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Aeronautical Design Standard 79-A Handbook

For

Conditioned Based Maintenance Systems on US Army Aircraft

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Abstract

The purpose of this paper is to provide the widest dissemination of the Army"s efforts to further Condition Based Maintenance (CBM) which is documented in Aeronautical Design Standard 79-A Handbook (ADS-79A HDBK). The Army has spent over ten years and hundreds of millions of dollars to refine a practical approach to implementing CBM and is pioneering end-user benefits from CBM (with about half the fleet equipped with monitoring systems). The Handbook outlines the engineering approach for obtaining maintenance credits utilizing four proven methodologies. These four methodologies are: Embedded Diagnostics (vibration monitoring), Fatigue Damage Monitoring, Regime Recognition, and Fatigue Damage Remediation.

ADS-79A HDBK describes the Army"s various CBM systems and defines the overall engineering guidance necessary to achieve the CBM goals and objectives for Army Aviation rotary wing helicopters. Future versions of the Handbook will provide guidance for Unmanned Aerial Systems (UAS) as well. The ADS-79 HDBK was first published in January 2009 and is updated on an annual basis. Feedback on the contents of the Handbook are solicited and highly encouraged from all facets of the aviation community during the annual update cycle. ADS-79-A HDBK provides guidance and standards to be used in development of the data, software and equipment to support Condition Based Maintenance (CBM) for systems, subsystems and components of US Army rotary wing helicopters. This guidance can be readily adapted by other governmental agencies (US and foreign) as well as commercial implementations.

The purpose of Condition Based Maintenance is to take maintenance action on equipment where there is evidence of need. Maintenance guidance is based on the condition or status of the equipment instead of specified calendar or time based limits such as Maximum Operating Time (MOT) while preserving the system baseline risk. The key to implementing CBM is to „right size" CBM for the targeted platform. This is achieved by defining what is practical to implement vs. attempting to implement condition based maintenance on all possible equipment. The Design Handbook describes the elements that enable the issuance of CBM Credits, or modified inspection and removal criteria of components based on measured condition and actual usage utilizing systems engineering methods proven by Army Aviation Engineering Directorate"s team of highly skilled engineers.

CBM is a set of maintenance processes and capabilities derived primarily from the real time assessment of system condition which are obtained from embedded sensors and/or external test and measurements using portable equipment. This paper will examine the general guidance and associate required reliability guidance (validation) for Embedded Diagnostics, Fatigue Damage Monitoring, Regime Recognition, and Fatigue Damage Remediation. The paper will further examine specific guidance in areas such as State Detection, Data Acquisition, Health Assessment, Prognostics Assessment, Modifying Maintenance Intervals, Seeded Fault Testing, and the creation of the CBM Management Plan.

Discussion

Background

CBM is dependent on the collection of data from sensors and the processing, analysis, and correlation of that data to material conditions that require maintenance actions. Maintenance actions are essential to the sustainment of air vehicles to standards that insure continued airworthiness.

Data provide the essential core of CBM, so standards and decisions regarding data and their collection, transmission, storage, and processing dominate the requirements for CBM system development. CBM has global reach and multi-systems breadth, applying to everything from fixed industrial equipment to air and ground vehicles of all types. This breadth and scope has motivated the development of an international overarching standard for CBM. The ISO standard, “Condition Monitoring and Diagnostics of Machines,” [1] provides the framework for CBM.

This handbook is supported by the Machinery Information Management Open Standards Alliance (MIMOSA), a United States organization of industry and Government, and published as the MIMOSA Open Systems Architecture for Condition Based Maintenance (OSA CBM) [2]. The standard is embodied in the requirements for CBM found in the Common Logistics Operating Environment (CLOE) component of the Army‟s information architecture for the Future Logistics Enterprise. The ISO standard, the OSA CBM standard, and CLOE all adopt the framework shown in FIGURE 1 for the information flow supporting CBM with data flowing from bottom to top.

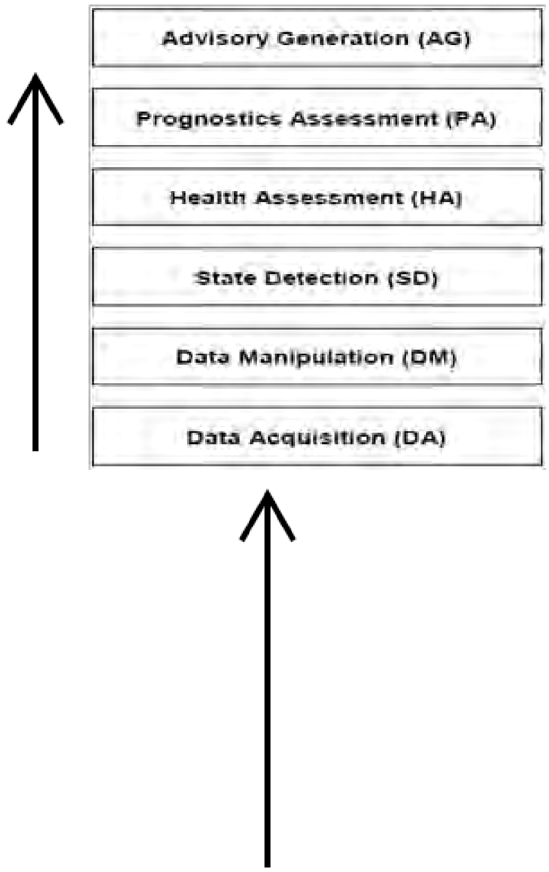

FIGURE 1: ISO-13374 Defined data processing and information flow

CBM practice is enabled through three basic methodologies. Each methodology must be based in physics. CBM benefits are achieved by reducing the uncertainty of the original design (while maintain baseline risk). The three methodologies are embedded diagnostics, usage monitoring, and fatigue life management. These methodologies are discussed further below.

1. Embedded diagnostics for components that have specific detectable faults (example, drive systems components with fault indicators derived from vibratory signature changes and sensors acceptable for tracking corrosion damage).

2. Usage monitoring, which may derive the need for maintenance based on parameters such as the number of power-on cycles, the time accumulated above a specific parameter value or the accumulation of a number of discrete events. Within this context, specific guidance is provided where benefits can be derived.

3. Fatigue life management, through estimating the effect of specific usage in flight states that incur fatigue damage as determined through fatigue testing, modeling, and simulation.

Embedded Diagnostics

Health and Usage Monitoring Systems (HUMS) have evolved over the past several decades in parallel with the concepts of CBM. They have expanded from measuring the usage of the systems (time, flight parameters, and sampling of performance indicators such as temperature and pressure) to forms of fault detection through signal processing. The signal processing typically recorded instances of operation beyond prescribed limits (known as "exceedances"), which then could be used as inputs to troubleshooting or inspection actions to restore system operation. This combination of sensors and signal processing (known as "embedded diagnostics") represents a capability to provide the item"s condition and need for maintenance action. When this capability is extended to CBM functionality (state detection and prognosis assessment), it should have the following general characteristics:

a. Sensor Technology: Sensors should have high reliability and high accuracy and precision. There is no intent for recurring calibration of these sensors.

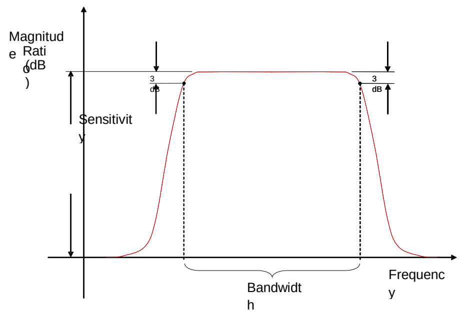

Figure 2. Sensor response characteristics

b. Data Acquisition: Onboard data acquisition hardware should have high reliability and accurate data transfer.

c. Algorithms: Fault detection algorithms are applied to the basic acquired data to provide condition and health indicators. Validation and verification of the Condition Indicators (CIs) and Health Indicators (HIs) included in the CBM system are required in order to establish maintenance and airworthiness credits, inherently a government function. Basic properties of the algorithms are: (1) sensitivity to faulted condition, and (2) insensitivity to conditions other than faults. The algorithms and methodology should demonstrate the ability to account for exceedances, missing or invalid data.

HUMS operation during flight is essential to gathering data for CBM system use, but cannot be flight critical or mission critical when it is an independent system which obtains data from primary aircraft systems and subsystems. When this independence exists, the system should be maintained and repaired as soon as practical to avoid significant data loss and degradation of CBM benefits. As technology advances, system design may lead to more comprehensive integration of HUMS with mission systems. The extent of that future integration may lead to HUMS being part of mission or flight critical equipment or software. In this case, the HUMS bear the same priority as mission or flight critical equipment relative to the requirement to restore its proper operation and requires the same level of software qualification as all flight critical systems. The US Army does not intend to make HUMS a critical system. The flight of the aircraft must be permitted if HUMS is inoperative.

Health Assessment

Health assessment is accomplished by the development of HIs or indicators for maintenance action based on the results of one or more CIs. HIs should be indexed to a range of color-coded statuses such as: green (nominal – no action required), yellow (elevated advisory – watch/prepare for maintenance), orange (caution/remaining life limited-schedule and perform maintenance when optimal for operations), and red (warning/increased risk-ground aircraft/maintenance required. Each fault should contribute to the determination of the overall health of the aircraft. Status of the equipment should be collected and correlated with time for the condition during any operational cycle.

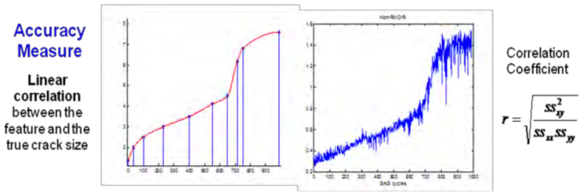

***FIGURE* 3. An example correlation of fault dimension and HI/CI value**

Prognostic Assessment

Using the description of the current health state and the associated failure modes, the PA module determines future health states and remaining useful life (RUL). The estimate of RUL should use some representation of projected usage/loads as its basis. RUL estimates should be validated during system test and evaluation, and the estimates should show 90% or greater accuracy to the failures observed. For Army aviation CBM, the prognostics assessment is not required to be part of the onboard system.

The goal of the PA module is to provide data to the Advisory Generation (AG) module with sufficient time to enable effective response by the maintenance and logistics system. Because RUL for a given fault condition is based on the individual fault behavior as influenced by projected loads and operational use, there can be no single criteria for the lead time from fault detection to reaching the RUL. In all cases, the interval between fault detection and reaching the removal requirement threshold should be calculated in a way that provides the highest level of confidence in the RUL estimate without creating false positive rates higher than 5% at the time of component removal.

Modifying Maintenance Intervals

A robust and effective CBM system can provide a basis for modifying maintenance practices and intervals. As part of the continuous analysis of CBM data provided by the fielded systems and or seeded fault testing, disciplined review of scheduled maintenance intervals for servicing and inspection can be adjusted to increase availability and optimize maintenance cost. Similarly, the data can be used to modify the maximum Time Between Overhauls (TBO) for affected components. Finally, CBM data can be used to transition from current reactive maintenance practices to a proactive maintenance strategy in a manner that does not adversely impact the baseline risk associated with the aircraft‟s certification.

Modifying Overhaul Intervals

In general, TBO interval extensions are limited by the calculated fatigue life of the component, unless the failure mode is detectable utilizing a reliable detection system and will not result in a component failure mode progressing or manifesting into a failed state within 2 data download intervals. A good example would be Hertzian Contact Fatigue Limit for bearings. Exceeding this limit would result in spalling, which is easily detected (through current methods or vibration monitoring) and also is associated with significant life remaining from the onset of spalling.

In the case of vibration monitoring, the capability of the monitoring system to accurately depict actual hardware condition should be verified prior to allowing incremental TBO increases. In addition, detailed analysis will be required to show that no other hardware restrictions, such as component fatigue life limits, are exceeded by before granting the TBO increase. Verification that CI‟s are representative of actual hardware condition will generally require a minimum of 5 detailed teardown inspections of the component to ensure commensurate confidence associated with the teardowns capturing the inherent variability that may occur with actual field usage. The results of these teardowns should confirm that the measured condition indicator value is representative of the actual hardware condition. Incremental TBO extensions should be limited to twice the current limit until the requirements of transitioning to on condition are satisfied.

It is possible to obtain TBO extensions on unmonitored aircraft through hardware teardowns on components at or near their current TBO. To extend overhaul intervals on unmonitored aircraft, a compelling case must be developed with supporting detailed analysis, enhanced or special inspections, and field experience. Final approval of the airworthiness activity is required. The criticality of the component and all associated failure modes should also be taken into account. These factors will also impact the required number of satisfactory teardowns and associated TBO interval extensions. TBO increases may be used as a valuable tool for accumulating the data needed to show confidence level/reliability of a monitoring system in support of CBM programs.

Transitioning to On-Condition

Prior to transition to On-Condition for legacy components/assemblies the requirements for modifying overhaul intervals should be met. Guidelines for obtaining on-condition status for components on monitored aircraft having performed seeded fault testing versus data acquisition via field faults are outlined in the Seeded Fault Testing and Field Fault Analysis paragraphs. Achieving on-condition status via field faults could take several years, therefore, incremental TBO extensions will be instrumental in increasing our chances of observing and detecting naturally occurring faults in the field. This also holds true for seeded fault selected components which have not completed the entire seeded fault test required to ensure each credible failure mode can be detected. Credible critical failure modes are determined through Failure Modes Effects Criticality Analysis (FMECA) and actual field data. Damage limits are to be defined for specific components in order to classify a specific hardware condition to a CI limit through the use of programs that capture and record the physical hardware condition of component in relationship to the CBM data available for that component. The Army utilizes such programs as the Reliability Improvement through Failure Identification and Reporting (RIMFIRE) or Structural Component Overhaul Repair Evaluation Category and Remediation Database (SCORECARD), Tear Down Analysis‟s (TDA), 2410 forms, and more to capture this information. Implementation plans should be developed for each component clearly identifying goals, test requirements and schedule, initial CI limits, and all work that is planned to show how the confidence levels in the Statistical Considerations paragraph will be achieved.

Seeded Fault Testing

Seeded fault testing may dramatically reduce the timeline for achieving on-condition maintenance status because it requires less time to seed and test a faulted component than to wait for a naturally occurring fault in the field. However, if during the seeded fault test program a naturally occurring fault is observed and verified, it can be used as a data point to help reduce the required testing. Test plans will be developed, identifying each of the credible failure modes and corresponding seeded fault tests required to reliably show that each credible failure mode can be detected. The seeded fault test plan should include requirements for ensuring that the test is representative of the aircraft. Also, on aircraft ground testing may be required to confirm the detectability of seeded faults provided there is sufficient time between detection and component failure to maintain an acceptable level of risk to the aircraft and personnel. An initial TBO extension could be granted, assuming successful completion of the prescribed seeded fault tests for that particular component and verification that the fault is reliably detected on the aircraft. A minimum of three "true" positive detections for each credible failure mode are to be demonstrated by the condition monitoring equipment utilizing the reliability guidelines specified in the Statistical Considerations paragraph in order to be eligible for on-condition status. TDA‟s will be ongoing for components exceeding initially established CI limits. Once the capability of the monitoring system has been validated based on three "true" positive detections for each credible failure mode, incremental TBO interval increases are recommended prior to fully implementing the component to on-condition status. The number of incremental TBO extensions will be based on the criticality of the component and will never increase the baseline risk for the aircraft as a whole.

Field Fault Analysis

The guidance for achieving on condition status via the accumulation of field faults are essentially the same as those identified in Seeded Fault Testing paragraph. Incremental TBO extensions will play a bigger role utilizing this approach based on the assumption that the fault data will take much longer to obtain if no seeded fault testing is performed. A minimum of 3 "true" positive detections for each credible failure mode are to be demonstrated via field representative faults utilizing the detection guidelines specified in the Statistical Considerations paragraph in order to be eligible for on-condition status. TDA"s will be ongoing for components exceeding initially established CI limits. Once the capability of the monitoring system has been validated based on three "true" positive detections for each credible failure mode, incremental TBO interval increases are recommended prior to fully implementing the component to on-condition status. The number of incremental TBO extensions will be based on the criticality of the component.

Statistical Considerations

We are interested in the likelihood that the monitoring system will detect a significant difference in signal when such a difference exists. To validate our target detection and confidence levels (target detection = 90%, target confidence = 90 to 95%). Depending on criticality component using a sample size of three possible positive detections, the minimum detectable feature difference is 3 standard deviations from the signal mean.

If at least one of the detections is a false positive, then evaluate to determine the root cause of the false positive. Corrective actions may involve anything from a slight upward adjustment of the CI limit to a major change in the detection algorithm. Once corrective action is taken and prior to any further increase in TBO, additional inspections/TDAs of possible positive detections is necessary to continue validation of the CI.

A false negative occurrence for a critical component will impact safety, and should be assessed or cleared to determine the impact on future TBO extensions. Each false negative event will require a detailed investigation to determine the root cause. Once corrective action is taken and prior to any further increase in TBO, additional inspections/TDAs of possible positive detections is necessary to continue the validation of the CI.

Components used for TDA and validation may be acquired through either seeded fault testing or through naturally occurring field faults.

Fatigue Damage Monitoring

Fatigue damage is estimated through calculations which use loads on airframe components experienced during flight. These loads are dependent on environmental conditions (example, temperature and altitude) aircraft configuration parameters (examples: gross weight (GW), center of gravity (CG)), and aircraft state parameters related to maneuvering (i.e.: air speed, aircraft attitudes, power applied, and accelerations). To establish these loads, regime recognition algorithms are used to take these parameters and map them to known aircraft maneuvers for which representative flight loads are available from loads surveys. In order to establish regime recognition algorithms as the basis for loads and fatigue life adjustment, the algorithms should be validated through flight testing.

Legacy aircraft operating without CBM capabilities typically use assumed usage, test established fatigue strength, and Safe Life calculation techniques to ensure airworthiness. Structural loading of the aircraft in flight, including instances which are beyond prescribed limits (i.e.: exceedances) for the aircraft or its components on legacy platforms typically use a rudimentary sensor or data from a cockpit display with required post-flight inspection as the means to assess damage. The advent of data collection from sensors onboard the aircraft, typically performed onboard an aircraft by a Digital Source Collector (DSC) enable methods that improve accuracy of the previous detection and assessment methods. The improvement is due to the use of actual usage or measured loads rather than calculations based on assumptions made during the developmental design phase of the acquisition.

Regime Recognition

A series of flights should be performed with a test aircraft that is fully equipped with the regime measurement package and additional recording systems for capturing data needed to evaluate and tune the algorithms. The regime recognition algorithms should demonstrate that they can define 97% or greater of the actual flight regimes. Also, for misidentified or unrecognized flight regimes, the system should demonstrate that it errs on the side of selecting a more severe regime. This insures that a component is not allowed to receive maintenance credit where it is not due and therefore allows a component to fly beyond its margin of safety.

Accurate detection and measurement of flight regimes experienced by the aircraft over time enable two levels of refinement for fatigue damage management: (1) the baseline “worst case design estimate” usage spectrum can be refined over time as the actual mission profiles and mission usage can be compared to the original design assumptions, and (2) individual aircraft damage assessment estimates can be based on specific aircraft flight history instead of the baseline “worst case design estimate” for the total aircraft population. To perform individual aircraft damage assessment estimates for specific aircraft components will require a data management infrastructure that can relate aircraft regime recognition and flight history data to individual components and items which are tracked by serial number. Knowledge of the actual aircraft usage can be used to refine the baseline „worst case design estimate‟ usage spectrum used to determine the aircraft service schedules and component retirement times. The refinement of the “worst case design estimate” usage spectrum, depending on actual usage, could result in improved safety and reduced cost, or improved safety or reduced cost.

The refined usage spectrum enables refining fleet component service lives to account for global changes in usage of the aircraft. The usage spectrum may be refined for specific periods of operation. An example is refining the usage spectrum to account for the operation of a segment of the fleet in countries where the mean altitude, temperature, or exposure to hazards can be characterized. The use of DSC data to establish an updated baseline usage spectrum is the preferred method (compared with pilot survey method).

The individual aircraft damage assessment is dependent on specific systems to track usage by part serial numbers. In this case, the logistics system must be capable of tracking the specific part (by serial number) and the specific aircraft (by tail number). The actual usage of the part, and its Remaining Useful Life, can be determined from the usage data of the aircraft (tail numbers) for the part (serial numbers). Because usage monitoring and component part tracking are not flight critical systems, if either of these systems fail, the alternative is to apply the most current design usage spectrum and the associated fatigue methodology for any period of flight time in which the usage monitor data or the part tracking data is not available. As such, use of the running damage assessment method does not eliminate the need to periodically refine the fleet usage spectrum based on use of DSC data.

State Detection

State Detection uses sensor data to determine a specific condition. The state can be “normal” or expected, an “anomaly” or undefined condition, or an “abnormal” condition. States can refer to the operation of a component or system, or the aircraft (examples, flight attitudes and regimes). An instance of observed parameters representing baseline or “normal” behavior should be maintained for comparison and detection of anomalies and abnormalities. Sections of the observed parameter data that contain abnormal readings which relate to the presence of faults should be retained for archive use in the knowledge base as well as for use in calculation of CIs in near real time.

The calculation of a CI should result in a unique measure of state. The processes governing CI and HI developments are:

a. Physics of Failure Analysis: This analysis determines the actual mechanism which creates the fault, which if left undetected can cause failure of the part or subsystem. In most cases, this analysis is to determine whether material failure is in the form of crack propagation or physical change (example: melting, corrosion, and embrittlement). This analysis determines the means to sense the presence of the fault and evolves the design decisions which place the right sensor and data collection to detect the fault.

b. Detection Algorithm Development (DAD): The process of detection algorithm development uses the Physics of Failure Analysis to initially select the time, frequency or other domain for processing the data received from the sensor. The development process uses physical and functional models to identify possible frequency ranges for data filtering and previously successful algorithms as a basis to begin development. Detection algorithms are completed when there is sufficient test or operational data to validate and verify their performance. At a minimum, systems underlying algorithms should provide a 90% probability in detection of incipient faults and also have no more than a 5% false alarm rate (indications of faults that are not present).

Fault Validation/Seeded Fault Analysis: Detection Algorithms are tested to ensure that they are capable of detecting faults prior to operational deployment. A common method of fault validation is to create or to "seed" a fault in a new or overhauled unit and collect data on the fault‟s progression to failure in controlled testing (or "bench test") which simulates operational use. Data collected from this test are used as source data for the detection algorithm, and the algorithm‟s results are compared to actual item condition through direct measurement.

Anomaly detection should be able to identify instances where data are not within expected values and flag those instances for further review and root cause analysis. Such detection may not be able to isolate to a single fault condition (or failure mode) to eliminate ambiguity between components in the system, and may form the basis for subsequent additional data capture and testing to fully understand the source of the abnormality (also referred to as an "anomaly."). In some cases, the anomaly may be a CI reading that is created by maintenance error rather than the presence of material failure. For example, misalignment of a shaft by installation error could be sensed by an accelerometer, with a value close to a bearing or shaft fault. CBM can also be used to control the conditions that cause the vibrations; which prevents the failures from occurring.

Operating state parameters (examples: gross weight, center of gravity, airspeed, ambient temperature, altitude, rotor speed, rate of climb, and normal acceleration) are used to determine the flight regime. The flight environment also greatly influences the RUL for many components. Regime recognition is essentially a form of State Detection, with the state being the vehicle‟s behavior and operating condition. Regime recognition is subject to similar criteria as CIs in that the regime should be mathematically definable and the flight regime should be a unique state for any instant, with an associated confidence boundary. The operating conditions (or regime) should be collected and correlated in time for the duration of flight for use in subsequent analysis.

For CIs that are sensitive to aircraft state or regime, maintenance threshold criteria should be applied in a specific flight regime to ensure consistent measurement and to minimize false alarms caused by transient behavior. Operating state parameters (examples: gross weight, center of gravity, airspeed, ambient temperature, altitude, rotor speed, rate of climb, and normal acceleration) are used to determine the flight regime.

Data Acquisition

Data acquisition standards for collecting and converting sensor input to a digital parameter are common for specific classes of sensors (examples:

vibration, temperature, and pressure sensors). The same standards exist for this purpose remain valid for CBM application, but with a few exceptions. In many cases, data from existing sensors on the aircraft are sufficient for CBM failure modes. Some failure modes, such as corrosion, may require new sensors or sensing strategies to benefit CBM. In all cases, certain guidance should be emphasized:

a. Flight State Parameters: Accuracy and sampling rates should be commensurate to effectively determine flight condition (regime) continuously during flight. The intent of these parameters is to unambiguously recreate that aircraft state post-flight for multiple purposes (example: duration of exposure to fatigue damaging states).

b. Vibration: Sampling rates for sensors on operational platforms should be commensurate for effective signal processing and "de-noising." Vibration transducer placement and mounting effects should be validated during development testing to ensure optimum location.

c. System-Specific: Unique guidance to sense the presence of faults in avionics and propulsion system components (engines, drive trains, APUs, etc.) are in development and will be addressed in subsequent versions of this ADS. Similarly, the promise of technology to sense corrosion-related damage in the airframe may mature to the point where detection with high confidence is included in the scope of this ADS at a later date.

Fatigue Damage Remediation

Remediation may be used to address components that are found to be routinely removed from service without reaching the fatigue safe life (a.k.a. component retirement time, CRT). The process of remediation involves the identification of removal causes that most frequently occur. Often the cause of early removal is damage such as nicks, dings, scratches or wear. When remediation action is taken to increase repair limits, it should be documented in maintenance manuals, including Technical Manuals (TMs) and Depot Maintenance Work Requirements (DMWRs).

There are myriad reasons why structural components are removed from service before reaching their respective component retirement time (i.e. fatigue life). In fact, the majority of Army components are removed due to damage (examples: nicks, corrosion, wear) prior to reaching a retirement life. Remediation is the concept of identifying and mitigating the root causes for part replacement in order to obtain more useful life from structural components (including airframe parts and dynamic components). The safe life process for service life management bases fatigue strength on "as manufactured" components. Damage, repair and overhaul limits are established to maintain component strength as controlled by drawing tolerance limits.

The remediation process provides the means to trade repair tolerance for retirement time. Utilization of actual usage and loads provides the means to extend the retirement time at acceptable levels of risk. The steps in the remediation process follows:

a. Categorize and quantify the primary reasons for component removal and decision not to return the component to service.

b. Investigate regime recognition data for casual relations between usage and damage.

c. Perform engineering analysis on the component and evaluate the impact of expanded repair limits on static and fatigue capability. Regime recognition data provides information on load severity and usage for projecting revised fatigue life.

d. Perform elemental or full-scale testing to substantiate analysis.

e. Implement the results of the analysis and testing phase by adjusting repair limits and repair procedures where applicable, thereby increasing the useful life of the component and reducing part removals.

The result is an increase in damage repair limits in the TMs and DMWRs allowing the component to stay on the aircraft longer. Remediation enhances the four goals of the FLM process and can be considered a subset of the elements; analysis and correlation of data to component fatigue strength.

CBM Management Plan

This handbook provides the overall standards and guidance in the design of a CBM system. It is beyond the scope of this document to provide specific guidance in the implementation of any particular CBM design. A written Management Plan or part of an existing Systems Engineering Plan should be developed for each implemented CBM system that describes the details of how the specific design meets the guidance of this ADS. At a minimum, this Management Plan is to provide the following:

Describe how the design meets or exceeds the guidance of this ADS by citing specific references to the appropriate sections of this document and its appendices.

a. Describe in detail how the CBM system functions and meets the requirements for end-to-end integrity.

b. Specifically describe what CBM credits are sought (examples are extended operating time between maintenance, overhaul, and inspection or extended operating time between overhaul or inspection).

c. Describe how the CBM system is tested and validated to achieve the desired CBM credits.

This Management Plan may be developed either by the US Army or by the CBM system vendor/system integrator subject to approval by the US Army. The Management Plan should be specified as a contract deliverable to the Government in the event that it is developed by the CBM system vendor or end-to-end system integrator. Also, the Management Plan for CBM design compliance should be a stand-alone document.

Distribution

Due to the ever evolving nature of CBM, the Army will continue to update the ADS on an annual basis. The annual version usually is published at the end of each calendar year. To retrieve the document, please visit this website: http://www.redstone.army.mil/amrdec/sepd/tdmd/StandardAero.htm. The Army's point of contact for any questions or concerns with the ADS is Ms. Gail Cruce, 256-313-8996 gail.e.cruce@us.army.mil.

References

1. ISO 13374:2003. Condition Monitoring and Diagnostics of Machines.

2. MIMOSA Open Systems Architecture for Condition Based Maintenance, v3.2.

Copies of these documents are available online at:

http://www.iso.org/iso/iso_catalogue.htm

http://www.mimosa.org/