

## CBM Fleet Implementation and Maintenance Decision Making Through Fatigue Life Management: Utilization and Parts Remediation Processes<sup>1</sup>

Ms. Michele Kochoff Platt, Apache Logistics Modernization Division, AVNIK Defense Solutions, Inc, Huntsville, AL, michele.platt@us.army.mil

Tony M. Page, Senior Aerospace Engineer, Westar A & DG, St. Louis, MO, Structures and Materials Division, US Army, AMRDEC Redstone Arsenal, AL 35898, page@westar.com

Ms. Deta Adams, Honeywell Aerospace, Huntsville, AL, deta.adams@honeywell.com

Robert E. Vaughan, Ph.D., Lead Aerospace Engineer, Structures and Materials Division, US Army, AMRDEC Redstone Arsenal, AL bob.vaughan@us.army.mil

### ABSTRACT

Apache's CBM Objectives of Reduced Soldier Burden, Increased Aircraft Availability, Enhanced Safety and Reduced Operational & Support (O&S) Costs drive Technical Initiatives. These initiatives include the management of Fatigue Life Limited Components (FLLC) to extend a component's useful life on the aircraft and monitoring that component's cumulative damage. A Remediation program combined with a Usage Monitoring process produces an achievable Fatigue Life Management Program. By extending a component's time-on-wing, the CBM objectives of reduced soldier burden is achieved because the soldier is not removing components prematurely; Increased Aircraft Availability is achieved because the aircraft is not down for maintenance, while the part is being removed; and Reduced O&S costs are achieved because good parts are not thrown away. Sandia National Labs (SNL) brief to PEOAVN MG Bergantz, dated 18 September 2002, analyzed Apache data which indicated contributors to availability such as: Maintenance performed with no parts replacement; Scheduled inspections/maintenance; and Phase maintenance inspections. See Figure 1 below.

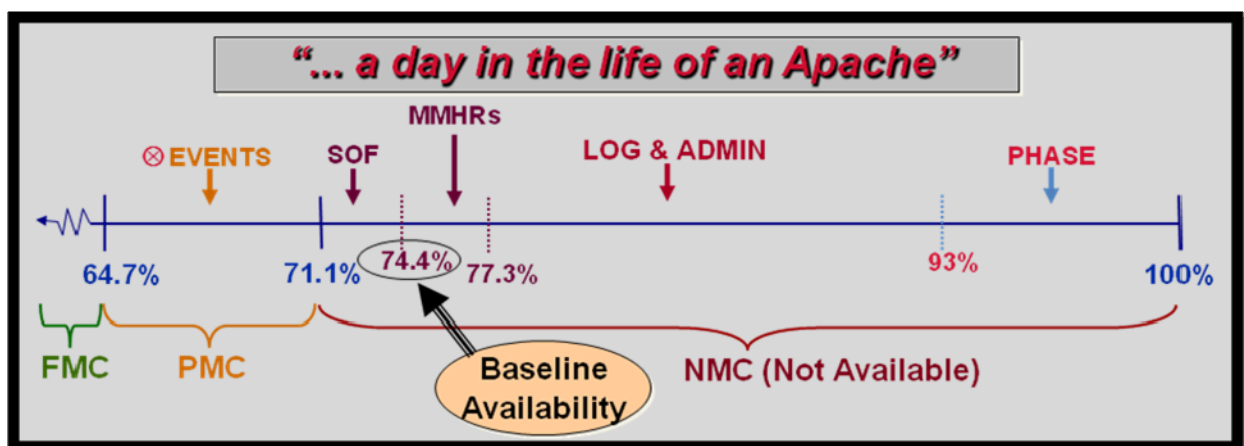


Figure 1: Scheduled Phase Maintenance is a contributor to Aircraft Availability

<sup>1</sup> Presented at the American Helicopter Society CBM specialist Workshop, Huntsville, AL: February 10, 2009. Copyright © 2009 by the American Helicopter Society International, Inc. All Rights reserved.

Enhanced Safety is achieved by Usage Monitoring and understanding the actual affects of the maneuvers and environments. Instead of using flight hours as the criterion for retiring a component, actual aircraft usage can be used to monitor cumulative damage to the component. The components may then be retired much later with this more accurate approach. If the actual usage is more severe for a specific aircraft or group of aircraft, early retirement based on the actual usage enhances safety.

Usage-Based Maintenance Philosophy offers the potential to make significant savings to the maintenance burden (also affecting aircraft availability and O&S costs). The rationale for this new philosophy is that Design Usage Spectrum which drove the OEM original maintenance and Maximum Allowable Operating Time (MOAT)/Retirement Time intervals are assumed 'Worst-On-Worst' case with an added risk factor for a conservative safe-life approach. Composite spectrums are intentionally conservative to cover all missions envisioned at the time of system development. However, analysis shows that the most damaging regimes are not experienced in most common missions.

The End-State objective, in figure 2 below, is to order an aircraft component in the supply system, not based on time, but on damage accrued to that component (how it was flown, in which environment, in which missions (Training, High Alt, Low Alt, Combat, Iraq, Afghanistan, S. Korea, etc.)). Actual Usage Spectrums will be used to retire and maintain parts from a *part number* prospective. Selected parts tracked by *serial numbers* can be replaced based on the Remaining Useful Life (RUL) calculated from individual aircraft usage monitoring. This will establish maintenance, operations, and sustainment based on Individual Aircraft Tracking (IAT) and Loads/Environment Spectra Surveys (LESS) (Ref 1).

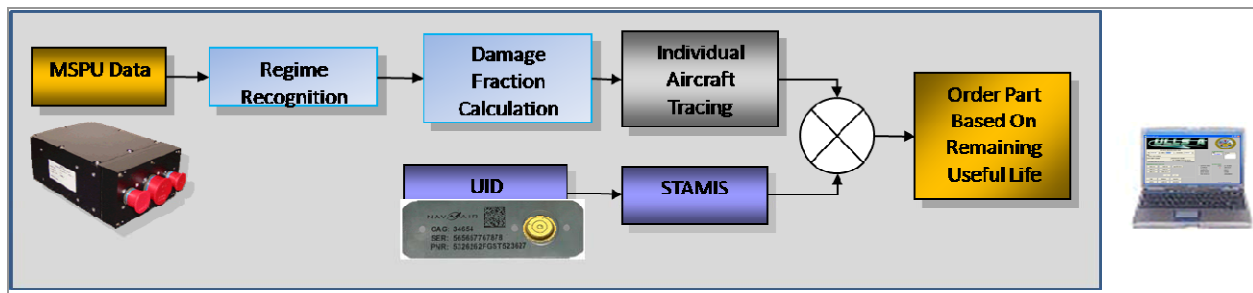


Figure 2 End-State: Order a New Part Based On Accumulated Damage/Remaining Useful Life (RUL).

## Introduction

Fatigue Life Management (FLM) is a Condition Based Maintenance (CBM) technical initiative to extend useful lives of Fatigue Life Limited Components (FLLC) through the combined application of Remediation and Regime Recognition (RR). The purpose of the initiative is to continuously improve the aircraft's readiness, maintainability, and component service life without negatively impacting the safety or reliability of the aircraft system.

FLLC are those components whose service lives are limited due to the cyclic loading environment found in rotary-winged aircraft. Most of these components are critical to the aircraft's safety of flight and therefore were initially given very stringent criteria and limits on allowable damage (knicks, dings, scratches, etc) and repairs. These components' maintenance schedule and retirement life is currently based on allowable physical damage criteria and aircraft flight hours. A CBM approach to fatigue life management must therefore address both the fatigue lives of these critical components as well as the physical damage and the associated repair limits.

The approach for fatigue life management requires incorporation of fleet data to establish maintenance requirements. For structural components managed by safe life methodology, the incorporated data are the aircraft's usage environment and damage criteria (corrosion, nicks, wear, etc.). These parameters will be compared to values established in the design qualification process to determine the potential for enhancement of fatigue life management of Army aircraft. The actual loads environment (usage monitoring) will be compared to the design loads established during flight loads survey(s). The actual fatigue damage experienced by fielded

components will be compared to the limits conservatively established during the program design phase. These design damage limits are established with the objective of minimizing any impact that repairable damage might have on the parts fatigue strength and resulting safe life. Field experience has demonstrated that the optimum service life of the component does not result when fielding parts with *minimal* damage and repair limits. Efforts completed to date comparing fleet data to qualification data and established damage limits reveal the potential for increases in safe lives and/or damage limits in certain regions (zones) of dynamic components. The incorporation of *actual fleet usage and damage experienced by parts during service* reduces the uncertainty of these parameters that existed in the design and qualification phases. The effect of using fleet data versus design data for establishing maintenance requirements is an increase in service life and a more realistic inspection schedule for most parts. The benefit is improved fleet readiness at a lower life cycle cost while maintaining system level reliability against a catastrophic material failure. AED Structures and Materials Division (SMD) is proposing a two-pronged approach, utilizing Regime Recognition (RR) and/or Loads Monitoring to manage component service lives in conjunction with a component Remediation program to increase the useful service lives of parts damaged in the field. Both of these initiatives and their relationship to each other will be discussed in detail in the following pages.

Regime Recognition, loads monitoring, and component remediation are inextricably linked within the overall program. Each topic will be discussed separately as well as collectively.

## Background

The fatigue lives of dynamic components on the AH-64 are based upon the interaction of three variables: the fatigue strength of each component, the measured flight loads, and the design usage spectrum.

The fatigue strength of each component is established by locating the material S-N (applied load vs number of cycles) curve through the results of laboratory fatigue tests. The tests are typically run at a constant load amplitude for a given number of cycles to failure. Testing each specimen to failure allows the mean of the full scale specimen population to be established. The shape of the S-N curve varies by material type and part details (stress risers) and is normally established by coupon testing. A reduction from the mean curve to a “working curve” provides a degree of reliability that the strength used in the life

calculation will address potential scatter in the strength of fielded parts. The typical reduction is 3 standard deviations ( $\sigma$ ), but may vary depending upon the number of specimens tested and the fatigue methodology of the OEM. No adjustment is incorporated for a sample of six (6) or more when establishing the mean population strength. For a normal strength distribution, a 3 sigma reduction from mean strength insures that only 1.35 parts per thousand will have fatigue strength lower than the minus 3 sigma value. Populations of less than six test specimens require an additional reduction from the mean curve to account for statistical considerations. A typical S-N curve for the Apache Main Rotor Truss Lug based on 6 full-scale specimens is shown in Figure 3.

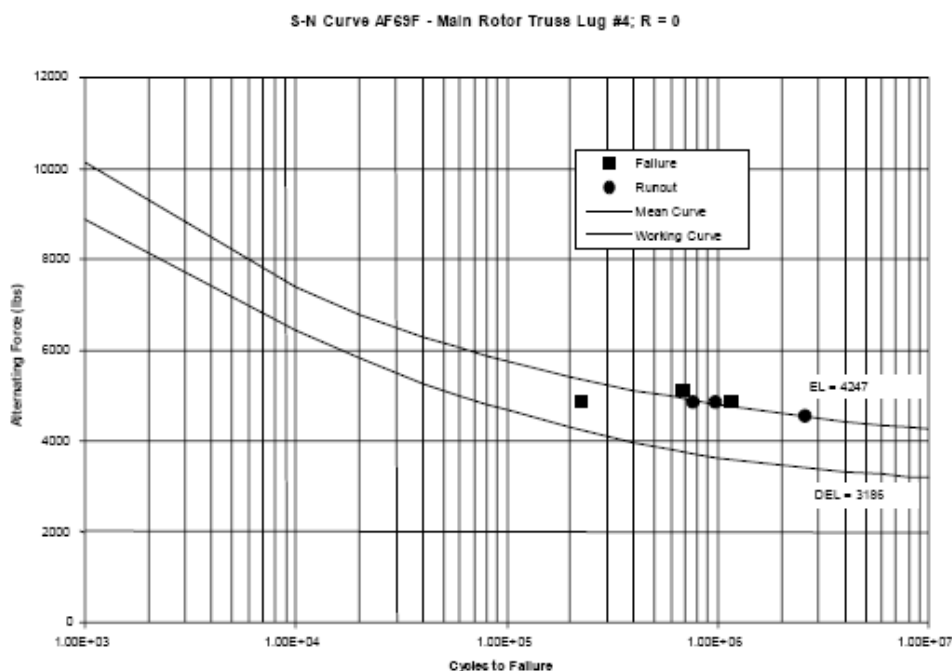


Figure 3: S-N Curve construction based upon six fatigue test specimens.

Maneuver loads measured during the flight loads survey (sometimes called flight strain survey) portion of qualification testing characterize the loads used to calculate the fatigue lives. Each maneuver in the usage spectrum is performed to record the loads (strain) versus time data for all critical dynamic components. The number of times each maneuver is conducted depends upon the OEM methodology and the qualification requirements specified in the statement of work. Significant changes in aircraft configuration or mission will require that a new flight loads survey be conducted to assess the impact on service lives of aircraft dynamic components. Some programs have as few as one set of data points for each maneuver while others have more. Load variability will be considered when planning the survey. Load variability introduces some uncertainty into the reliability of the life calculation and must be addressed to meet Army system level reliability goals. Loads of special interest includes loads from combat maneuvers, maneuver to maneuver loads and ground-air-ground (GAG) loads. To date, considerable attention has been given to the variability of maneuver loads. However, for many parts, the uncertainty in maneuver to maneuver and GAG loads/frequencies must be minimized to achieve maximum CBM benefits.

The design usage spectrum is the third component of the fatigue life calculation. It is primarily based on either the anticipated use of the aircraft (in the case of a newly developed aircraft) or the understanding of how the aircraft is currently being used. Initial design usage spectrums are developed by considering the missions that the User Community expects the aircraft to perform, identifying missions of similar existing aircraft, and discussions with the OEM on anticipated aircraft capabilities. Once the

aircraft are fielded, usage spectrums can be updated by conducting pilot interviews to determine how the aircraft are actually being used and modifying the spectrum to capture any significant differences between the expected and actual usage. Once the usage spectrum is updated, the retirement lives of the dynamic components are adjusted to capture the current use of the aircraft. The usage spectrum is the least scientific of the three components due to the means by which it is established (pilot sampling by interview). Therefore, a conservative approach is taken whenever possible to avoid underestimating. The commonly used Composite Worst Case approach combines the most significant events from each of the different missions an aircraft may fly and assumes that they will all happen with a certain frequency during each mission. The AH-64 currently has six usage spectrums in an attempt to limit excessive conservatism. An example is decoupling the frequent landings of the training mission from the heavier gross weight configurations flown by fielded units. The latest two spectrums incorporated combat maneuvers. The lowest retirement life resulting from any of the spectrums is utilized for safe life management.

### **Regime Recognition and Loads Monitoring**

Regime Recognition (RR) is an approach for validating or refining the design usage spectrum in the calculation of component retirement lives. RR involves the measurement and recording of flight parameters via a flight data recorder or digital source collector (DSC) and the aircraft data bus to identify the maneuvers flown by an aircraft on a given mission. The flight parameter data can be quickly downloaded after each flight to a ground station. Established algorithms are used to

identify the individual maneuvers performed during the flight, their severity, and their duration. This data will be used to validate and adjust the aircraft usage spectrum and form the basis for component retirement lives. Once the process is mature, damage tracking software could then take the maneuvers identified during a given flight and use the load associated with those maneuvers (established during the flight loads survey) to calculate the fatigue damage incurred on each component during that flight. The total damage incurred will consist of within maneuver, maneuver to maneuver, and GAG damage. Within maneuver damage, adjustments must be incorporated for time duration based on the dependency of damage to duration. For those maneuvers where damage occurs primarily during the onset and recovery portions, damage does not have a high correlation with maneuver duration. For those maneuvers that create damage on a per revolution basis, there will be a high correlation between duration and damage. The software will then track the cumulative damage on each component and provide guidance to maintenance personnel when a component is reaching its maximum allowable retirement life. RR can be used to either improve the accuracy of the current usage spectrum (enhancing data from pilot interviews) or to replace the usage spectrum by tracking damage based on damage fraction. It should be noted that an updated usage spectrum will be required for utilization during those periods of time when the monitoring system is inoperative and for management of parts where there are no readiness or cost benefits resulting from direct tracking. The use of RR should result in extending retirement lives for most components because the current spectrums are thought to be very conservative. In addition, RR will enhance safety for any component for which the current spectrum is

unconservative. Both results represent improvement over the current approach.

### **Implementation**

This paper is proposing a Five Phase CBM approach for fatigue life management improvements on the AH-64 aircraft. The following paragraphs describe each phase:

#### **Phase I: Overall Concept Feasibility**

Phase I of the RR Program has five (5) objectives and associated efforts. These objectives are: 1) identify data requirements and methodology for updating the usage spectrum(s), 2) identify parts with potential for readiness and cost benefits as direct monitoring candidates, 3) identify the maneuvers, conditions and configurations that are significant for fatigue life management, 4) establish a methodology for accounting for within maneuver, maneuver to maneuver and GAG damage while maintaining system level reliability, 5) demonstrate that RR algorithms can accurately provide the data required for updating the usage spectrum and for performing damage calculations of candidate parts.

#### **Phase II: Regime Recognition System Field Trial**

Phase II of the effort will involve evaluating the data from the field to update the usage spectrum(s). The damage fraction calculations will be executed in compliance with the methodology established during phase I, effort 4. Damage fraction calculations utilize recorded field data with the loads measured in flight loads survey. Frequency of maneuver occurrence will be based on actual fleet data not the worst-on-worst case predictions. The goal of this phase will be to demonstrate the ability to determine fatigue damage levels and remaining component life based upon its actual rather than predicted use. An additional

requirement is to determine the damage fraction used to maintain the required component and system level reliability (ref 2,3).

### **Phase III: Individual Aircraft Tracking**

Phase III of the RR program on the AH-64 will be to implement the results of Phase II across the aircraft fleet. This will be accomplished by equipping the fleet with data recorders and monitoring the maneuvers flown on each mission by individual aircraft. This data will be compiled and sorted to determine the actual maneuvers performed on a fleet-wide basis and the percentage of time (duration and frequency) associated with each maneuver. This information will then be incorporated into a composite usage spectrum based on actual flight data, supported by continued pilot interviews. This is significant because one of the more serious weaknesses of the current interview approach is that pilots have difficulty describing how they perform a specific mission in a “maneuver by maneuver” manner. They have even greater difficulty assigning severity or load factors to those maneuvers. Actual measurement of the aircraft usage is critical to understanding the resulting impact on fatigue lives. Pilot interviews will continue to supplement this approach because their input provides valuable insight for understanding the how and why of mission execution. For this reason, continued periodic pilot interviews are planned as a part of RR. The updated usage spectrum(s) will then be used in combination with the measured flight loads and fatigue strength to generate new retirement lives for all AH-64 fatigue critical items. This will require an engineering evaluation of past and current aircraft missions and the severity of each. Once established, the component retirement lives listed by part number (PN) in the maintenance manuals and DMWRs will

need to be updated as will the Fatigue Substantiation report for the AH-64.

### **Phase IV: Individual Component Tracking**

Phase IV considers the initial three phases of the RR initiative and uses that information to manage fatigue critical components on an individual component basis. For those components identified in phase I, item 2 as candidates for direct monitoring, damage fraction will be calculated based on the actual usage of each individual aircraft or serial number. The initial/interim approach will be to perform the service life calculations offline with the goal of onboard life calculations. The retirement life of directly monitored components will be based on accumulated damage fraction with updating of remaining useful life. This retirement life will be managed through the aircraft’s electronic logbook as the data is downloaded from the aircraft after each flight. The remaining useful life (prior to retirement) of each serialized fatigue critical component will be updated after each flight. Maintenance personnel will have real-time access to identify any components approaching retirement due to accumulated fatigue damage.

### **Phase V: Loads Monitoring**

Phase V utilizes continuous strain measurements either in the fixture airframe structure or rotor system to determine the fatigue damage. This approach is known as “loads monitoring”. Loads monitoring involves the measurement and monitoring of actual loads being experienced by the aircraft components rather than assigning previously measured loads to maneuvers as is done in Phase IV. This approach is much more accurate than the current approach. The current approach applies loads measured during the flight loads survey to those maneuvers flown by all other Army pilots in

their fielded environments and aircraft configurations. The “loads variability” between the flight loads survey measurements and the actual loads experienced in the fielded aircraft is eliminated under the loads monitoring approach. Once the data is downloaded after the flight, the maintenance personnel can update the remaining useful lives of all of the aircraft’s dynamic components. Maintenance can be scheduled to replace components based upon *accumulated fatigue damage*. The goal is to evolve to onboard life calculations.

### **Remediation**

Regime Recognition is an important element of the Apache Fatigue Life Management Program. Increasing the retirement lives of Apache dynamic components is effective only when components are not removed for other causes before they reach that life. Based upon a review of field data, only 23% of Apache dynamic components reach their retirement life before being removed from service. The remaining 77% of Apache dynamic components are removed from service prior to this time for other reasons, primarily damage due to nicks, scuffs, or corrosion. This is where the second element of the FLM program, Remediation, becomes crucial. Remediation is a process by which aircraft components, which would otherwise have been condemned due to their perceived condition, have their useful service lives extended beyond what is currently allowable through a combination of analysis and testing. The goal of the Apache FLM Remediation Program is to improve the useful life of Apache dynamic components by increasing the damage and repair limits

or by trading “excess” fatigue life for more lenient damage limits.

When new components are designed, the analytical and testing effort used to establish and qualify the designs is not typically carried over into the life cycle aspects of the components. Detail drawings specify the allowable manufacturing tolerances. Required processes, analysis, and testing is performed to qualify the part. This engineering effort does not usually extend to parts outside of this “pristine” envelope. Once fielded, damage limits are established by OEM maintenance engineers, typically by the application of “best practices” and consideration of the processes and tolerances of the drawing. This is typically done with some oversight from the OEM Structural Engineering group. Typical damage to the part is unknown. As a result, limits tend to be conservative. The limits are then published in Technical Manuals (TM’s) and Depot Maintenance Work requirements (DMWRs) and they determine whether the part can remain in service, repaired and returned to service, or condemned. Despite the engineering efforts to validate and qualify the pristine “as manufactured” components, structural analyses and testing are almost never performed to support the damage limits used once the part is fielded.

### **Phase I: Component Identification.**

Phase I of the Apache Remediation program involved identifying dynamic components with damage criteria that allow little or no damage or repair.

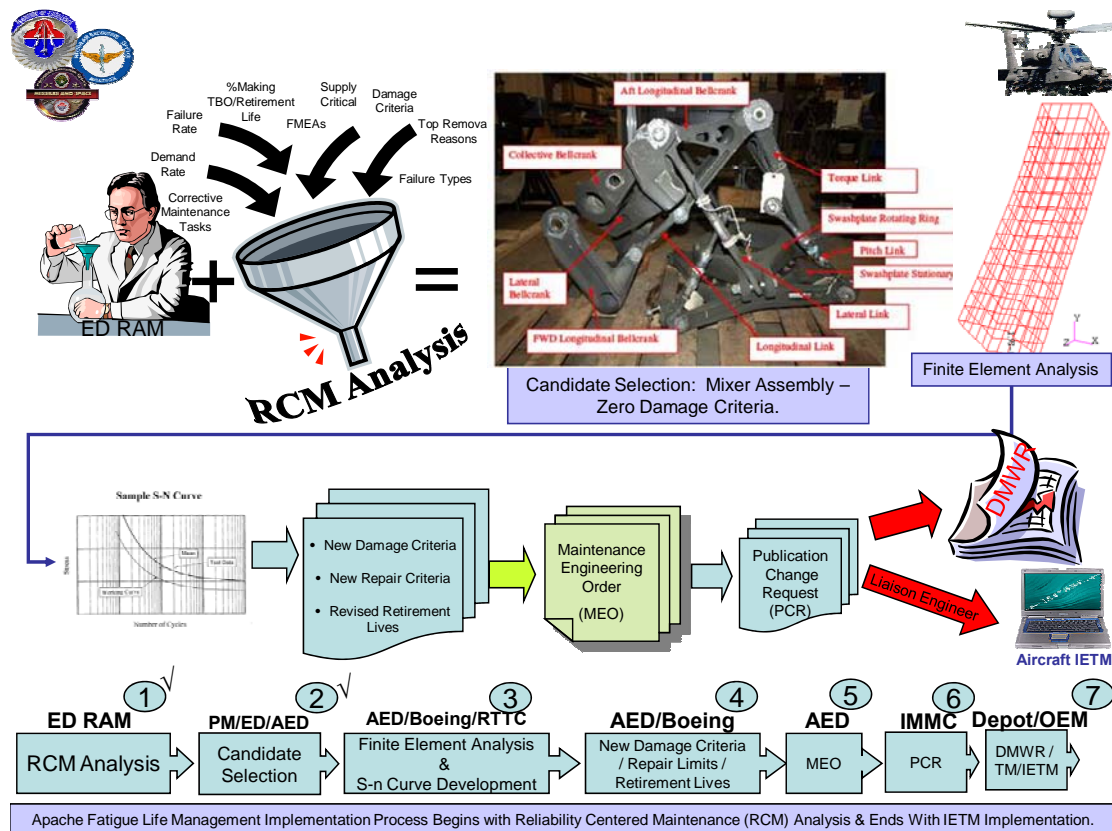


Figure 4: Apache Fatigue Life Management Process Seeks To Increase Damage Criteria At the Aircraft IETM and Depot Repair Procedures

Furthermore, a Reliability Centered Maintenance (RCM) Analysis was used to include additional criteria such as component cost, parts shortages, and other logistical considerations, (Figure 4). Based upon guidance from the Apache Program Manager's office, eight Apache components have been funded as remediation candidates at this time. These components, shown in Figure 5, are the Lateral Link Assembly, the Longitudinal Link Assembly, the Lateral Bellcrank Assembly, the Forward Longitudinal Bellcrank Assembly, the Collective Bellcrank Assembly, the Aft Longitudinal Bellcrank Assembly, the Torque Arm Assembly, and the Support Bolt. These components are removed from service and condemned if they are found to be damaged beyond existing repair limits.

## Phase II: Damage Characterization.

Phase II involves identifying meaningful damage limits based on field experience and inspection results. Historical data, including 2410 information, will be reviewed to identify causes of removal for these parts. In addition, these parts will be inspected as they come into CCAD. The parts will be categorized according to type, degree, and location of damage to establish a damage database. Digital photographs of the damage will be taken and loaded into the searchable RIMFIRE database. Once sufficient data is collected to characterize typical component damage, detailed Finite Element Analysis of these components will be conducted to identify the stress levels associated with this damage before and after a typical repair (such as a blendout). This

analysis effort will identify areas that have the potential for repair without impacting fatigue life. This effort will utilize the ongoing ARL fatigue testing of repaired coupons that will substantiate the degree that damage can be healed (shot peening) and will establish material strength reductions (if any). The fatigue strength analysis will compare the repair location with the critical part fatigue location normalizing the influence of different stress gradients and R ratios. A 15% analytical margin of safety will be maintained. Fatigue testing will be performed to qualify the repair for any

locations/parts where this analytical approach produces an unacceptable fatigue life. This will require the development of new fatigue fixtures in some cases. The results from the tests will be used to support the remediation concept and to identify the reduction in fatigue strength, if any, that is associated with that repair. The revised fatigue strength will then be considered along with the usage spectrum and the loads to determine the residual retirement life based upon the repair.

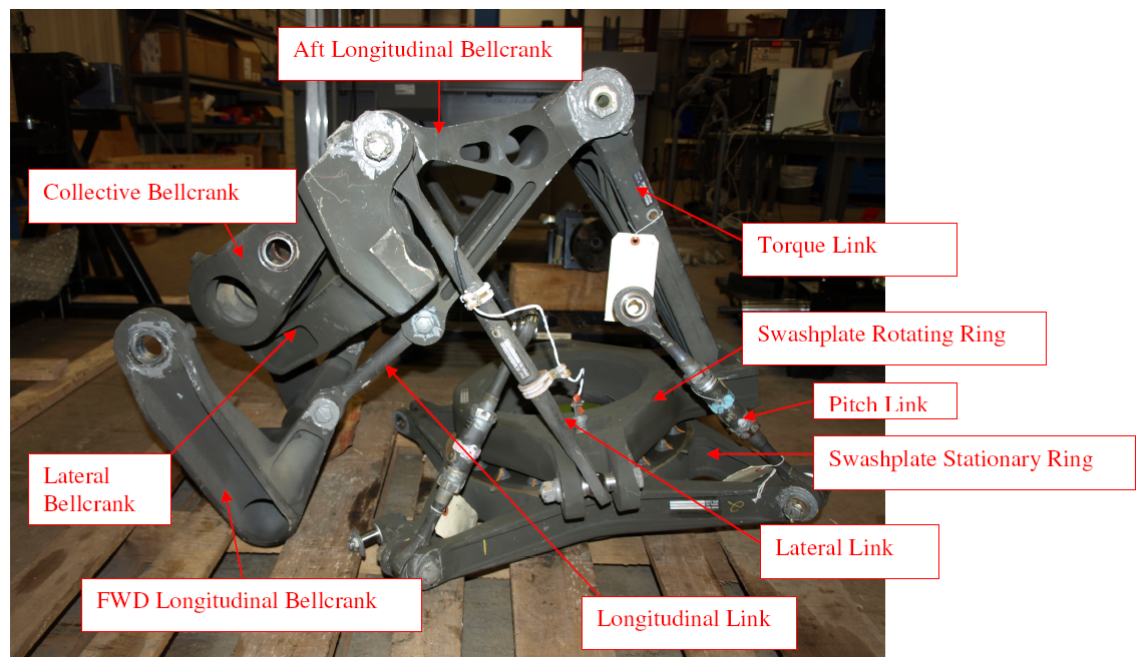


Figure 5: Apache Control Components

**Phase III: Damage Limit Revision.** The Phase III effort will document the revision of current damage limits and “rezoning” of damage criteria. The parts will be “zoned” to identify the repairable damage limits and the repair process for each zone. Once acceptable damage limits and locations have been identified and repair procedures and associated retirement lives determined, the maintenance documents associated with these parts will need to be revised (Figure 6). DMWRs for these parts will need to be prepared showing allowable damage, repair limits and procedures, and associated processes. Maintenance TMs will be updated with new inspection criteria and any retirement life changes. This will include the Interactive Electronic Technical Manuals (IETMs) and the Standard Army Management Information System (STAMIS) inspection requirements.

### **Fatigue Life Management Synergy**

Regime Recognition (RR) and Remediation have the potential to significantly benefit Army aviation. The Army can better and more accurately understand how its aircraft are being flown in service ensuring that the usage spectrum associated with Apache aircraft is both accurate and appropriate. RR provides the potential for increasing individual component service life by basing it upon actual usage/loads. Remediation provides a path by which expensive damaged parts that are currently condemned and discarded can be returned to service reducing cost and improving readiness. These two processes complement each other.

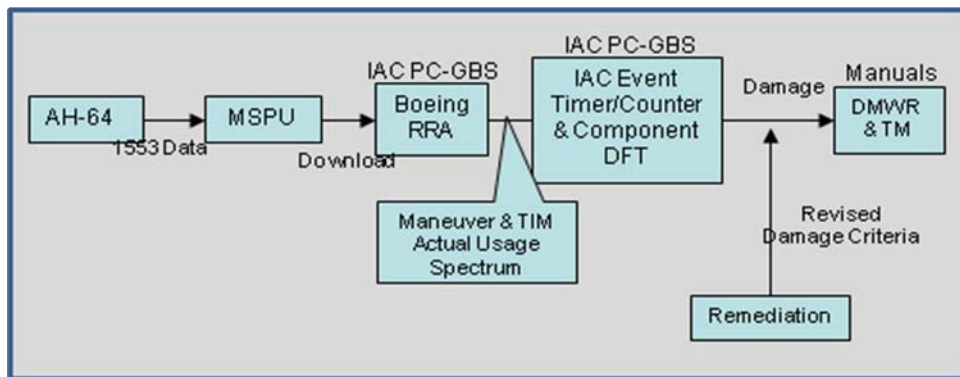


Figure 6: New Fatigue Lives/Revised Damage Criteria to DMWR/TMs

The design usage spectrum of the Apache aircraft is generally considered to be a conservative spectrum. This is intentional in that it must consider and account for maneuvers and missions performed by all of the aircraft and all of the pilots in all of the locations that Apache fights or trains. Therefore, a generic “one size fits all” approach is necessary to capture that “worst case” condition. The current spectrum was derived during the initial development of Apache and has been occasionally updated to reflect the results of pilot interviews. Once RR is implemented and the *actual* aircraft usage is known, the spectrum will be adjusted to reflect a less demanding spectrum that results in an increase in the retirement life of Apache components. Only 23% of Apache dynamic components reach calculated retirement time without being replaced for other reasons. Increasing the retirement lives of dynamic components will not result in a significant cost or readiness improvement unless a solution can be found to keep the parts that currently do reach retirement in service longer. The remediation addresses the majority of dynamic components. By increasing damage limits and qualifying repairs in areas that are currently off limits, remediation will allow a portion of the 77% of components not aided by RR to benefit from those increased retirement lives.

Remediation improves the effectiveness of RR by increasing the population of components to which it can be applied. RR can also have a significant positive improvement in the outcome of the remediation process. The purpose of fatigue testing is to identify the component’s fatigue strength. When a component is fatigue tested with typical damage, there are two possible outcomes; the component will either exhibit the same fatigue strength (no

impact from the damage in some non-critical locations) or the component will have reduced fatigue strength. Fatigue strength is one of the three factors (strength, usage, loads) used to determine the fatigue life. A reduced fatigue strength will always result in a life reduction for limited life components unless one of the remaining two factors can be improved to offset the strength reduction. RR allows a repaired component with lower fatigue strength that would be unacceptable under the current usage spectrum to be remediated with an acceptable fatigue life. The more a pristine component’s retirement life can be increased by improving the usage spectrum through RR, the better the odds are that a repair to a previously unrepairable component will provide economic value to the Army. Conversely, the more that the damage and repair limits on critical parts can be expanded, the more likely it will be that they will be able to reach the increased retirement lives made available under regime recognition. This concept is illustrated in Figure 7 below.

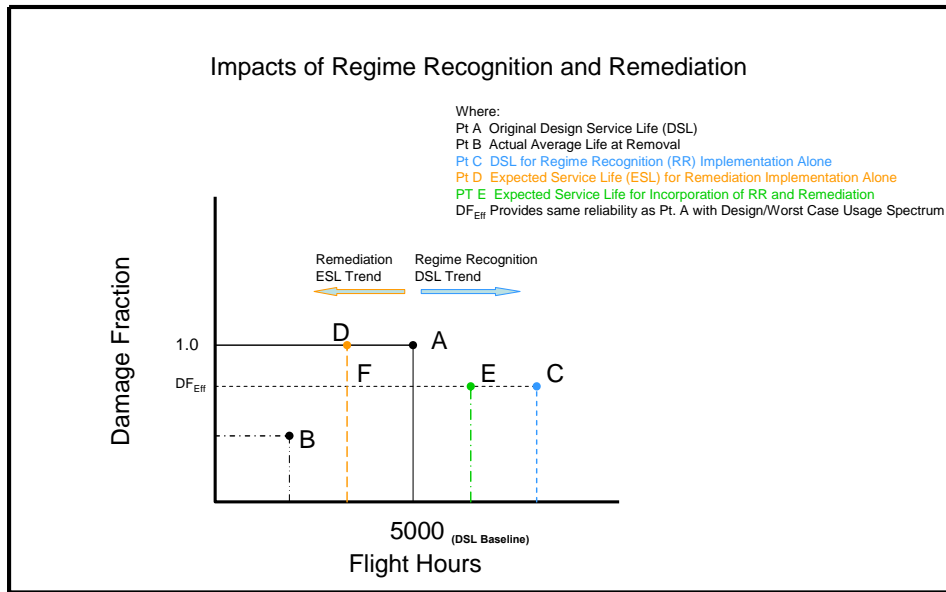


Figure 7: Combined Influence of Remediation and Regime Recognition.

Point A is the original 5,000 hour retirement life of a pristine specimen as determined through fatigue testing, flight loads survey measurements and the design usage spectrum. Point B represents the actual average life of the part as is usually removed prematurely because of damage that exceeds the current repair limits. Point C represents the implementation of RR, which is expected to increase the retirement life of the pristine specimen because the design usage spectrum is believed to be very conservative. The part is retired at a damage fraction less than one ( $DF_{Eff}$ ) to maintain the same reliability level as the original design/worst case usage spectrum. In an unusual instance where usage monitoring shows the design usage spectrum to be unconservative, the retirement life would be

reduced from the original life of 5,000 hours. Point D represents the trend due to implementation of remediation. Repairs and increased damage limits will either have no effect on the retirement life (coincident with point A) or will result in a reduced retirement (trending towards point D) since fatigue damage is accumulated more quickly due to higher local stresses and the introduction of stress concentrations. Point E demonstrates the trend expected through the combined application of Remediation and RR. Point E could be located anywhere along the horizontal line between Point C and the intersection F. It is important to note that points C, D, and E represent increases in retirement life beyond Point B, which is the current average life at removal.

## Conclusion

In conclusion, when used together, both Remediation and Regime Recognition (RR) produce an achievable fatigue life. *Remediation* returns dynamic components to service which would otherwise be condemned due to damage experienced while in service. *Regime Recognition* (RR) provides an achievable approach to understanding the current usage of the Army's Apache helicopters. Due to the assumed conservative nature of the existing usage spectrum, it seems likely that the retirement lives of some Apache dynamic components can be increased by implementing this program. *Regime Recognition and Remediation* clearly complement each other, so it is recommended that they be implemented in a parallel path to achieve the highest return on investment. The *Fatigue Life Management* (FLM) process described combines these initiatives and represents a significant opportunity to reduce cost and improve readiness by increasing the useful life of Apache dynamic components. The bullets below identify benefits from a combined program.

- Remediation optimizes expanded damage limits, enhancing the design usage spectrum to get more useful parts life.
- Spare parts removal and replacement costs will be lowered.
- Reduced demand rates will be obtained as parts are staying on-wing longer.
- Reduced Non Mission Capable For Supply (NMCS) – Parts on wing longer, aircraft not down waiting for supply.
- Usage - Regime Recognition provides increased engineering rationale to replace historical design assumptions with actual aircraft usage and environmental measurements.
- On-condition replacement. Only remove parts when fatigue life is expended. Increased Availability.
- Reduced Maintenance Man Hours as parts are on-wing longer, not replacing parts as often.
- Reduced collateral damage – not incurring damage associated with parts removal.
- Revised Inspection Intervals (as needed) - Fracture mechanics analysis with Regime Recognition will provide the basis for revising the inspection intervals. Reduces Soldier Burden.
- Improved Load Understanding – Enabling the study and characterization of the relationship between maneuver performance and loads to minimize conservatism.
- Enhanced Pilot Training – Enables pilot training to minimize fatigue damage due to flight loads. Providing insight into maneuver severity and the relationship to airframe and component fatigue damage.
- Usage and Damage Fraction Accrual - Provides risk management on a component by components basis (i.e., parts tracking), which will increase the 'on-wing' time of aircraft components.
- Maintain System Level Reliability by Monitoring Individual Component Damage Fraction.
- Reduced NMCM (S) – Scheduled maintenance is optimized

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