experiencing operational tempos that are two to five times the peacetime rate. The report also confirms that the heavy armor kits on trucks are causing excessive wear that is estimated to be five to six times the wear experienced during peacetime. In addition, the harsh operating conditions and the duration of operations in Iraq are increasing equipment maintenance and replacement costs and consequently are also increasing operating and maintenance and procurement funding.

- **Inspector General of the Marine Corps; US Marine Corps Ground Equipment in Iraq: May 2005.** This report confirmed that environmental factors such as heat, sand and dust have taken their toll on filters, lubricants, and heat-sensitive components of equipment. The high combat operational tempo and harsh conditions have adversely impacted the life expectancy of the equipment deployed to Iraq. Commanders have reacted to enemy tactics and techniques, such as the use of IEDs, by adding armor protection to vehicles, thereby increasing weight to the vehicles and ultimately impacting on the wear and tear on frames, axles, and suspension systems.
- **U.S. Army; Equipping America's Army: October 2007.** This report confirmed that the increased operational tempo due to combat operations (battle loss and damage, increased operations, climate, and terrain) is causing significant operational challenges for the Army, such as wear and tear on equipment. Theater conditions and increased weight from armor wear out the Army's equipment up to six times the established peacetime usage rates.
- **Congress of the United States, Congressional Budget Office (CBO); Replacing and Repairing Equipment Used in Iraq and Afghanistan: The Army's Reset Program, September 2007.** CBO confirmed in this report that the Army's equipment is being operated at higher rates than ever before. Based on data provided by the Army, CBO was unable to determine why the Administration's annual funding requests for the Army's RESET program have grown over the 2005-2007 period. Due to lack of data provided by Army, CBO was unable to fully explain discrepancies in the Army's budget requests.
- **Institute for Defense Analyses (IDA); Stress on Equipment, September 2007.** This study found that between 2003 and 2006, approximately $100B was spent for increased O&M expenditures, but a conclusion could not be made to relate these expenditures directly to GWOT OPTEMPO. This study also confirmed that a model does not exist that relates GWOT environmental conditions and driving cycles of the M1A1 Abrams to age accumulation. There is no generally agreed means to characterize fleet health or remaining service life for ground vehicles. For aircraft, models are available that allow the length of cracks to be computed as a function of loading and environmental conditions.
- **U.S. Army Audit Agency (AAA); Developing Depot Workload Requirements for Major End Items, U.S. Army Aviation and Missile Life Cycle Management Command, June 2007.** AAA focused on three major aircraft for this audit: Apache, Blackhawk, and Chinook. The audit was focused mainly on the RESET and recapitalization efforts for all three programs. The AAA made the recommendation for the programs to maintain adequate and reliable data regarding aircraft selected and the rationale for induction into recapitalization programs, since that data needed to rationalize RESET and recapitalization decisions was limited in availability.
- **United States Government Accountability Office (GAO); Defense Logistics, Preliminary Observations on Equipment Reset Challenges and Issues for the Army and Marine Corps, March 2006.** This report confirms the lack of clarity and sufficient supporting information on the budget supplemental request and justification provided by the Military Departments. This report emphasized the need for the Army and Marine

Corps to better align their funding requests with the related program strategies to sustain, modernize, or replace existing legacy equipment systems. Until the Military Departments are able to firm up these requirements and cost estimates, neither the Office of the Secretary of Defense (OSD) nor the Congress will be in a sound position to weigh tradeoffs and risks in relation to RESET and procurement funding.

- **Center for Strategic and Budgetary Assessments (CSBA); <u>The Global War on Terror (GWOT): Costs, Cost Growth and Estimating Funding Requirements</u>, February 2007.** Serious data limitations prevent CBO and others from evaluating the reasonableness of DoD's requests for GWOT funding. Data limitations also make it impossible to confidently project future GWOT funding requirements, according to this report. With improved data, CBO may be able to provide significantly better analysis and oversight related to GWOT costs and funding requirements. CBO and the Congress have made it clear to DoD the importance of receiving such data.
- **Logistics Management Institute (LMI); <u>The Relationship Among Cost, Age, and Usage of Weapon Systems</u>: January 2003.** This report verified that there is little to no relationship between age in years and usage of military equipment.

The data collection and research efforts were ongoing throughout the duration of the study, simultaneously with the analysis of the programs and the development and validation of the OPTEMPO methodology. The next section describes the development of the OPTEMPO methodology.

Development of the Methodology

The approach to developing the methodology was two-fold. First, analysis was completed on two programs to develop a draft methodology for approval by USD(C) and the Principal Deputy, USD(C) on December 14, 2007. The methodology presented was approved, and then the methodology was validated on the remaining programs included in the study to complete and assess the scalability of the methodology.

<u>Initial Analysis on Two Programs</u>

After beginning the data collection and research effort and at the direction of OUSD(AT&L) and OUSD(C), the team worked to draft an OPTEMPO methodology based on a complete deep-dive analysis into two programs, for presentation to and approval by the Principal Deputy, USD(C) during a Pre-Decisional Brief on December 14, 2007. An aircraft program and a vehicle program, the Navy F/A-18 and Army Abrams Main Battle Tank programs, were chosen for this initial analysis.

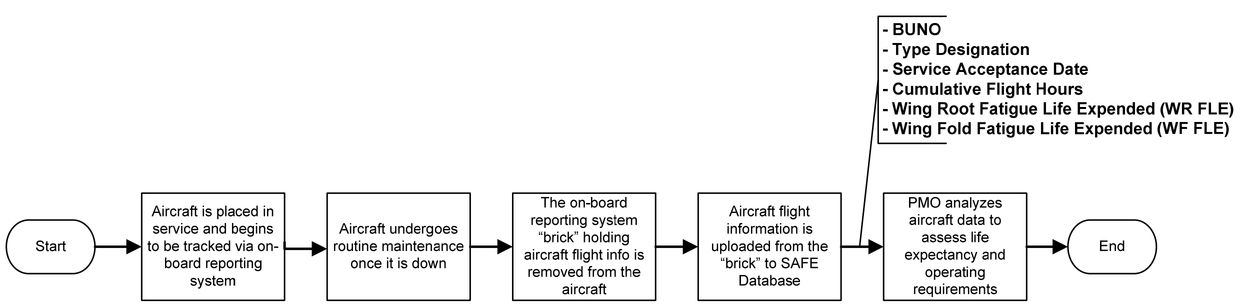
During meetings and interviews with the program managers (PMs) and engineers for the two programs, it was confirmed that usage and fatigue are the drivers of military equipment service life degradation and should be included in the OPTEMPO methodology to evaluate the impacts of OPTEMPO on service life. That is, if a piece of equipment is used more than programmed and under more extreme conditions, then its service life is degraded faster, which results in accelerated replacement or recapitalization requirements.

The team found that service life limits are typically defined by usage boundaries (i.e., 8,000 flight hours or 6,000 driving miles before replacement or recapitalization would be required) and should be the basis for evaluating programmatic consumption in terms of the ratio of usage expended to usage available. This usage ratio must be further adjusted using a multiplier that factors structural fatigue conditions that further degrade service life of military equipment beyond usage.

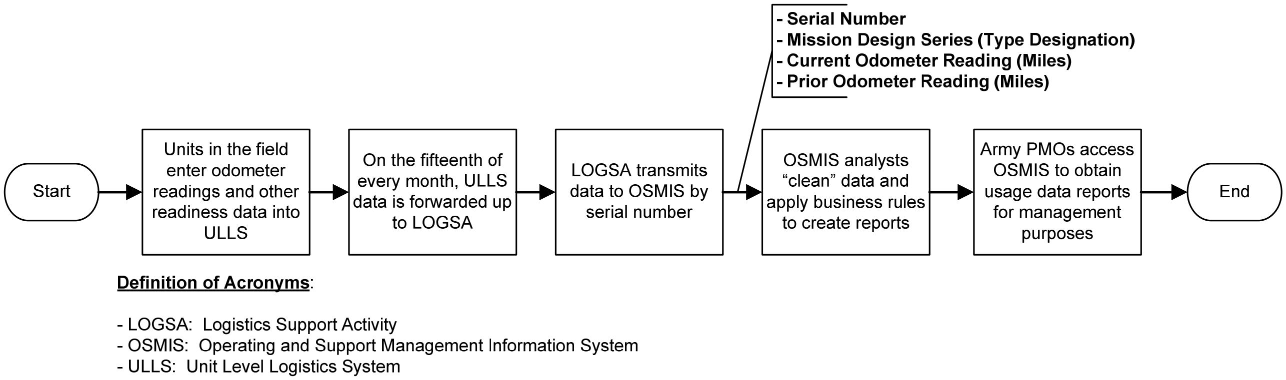
For military equipment platforms, such as the F/A-18 and Abrams programs, there may be multiple usage boundaries that define the service life of the platform. For example, an F/A-18 aircraft has usage boundaries for flight hours, catapults/traps, and landings, and an Abrams tank has usage boundaries for driving miles, engine hours, and rounds fired from the gun tube. The team found that for these two programs, a primary usage driver exists that usually limits the equipment service life before the other usage boundaries are realized. The primary usage drivers are flight hours for the F/A-18 program and driving miles for the Abrams program. These primary life-limiting usage drivers should be factored into the methodology.

The F/A-18 program monitors structural fatigue on its aircraft via an automated fatigue-tracking capability, which produces fatigue life expended (FLE) metrics for each aircraft based on every flight hour that can be incorporated into the methodology. However, the Abrams program does not have a structural fatigue-tracking capability that measures the impacts of fatigue on the service life expectancy. The Army Abrams engineers felt that structural fatigue should still be incorporated into the methodology using an estimate based on quantifying the primary fatigue factor that the program experiences, caused by operating the tanks beyond their engineering-based specifications. The PMO agreed that a reasonable basis for estimating the impact of structural fatigue on the Abrams fleet was to apply a multiplier to adjust mileage where fatigue is experienced (typically in combat and contingency operations), based on quantifying the percent increase in weight carried beyond the engineering-based gross vehicle weight (GVW) specification.

The team found that the F/A-18 and Abrams PMs manage their programs based on usage and that they track usage data for use in management purposes, such as evaluating program service life and consumption. Below is a depiction of the process, data, and system flow for the tracking of usage and fatigue data in the Structural Appraisal of Fatigue Expended (SAFE) database for the F/A-18 program. The SAFE database houses cumulative usage and fatigue data back to program inception by bureau number (BUNO) for F/A-18 models A-F. F/A-18 usage data is also available in the Aircraft Inventory and Readiness Reporting System (AIRRS), which is the system of record for inventory and usage data for Navy aircraft.



Below is a depiction of the process, data, and system flow for the tracking of usage data in the Operating and Support Management Information System (OSMIS) for the Abrams tank program. OSMIS also houses cumulative usage information by serial number for other major Army vehicle and aircraft platforms. OSMIS holds usage data since 1993, although cumulative odometer readings recorded after 1993 would include usage prior to 1993. Concerns were expressed over the completeness and reliability of the usage data in OSMIS, especially for ground systems, due to the dependability on the units to report accurate data on a timely basis for each asset.



Data to support incorporating usage and fatigue for evaluating service life in a methodology was confirmed to be available and were used to draft an OPTEMPO methodology, illustrated to show its application to the F/A-18 and Abrams programs. This draft methodology and its application to these programs were validated with representatives from the PMOs of both programs as a reasonable estimate for the impacts of OPTEMPO on the service lives of their military equipment.

The draft OPTEMPO methodology was presented to and approved by USD(C) and the Principal Deputy, USD(C) during the Pre-Decisional Brief on December 14, 2007. Upon approval, further analysis was completed on the remaining seven programs to assess whether the methodology was repeatable and scalable to other platforms.

Validation of Methodology on the Remaining Programs

To validate the methodology on the remaining programs, the program questionnaire responses, usage data, and program-specific fatigue factors were assessed to determine whether the methodology applied and could be repeated on those programs. Meetings with depots were held and a supplemental questionnaire was developed to explore the impacts that maintenance actions could have on the service lives of ground vehicle systems. The supplemental questionnaire was distributed to the Army and Marine Corps HMMWV and SOCOM GMV programs. The program questionnaire and supplemental ground vehicle questionnaire are referenced in Appendix A and Appendix B, respectively.

Interviews with Navy, Air Force, and Marine Corps in the Pacific commands were also conducted to validate the applicability of the OPTEMPO methodology to aircraft, sea craft, and ground systems. Additionally, work was completed with OSD(C/PB) and OSD(PA&E) to determine how the methodology could be implemented across the Department to assist in the budgeting process. The results of the analysis on these programs and the budget process are illustrated later in this report.

Work was also completed to determine the applicability of the methodology across the Department's military equipment inventory, and the results of this analysis are described later in this report as well.

In summary, the following was confirmed through the validation effort, demonstrating the scalability and repeatability of the OPTEMPO methodology to multiple military equipment platforms beyond the Navy F/A-18 and Army Abrams programs.

- Usage and fatigue were confirmed to be the primary life-limiting factors of OPTEMPO that result in accelerated service life degradation of military equipment. Usage and fatigue attributes vary by program depending on asset type and mission, and the methodology is adaptable to factoring the program-specific variables.
- The service lives of specific types of military equipment programs are defined by usage boundaries, and it is appropriate to assess the age of these programs on a usage and fatigue basis using the OPTEMPO methodology.
- Asset-level usage data is generally available, at some level, to support the use of the OPTEMPO methodology. Usage data is available in enterprise-level systems of record for many platforms, such as aircraft. For other platforms, such as tactical vehicles, data availability is limited. Data may be available in maintenance jackets or in the units and obtainable via manual data calls. Some programs do not track usage data at all. Policy guidance is recommended that would require the Military Departments to start tracking and reporting asset-level usage data for their programs.
- Not all programs have structural fatigue measurement capabilities that estimate fatigue life expended metrics for use in the methodology. Some programs are currently developing those capabilities for use in the future. Other programs, such as ground vehicle programs and older aircraft programs, do not have these measurement capabilities, and it is appropriate for them to estimate the impact of fatigue on service life degradation in the methodology based on a quantifiable and reasonable fatigue factor.
- Technology plays a role in determining replacement and recapitalization requirements, separately from the role that OPTEMPO plays based on usage and fatigue. The decision to replace or recapitalize a piece of military equipment can be determined based on the need to upgrade or install capabilities needed to meet mission threats and requirements. Technology is therefore a consideration in determining replacement and recapitalization requirements, which goes beyond accelerated aging based on usage and fatigue.
- Ongoing maintenance actions keep military equipment at operational readiness standards but do not restore lost service life due to usage and structural fatigue.

The final OPTEMPO methodology is defined in the next section.

OPTEMPO Methodology Defined

The OPTEMPO methodology is a formula that determines the number of equivalent lives consumed for a program, based on losses, usage, and fatigue, serving as a signal for when to begin planning for the replacement or recapitalization of military equipment. The methodology is intended to provide an estimate of the impacts of changes in OPTEMPO on the service life estimates of a military equipment program, which will assist in providing additional budget justification support for the recapitalization and replacement of military equipment.

The methodology does not tell a user when to replace or recapitalize military equipment, nor does it tell a user what action to take to recover lost capability. Instead, the output of the methodology, which is the number of equivalent lives consumed over the lifetime of the program, is intended to provide an estimate of the capability that has been consumed over the lifetime of the program, signaling decision-makers for when to begin planning for future procurement actions. To determine the appropriate actions to take and when to take those actions to recover lost capability for a program, this information should be analyzed during the capital planning process along with information regarding future program/mission requirements, such as remaining capability, funding availability, and fielding schedules for existing and new systems.

The OPTEMPO methodology is depicted below.

Losses — Usage — Fatigue

$$\text{Equivalent Lives Consumed} = \underbrace{\text{Battle Losses} + \text{Non-Combat Losses}}_{\text{Losses}} + \left(\text{Active Asset Quantity}\right)\left\{\underbrace{\left(\frac{\sum \text{Actual Use per Active Asset}}{\text{Active QTY x Design Service Life}}\right)}_{\text{Usage}}\underbrace{\left(1+\text{Fatigue}\right)}_{\text{Fatigue}}\right\}$$

The inputs to the methodology are standardized but allow for program-specific attributes to be considered, allowing the Department to use data metrics that most appropriately capture the activities within the programs that are resulting in a reduction of military equipment service lives.

Program losses have a direct impact on a program's mission readiness and should be factored into the methodology to determine the full impact of changes in OPTEMPO on the service life expectancy of a program and to obtain an accurate estimate of the total equivalent lives consumed. *Battle Losses* are the number of equipment losses the program has experienced due to combat operations. *Non-Combat Losses* are the number of all other losses not associated with combat operations, such as attrition, training losses, and maintenance washouts.

Changes in OPTEMPO due to combat and contingency operations cause much of DoD's military equipment to experience increased utilization beyond programmed peacetime utilization rates, resulting in increased consumption of a program's capability and therefore a decrease in life expectancy. Usage is the *Sum of Actual Use* (e.g., miles driven or hours flown) per active asset included in the *Active Asset Quantity,*[2] which is the number of assets a program has available for deployment or within the active inventory, and is related to the metric on which the

[2] Some assets may be excluded from the *Active Asset Quantity* number depending on the program, such as Research, Development, Testing, and Evaluation (RDT&E) assets that are used only for testing purposes and not considered part of the active inventory for the program.

Design Service Life of the program is based.[3] The ratio of actual usage to available usage is calculated to determine the percent of the program that has been consumed based on utilization. This ratio gives a snapshot of the current age of a program based on usage before adjusted to incorporate the impact of fatigue on the service life expectancy of the program. Design service life estimates can change over the life of a program based on how the assets are used, how much fatigue they experience, and how well they are maintained, and this can affect the usage ratio determined by the methodology. As the Military Departments assess and revise the service lives of their equipment by managing mission profiles, performing maintenance, and through inventory rotation, these revisions should be factored when applying the methodology.

Much of DoD's military equipment is being deployed in harsher environments and used in demanding ways due to combat and contingency operations, leading to asset structural fatigue that contributes to the reduction of service life beyond usage. The impact of structural fatigue on military equipment service life is applied in the methodology using actual fatigue life expended metrics obtained from fatigue-measurement capabilities or by using an estimate that is quantified based on a primary fatigue factor for the program that results in lost service life. The fatigue multiplier does not account for fatigue that occurs on select components (subsystems or expendables, such as tires, shocks, axles, engines, etc.), which are typically replaced or repaired during maintenance actions. The fatigue multiplier accounts for structural fatigue, on the final military equipment end item, that is unable to be reversed through maintenance actions. Fatigue varies by program, and the fatigue calculation or estimate should be program-specific. For programs that do not experience fatigue that results in a degradation in service life, a fatigue sum of zero would be used.

The following are assumptions within the methodology:

- Regular scheduled maintenance and RESET actions occur while the assets are in theater or at centralized depots. These maintenance actions are restoring the lost capability of subsystem impairments (restores assets to operational standards by replacing and/or repairing impaired consumables such as engines, axles, brakes, transmissions, etc.), and these maintenance actions allow the assets to meet operational standards and requirements.
- PMs provide usage (e.g., hours flown, miles driven), fatigue criteria (i.e., what the structural fatigue factors are), and total losses information.

The following are constraints within the methodology:

- *Data availability for some ground systems*. For some programs, such as the HMMWV/GMV programs in the Army, Marine Corps, and SOCOM, usage data is not as readily available as it is for aircraft programs. Army data is available in OSMIS, but it is usually incomplete for high density programs. For the Marine Corps and SOCOM, the data could be obtainable via manual data calls to the units or in maintenance records at the depots.

[3] For example, if the design service life for the program is a number of hours an aircraft can fly before it is retired/disposed or requires a service life extension, then the usage input into the methodology should be the sum of the actual hours flown per active asset in that program.

- *Accuracy of the data*. Usage data accuracy and integrity can be an issue for some programs, due to large program densities, human error, lack of reporting by the units, or age of the program.
- *Quantifiable data for structural fatigue estimates*. Not all programs have structural fatigue-measurement capabilities that provide quantified structural fatigue estimates. Some programs must use an estimate based on primary fatigue factors, as demonstrated in the methodology illustrations later in this briefing, to include in the methodology calculation.

For platforms to which the OPTEMPO methodology applies, the methodology is applied at the program level to capture program and mission-specific usage and fatigue attributes that impact the service life of the program. The methodology can be run for a total program (e.g., the Army Abrams total program), for an individual type designation (e.g., the Army M1A1 Abrams), or for a grouping of type designations (e.g., the Army M1A1 and M1A2 Abrams).

The OPTEMPO methodology can be run for any time period (from fiscal year to fiscal year to calculate period aging) to obtain an estimate for program consumption for the specified time period. The methodology can also be run to illustrate over or under runs in the program using actual data versus budgetary programmed numbers to determine and quantify the net budgetary impacts (plus or minus) for a given budget year or period.

To illustrate the application of the methodology to various military equipment programs, the study looked at nine programs that provided a representative but non-statistical sample of programs representative of five major military equipment asset classes. These programs include the Navy F/A-18 (attack aircraft), Air Force C-17 (airlift aircraft), Army CH-47/SOCOM MH-47 (rotary wing aircraft), Army and Marine Corps Abrams Main Battle Tank (combat vehicles), and Army and Marine Corps HMMWV and SOCOM GMV (tactical vehicles).

Discussions of the applicability of the methodology for capital planning along with illustrations of the methodology applied to the programs and to the budgeting process are shown in the next section.

Application of the Methodology for Capital Planning

The OPTEMPO methodology is a tool that provides an estimate of the aging of a military equipment program based on the impacts of usage and fatigue, expressed in terms of the number of equivalent lives consumed over the life of the program. This results in a quantitative metric that can be used to assist with budget justification and capital planning.

The methodology will assist with budget justification and capital planning across the Department by providing information to support each of the five principles of capital planning,[4] as described below:

1. *Strategic linkage.* By providing an estimate of program age and insight into the amount of capability that has been consumed for a program, the methodology will assist organizational leaders with developing appropriate long-range plans for the capital asset (military equipment) portfolio in order to meet mission requirements. This strategic planning helps guide and justify decision-making for budgeting and spending.
2. *Needs assessment and gap identification.* The resources that are needed to fulfill immediate requirements and anticipated future needs based on organizational objectives that flow from the organization are identified through a comprehensive needs assessment. A comprehensive evaluation of needs considers the capability of existing resources and makes use of an accurate and up-to-date inventory of capital assets as well as current information on asset condition.

   The methodology is an additional tool that can be used to assess a military equipment program's needs, by considering the impacts of usage and fatigue on current asset inventories. Using this information, an organization can properly determine any performance gaps between current and needed capabilities. For example, if the methodology reveals that a program is nearing the end of its service life sooner than planned, causing a gap in a program's capability, this can serve as a signal for the PM to begin planning for additional capability to fill that gap.
3. *Alternatives evaluation.* Agencies should determine how best to bridge performance gaps by identifying and evaluating alternative approaches. As described in principle # 2, the methodology provides information that can guide military equipment program decision-makers as to when additional capabilities are required to fill performance gaps. Decision-makers can use this information to signal when discussions and evaluations should begin regarding how to bridge those performance gaps.
4. *Review and approval framework with established criteria for selecting capital investments.* This principle requires that agencies establish a formal process for senior management review and approval of proposed capital assets. Currently, the Department struggles with reviewing budget justification requests for military equipment replacement and recapitalization proposed by the Military Departments. This struggle is due to the lack of a formal process or methodology for assessing where a military equipment acquisition program is relative to its service life for determining the future capital asset requirements (military equipment replacement and recapitalization).

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[4] Source: Government Accountability Office, February 2007. Federal Capital: Three Entities' Implementation of Capital Planning Principles is Mixed. The five principles are based on GAO's analysis of OMB's *Capital Programming Guide* and GAO-04-138.

The methodology provides a standardized, scalable tool that can be applied across multiple military equipment platforms to assist decision-makers with objectively reviewing budget requests and capital investment proposals. With proper policy in place to facilitate the use of the methodology in budget justification and capital planning processes, the methodology will help strengthen the framework for reviewing and approving capital investments.

5. *Long-term capital investment plan.* The methodology can be used to assist with developing long-term capital investment plans by providing insight into what the proper mix of existing assets and new investments are required to fulfill organizational missions and goals, based on an assessment and a review of performance gaps and risks that are identified by applying the methodology.

Due to recent increased budgetary pressures that require the DoD to provide improved justification and make better decisions for military equipment replacement and recapitalization, the impact of the OPTEMPO methodology's ability to provide an additional tool that will help define and justify military equipment asset requirements for meeting organization missions and goals is significant to improving the capital planning process.

Below are illustrations of the methodology to programs within the five asset classes reviewed during this study, including F/A-18 (attack aircraft), C-17 (airlift aircraft), CH/MH-47 (rotary wing aircraft), Abrams Main Battle Tank (combat vehicles), and HMMWV/GMV (tactical vehicles) programs. Detailed program-specific observations and findings related to applying and implementing the OPTEMPO methodology discovered during the study are discussed within the program illustrations. Data and information used in these examples were provided by representatives of the respective program management offices. The programs also generally agreed with the use of methodology for assisting with capital planning and budget justification.

Following the program methodology illustrations, an illustration of the methodology applied to assist with budget justification for the FY2009 Supplemental Request for F/A-18 E/F aircraft is provided. This illustration demonstrates how the methodology can be applied directly to the budget process to assist with budget justification.

Methodology Illustration: Attack Aircraft - Navy F/A-18C Program

The F/A-18C program has four life-limiting criteria: flight hours, wing root fatigue life expended (WR FLE), catapults and traps, and landings. The PM manages to all of these criteria to maximize the lifetime of the aircraft fleet, but flight hours and WR FLE are the two primary life-limiting factors that result in lost aircraft. The service life of the F/A-18C is 8,000 flight hours. The WR FLE is a measurement of the impact of flight activities on the main structural components of the aircraft and has a limit of 1.0, or 100%.

The F/A-18 PMO has evaluated the impact of wartime on aircraft and discovered that while utilization (flight hours) has increased, WR FLE does not always increase based on how the aircraft are flying and used in combat (i.e., straight missions, without aggressive maneuvers). On the other hand, training missions (peacetime use) can result in aggressive maneuvers and have a greater impact on WR FLE. The methodology accounts for these variations and conditions.

Usage and WR FLE data for all F/A-18 aircraft are available at the asset level in the SAFE database. The data is available back to program inception for the F/A-18 A-F model aircraft. Usage data is also available at the asset level in AIRRS for the F/A-18 program. Although AIRRS is a system of record for Navy aircraft data, the PMO recommended using the flight hours from SAFE since they correspond to the fatigue data available in SAFE to support the methodology illustration for the F/A-18C.

The methodology factors all flight hours and all WR FLE for the program. It cannot be assumed that each aircraft will reach 8,000 hours due to WR FLE limits. 8,000 flight hours is < 1.0 FLE. When an aircraft reaches one of the two ceilings, it may be retired.

In order to factor usage and fatigue, the fatigue factor, WR FLE, must be normalized to hours. The conversion is done by multiplying cumulative hours flown by .000125, which is 1.0 WR FLE divided by 8,000 hours. In other words, 1 flight hour is equal to .000125 FLE. A fatigue multiplier is then used if the actual sum of WR FLE on the program is greater than the FLE-to-hour conversion calculation based on hours flown times the WR FLE multiplier of .000125 (equation must be > 1). This means that the aircraft is experiencing greater than normalized WR FLE for the hours flown and a weighting is required. If the actual sum of WR FLE is less than the FLE-to-hour conversion, making the equation negative, the actual WR FLE is less than expected, and a fatigue weight is not applied. In sum, actual FLE must be > FLE-to-hour conversion factor for a fatigue multiplier to apply.

Below is the application of the OPTEMPO methodology to the F/A-18 program.

$$\text{Equivalent Lives Consumed} = \underbrace{\text{Battle Losses} + \text{Non-Combat Losses}}_{\text{Losses}} + \left[\text{Active Asset Quantity}\right]\left\{\underbrace{\left[\frac{\text{Hours Used}}{\text{Total Hours Available}}\right]}_{\text{Usage}}\left[1 + \underbrace{\left[\frac{\sum \text{FLE} - \text{Est. FLE}}{\text{Active Asset Qty}}\right]^{*}}_{\text{Fatigue}}\right]\right\}$$

* Use if > 1

$$\text{Equivalent Lives Consumed} = 1 + 86 + \left[379\right]\left\{\left[\frac{2,121,231}{3,032,000}\right]\left[1 + \left[0\right]\right]\right\}$$

= 352 Equivalent Lives Consumed, or 76% [352/466] of Program Life Expended

The Navy F/A-18C program-level example factors total losses, utilization expressed in flight hours, and fatigue over the lifetime of the program. From program inception, battle losses totaled one aircraft and non-combat losses totaled 86 aircraft. Total usage is calculated by summing the cumulative flight hours for active assets. Usage expended is calculated by taking total active asset cumulative flight hours divided by total available hours (8,000 hours times 379 active assets). Fatigue is calculated by first summing the cumulative WR FLE for all active assets. Then, a FLE limit to flight hour multiplier is applied to the flight hour total (.000125 times flight hours). Next, the FLE limit to flight hour number is subtracted from the actual cumulative WR FLE amount. Since the number is negative in this example (153.05 – 265.15 = -.112.10), then a value of zero is used for the fatigue factor. *The sum is negative because cumulative FLE is less than the estimated FLE to flight hour calculation.* A one is then added to the fatigue factor of zero and that number is multiplied by the usage calculation (hours expended/total hours). The usage value is then multiplied by the total active asset quantity. This number is added to battle losses and non-combat losses. The result is 352.30 equivalent lives consumed, or 75.6% of the program service life has been consumed [352/466].

When applying the methodology to a program such as the F/A-18 program, it is important to consider changes in program service life estimates. The Military Departments are extending some of the service lives of their equipment by managing mission profiles, performing maintenance, and through inventory rotation to control how the equipment are used, how much fatigue they experience, and how well they are maintained (e.g., a program may be subject to accelerated service life degradation if it is not maintained properly). These management practices can result in an increase in service life expectancy for a program.

For example, engineering analysis and testing of the F/A-18 program have resulted in revised service life estimates, from 6,000 flight hours to 8,000 flight hours for the A/C models, and another change is possible to 8,000 or 10,000 flight hours for the E/F models. These changes are based on the amount of fatigue life that is remaining on the aircraft at the time of inspection. Initial flight hour projections were made based on the engineering assessment (expressed in terms of hours) of when the aircraft would reach a fatigue life expended of 100%. Initial analysis resulted in an estimate of 6,000 flight hours. However, due to Navy aircraft mission management and maintenance, the fatigue life expended is less than originally planned at the current level of flight hours consumed, and this is leading to additional flight hours or service life for the program. For example, the F/A-18 aircraft does not carry missiles on the wing tips unless it is critical for carrying out mission requirements. This action has resulted in a decrease in the total amount of wing fold fatigue life expended for the aircraft, which in turn, enables the aircraft to realize more flight hours than initial planned estimates because the aircraft has more fatigue life remaining than originally planned based on the 6,000 flight hour estimate. The 6,000 flight hour estimate was an estimate for when the aircraft would reach a FLE of 1.0. The Military Departments are extending some of the service lives of their equipment by managing mission profiles, performing maintenance, and through inventory rotation. The methodology allows for such revisions to service life estimates to be incorporated into the methodology as they are determined to compute a more accurate aging estimate for the program.

Methodology Illustration: Airlift Aircraft - Air Force C-17A Program

The C-17A program has a design service life of 30,000 flight hours per aircraft. Currently, the C-17 airframes are not experiencing operational usage or fatigue that impacts their ability to achieve the 30,000 hour service lives. The missions that are flown are within the design assumptions/parameters of the aircraft. More specifically, the airframe was designed to withstand a higher percentage of airdrop, assault landing, and low level missions than has been experienced during C-17 operations. Because of that, the actual usage severity, in most cases, is less than predicted; therefore, there is no indication that C-17 airframes will be unable to meet or exceed the specified usage-based service life. However, future changes in C-17 operations/deployment strategies could have an adverse effect on service life and would need to be considered during service life analysis by factoring weighted hours using the methodology.

The PM monitors the critical aircraft components and assesses severity of usage on those components through the U.S. Air Force Aircraft Structural Integrity Program (ASIP), which is a preventive maintenance program of regularly scheduled inspections and replacement or repair of various elements of the airframe. This is accomplished on an aircraft by aircraft basis. While the airframe is not experiencing a decrease in service life due to GWOT operations, the critical aircraft components are experiencing accelerated wear and tear due to GWOT operations. Exposure to the sand environment, extreme heat, evasive maneuvering, and steeper takeoffs and landings contribute to the increased wear and tear on the components of the aircraft, most notably the engine, landing gear, and flight controls. The wear and tear on these subsystems is mitigated by maintenance and repair, which drives up maintenance and repair/overhaul costs in order to maintain aircraft availability. In summary, the C-17 ASIP manages the fleet and identifies maintenance on the aircraft as needed to ensure each aircraft reaches its 30,000 hour service life.

Usage data at the asset level for C-17 aircraft is available in the Reliability and Maintainability Information System (REMIS), which holds usage data for Air Force aircraft. The C-17 program does not have an automated fatigue measurement tool that tracks fatigue on the airframes, so an estimate of fatigue must be applied in the methodology when operational and mission demands warrant that fatigue be incorporated within the calculation. Since the PMO has determined that fatigue currently has not posed a threat to the service life of the C-17 fleet since the aircraft are not operating beyond their design life operating boundaries, fatigue is estimated to be zero. C-17 engineers have noted that in the future, based on changes in mission profiles and operating conditions, fatigue could pose an impact on the service life and an estimate of the impact would need to be incorporated in the methodology.

Some programs have sophisticated fatigue tracking sensors and monitors that are used to track and monitor fatigue. For example, the Navy has a capability called the Structural Data Recording System (SDRS) that measures fatigue/strain, in terms of a metric called Fatigue Life Expended (FLE) or Total Life Index (TLI) based on the wing root and wing fold, on a variety of their attack (F/A-18) and fixed wing (P-3) airframes. The application of the FLE metric to the

F/A-18 program was demonstrated in the methodology illustration to the F/A-18 program above. In addition, the C-130 Program has a computer system that calculates Equivalent Baseline Hours (EBH) on the airframes, which is based on flight hours, mission type, and environment. The EBH is a weighted flight hour calculation that is adjusted for fatigue impacts based on the mission the aircraft flies, similar to that in the OPTEMPO methodology. The C-17 Program is currently developing a similar EBH tracking system, but it is not yet fielded, and this EBH metric can be applied in the OPTEMPO methodology to determine consumption for the C-17 program in place of an estimate in the future.

Below is the application of the OPTEMPO methodology to the C-17 program.

Losses | **Usage** | **Fatigue**

$$\text{Equivalent Lives Consumed} = \text{Battle Losses} + \text{Non-Combat Losses} + \left(\text{Active Asset Quantity}\right)\left\{\left(\frac{\sum \text{Actual Use per Active Asset}}{\text{Active QTY x Design Service Life}}\right)\left(\text{1+ Fatigue}\right)\right\}$$

$$\text{Equivalent Lives Consumed} = 0 + 0 + \left(169\right)\left\{\left(\frac{1{,}245{,}169.20}{5{,}070{,}000}\right)\left(1 + \left[\ 0\ \right]\right)\right\}$$

= 42 Equivalent Lives Consumed, or 25% [42/169] of Program Life Expended

The C-17A program-level example factors total losses, utilization expressed in flight hours, and fatigue at a rate of zero since fatigue currently does not have an adverse impact on the service life of the C-17 airframes. Since program inception, the C-17A program has not experienced any losses. Total usage is calculated by summing the cumulative flight hours for active assets, and the total available usage is calculated by summing the total hours available per aircraft (30,000) for the fleet of active assets. Usage expended is calculated by taking total active asset cumulative flight hours divided by total available hours (30,000 hours times 169 active assets). The usage value is then multiplied by the total active asset quantity. The result is 41.51 equivalent lives consumed, or 24.9% of the program service life has been consumed [42/169]. Data used in this example is current as of September 2007.

Similar to the F/A-18 program, the C-17 program is experiencing changes in service life estimates that should be considered when applying the methodology. For example, the Air Force Materiel Command has assessed that the C-17 program's service life is 45,000 flight hours as opposed to the initial 30,000 flight hours projected by the original equipment manufacturer and PM based on fatigue and mission-type analysis. The methodology allows for such revisions to service life estimates to be incorporated into the methodology as they are determined to compute the aging estimate for the program to support the budget justification and capital planning processes.

Methodology Illustration: Rotary Wing Aircraft - Army CH-47D and SOCOM MH-47G

The CH-47D aircraft has a design service life of 10,000 flight hours. The MH-47 engineering staff estimated that the service life of the MH-47G is 3,000 hours. The MH-47G aircraft are remanufactured from CH-47D, MH-47D and MH-47E aircraft, which already have an average of 6,400 hours on their airframes for an airframe total service life of 9,400 hours. At the end of the service life, a decision is made to recapitalize or replace the aircraft. A recapitalization results in a type designation change, capability upgrades, and additional service life.

The CH/MH-47 programs are experiencing increased usage due to current combat and contingency operations. For example, the CH-47 program is flying at up to three times peacetime programmed rates due to ongoing GWOT operations.

Usage data at the asset level for CH-47 aircraft is available in OSMIS, along with usage data for other Army aircraft and ground systems. Usage data at the type designation (mission design series) level for the MH-47 program is available via a manual data call from PEO Rotary Wing. Through this study, it has been confirmed that usage data is generally available for aircraft programs. However, a requirement should be established that requires usage data to be collected and reported in enterprise-level systems on a routine basis. This will provide enterprise-wide data visibility and availability for use within the OPTEMPO methodology for budget justification and capital planning purposes.

In addition to increased usage, the CH/MH-47 programs have experienced structural fatigue due to operating at increased weights or at the maximum weight capacity for extended periods of time. Harsh environmental conditions (extreme temperatures, salt water, sand, mountainous climate and terrain), higher altitudes (which stresses the airframe), increased take-offs and landings, and more aggressive maneuvering (turns and banks) are also leading to increased stress. These conditions are leading to increased strain and stress on the airframes, including cracking in the airframe, as the increased weight coupled with combat maneuvers and altitude continue to stress the airframe and shorten life expectancies, despite solid maintenance procedures and effective service life extension programs. The sand environment also has a significant impact on the rotary wings.

Structural fatigue is evaluated by manual inspection and testing for the CH/MH-47 aircraft. The program does not have a method for quantifying the overall impact of fatigue on the airframe due to the factors and conditions noted above. CH/MH-47 engineers have indicated that the primary cause of structural fatigue is the operating weights at which the aircraft are flying to support combat and contingency operations and that this should be addressed in the methodology by factoring the percentage increase in weight carried to support combat operations above the aircraft's typical peacetime operating weight.

Similar to other aircraft programs, such as the C-17, the CH-47 program is currently developing a fatigue-tracking capability. The CH-47 is developing the Health and Usage Monitoring System (HUMS), which is a capability that will measure and track structural fatigue impacts on the program when future F model aircraft are fielded. When HUMS data is available, this data should replace the existing fatigue estimate in the OPTEMPO methodology.

Below is the application of the OPTEMPO methodology to the Army CH-47 and SOCOM MH-47 programs.

$$\underset{\text{Consumed}}{\text{Equivalent Lives}} = \underbrace{\text{Battle Losses} + \text{Non-Combat Losses}}_{\text{Losses}} + \left\{ \left(\text{Active Asset Quantity} \right) \left(\frac{\text{Peacetime Use} + \{\text{Wartime Use} * (1 + \underbrace{\text{Fatigue}}_{\text{Fatigue}})\}}{\text{Total Available Use}} \right)_{\text{Usage}} \right\}$$

Army CH-47D

$$\text{Equivalent Lives Consumed} = 9 + 7 + \left\{ \left(336 \right) \left(\frac{1{,}829{,}518.40 + \{325{,}835.60 * (1 + .4286)\}}{3{,}360{,}000} \right) \right\}$$

= 246 Equivalent Lives Consumed, or 70% [246/352] of Program Service Life Expended

The OPTEMPO methodology factors total losses, utilization expressed in flight hours, and a fatigue multiplier at a rate of 42.86%, which is based on the percentage increase in weight carried, to support combat operations, above the aircraft's typical peacetime weight. For the Army CH-47D, the typical peacetime operating weight is approximately 35,000 pounds, while the weight typically carried to support combat operations is 50,000 pounds, the maximum weight capacity. This equates to a 42.86% increase in weight above that normally sustained during non-combat operations.

Currently, the D model fleet has 336 active assets. From program inception in 1982 for the D model, battle losses totaled nine and non-combat losses were seven. The total number of hours flown on the active assets for the D fleet is 2,155,354. Of these hours, the wartime hours flown is 325,835.60, which supported GWOT operations from 2001 to present in Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF). This results in a peacetime usage of 1,829,518.40 hours. The fatigue multiplier, which is applied to the wartime hours to account for asset fatigue that is occurring during contingency/GWOT operations, is calculated by adding one to the 42.86% weight increase carried for GWOT operations. The peacetime hours and the wartime hours, after being weighted by the fatigue multiplier, are summed and divided by the total hours available (10,000 hours per aircraft times 336 active assets). The resulting number is multiplied by the active asset quantity. Battle losses and non-combat losses are then added to this number to determine the number of equivalent lives consumed. The result is 245.50 equivalent lives consumed, or 69.89%, or 70%, [246/352] of the program service life has been consumed. Data provided for the D fleet is current as of February 14, 2008.

SOCOM MH-47G

$$\text{Equivalent Lives Consumed} = 0 + 1 + \left\{ \left(40 \right) \left(\frac{12{,}009.80 + \{2{,}517.20 * (1+.175)\}}{120{,}000} \right) \right\}$$

= **6 Equivalent Lives Consumed, or 15% [6/41] of Program Service Life Expended**

The OPTEMPO methodology factors total losses, utilization expressed in flight hours, and a fatigue multiplier at a rate of 17.5%, which is based on the percentage increase in weight carried, to support combat operations, above the aircraft's typical peacetime weight. For the SOCOM MH-47G, the typical peacetime operating weight is approximately 40,000 pounds, while the average weight typically carried to support combat operations is 47,000 pounds. This equates to a 17.5% increase in weight above that normally sustained during non-combat operations.

An estimate for the hours flown to support combat and non-combat operations based on trends was provided by the program office. MH-47 logisticians estimate that 35% of the hours flown on the program are hours flown to support combat operations, while the remaining 65% of the hours flown on the program are hours flown to support non-combat operations. Since the MH-47G did not deploy to combat until February 2007, all hours flown prior to February 2007 are considered non-combat (training) hours and the percentage estimates should be applied to the hours count from February 2007 onward.

Currently the G fleet has 40 active assets. From program inception for the G model, battle losses totaled zero and non-combat losses were one. The total number of hours flown on the active assets for the G fleet is 14,527. Prior to deployment in February 2007, 7,335 hours were flown to support training. From February 2007 through the end of 2007, 7,192 hours were flown. Applying the aforementioned percentages to estimate the number of hours flown to support combat and non-combat operations results in 2,517.20 combat hours (35% of 7,192 hours) and 4,674.80 non-combat hours (65% of 7,192 hours). This results in a total of 2,517.20 combat hours and 12,009.80 non-combat hours (7,335 + 4,674.80 hours). The fatigue multiplier, which is applied to the wartime hours to account for asset fatigue that is occurring during contingency/GWOT operations, is calculated by adding one to the 17.5% weight increase carried for GWOT operations. The peacetime (non-combat) hours and the wartime hours, after being weighted by the fatigue multiplier, are summed and divided by the total hours available of 120,000 (3,000 hours per aircraft times 40 active assets). The resulting number is multiplied by the active asset quantity. Battle losses and non-combat losses are then added to this number to determine the number of equivalent lives consumed. The result is 5.99 equivalent lives consumed, or 14.63% [6/41] of the program service life has been consumed. Data provided is as of December 31, 2007.

Methodology Illustration: Combat Vehicles - Army and Marine Corps M1A1 Abrams Main Battle Tank

The Abrams Main Battle Tank has three usage-based service life limiters: miles driven, engine hours, and equivalent full charges/rounds fired from the gun tube (EFCs). The hull may last indefinitely, and components are replaced and upgraded through maintenance and recapitalization activities as needed to maintain operational capabilities. Therefore, the service life of the tank is defined as the amount of usage that can be expended before a recapitalization or rebuild is required, as defined by the PMO and tank rotational guidance (e.g., Marine Corps Combat Vehicle Evacuation Program). The primary usage driver is mileage since the tank typically reaches the mileage limit prior to reaching the hours or EFC limits and should be the basis of service life for analysis in the methodology. The Army Abrams Main Battle Tank has an engineering-based service life of 6,000 miles, and the Marine Corps Abrams has a service life of 3,000 miles.

Usage data for Army Abrams tanks at the asset level is available in OSMIS, as well as for other Army aircraft and ground systems. Some limitations exist with OSMIS data, especially for ground systems, however, due to inconsistent and decentralized reporting requirements. First, data is only available back to 1993. Secondly, data input relies heavily on the units reporting on a monthly basis, and this poses risks for inconsistent and inaccurate data. Therefore, a requirement should be established that requires usage data to be collected and reported in enterprise-level systems on a routine basis. This will provide enterprise-wide data visibility for use within the OPTEMPO methodology.

Usage data for Marine Corps Abrams is not available in a centralized system. It is available in an internal database located with the Marine Corps Systems Command, Armored Fire Support Systems, Tank Systems.

For Army and Marine Corps tanks, a mile or hour in theater is not equal to a mile or hour in the Continental United States (CONUS). Along with increased usage, the type of use that the tanks are experiencing while supporting GWOT operations is accelerating the degradation of the service life of the tank. PEO Ground Combat Systems has determined that the increased weight that tanks carry over the specified design weight, due to up-armor and carrying extra weapons and ammunition, is a significant fatigue factor that decreases the tank's service life. The increased weight that the tanks carry for combat operations is beyond the designed weight specifications and leads to fatigue on the frame, axles, tracks, suspensions, and other components. This added wear and tear may prevent the tank from reaching its service life before requiring a recapitalization or rebuild.

The Army and Marine Corps Abrams programs do not have a method for quantifying the impact of fatigue on the service lives of the tanks. However, the engineers agreed that a reasonable basis for estimating the impact of fatigue is to apply the percentage increase in weight carried to support combat operations above the tanks' maximum design specified weight.

This fatigue would be applied to wartime usage, as this fatigue typically occurs during combat and contingency operations.

Below is the application of the OPTEMPO methodology to the Army and Marine Corps Abrams Main Battle Tank programs.

$$\text{Equivalent Lives Consumed} = \underbrace{\text{Battle Losses} + \text{Non-Combat Losses}}_{\text{Losses}} + \left\{ \left(\text{Active Asset Quantity} \right) \left(\frac{\overbrace{\text{Peacetime Use} + \{\text{Wartime Use} * (1 + \text{Fatigue})\}}^{\text{Usage / Fatigue}}}{\text{Total Available Use}} \right) \right\}$$

Army M1A1 Abrams Main Battle Tank

$$\text{Equivalent Lives Consumed} = 4 + 0 + \left\{ \left(1{,}729 \right) \left(\frac{3{,}090{,}624 + \{2{,}000{,}431 * (1+.0714)\}}{10{,}374{,}000} \right) \right\}$$

= 876 Equivalent Lives Consumed, or 50% [876/1,733] of Program Service Life Expended

The Army M1A1 program-level example factors total losses, utilization expressed in miles, and fatigue over the lifetime of the program. From program inception, battle losses totaled four (all resulting from GWOT) and non-combat losses were zero (tank hulls are rarely disposed of as a result of maintenance wash-out; they are refurbished through a recapitalization/rebuild effort for model conversion). Total actual usage is calculated by adding peacetime miles to wartime miles. A fatigue multiplier has been applied to the wartime miles to account for asset fatigue. The M1A1 engineering-based design weight is 63 tons and current carrying weight is 67.5 tons. This equates to a 7.14% increase in weight above engineering-based design specifications. The fatigue factor is calculated by adding 1 to the 7.14% weight increase. The peacetime miles and the wartime miles, after being weighted by the fatigue multiplier, are summed and divided by the total miles available (6,000 miles per tank times 1,729 active assets). The resulting number is multiplied by the active asset quantity. Battle losses and non-combat losses are then added to this number to determine the number of equivalent lives consumed. The result is 876.32 equivalent lives consumed, or 50.57% [876/1733] of the program service life has been consumed.

Marine Corps M1A1 Abrams Main Battle Tank

$$\text{Equivalent Lives Consumed} = 16 + 0 + \left\{ \left(416 \right) \left(\frac{759{,}500.25 + \{253{,}166.75 * (1+.1248)\}}{1{,}248{,}000} \right) \right\}$$

= 364 Equivalent Lives Consumed, or 84% [364/432] of Program Service Life Expended

The Marine Corps M1A1 program-level example factors total losses, utilization expressed in miles, and fatigue over the lifetime of the program. Battle losses totaled 16 and non-combat losses were zero (tank hulls are never disposed of as a result of maintenance wash-out; they are refurbished through a recapitalization/rebuild effort for model conversion). Total actual usage is determined by summing the current mileage on the tanks, for a total of 1,012,667 miles. Since the PMO does not capture wartime mileage and peacetime mileage for their tanks, an estimate was provided for determining wartime and peacetime mileage based on current data trends. The estimate for wartime mileage is 25% of total mileage and the estimate for peacetime/non-combat mileage is 75% of total mileage. Applying the aforementioned percentages to estimate the number of miles supporting combat and non-combat operations results in 253,166.75 wartime miles (25% of 1,012,667 miles) and 759,500.25 peacetime miles (75% of 1,012,667 miles).

A fatigue multiplier has been applied to the wartime miles to account for asset fatigue. The M1A1 engineering-based design weight is 63 tons and current average carrying weight for the MC M1A1 tanks is 70.86 tons. This equates to a 12.48% average increase in weight above engineering-based design specifications that would be applied to wartime/combat mileage. The fatigue factor is calculated by adding one to the average 12.48% weight increase. The peacetime miles and the wartime miles, after being weighted by the fatigue multiplier, are summed and divided by the total miles available (3,000 miles per tank times 416 tanks). The resulting number is multiplied by the active asset quantity. Battle losses and non-combat losses are then added to this number to determine the number of equivalent lives consumed. The result is 364.09 equivalent lives consumed, or 84.26% [364/432] of the program service life has been consumed. Data applied to this example is as of August 2007.

The Marine Corps Systems Command, Armored Fire Support Systems, Tank Systems has recently noticed a trend that tanks are currently experiencing increased hours of operation, while accumulating less mileage, which indicates that the tanks are running but sitting idle for extended periods of time. It has been noted that possibly in about three years the main usage driver may become hours for the M1A1 if this trend continues in theater. This would cause the tanks to meet their hours-based service life limit prior to that based on mileage, meaning that the service life analysis should be based on hours. The methodology allows for these changes to be incorporated into the methodology as they are determined, to more accurately determine program aging.

Methodology Illustration: Tactical Vehicles - Army M1151 HMMWV, Marine Corps M1114 HMMWV, and SOCOM GMV

The HMMWV has a design service life of 45,000 miles. Historically, the programmed usage in a peacetime environment under normal use was approximately 3,000 miles per year, which resulted in a 15-year [45,000 / 3,000] useful life for the vehicles.

The HMMWV and GMV programs, specifically the M1114 and M1151 HMMWV variants, have experienced a significant increase in utilization over programmed estimates as a result of GWOT operations, at a rate of two to five times the programmed estimates. GWOT has resulted in some vehicles reaching 3,000 miles in one month. The M1114 and M1151 vehicles have also been configured with retro-fit capabilities that have pushed the vehicles to operate above their design gross vehicle weight limit specifications. This has resulted in increased stress and structural fatigue.

Significant data limitations are presented with regard to usage data availability for the HMMWV/GMV programs due to inconsistencies and the lack of a requirement for reporting usage data on a regular basis. Usage data for Army HMMWV is available in OSMIS at the asset level. However, due to the reliance on the units to input the data and given the high densities of tactical vehicle programs, many of the vehicle records are incomplete or inaccurate. Usage data for Marine Corps HMMWVs and SOCOM GMVs are not tracked in a centralized database. Usage data would be available via manual data calls from the individual units or in maintenance records, which is a challenging task due to the large program densities. Usage data was obtained for the Army and Marine Corps HMMWV programs to support the methodology illustrations completed during this study, but usage data for the SOCOM GMV program was not available for use. Requirements should be established for consistent reporting of usage data in enterprise-level systems to facilitate the use of the methodology in capital planning and budget justification efforts.

The degradation of the main structure of the HMMWV/GMV and other ground vehicles caused by operational fatigue is not addressed or repaired through maintenance (depot and intermediate-level) actions targeted at replacing subcomponents and repairable parts and should not be disregarded during service life analysis. Recent combat operations due to GWOT have resulted in increased requirements for maintenance, and this maintenance is targeted at restoring the vehicles back to operational and mission-readiness standards through the replacement of consumable and repairable parts (e.g., tires, engines, transmissions, shocks, etc.). The PM has stated that this maintenance is not mitigating life-limiting structural fatigue and cracks that the vehicles experience when they are operated at extreme weights and under more severe environmental conditions. In field visits to Marine Corps maintenance units located at PACOM, it was further confirmed that maintenance actions are unable to restore, or buy-back, the structural degradation that is occurring to these vehicles that results in lost service life. The maintenance actions keep the vehicles operational, but they do not buy back the lost service life resulting from both increased usage and fatigue that is occurring on these vehicles.

PM Tactical Vehicles recommended that the impacts of increased usage and operational fatigue expressed in terms of weight be evaluated for the HMMWV program. Based on experience, the PM and depots have concluded that the increasing operating weight is the primary fatigue factor that is resulting in more stress cracks and structural fatigue. Sand, extreme temperatures, and corrosion are also causing degradation to the platform. The PM felt that the percent increase in weight beyond the design gross vehicle weight is a good basis for quantifying the differences of a peacetime mile versus a wartime mile on the program.

In addition to changes in OPTEMPO, technology also plays a key role in determining service life of HMMWVs and GMVs and the subsequent RESET and replacement requirements. A RESET program for Army HMMWVs, for example, began based on GWOT. The program began in FY03, with a quantity of 63 RESETs. In FY04, FY05, FY06, and FY07, there were 267, 368, 368, and 1160 RESETs, respectively. Some HMMWVs have been inducted into the RESET program because they have been degraded to the point where depot-level repair is required. However, the direction has been to RESET the soft-skinned fleet, because these vehicles are being replaced by more advanced technological capabilities of the M1114, M1151, and MRAP. In addition, due to MRAP fielding, some of the M1114s have been displaced and are being inducted into the RESET program.

Below is the application of the OPTEMPO methodology to the HMMWV/GMV programs.

Losses / Usage / Fatigue

$$\text{Equivalent Lives Consumed} = \underbrace{\text{Battle Losses} + \text{Non-Combat Losses}}_{\text{Losses}} + \left\{ \left(\text{Active Asset Quantity} \right) \left(\frac{\text{Peacetime Use} + \{\text{Wartime Use} * (1 + \text{Fatigue})\}}{\text{Total Available Use}} \right) \right\}$$

Army M1151 HMMWV

$$\text{Equivalent Lives Consumed} = 64 + 0 + \left\{ \left(2{,}852 \right) \left(\frac{0 + \{13{,}010{,}475 * (1 + .2727)\}}{128{,}340{,}000} \right) \right\}$$

= 432 Equivalent Lives Consumed, or 15% [432/2,916] of Program Service Life Expended

The OPTEMPO methodology factors total losses, utilization expressed in miles, and a fatigue multiplier at a rate of 1.2727, which is based on the average percent increase in operating weight for the M1151 above the engineering-designed and certified operating weights. The M1151 engineering-based design weight is 12,100[5] pounds and the average operating weight of the M1151 is 15,400 pounds. This equates to a 27.27% increase in weight above engineering-based design specifications, which has been used as a fatigue multiplier for wartime mileage data.

Total battle losses of 64 for the M1151 HMMWV are a result of GWOT operations since the M1151 was fielded beginning in Q4 FY2005. Total actual usage for the 2,852 vehicles based on OSMIS is 13,010,475 miles. Since the program was fielded during GWOT, all miles are considered wartime miles. A fatigue multiplier has been applied to the wartime miles to

[5] The actual GVW of the M1151 is 12,100 pounds. This is revised from the estimate of 12,500 lbs. used in the methodology illustration provided in the Summary Annotated Briefing dated 4/30/08.

account for additional asset fatigue. The fatigue factor is calculated by adding 1 to the 27.27% weight increase. The wartime miles, after being weighted by the fatigue multiplier, are divided by the total miles available (design service life of 45,000 miles multiplied by 2,852 M1151 assets in OSMIS). The resulting number is multiplied by the active asset quantity. Battle losses and non-combat losses are then added to this number to determine the number of equivalent lives consumed. The result is 431.97 equivalent lives consumed, or 14.8%, or 15%, [432/2916] of the program service life has been consumed. Data provided is current as of February 29, 2008.

<u>Marine Corps M1114 HMMWV – Regiment Level</u>

$$\text{Equivalent Lives Consumed} = 1 + 1 + \left\{ \left[474 \right] \left[\frac{0 + \{5{,}287{,}906.40 * (1+.3636)\}}{21{,}330{,}000} \right] \right\}$$

$$= \text{162 Equivalent Lives Consumed, or 34\% [162/476] of Program Service Life Expended}$$

The OPTEMPO methodology factors total losses, utilization expressed in miles, and a fatigue multiplier at a rate of 1.3636, which is based on the average percent increase in operating weight for the M1114 above the engineering-designed and certified operating weights. The M1114 engineering-based design weight is 12,100 lbs, and the average operating weight of the M1114 is 16,500 lbs. This equates to a 36.36% increase in weight above engineering-based design specifications, which has been used as a fatigue multiplier for wartime mileage.

Due to the data availability constraints at the enterprise-level within the Marine Corps logistics systems as noted above, contacts were leveraged at the Marine Corps Systems Command to obtain M1114 data via a manual data call from a Marine Corps Infantry Regiment in theater to support the methodology illustration for the M1114 program. Data used is as of May 8, 2008.

This regiment's battle losses totaled 1 and non-combat losses were one. Total actual usage for the 474 active vehicles is 5,287,906.40 miles. A fatigue multiplier has been applied to the wartime miles to account for additional asset fatigue. The fatigue factor is calculated by adding one to the 0.3636% weight increase. The wartime miles (all mileage provided is from GWOT; there are zero peacetime miles), after being weighted by the fatigue multiplier, are divided by the total miles available (45,000 miles per HMMWV times 474 active regimental M1114 assets). The resulting number is multiplied by the active asset quantity. Total losses are then added to this number to determine the number of equivalent lives consumed. The result is 162 equivalent lives consumed, or 34% [162/476] of the program service life has been consumed.

Using a traditional straight-line aging model based on a program plan of 3,000 miles per year for the M1114's in this regiment would yield an approximate age of three years or 95 equivalent lives consumed, or 20% [95/476] of the program service life having been consumed. After factoring usage and fatigue, the formula calculates an estimated age of 5.12 years. The derived age more closely reflects the current state of these vehicles and will equip the Department with a tool and a process for determining and justifying recapitalization and new procurement requests for the M1114 in the future.

SOCOM GMV

The life expectancy of the GMV program has been impacted by changes in OPTEMPO, and it is appropriate to evaluate the impact of usage and fatigue on the life expectancy of the program using the OPTEMPO methodology.

Due to the data availability constraints at the enterprise-level within SOCOM as noted above, usage data was unable to be obtained to illustrate the application of the methodology to the GMV program. Usage data for GMVs is available in vehicle maintainer forms and records and not centrally maintained. Requirements should be established for consistent tracking and reporting of usage data at the enterprise-level to facilitate the use of the methodology for programs such as the GMV program.

SOCOM has seen that the impacts of OPTEMPO in terms of usage and fatigue have resulted in a significant decrease in the service life of the GMV program. Instead of lasting through the original useful life estimate of eight years before a depot-level RESET is required, which results in increased service life, the GMVs now require a RESET after two to three years. Field inspections have indicated that operating gross weights up to 14,000 pounds combined with special operations modifications, such as communications and weapons, was accelerating the degradation of the vehicle and its subsystems.

In a memo dated August 4, 2006, SOCOM reduced the useful life estimate of the GMV from eight years to two to three years, citing usage trends and extreme operating weights and environment over the period of GWOT as the reasons for the decrease.

The methodology can be used in the future, when usage data is available, to quantify the effects of OPTEMPO and determine an estimate for the consumption and aging of the GMV program.

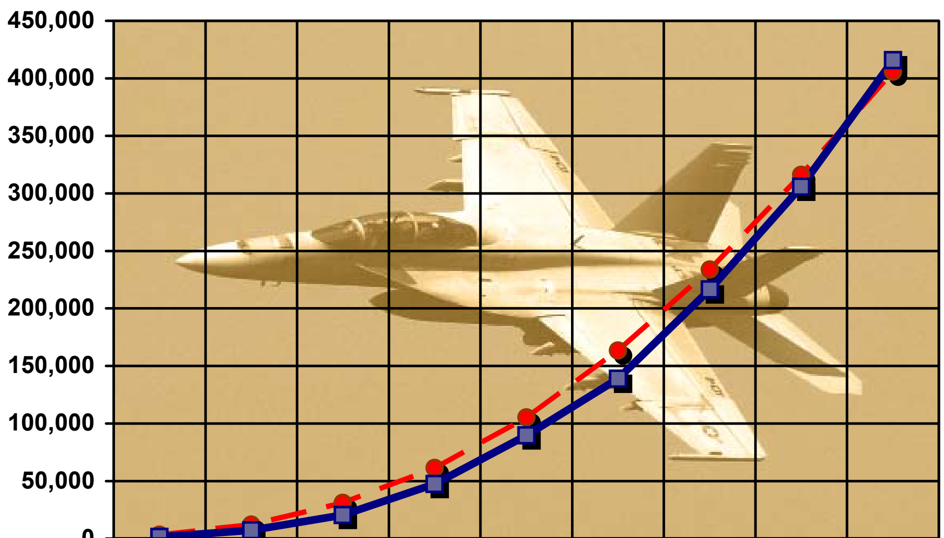
Methodology Illustration: Application to the Budget Process

At the direction of OSD(C/PB), the OPTEMPO methodology was used to assist with providing additional budget justification support for the FY2009 Supplemental Budget request for eight additional F/A-18 E/F model aircraft due to GWOT consumption.

The Navy F/A-18 PMO requested the aircraft through the Supplemental budget request and OSD(C/PB) requested that the PM justify the request using the OPTEMPO methodology to 'battle test' the OPTEMPO methodology and to illustrate its application to the budget process.

To apply the OPTEMPO methodology to the FY2009 Supplemental Budget request, the OPTEMPO methodology was applied using the methodology against two data sets – actual cumulative usage data compared to the straight-line programmed flight hour estimate of 300 flight hours per aircraft (straight-line usage estimate based on a 20-year useful life and a 6,000 flight hours design service life estimate).

Charting the actual cumulative usage data from program inception compared to the straight-line programmed flight hour estimate for the active F/A-18 aircraft per year graphically depicts the under runs in utilization that the F/A-18 E/F program experienced through FY06. Beginning in FY07, the program experienced utilization above the programmed estimate.



	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07
Straight-Line Programmed Hrs	3,300	12,300	31,200	61,500	105,300	163,500	233,700	315,900	405,900
Actual: Cumulative Hrs	1,430	7,199	20,573	47,419	89,842	138,995	216,538	305,770	415,753

The OPTEMPO methodology can be applied to determine the net (delta) consumption of aircraft service lives beyond programmed over the life of the program, considering both the under and over runs in utilization. The number of equivalent lives consumed calculated from this analysis can be used to quantitatively support supplemental budget requests and determine replacement requirements.

The analysis looks at determining the number of delta equivalent lives consumed as follows:

1. Determining the current actual cumulative total program service life expended by factoring total usage to total available usage according to the OPTEMPO methodology.
2. Determining the program service life expended using baseline (straight-line programmed) utilization. This is how much service life has been expended on a straight-line estimate basis that correlates to the 20-year useful life of the aircraft.
3. Subtracting the current actual program service life expended versus the baseline (straight-line programmed) program service life expended to calculate the delta and then adding the program losses to calculate the total number of equivalent lives consumed over the baseline estimate.

Below is the application of the methodology for determining the number of delta equivalent lives consumed beyond programmed estimates due to GWOT.

Losses + (Current Actual Program Service Life Expended - Baseline Utilization Estimate)

$$\text{Equivalent Lives Consumed} = \text{Losses} + \left[\text{Active Asset Qty}\right]\left\{\left[\frac{\text{Actual Usage}}{\text{Usage Available}}\right]\left[1+\left[\text{Fatigue}\right]\right]\right\} - \left[\text{Active Asset Qty}\right]\left\{\left[\frac{\text{Baseline Usage}}{\text{Usage Available}}\right]\left[1+\left[\text{Fatigue}\right]\right]\right\}$$

Losses + (Current Actual Program Service Life Expended - Baseline Utilization Estimate)

$$\text{Equivalent Lives Consumed} = 5 + \left[300\right]\left\{\left[\frac{415{,}753.30}{1{,}800{,}000}\right]\left[1+\left[0\right]\right]\right\} - \left[300\right]\left\{\left[\frac{405{,}900.00}{1{,}800{,}000}\right]\left[1+\left[0\right]\right]\right\}$$

Applying the OPTEMPO methodology as depicted above resulted in a 6.64, or 7 aircraft required based on program losses and the variance between actual and baseline programmed flight hours. Fatigue was not applied to the methodology because the normalized WF FLE to flight hours was normal (no overage has been experienced on the program).

The result of this analysis illustrates the application of the methodology to the budget process. It demonstrates that the Department can leverage the methodology for use in the capital planning process by drawing from actual usage to drive the need for investment decisions. It can also be used to justify and support budget requests based on program aging that factors utilization, stress, and losses. It cannot, however, be used to determine what type of investment to make – whether to buy new assets to replace the asset lives lost (except in the case of assets lost) or to initiate a service life extension program, nor can it determine when to make those investments. These investment decisions must be based on a broader, programmatic look at requirements, alternatives, and out-year budgets. In the case of the F/A-18, for example, assuming the number of aircraft needed to meet mission requirements remains the same, a decision on replacement or service life extension depends on the status of the F-35 and when it will be introduced into active service and whether or not current assets are demonstrating longer service lives than the design estimate.

The OPTEMPO Universe Listing: Where the Methodology Applies

The applicability of the methodology across the Department's military equipment inventory was analyzed to determine which programs beyond the nine sample programs reviewed in this study are impacted by changes in OPTEMPO and should be evaluated, using the OPTEMPO methodology, for changes in service life expectancies. The result of this analysis is the OPTEMPO universe listing, which is a listing of programs by type designation (variant) that could potentially experience service life expectancy adjustments due to changes in OPTEMPO. The final OPTEMPO universe listing is referenced in Appendix C.

The OPTEMPO universe was developed beginning with the military equipment inventory included in the Military Equipment Valuation (MEV) program universe, which was generated from the Capital Asset Management System – Military Equipment (CAMS-ME) and provided by the OUSD(AT&L) Property and Equipment Policy Office. The MEV universe listing included military equipment programs, by Component or Agency, which report military equipment values to support financial reporting. This listing was current as of December 31, 2007.

A set of criteria was applied to the MEV universe to determine the listing of programs that experience changes in OPTEMPO. The criteria were as follows:

- Include major platforms. A major platform is defined as the final assembly of a piece of military equipment, such as operational tracked and wheeled vehicles or mission-ready fixed wing and rotary wing aircraft.
- Exclude support equipment and support-type programs. General property, plant, and equipment (e.g., support equipment) programs have been excluded. Support-type programs (e.g., yellow gear, common communications) that do not result in a major platform are excluded.
- Include group composite programs. These programs that are major platforms were broken down to include the asset type designations (e.g., type/model/series) within the program.
- Exclude modification programs unless the modification resulted in an asset type designation change.
- Include programs and assets that deploy or would be subject to decreases in service life expectancies as a result of changes in OPTEMPO.

The listing that resulted after applying the above criteria was validated for completeness and accuracy by the OUSD(AT&L) Property and Equipment Policy Office and the Component/Agency leads. The final OPTEMPO universe listing will serve as a guide for where the OPTEMPO methodology could be used to evaluate changes in service life expectancies for military equipment programs.

The results of the OPTEMPO universe analysis reveal that the OPTEMPO methodology applies to all equipment that are impacted by changes in OPTEMPO, where a usage basis, as opposed to a straight-line years basis, is the appropriate method for measuring program aging. The types of equipment that were found to be impacted by changes in OPTEMPO include fixed wing aircraft (attack aircraft and airlift aircraft), rotary wing aircraft, combat vehicles, and tactical vehicles.

It is appropriate to evaluate changes in service life expectancies for these types of programs using the OPTEMPO methodology for budget justification and capital planning purposes since changes in OPTEMPO may accelerate the consumption of these programs beyond straight-line programmed utilization rates. This analysis also reveals that a straight-line depreciation method is not appropriate for these programs because they experience changes in utilization due to OPTEMPO. Therefore, this listing also serves as a guide for the military equipment programs that should be evaluated for a change in depreciation method, from a straight-line time (years) basis to a usage basis, in CAMS-ME. Changing the depreciation method to a usage basis will more accurately reflect the value of military equipment according to the amount of utilization experienced. This, in turn, will allow for more accurate military equipment values to be reported on the Military Departments' financial statements.

For other types of military equipment, such as ships, submarines, small craft, and satellites, the OPTEMPO universe analysis reveals that usage is not required to assess service life estimates. These types of equipment are in constant use, so changes in OPTEMPO do not have an impact on remaining life expectancy. The OPTEMPO methodology would not apply since a time-based metric (i.e., years) is the most appropriate basis for expressing the service lives of these platforms. These types of programs are fatigued due to environmental factors, speed, and mission; however, maintenance plays a key role in restoring these assets to like-new conditions, mitigating the fatigue impacts that are experienced during the lifetimes of these assets. Therefore, the service lives of these programs are best expressed in terms of years (based on hull life, etc.), as opposed to steaming hours or hours on orbit, for example.

Summary of Findings and Conclusions

A methodology that accounts for the impacts of changes in OPTEMPO on the service lives of the Department's military equipment has been developed and validated during this study and presented within this report. The methodology has proven to be a scalable and repeatable estimation tool that provides additional budget justification support for assessing requests for military equipment replacement and recapitalization.

Usage and fatigue were validated as the primary life-limiting drivers of OPTEMPO that result in accelerated service life degradation of military equipment and are factored in the methodology. Usage and fatigue attributes vary by program depending on asset type and mission, and the methodology is adaptable to factoring the program-specific variables.

PMs manage the service life expectancies of their programs based on usage data where program limits are defined by usage boundaries. Asset-level usage data is available for most programs, at some level, to support the use of the OPTEMPO methodology, but it is not consistently available at a centralized, enterprise-level. For example, usage data for Navy aircraft, Air Force aircraft, and Army aircraft and vehicles are available in the Aircraft Inventory and Readiness Reporting System (AIRRS), the Reliability and Maintainability Information System (REMIS), and the Operating and Support Management Information System (OSMIS), respectively. However, for some programs, such as HMMWVs, usage data is generally maintained at the unit level and is not consolidated in an enterprise-level system. In order to consistently and effectively apply the OPTEMPO methodology for programs with data limitations, policy guidance is suggested that would require the Military Departments to start tracking and reporting asset-level usage data for their programs.

With regard to fatigue, each program has an engineering-based operating design envelope that specifies the operating boundaries and conditions for the program (weight limits, structural fatigue limits, altitude limits, etc.). The Military Departments use these design life operating boundaries to monitor and track fatigue on the platforms over their lives and to manage and schedule missions. Some programs, such as the F/A-18 program, have sophisticated fatigue tracking sensors and monitors are used to track and monitor fatigue. For example, the Navy has a capability called the Structural Data Recording System (SDRS) that measures fatigue/strain, in terms of a metric called Total Life Index (TLI) based on the wing root and wing fold, on a variety of their attack (F/A-18) and fixed wing (P-3) airframes. In addition, the C-130 Program has a computer system that calculates Equivalent Baseline Hours (EBH) on the airframes, which is based on flight hours, mission type, and environment. The EBH is a weighted flight hour calculation that is adjusted for fatigue impacts based on the mission the aircraft flies; similar to that in the OPTEMPO methodology. In addition, the C-17 Program is currently developing a similar EBH tracking system, but it is not yet fielded. FLE, TLI, EBH, and similar fatigue-measurement metrics can be applied in the OPTEMPO methodology to determine consumption for aircraft programs with those capabilities.

However, not all programs have structural fatigue measurement capabilities that estimate fatigue life expended metrics for use in the methodology. For programs such as CH-47 rotary wing aircraft and ground systems such as the HMMWV and Abrams, fatigue tracking sensors or monitors do not exist. However, fatigue is occurring that should be accounted for within the methodology, estimated based on a primary and quantifiable fatigue factor until the programs field fatigue measurement capabilities. Estimates are program-specific and are illustrated within the Abrams, CH/MH-47, and HMMWV illustrations included within this report.

Illustrations of how to apply the methodology to various military equipment platforms based on program-specific usage and fatigue attributes have been provided to demonstrate the applicability of the methodology to attack aircraft, airlift aircraft, rotary wing aircraft, combat vehicle, and tactical vehicle programs. The service lives of these types of military equipment programs are defined by usage boundaries, and it is appropriate to assess the age of these programs on a usage and fatigue basis using the OPTEMPO methodology.

This study has also demonstrated that the methodology is valid for assisting with providing additional quantitative budget justification support for additional funding for aircraft replacement due to GWOT consumption based on the analysis completed on the Navy F/A-18 PMO and the FY2009 Supplemental Budget request.

This study has also determined, through the OPTEMPO Universe analysis, to which platforms the methodology does not apply. Not all of the Department's military equipment requires usage and fatigue analysis for evaluating service life consumption and program aging. For programs such as surface ships, subs, and small craft, service life can be measured by years versus usage. The ways the assets are used, managed, and maintained make it possible for the Military Departments to manage these assets on a time basis. For example, the hull of a ship lasts 20 years, or the nuclear reactor lasts 15 years. The study has determined that the methodology applies to programs where a usage basis is the most appropriate method for assessing service life because they are impacted by changes in OPTEMPO and a straight-line aging method based on programmed utilization is not accurate. For these programs, the methodology is also a guide for switching the Department's method for depreciating military equipment from a time to a usage basis and subsequently determining more accurate values for financial reporting.

In summary, given data availability, the methodology provides the Department with a standardized tool, which factors the impact of OPTEMPO on the service lives of military equipment, for determining and supporting replacement and recapitalization requirements and budget requests. A series of policy actions to facilitate the implementation of the OPTEMPO methodology within the Department's budget justification process is recommended below.

Recommendations

The DoD requires a standard, repeatable, and supportable process for calculating and accounting for changes in OPTEMPO for the Department's military equipment impacted by changes in OPTEMPO.

Currently, an effective and clear way of justifying billions of dollars in requested funding for military equipment programs impacted by changes in OPTEMPO does not exist. The OPTEMPO methodology is intended to help fill this void. By factoring the effects of usage, fatigue, and losses on a program in the methodology, the Department will have a better estimation tool and a process for determining replacement and recapitalization requirements and justifying budget requests. Integration of quantitative OPTEMPO analysis into capital planning efforts will allow for more accurate assessments of the current age of a program and will ultimately provide decision-makers with the information needed to define and justify recapitalization and replacement requirements for a given program.

Some obstacles exist that prevent the Department from implementing the methodology on all military equipment programs. Some are systemic issues resulting in data accuracy problems due to source feeder system data issues, and some are issues that result in data not being captured in enterprise-wide systems due to the lack of policy instruction that require the Military Departments to collect and report usage data within their systems. These issues can be addressed by policy and management oversight, as outlined in the policy actions suggested below. However, the methodology can be immediately applied to many other programs (i.e., aircraft and combat vehicles) to assist the Department with emergent budgetary issues.

In order for the Department to realize the full benefits of the OPTEMPO methodology across all Military Departments in budget justification and capital planning efforts, several policy actions are recommended. Integrating these policy actions within the budgeting process will promote consistent and complete data reporting requirements across the Department and will facilitate the effective use and application of the OPTEMPO methodology for supporting budget requests for recapitalization and replacement of military equipment, as well as for supporting capital planning efforts.

1. Policy directives must be published to require the Military Departments to include the OPTEMPO methodology within the existing budget exhibit documentation. Currently, military equipment aging and fatigue analysis is not included within the budget formulation and justification process. Policy requirements should be included within the FMR that require the Military Departments to include the OPTEMPO methodology within the budget justification narrative of the P-40 Budget Exhibit. In addition, language should be included within the FMR that allows for accelerated aging and accelerated depreciation of ME assets. By creating a supplemental 'OPTEMPO Effects' budget exhibit within the existing P-40 Budget Exhibit and by allowing for accelerated aging in financial reporting, which can be used to drive capital planning, the OPTEMPO methodology can be used for calculating the effects of changes in OPTEMPO over the life of a program and for determining future replacement requirements.

2. The Military Departments should consistently and accurately collect and report OPTEMPO data within their enterprise-wide systems. The following data requirements should be included within their enterprise-wide systems for use in the OPTEMPO methodology and within the budget and financial management processes:

a. Service Life Expectancy expressed in terms of available usage (available hours, miles, etc.), which includes all modifications, upgrades, and service life extensions that add use (e.g., original OEM service life + SLEPs).

b. Usage data at the asset level that registers utilization consumed against the service life expectancy of the program (e.g., miles driven or hours flown at the asset-level). Establishing requirements to collect and report usage data across the Department will assist with remedying the data availability issues for certain asset classes (i.e., ground vehicles) for use within the methodology and will allow the Department to switch from a time to a usage basis for depreciation and capital planning purposes.

c. Capture and establish fatigue measurement reporting capabilities or provide estimates for fatigue that are engineering-based and supportable to determine OPTEMPO fatigue impacts, when applicable and valid. Fatigue metrics should only be included within the OPTEMPO methodology when the fatigue results in service life expended, such as structural degradation, that is not recouped or restored with O&S investments, or fatigue life expended for aircraft on the main structure.

A discussion of these policy recommendations along with a draft policy transmittal memorandum and policy position papers are presented in the "Discussion Paper: Calculating and Accounting for Changes in OPTEMPO for DoD Military Equipment" referenced in Appendix D.

The OPTEMPO methodology has proven to be a valid estimation tool that would assist the Department in its capital planning efforts, providing quantifiable management information to support budget justification requests for military equipment replacement and recapitalization.

Additional work is required for assessing the impact of changes in OPTEMPO on military equipment, specifically with regard to military equipment valuation and financial reporting. For the capital planning system to work as intended, DoD's accounting systems and financial management reporting must do two things. First, they must accurately report expenditures in the correct period of performance. Second, they must support budget requirements. This report has addressed the second purpose. Additional work must be done to align systems and gather data, as specified in the recommendations above, to support accurate financial reporting. Currently, the Department is assessing a switch from depreciating military equipment on a time basis to depreciating military equipment on a usage basis. The OPTEMPO universe developed during Phase II serves as a guide for which programs should be evaluated for a switch in depreciation method. The policy changes in Appendix D provide the regulatory basis for the switch.

The next steps for the Department are to consider and implement these policy recommendations to ensure data availability and usability for supporting the use of the OPTEMPO methodology. The suggested policy and process changes will assist the Department with preparing more supportable, accurate, and defendable budget requests, as well as with capital planning efforts and improved financial reporting in the future.

Appendices

Appendix A: Program Questionnaire

Program Questionnaire

Instructions: Please review the Questionnaire prior to meeting with the KPMG team and have the appropriate personnel in attendance to answer these questions and any follow-up questions.

I. Original Program Estimated Useful Life Determination

The following questions will review how the initial estimated useful life for your Military Equipment Program was determined.

1) What is the engineering estimate for the program **BEFORE** any major modifications, recapitalizations, or useful life extensions are performed that would add additional useful life to the assets within your program? If your program currently exists as a result of a useful life extension program, please answer the question as it relates to the useful life extension (how you determined the additional life expectancy).

a) What is the basis for the engineering estimate (hours, miles, etc.) that determined the useful life estimate?

b) Are there particular components (primary components or systems) of the finished asset that are the primary drivers for the useful life estimate of the program.

c) What documentation was used to determine the useful life estimate for your program? Please be prepared to provide the supporting documentation used for determining the initial useful life estimate, such as engineering estimates, acquisition documentation, etc.

Response:

2) Does useful life information for your program reside in any type of automated information system or data base?

a) What other information does this system retain?

Response:

3) What is the process used to evaluate whether the initial useful life of the program is still valid as the program experiences changes in usage (miles driven, hours flown, etc.), fatigue (location, terrain, etc.), operational use (asset maneuvers, number of shots fired, etc.), and other factors that impact useful life?

a) How often do you evaluate/validate the useful life of the program?

b) Where do you document the changes to your program's useful life?

c) What factors of OPTEMPO are considered when evaluating the useful life?

d) How do you calculate the effects and impacts of OPTEMPO to your program's useful life?

e) How are changes to the useful life applied to the program (used in budgeting or for reporting)?

Response:

4) Do you currently use useful life information for management reporting, both internal and external to your Program Management Office?

a) If so, how is it used and what information is included?

Response:

II. Usage Data

Usage data (miles driven, hours flown) by end item for those ME assets experiencing increased utilization from OPTEMPO is required. For many programs, initial useful life estimates were determined using planned usage rates (hours/miles per year) over the expected usage capacity (total number of miles/hours the asset is capable of providing before major modifications and recapitalizations) of the platform. The Phase I Study concluded that DoD should report useful life estimates on the basis of usage, not straight line years. Usage data at the asset level for those assets impacted by OPTEMPO is requested to provide a more accurate report on the remaining life expectancy for the ME end items that are experiencing the impacts of OPTEMPO. **Please provide supporting documentation for all responses.**

1) Please list the various types/models/series of the Program (A, B, C models, etc.).

a) Denote whether each type/model/series is experiencing increased OPTEMPO usage as a result of combat and/or contingency operations over and above the mean peacetime planned rates of utilization.

b) Use the table below to list the type/model/series of assets within your program and note whether they are assets that deploy and whether they are experiencing significant fluctuations in usage resulting from OPTEMPO.

Type/Model/Series	Do they Deploy (Presently or Previously)	Prone to OPTEMPO	Percent of Assets Deployed (Currently/Previously)	Additional Notes
	Y or N	Y or N		
	Y or N	Y or N		
	Y or N	Y or N		
	Y or N	Y or N		

Response:

2) Please provide usage data (miles driven, hours flown) for those asset types *by end item identifier* (tail number, serial number) that you identified in question 1a that are or have been deployed for your program.

Response:

3) In what system(s) is usage data recorded and tracked for your program? Please include a point of contact for this information.

Response:

III. Fatigue and Operational Factors/Conditions Impacting ME Useful Life Estimates

The following questions will be used to determine and identify fatigue factors and/or conditions that have the most significant impact on the initial useful life estimate for your program. Various factors that are unique to a specific ME program could degrade/impair the usefulness of the asset/program more than originally estimated. For example, the following factors may substantially impact a ME asset's useful life:

- Locale in which the ME is used
- Terrain
- Weather conditions
- Levels of usage (miles driven, hours flown, projectiles emitted, etc)
- Scheduled release of newer model (especially if it's intended to replace current model)

These factors and conditions should be evaluated when evaluating the useful life of ME. Data and management's opinions on which fatigue factors have the most significant impact on the life expectancy of DoD ME will be requested. In addition to increased usage rates, the fatigue resulting from operating environment and location must be analyzed to determine its impact on initial useful life estimates.

Please provide supporting documentation for all responses.

1) What are the conditions (environment, weather, temperature, terrain, etc.) that are having the most significant impact on the life expectancy of the types/models/series of assets within your program that are experiencing OPTEMPO fatigue?

a) List the conditions in order of significance to your program.

b) How do you quantify the effects the conditions have on the useful life of the assets within your program?

c) Do you have any tools or processes that are used to estimate the effects of fatigue on the useful life expectancy of your program?

Response:

2) Do your maintenance activities, that are not associated with useful life extension activities (that would add additional service life to the asset's initial useful life), significantly reduce or eliminate the impact fatigue has on your program's remaining useful life expectancy (are they buying back hours flown or miles driven)?

a) If so, what are these procedures for your program?

Response:

3) Please provide any reports / studies that have been conducted related to the fatigue of your program as they relate to useful life or life expectancy analysis for your program.

Response:

IV. Capital Budgeting and Planning Process
The following questions will be used to describe the capital budgeting process to include the process used to evaluate the current and remaining life expectancy of the program and how replacement, modification, or improvement decisions are evaluated and supported. These questions apply to both the base and supplemental budgets. **Please provide supporting documentation for all responses.**
1) What is the process used to determine replacement, remodernization, modification, or new acquisition requirements of the primary assets for your program?
a) Please provide an example of the process and tools (analytical and cost estimation models) that are used for capital budgeting and planning.
b) How is useful life analysis (estimating remaining life expectancy of the program, determining the aging of the program, etc.) used in the process of planning and forecasting budget requirements?
c) What factors and information are used during the capital budgeting process? For example, when entering into the budgeting process for out years, are calculations made for determining the age of the program's assets, how OPTEMPO has impacted the program, and what funding will be required to offset the impacts of increased OPTEMPO?
Response:
2) How do you factor OPTEMPO and useful life analysis in the PB process?
Response:
3) What communication occurs between your program and the maintenance depots that contributes to the PB process?
a) What information do your program's capital budgeting POCs receive from the maintenance depots to assist with planning for replacements, modifications, and/or recapitalization requirements for your program?
Response:

Appendix B: Supplemental Ground Vehicle Questionnaire

ME OPTEMPO PHASE II -- GROUND VEHICLE QUESTIONNAIRE

		ARMY HMMWV	USMC HMMWV	SOCOM GMV	NOTES
Questions for the OEM (AM General)					
1	What is the basis (metrics used) for determining the projected life expectancy, or useful life of the HMMWV (years, miles, hours, etc.)?				
2	What is the mileage estimate for the projected life expectancy, or useful life of the HMMWV? Does this estimate include a long-term maintenance plan that requires the DoD to perform certain maintenance overhauls or rebuild cycles (often referred to as RESET) in order to achieve the useful life estimate, or is the useful life estimate based solely on routine maintenance actions (change oil, replace filters, lube chassis, etc.)?				
3	Do you think Depot and Intermediate-level maintenance actions that are targeted at restoring lost capabilities (changing of transmission, engines, and critical subassemblies) have a 'restoration' effect on useful life? Meaning, do you believe these actions can restore lost useful life that would have been consumed during long periods of utilization in OIF and OEF?				
4	How do you analyze current operational use and maintenance actions on the HMMWV platforms against initial useful life projections for the HMMWV programs? Specifically, have you done any analysis to determine whether HMMWVs are experiencing a shortened useful life over initial projections due to consequences of GWOT?				
5	Have you found that maintenance and RESET actions are restoring much of the lost capability and degradation of service life as a result of prolonged combat use? Do you belive initial useful life estimates expressed in terms of years is still appropriate for the HMMWV program given the maintenance and RESET actions are mitigating factors for accelerated aging of the HMMWV?				
Questions for the PMOs and/or the Depots					
6	Please provide the total number of battle losses and other attritions (maintenance wash outs, training losses, etc.) for the program (only include those variants that are subject to deployment activities) from program inception through FY07.				
7	Please provide the total appropriated amounts for O&M (base and supplemental) for the program that are used to support repair, maintenance, and RESET programs for the HMMWV platforms. If actuals are not available, please provide an estimate or percentage change from year to year. Please provide data from FY98 - FY07.				
8	Please provide the total number of planned RESETs for your program. Have you had an increase in the number of RESET requirements for your program due to GWOT? Are these RESETs targeted at restoring lost capability and degradation to the assets due to increased use and fatigue resulting from combat operations? If actual data is not available, please provide an estimate for the period of FY98 - FY07 on the total number of RESETs that have been planned for the program.				
9	Do you believe that Maintenance and RESET investments are restoring (or helping to restore) the lost capability and degradation (expended useful life) of your vehicles due to the operations they have endured during combat operations? Do you believe it is appropriate to view the aging and useful life of the program on a straight-line basis (i.e., 15-year estimated service life) given the maintenance and RESET investments that are targeted at bringing the assets back to operational standards?				
10	We have found mileage data for HMMWVs in OSMIS. The data is not always complete, but it does represent a basis of estimate at the program level. Do you believe that the OSMIS data could be used as an 80% solution for measuring OPTEMPO or is straight-line depreciation a better measure?				
11	Do you believe it is accurate to say that as long as maintenance and RESET actions are performed and funded, there is no significant 'net' decrease in overall service life of the vehicles used in combat and a straight-line curve for aging and depreciation is appropriate?Do you believe it is accurate to say that as long as maintenance and RESET actions are performed and funded, there is no significant 'net' decrease in overall service life of the vehicles used in combat and a straight-line curve for aging and depreciation is appropriate?				

Appendix C: OPTEMPO Universe Listing

Air Force

Air Force Military Equipment OPTEMPO Universe		
	Program Name	**Variant (Type/Model/Series)**
1	**Cargo-130**	
		C-130E
		C-130H
		HC-130N
		HC-130P
		TC-130H
		EC-130H
2	**Fighter-15**	
		F-15A
		F-15B
		F-15C
		F-15D
		F-15E
3	**Fighter-16**	
		F-16A
		F-16B
		F-16C
		F-16D
4	**Attack-10**	
		A-10A
		A-10C
5	**Cargo-10A**	
		KC-10A
6	**Cargo-5**	
		C-5A
		C-5B

Air Force Military Equipment OPTEMPO Universe		
	Program Name	**Variant (Type/Model/Series)**
		C-5C
7	**Special Electronic Installation-3**	
		E-3B
		E-3C
8	**Utility-2**	
		U-2S
9	**Special Electronic Installation-4B (E-4B)**	
		E-4B
10	**Global Hawk (RQ-4A)**	
		RQ-4A
11	**Special Electronic Installation-8C JSTARS (E-8C)**	
		E-8C
12	**Unmanned Aerial Vehicle**	
		RQ-1A Predator
13	**B-Series Bomber**	
		B-1B
		B-2A
		B-52H
14	**Helicopter-1**	
		UH-1N
15	**Helicopter-60**	
		HH-60G
16	**Cargo-17**	
		C-17

Army

Army Military Equipment OPTEMPO Universe		
	Program Name	**Variant (Type/Model/Series)**
1	**Apache (AH-64)**	
		AH-64A
		AH-64D
2	**CH-47**	
		CH-47D
		CH-47F
3	**UH-60**	
		UH-60A
		UH-60L
		UH-60M
4	**OH-58**	
		OH-58D
5	**Utility Helicopter**	
		Light Utility Helicopter- UH-72 LAKOTA
6	**Cargo/Fixed Wing**	
		C-23B - SHERPA
		C-23B+
		C-23C
		UC-36B Citation Ultra (CESSNA)
		RC-12K Guardrail Common/Sensor
		RC-12N Guardrail Common/Sensor
		RC-12P Guardrail Common/Sensor
		RC-12Q Guardrail Common/Sensor
		C-12 R1
7	**Hercules M88**	
		M88A2 Hercules
8	**Abrams**	

Army Military Equipment OPTEMPO Universe		
	Program Name	**Variant (Type/Model/Series)**
		M1A1
		M1A1 AIM
		M1A2
		M1A2 SEP
9	**Light Tactical Vehicle**	
		Armored Security Vehicle
		M966 HMMWV TOW Armored
		M996 Mini-Ambulance, Armored
		M997 Maxi-Ambulance, Armored
		M998 Cargo/Troop
		M1025 Armament Carrier, Armored
		M1026 Armament Carrier, Armored W/W
		M1035 Soft-Top Ambulance
		M1036 TOW Armored W/W
		M1037 S-250 Shelter Carrier
		M1038 Cargo/Troop Carrier W/W
		M1042 S-250 Shelter Carrier, Up-Armored
		M1044 Armament Carrier, Up-Armored W/W
		M1045 TOW Up-Armored Armor
		M1046 TOW Up-Armored Armor W/W
		M1069 Tractor for M119 105mm Gun
		M1097 Heavy
		M1097 Heavy HMMWV Avenger
		M1109 Up-Armored Armament Carrier
		M1113 Expanded Capacity
		M1114 Up-Armored Armament Carrier
		M1116 Up-Armored HMMWV
		M1123 Heavy

Army Military Equipment OPTEMPO Universe		
	Program Name	**Variant (Type/Model/Series)**
		M1121 TOW Armored
		M1145 Up-Armored HMMWV
		M1151 Enhanced Armament Carrier
		M1152 Enhanced Shelter Carrier
10	**Stryker**	
		M1126 Infantry Carrier Vehicle
		M1134 Anti-Tank Guided Missile Vehicle
		M1130 Commander's Vehicle
		M1132 Engineer Squad Vehicle
		M1131 Fire Support Vehicle
		M1129 Mortar Carrier
		M1133 Medical Evacuation Vehicle
		M1127 Reconnaissance Vehicle
		M1135 NBC Reconnaissance Vehicle
		M1128 Mobile Gun System
11	**Medium Tactical Vehicles**	
		M1078 Standard Cargo Truck
		M1079 Van
		M1081 Standard Cargo Low Velocity Air Drop Truck
		XM1082 Trailer
		M1083 Standard Cargo Truck
		M1084 Standard Cargo Truck
		M1085 Long Wheel Base Truck
		M1086 Long Wheel Base Truck
		M1087 Expandable Van
		M1088 Tractor Truck
		M1089 Wrecker
		M1090 Dump Truck

Army Military Equipment OPTEMPO Universe		
	Program Name	**Variant (Type/Model/Series)**
		XM1091 Fuel/Water Tanker
		M1093 Standard Cargo Low Velocity Air Drop Truck
		M1094 Dump Low Velocity Air Drop Truck
		XM1157 10-Ton Dump Truck
12	**M939 Series Truck**	
		M939 Cargo
		M939 Cargo Long Wheel Based
		M939 Dump Truck
		M939 Tractor
		M939 Van
13	**Heavy Tactical Vehicles**	
		M1074 Palletized Load System
		M1075 Palletized Load System
		M916 Truck Tractor, Light Equipment Transporter
		M878 Yard Tractor
		M915 Truck Tractor Line Haul
		M917 20-Ton Dump Truck
		M969A3 5000 Gallon Refueler Trailer
		M977 HEMTT
		M978 HEMTT
		M983 HEMTT
		M9784 HEMTT
		M985 HEMTT
		XM1120 HEMTT
		M1000 Semitrailer
		M1070 Tractor
		M1997 Common Bridge Transporter
14	**High Mobility Artillery Rocket System**	

Army Military Equipment OPTEMPO Universe		
	Program Name	**Variant (Type/Model/Series)**
		XM142 5-Ton Truck
15	**M-270**	
		M270 Self-Propelled Loader/Launcher
		M270A1 Self-Propelled Loader/Launcher Upgrade
16	**M113**	
		M58A3 Wolf Smoke Generator System
		M1059A3 LYNX Dual Purp Smoke Mech
		M981A3 Fire Support Team Vehicle (FISTV)
		M981 Fire Support Team Vehicle (FISTV)
		M113A2 Armored Personnel Carrier
		M113A3 Armored Personnel Carrier
17	**Bradley**	
		M2A0 Bradley
		M3A0 Bradley
		M2A1 Bradley
		M3A1 Bradley
		M2A2 Bradley
		M3A2 Bradley
		M2A3 Bradley
		M3A3 Bradley
18	**Howitzer**	
		M119 105MM Towed Howitzer
		M777A1 155MM Lightweight Howitzer
		M109A6 Self-Propelled Paladin
19	**Family of Loaders**	
		Heavy Loaders Type I or Type II
		Light Loaders Type I or Type II
20	**Bridging**	

Army Military Equipment OPTEMPO Universe		
	Program Name	**Variant (Type/Model/Series)**
		M9 Armored Combat Earth Mover
		Mk2/MK2R Bridge Erection Boat (BEB)
		Main Girder Bridge (MGB)
		Common Bridge Transporter (CBT)
		Armored Vehicle Launch Vehicle (AVLB)
		XM21 Rapidly Emplaced Bridging System
21	**Construction Equipment**	
		Airborne Scraper
		AT422T All Terrain Crane
		D9 Dozer Armored
		Deployable Univ. Combat Earthmover
		Dual Steel Wheel Roller
		Hydraulic Excavator
		Water Distributor
		M074 Paving Machine
		Tractor Fully Tracked
		High Speed Compactor
		Small Emplacement Excavator (SEE)
22	**Unmanned Aerial Vehicle**	
		Hunter
		Raven
		Shadow
23	**Patriot**	
		Patriot
		PAC-3
24	**Wolverine**	
		M104 Wolverine
25	**Material Handling Equipment**	

Army Military Equipment OPTEMPO Universe		
	Program Name	**Variant (Type/Model/Series)**
		All Terrain Lifting Army System (ATLAS) CE
		Kalmar Rough Terrain Carrier Handler (RTCH)
		RTCC Crane
		4K RT F/L
		M10A RT F/L
		DV-43 RTCH
		M4K F/L
		7.5 Crane
		6K VR RTFL
26	**Assured Mobility Systems**	
		MPCV Buffalo
		MPCV Buffalo A1
		MPCV Buffalo A2
		MMPV RG-31 NYALA
		MMPV RG-31 MK I
		MMPV RG-31 MK II
		MMPV RG-31 MK III
		MMPV RG-31 MK V
		MMPV RG-33L (MMPV/EOD)
		MMPV JERRV 6X6
		MMPV Cougar 4X4
		IVMMD MEERKAT
		IVMMD HUSKY I
		IVMMD HUSKY II

Navy

Navy Military Equipment OPTEMPO Universe		
	Program Name	**Variant (Type/Model/Series)**
1	**Cargo-130**	
		C-130T
		KC-130J
2	**Engagement Capability-2**	
		E-2C
3	**Fighter / Attack-18**	
		F/A-18A
		F/A-18A+
		F/A-18B
		F/A-18C
		F/A-18D
		F/A-18E
		F/A-18F
		E/A-18G
4	**Attack Jet AV-8**	
		AV-8B
5	**Patrol-3**	
		P-3
6	**CH-46**	
		CH-46E
7	**Helicopter-60**	
		VH-60N
		MH-60R
		MH-60S
		SH-60B
		SH-60F
		SH-60H

Navy Military Equipment OPTEMPO Universe		
	Program Name	**Variant (Type/Model/Series)**
8	**Helicopter-1**	
		AH-1W
		UH-1Y
		AH-1Z
9	**Helicopter-53**	
		CH-53E
		MH-53E
10	**Vertical-22**	
		MV-22
11	**EA-6B Prowler (PMA 234)**	
		EA-6B
12	**Cargo**	
		C-2AR
		C-37A
		C-40A
		DC-9B
		C-9B
		C-20G
		C-20D
		UC-35
		UC-35 NGRE
		RC-12F
		UC-12B
		UC-12M
		C-26D
13	**Fighter-5**	
		F-5
14	**E-6B Merc-Airborne Strat**	

Navy Military Equipment OPTEMPO Universe		
	Program Name	**Variant (Type/Model/Series)**
		E-6B
15	**Vertical Helicopter-3D Sea King**	
		VH-3D
16	**Joint Strike Fighter**	
		F-35

Marine Corps[6]

Marine Corps Military Equipment OPTEMPO Universe		
	Program Name	**Variant (Type/Model/Series)**
1	**Hercules M88**	
		M88A2 Recovery/Hercules
2	**Abrams (M1)**	
		M1A1
3	**Light Armored Vehicles**	
		Light Armored Vehicle - C2
		Light Armored Vehicle - 25
		Light Armored Vehicle - Anti-Tank
		Light Armored Vehicle - Logistics
		Light Armored Vehicle - Mobile Electronic Warfare Support System
		Light Armored Vehicle - Mortar
		Light Armored Vehicle - Recovery
		Mobile Electronic Warfare Support System (MEWSS)
4	**Medium Tactical Vehicles**	
		AMK23 Truck
		AMK25 Truck
		AMK27 Truck
		AMK28 Cargo Truck
		AMK29 Truck
		AMK30 Dump Truck
		AMK36 Wrecker
		AMK48 Logistic Support Vehicle
		AMK31 Tractor
5	**High Mobility Artillery Rocket System**	
		M142 High Mobility Artillery Rocket System
		MK37 H1MARS Re-Supply Vehicle
		M538 HIMARS Re-Supply Trailer
6	**Panther (Unmanned)**	
		M60 Panther

[6] The Marine Corps Military Equipment OPTEMPO Universe is validated based on a 50% response from the Marine Corps. The remainder of the listing was reviewed by the Department of the Navy.

Marine Corps Military Equipment OPTEMPO Universe		
	Program Name	**Variant (Type/Model/Series)**
		M1A1 Panther II
7	**Commercial Cargo Vehicles**	
		M1008 Commercial Cargo Vehicle
8	**Expeditionary Fighting Vehicle**	
		Expeditionary Fighting Vehicle P1 Personnel Carrier
		Expeditionary Fighting Vehicle C1 Command Carrier
9	**Assault Breacher Vehicle**	
		M1 Grizzly
10	**Howitzer**	
		M198 Howitzer
		XM113 IPADS Howitzer
11	**AAV PIP**	
		Amphibious Assault Vehicle - 7A1
12	**MRAP**	
		Cougar
		Buffalo
		Backscatter
		JERRV
		MaxxPro
		Caiman
		RG33L MRAP
		RG33 MRAP
		RG31 Extended MRAP
		RG31 MRAP
13	**Light Tactical Vehicle**	
		M707 HMMWV Striker
		M966 HMMWV TOW Armored
		M996 Mini-Ambulance, Armored
		M997 Maxi-Ambulance, Armored
		M998 Cargo/Troop
		M998 HMMWV Avenger
		M1025 Armament Carrier, Armored
		M1026 Armament Carrier, Armored W/W
		M1035 Soft-Top Ambulance
		M1036 TOW Armored W/W

Marine Corps Military Equipment OPTEMPO Universe		
	Program Name	**Variant (Type/Model/Series)**
		M1037 S-250 Shelter Carrier
		M1038 Cargo/Troop Carrier W/W
		M1042 S-250 Shelter Carrier, Up-Armored
		M1044 Armament Carrier, Up-Armored W/W
		M1045 TOW Up-Armored Armor
		M1046 TOW Up-Armored Armor W/W
		M1069 Tractor for M119 105mm Gun
		M1097 Heavy HMMWV Avenger
		M1109 Up-Armored Armament Carrier
		M1113 Expanded Capacity
		M1114 Up-Armored Armament Carrier
		M1116 Up-Armored HMMWV
		M1121 TOW Armored
		M1123 Heavy
		M1145 Up-Armored HMMWV
		M1151 Enhanced Armament Carrier
		M1152 Enhanced Shelter Carrier
		MV-22 Internally Transportable Vehicle

Special Operations Command (SOCOM)

SOCOM Military Equipment OPTEMPO Universe		
	Program Name	**Variant (Type/Model/Series)**
1	**C-130**	
		AC-130U
		AC-130H
		EC-130E
		EC-130J
		MC-130E
		MC-130H
		MC-130P
		MC-130W
2	**MH-47**	
		MH-47D
		MH-47E
		MH-47G
3	**MH-60**	
		MH-60K
		MH-60L
		MH-60M
4	**A/MH-6M**	
		A/MH-6M
5	**Submarines/Craft**	
		Advanced Seal Delivery System
		Seal Delivery Vehicle
		MK V Special Operations Craft
		Semi-Autonomous Hydrographic Reconnaissance Vehicle
6	**Seal Delivery Vehicle**	
		SDV MK 8
7	**MRAP**	

SOCOM Military Equipment OPTEMPO Universe		
	Program Name	**Variant (Type/Model/Series)**
		Mine Resistant Ambush Protected (MRAP) = RG33 CAT I MRAP SOCOM Variant; NSN = 2355-01-557-3100
		Medium Mine Protected Vehicle (MMPV) = RG31 A1S
8	**Ground Mobility Vehicles**	
		GMV - Ranger = HMMWV M1113 and M1165 with SOF unique configuration changes
		GMV - Special Forces = HMMWV M1113, M1025A2, and M1165 with SOF unique configuration changes
		GMV - Marines = HMMWV M1152 and M1165 with SOF unique configuration changes
		GMV - Navy = HMMWV M1113 with SOF unique configuration changes

Chemical and Biological Defense Systems (ChemBio)[7]

CHEMBIO Military Equipment OPTEMPO Universe		
	Program Name	**Variant (Type/Model/Series)**
1	**Light Tactical Vehicle**	
		M31 BIDS
		M31E2 BIDS
2	**Stryker**	
		M1135 NBC Reconnaissance Vehicle
3	**M113**	
		M58A3 Wolf Smoke Generator System
		M56E1 Smoke Generating System
		M1059 LYNX Dual Purp Smoke Mech

[7] The ChemBio Military Equipment OPTEMPO Universe Listing was reviewed by OUSD(AT&L), Property and Equipment Policy Office.

Appendix D: Discussion Paper: Calculating and Accounting for Changes in OPTEMPO for DoD Military Equipment and Draft Policy Transmittal Memorandum

Description of Issue

Department of Defense (DoD) military equipment (ME) continues to experience increased usage and more fatigue due to combat and contingency operations. Higher than expected utilization rates and fatigue caused by operating environment and mission are resulting in reduced service life expectancies for some of the Department's ME. This is resulting in new and emerging requirements for ME replacement and recapitalization.

The DoD continues to experience problems with budget justification requests for ME replacement and recapitalization due to the lack of sufficient quantitative detail to support the requests and a formal method/process for analyzing and assessing expended service life (program aging). Without proper supporting detail and a standardized process for accounting for changes in operational tempos (OPTEMPO), the DoD will continue to struggle with preparing supportable budget requests and determining ME replacement requirements.

Discussion

Most DoD ME program inventories are measured and reported based on straight-line aging expressed in terms of years. In fact, the current Financial Management Regulation (FMR) permits the use only of the straight-line method of depreciation (Source: DoD FMR Volume 4, Chapter 6, Paragraph 060205B). Existing program aging practices/methods expressed in terms of years do not provide the means or visibility into OPTEMPO factors or conditions that are resulting in reduced service lives for DoD ME impacted by changes in OPTEMPO. In addition, these time-based methods are not providing the Military Departments with the program information or visibility required to effectively determine ME replacement and recapitalization requirements caused by varying OPTEMPO. Critical data such as how often equipment is used, where and how it is used, or how many assets have been lost, disposed, or destroyed are omitted from these existing program aging methods. These omissions result in weak budget justifications and inconsistencies in reporting program information across the Department (e.g., OSD(Program Analysis and Evaluation (PA&E)) may have one aging summary for a given program, and the Program Manager may have another).

Currently, each Military Department prepares budget justification documentation based on requirements provided within FMR Volume 2B, Chapter 4. The FMR requires the Military Departments to prepare three primary Budget Exhibits: the P-1 'Procurement Program' Exhibit, the P-5 'Cost Analysis' Exhibit, and the P-40 'Budget Item Justification Sheet' Exhibit. The budget exhibits and the supporting narratives included within the P-40 Exhibits do not provide sufficient detail on average age, usage rates, life expended, or life expectancy. Without adequate supporting documentation or a consistent and repeatable process for evaluating program aging that factors OPTEMPO conditions, the Department will continue to encounter difficulty predicting future inventory requirements and justifying budget requests and submissions for replacement and recapitalization.

In response to this issue, a methodology was developed to assist with calculating and accounting for changes in OPTEMPO for DoD ME. The OPTEMPO methodology is a formula-based algorithm that determines an estimate of the number of equivalent asset lives consumed on a given ME program by factoring various programmatic variables. The OPTEMPO methodology factors asset losses (battle losses and attrition), utilization (hours flown, miles driven), and fatigue (stresses on equipment that are not addressed by maintenance or repair actions and result in accelerated service life degradation).

The OPTEMPO methodology provides a tool and a means by which more accurate program aging can be determined and additional budget justification support for ME replacement and recapitalization can be provided. The OPTEMPO methodology is depicted below.

Losses (1) — 2 — 3 Usage (4) — Fatigue (5)

$$\text{Equivalent Lives Consumed} = \text{Battle Losses} + \text{Non-Combat Losses} + \left(\text{Active Asset Quantity}\right)\left\{\left(\frac{\sum \text{Actual Use per Active Asset}}{\text{Active QTY x Design Service Life}}\right)\left(1+\text{Fatigue}\right)\right\}$$

Methodology Metrics Key:

1. Losses: The total number of losses (battle losses and attritions/non-combat losses) for the program from program inception.
2. Active Asset Quantity: The total number of active assets in the program inventory.
3. Sum of Usage: The total amount of usage expended (hours flown, miles driven) for the active asset inventory based on the design service life estimate.
4. Design Service Life: The useful service life of a piece of ME expressed in terms of an engineering-based estimate for available usage for life expectancy.
5. Fatigue: The calculation (actual or estimate) of the total amount of degradation of the asset that goes beyond strictly utilization that results in additional service life degradation.

The OPTEMPO methodology applies to all ME where a straight-line years (time) basis is not appropriate for measuring program aging and service life expended, provided data for the respective program exists. The OPTEMPO methodology has proven to be a valid estimation tool that will assist the Department with its budgeting and financial reporting processes in the future.

Conclusion

The DoD requires a standard, repeatable, and supportable process for calculating and accounting for changes in OPTEMPO for the Department's ME.

Currently, an effective and clear way of justifying billions of dollars in requested funding for ME programs impacted by changes in OPTEMPO does not exist. By factoring the effects of usage, fatigue, and losses on a program in a methodology, the Department will have a better approximation and estimation tool and a process for determining replacement and recapitalization requirements and justifying budget requests. Integration of quantitative OPTEMPO analysis into the budget exhibit narratives will more accurately depict the current age of a program by factoring losses, usage, and fatigue. This will ultimately provide decision-makers with the information they need to determine replacement requirements for a given program.

Some obstacles exist that prevent the Department from implementing the methodology on all ME programs. Some are systemic issues resulting in data accuracy problems due to source feeder system data issues, and some are issues that result in data not being captured in enterprise-wide systems due to the lack of policy instruction that require the Military Departments to collect and report usage data within their systems. These issues can be addressed by policy and management oversight, as discussed and outlined in the recommendations section below. However, the methodology can be immediately applied to many other programs (i.e., aircraft and combat vehicles) to assist the Department with emergent budgetary issues.

Recommendations

In order for the Department to realize the full benefits of the OPTEMPO methodology across all Military Departments, several policy actions are suggested. Following these steps will promote consistent and complete data reporting requirements across the Department and will facilitate the effective use and application of the OPTEMPO methodology. Reference Tabs A through C for draft policy memorandums for each of the following recommendations.

3. Policy requirements should be included within the FMR that require the Military Departments to include the OPTEMPO methodology within the budget justification narrative of the P-40 Budget Exhibit. In addition, language should be included within the FMR that allows for accelerated aging and accelerated depreciation of ME assets. By creating a supplemental 'OPTEMPO Effects' budget exhibit within the existing P-40 Budget Exhibit and by allowing for accelerated aging in financial reporting, which can be used to drive capital planning, the OPTEMPO methodology can be used for calculating the effects of changes in OPTEMPO over the life of a program and for determining future replacement requirements.
4. The Military Departments should consistently and accurately collect and report OPTEMPO data within their enterprise-wide systems. The following data requirements should be included within their enterprise-wide systems for use in the OPTEMPO methodology and within the budget and financial management processes:
    a. Service Life Expectancy expressed in terms of available usage (available hours, miles, etc.), which includes all modifications, upgrades, and service life extensions that add use (e.g., original OEM service life + SLEPs).
    b. Usage data at the asset level that registers utilization consumed against the service life expectancy of the program (e.g., miles driven or hours flown at the asset level). Establishing requirements to collect and report usage data across the Department will assist with remedying the data availability issues for certain asset classes (i.e., ground vehicles) for use within the methodology and will allow the Department to switch from a time to a usage basis for depreciation and capital planning purposes.
    c. Capture and establish fatigue measurement reporting capabilities or provide estimates for fatigue that are engineering-based and supportable to determine OPTEMPO fatigue impacts, when applicable and valid. Fatigue metrics should only be included within the OPTEMPO methodology when the fatigue results in service life expended, such as structural degradation, that is not recouped or restored with O&S investments, or fatigue life expended for aircraft on the main structure.

These policy and process changes will assist the Department with preparing more supportable, accurate, and defendable budget requests and with capital planning efforts in the future. For those ME programs that currently have program data available, the Department should implement these policy changes effective with the FY2010 budget submission. Most aircraft and combat vehicle programs fall within this category. For those programs that currently do not have program data at the enterprise level, the Department should phase the policy in over the next three years; however, the requirement to begin collecting and reporting this data and centralized systems should be effective beginning in FY2010.

Reference Tabs A through C for a draft Policy Transmittal Memorandum and two draft Policy Position Papers for implementing the recommendations included within this Discussion Paper.

TAB A – DRAFT POLICY TRANSMITTAL MEMORANDUM

OFFICE OF THE SECRETARY OF DEFENSE

1000 DEFENSE PENTAGON
WASHINGTON, DC 20301-1000

MEMORANDUM FOR ASSISTANT SECRETARY OF THE ARMY (FINANCIAL MANAGEMENT AND COMPTROLLER)
ASSISTANT SECRETARY OF THE ARMY (ACQUISITION, LOGISTICS AND TECHNOLOGY)
ASSISTANT SECRETARY OF THE NAVY (FINANCIAL MANAGEMENT AND COMPTROLLER)
ASSISTANT SECRETARY OF THE NAVY (RESEARCH, DEVELOPMENT AND ACQUISITION)
ASSISTANT SECRETARY OF THE AIR FORCE (FINANCIAL MANAGEMENT AND COMPTROLLER)
ASSISTANT SECRETARY OF THE AIR FORCE (ACQUISITION)
DIRECTORS OF THE DEFENSE AGENCIES
USSOCOM, DIRECTOR OF SORR – J8
USSOCOM, OFFICE OF ACQUISTITION EXECUTIVE

SUBJECT: Accounting for Changes in Operational Tempo (OPTEMPO) for Military Equipment

The Department of Defense (DoD) military equipment inventory continues to experience increased usage and more fatigue due to combat and contingency operations. Higher than expected utilization rates and fatigue caused by operating environment and mission are resulting in reduced service life expectancies for the Department's military equipment inventory. This is resulting in new and emerging requirements for military equipment replacement and recapitalization.

To meet this challenge, the Department has developed an algorithm for assisting with calculating and accounting for changes in operational tempo (OPTEMPO) for certain DoD military equipment. The algorithm, or OPTEMPO methodology, is a formula-based calculation that determines an estimate of the number of equivalent asset lives consumed, or the aging of a program, by factoring various programmatic variables. Specifically, the OPTEMPO methodology factors asset losses (battle losses and attrition), utilization (hours flown, miles driven), and fatigue (stresses on equipment that are not addressed by maintenance or repair actions and result in accelerated service life degradation).

The OPTEMPO methodology will help the Department with preparing more accurate program aging estimates to assist with determining equipment replacement and recapitalization requirements and with capital planning efforts. In order to consistently implement the OPTEMPO methodology across the Department, several actions are required. These actions and implementation timelines are summarized in the attached policy papers. The detailed

OPTEMPO guidance will be included in the next update to Volume 2, Chapter 4 of the DoD Financial Management Regulation.

If you have any questions or need additional information, please contact Mr. Robert McNamara. He can be reached at Robert.McNamara@osd.mil.

Tina Jonas
Chief Financial Officer
OSD (Comptroller)

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

Attachments:
As Stated

TAB B – OPTEMPO METHODOLOGY POLICY PAPER

Policy Objective

- The DoD Financial Management Regulation (FMR) does not require DoD to account for fluctuations in military equipment usage due to combat operations, contingency operations, changes in mission readiness activities, or operating conditions when calculating the estimated service life and associated depreciation expense for military equipment.
- OUSD(AT&L) and OUSD(C) have developed a mathematical formula to estimate the impacts of operational tempo (OPTEMPO) on the Department's military equipment to assist the Department with determining replacement and recapitalization requirements. Prolonged combat and contingency operations continue to challenge the preservation and longevity of the Department's equipment. The Department felt that a more precise estimating capability was required to account for the impacts of increased OPTEMPO and for determining replacement requirements. The purpose of this formula is to estimate the impacts of utilization and stress/fatigue on military equipment service lives in order to better justify and support budget requests.
- The OPTEMPO methodology is required as part of the budget formulation and justification process for DoD military equipment replacement and recapitalization as a result of changes in OPTEMPO. The OPTEMPO methodology is to be included in addition to the narratives included within the P-40 budget exhibit. Reference the DoD FMR Volume 2B, Chapter 4 for specific guidance.

OPTEMPO Methodology

- Budget decisions for military equipment replacement and recapitalization should be driven by how much equipment is used, where it is used, and whether mission requirements are met with existing capabilities. The OPTEMPO methodology calculates an estimate of the remaining life of a program, expressed in terms of equivalent lives consumed, to assist the Department with formulating and justifying budget requests. The methodology links the Department's financial and budgetary transactions to assist with capital planning efforts. By moving from a time (straight-line years) to a usage and stress basis by factoring OPTEMPO data to determine program aging, the Department will have better financial information to support budget requests and more accurate aging estimates for justifying program budget decisions.
- The OPTEMPO methodology is illustrated below.

Losses | **Usage** | **Fatigue**

$$\text{Equivalent Lives Consumed} = \text{Battle Losses} + \text{Non-Combat Losses} + \left(\text{Active Asset Quantity}\right)\left\{\left[\frac{\sum \text{Actual Use per Active Asset}}{\text{Active QTY x Design Service Life}}\right]\left[\text{1+ Fatigue}\right]\right\}$$

- To apply the OPTEMPO methodology, the following inputs are required:

- LOSSES: The total number of program losses looks at battle losses and other losses/attrition (maintenance wash-outs, training losses, aged out of inventory, etc.) to determine the net number of all losses on the program. Total program losses have an impact on program requirements, such as meeting readiness requirements and the number of assets that are available for rotational demands.
- ACTIVE ASSET QUANTITY: The active asset quantity is the total number of active assets in the program inventory. This quantity represents the deployable/mission-ready inventory and does not include test assets that are not part of the active/deployable program inventory.
- USAGE: Actual usage looks directly at the utilization of the assets (i.e., hours flown, miles driven) and applies the ratio of actual usage to available usage (based on design service life) to determine what percent of the program has been consumed based on utilization. This ratio provides a snapshot of the current age of the program expressed in terms of utilization expended.
- DESIGN SERVICE LIFE: Design Service Life is a product of the engineering-based original design life plus any SLEP/RECAP/Rebuild actions (modifications that result in additional miles or hours). The service life must be updated to reflect revisions made by the program throughout the life of the program.
- FATIGUE: Fatigue looks directly at the structural stress that occurs as a result of operating environment or mission type that occurs over the life of the program. Fatigue looks at the degradation of the asset that goes beyond usage to quantify stresses resulting from operational conditions that further limit asset service life. This multiplier does not focus on select components (subsystems or expendables, such as tires, shocks, axles, engines, etc.), which are typically replaced or repaired by maintenance operations in theater and at the depots. Instead, it takes a holistic look at the additional degradation of the entire system that goes beyond utilization.

Implementation Requirement

- In order to allow for the use of accelerated aging, the OUSD(C) needs to update the definition of depreciation to account for increased operational tempo. The revised definition is as follows:

  Depreciation is the systematic and rational allocation of the acquisition cost of an asset, less its estimated salvage or residual value, over its estimated useful life. Estimates of useful life of general PP&E must consider factors such as physical wear and tear and technological change.

- The OPTEMPO methodology applies to all military equipment that is impacted by changes in OPTEMPO that result in reduced service lives (typically, usage-based systems). For these programs, the Department will switch from a time (straight-line years) to a usage (utilization-based) basis for determining program aging and service life estimates. Programs that fall within this category are those included within the Department's OPTEMPO Program Universe, which was developed by the Military Departments. To summarize the program universe, the Military Departments determined that ships, submarines, satellites, and support-types of equipment (yellow gear) should continue reporting on a straight-line time (years) basis. This was determined based on how these systems are managed, fielded, and used over their lifecycles. The Military Departments also identified those asset classes that should be switched from a time to a usage basis for reporting. They include, but are not limited to, attack aircraft, rotary wing aircraft, airlift aircraft, fighter aircraft, combat vehicles, and tactical vehicles. These systems were identified because their life expectancies were heavily impacted by increased utilization, and the service lives for these types of military equipment are typically based on available use (e.g., aircraft lives are expressed in terms of available flight hours, unlike a ship whose hull has a 20-year life span).

- Implementation requirements for this policy change are effective with the FY2010 budget submission. Most aircraft and combat vehicle programs fall within this category. For those programs that currently do not have program data at the enterprise level for populating the formula, the Department is phasing in these programs based on system fielding schedules over the next three fiscal years.

TAB C – OPTEMPO SYSTEM DATA REQUIREMENTS POLICY PAPER

Policy Objective

- The centralized collection of operational tempo (OPTEMPO) data is required to assist the Department with more accurately determining program aging, improving financial information, and with the capital budgeting and budget justification processes. The centralized collection and reporting of usage data (i.e., hours flown, miles driven) for those programs where switching from a time to a usage basis is required will assist the Department with these efforts. This policy is required for the DoD to more accurately account and report for the impacts of OPTEMPO on the service lives of military equipment.

OPTEMPO Data Collection and Reporting Requirements

- The Military Departments must begin to collect and report the following data within their official systems of record. This data will be used to prepare the Department's financial statements and assist with developing budget justifications for military equipment replacement and recapitalization.

  (1) Engineering-based design service life estimates
  (2) Usage information at the program and asset levels

- These requirements have been established to consistently and accurately collect and report usage and service life data within enterprise-wide systems for use within the financial reporting and budgeting process.

Implementation Requirement

- Many of the Department's military equipment programs currently collect and use utilization information for program management and planning purposes. The OUSD(AT&L) Property and Equipment (P&E) Policy Office will begin identifying systems that can interface with the Capital Asset Management System-Military Equipment (CAMS-ME). Once systems have been identified and interfaces with CAMS-ME built, program managers should work with the OUSD(AT&L) P&E Policy Office to begin switching from a time to a usage basis within CAMS-ME. This change must be completed within one year.
- For those programs that do not centrally collect usage data for their programs, the OUSD(AT&L) P&E Policy Office will begin working with you to establish and incorporate these reporting requirements within your enterprise-wide system development efforts (i.e., GCSS-MC and GCSS-Army). In addition, the OUSD(AT&L) P&E Policy Office will assist with developing implementation timetables for transition.
- For questions regarding this policy, please contact Mr. Richard Sylvester at Richard.Sylvester@osd.mil.