CBM - Condition Based Maintenance

In Theater

X

CAB

Transactional Data

PMEs

OEMs

Historical Supply Chain Data

LOGSA

Others

Analytical Data Warehouse

Service Life

Logistics Req’s

Failure Analysis

Regime Recog

IMMC

AED

AMCOM LCMC

PMs

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Transforming Army Aviation Maintenance From the Industrial Age to the Information Age!
OSD Policy and Army Guidance

- DOD – CBM Memorandum: 20 Nov 03
  - Develop CBM as One of Six Future Logistics Enterprise Initiatives

- DA, G4 – Army CBM+ Plan: 14 Apr 04
  - Shifts From Preventive and Reactive Maintenance to Proactive CBM

- DA, G4 – Army Aviation White Paper CBM+ Plan: 15 Dec 04
  - Task Force Aviation Is One of Sixteen Army Focus Areas
  - Task Force Goal – **Full CBM for Aviation By FY 2015**

- ASA, Acquisition, Logistics and Technology: 17 Aug 05
  - CBM+ Designed Into All New Weapon Systems

- AMCOM Conducted Proof of Principle for CBM: Jul/Aug 05
  - Validated Feasibility for Aviation

- CG, AMCOM Sets IOC Objective FY 2011
CBM Defined

A Set of Maintenance Processes and Capabilities That Improve Operational Availability and Reduce the Maintenance Burden on the Soldier By:

- Enhancing Diagnostics
- Evolving to Predicting Remaining Component Life
- Then to Proactive Supply Transactions

Derived From Near Real-Time Assessment and Analysis of Data From:

- Embedded Sensors
- Platform Maintenance Environments
- Aircraft and Supply Historical Data

(WALC CBM Working Group Feb 2005)
CBM Benefits for the Soldier

To Battlefield Commanders, CBM Is:
- The Ability to Meet Mission Requirements With Proactively Driven Maintenance
- The Ability to Optimize the Competing Demands of Warfighting and Planned Maintenance (CBM Working Group)

To the Soldier, CBM Is:
- Maintenance Instructions Based on Actual Condition and Usage
- Greatly Enhanced Diagnostics and Troubleshooting
- Fewer Maintenance Manhours
- Physical Inspections Are Reduced or Eliminated (CBM Working Group)

CBM Program Objectives Are:
- Decrease the Maintenance Burden on the Soldier
- Increase Platform Availability and Readiness
- Reduce O&S Costs
The Stakeholders ...

AMCOM
- G-3
- IMMC
- ACQ

PEO AVN
- PM AS
- AC PMs

RDECOM
- AMRDEC

OEMs

Combat Readiness Center

Aviation Missile Life Cycle Management Command

DA Staff
- G4
- LTA
- AVN TASK FORCE

AMC
- TACOM
- CECOM

DLA

JALC

OSD CBM AG

User Reps
- Soldiers
- USAAVNC
- USAALS

Condition Based Maintenance

Combat Aviation Brigade

Academia
CBM Continuum

- Overt Failures
- Troubleshooting
- Enhanced Diagnostics
- Proactive Maintenance
- Prognostics for Remaining Life
- Proactive Supply Actions

80’s | 90’s | 00’s | 2015

TODAY
CBM Enablers

- Embedded Health and Usage Monitoring
- Data Fusion Via a Centralized Data Warehouse
- Data Flow and Management Architecture
- Continuous Development and Validation of Condition Indicators
- Continuous Development and Validation of Prognostics
- Transformational Change Management
Example
AH64 Main Rotor Swashplate Bearing

- Unit Unable to Detect Fault With 3 Manual Inspections
- Onboard Sensors Detected Fault
- Teardown Analysis Confirmed Fault

### AH64 Main Rotor Swashplate Bearing

- Broken Cage
- Spalling/Corrosion

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Faulty Bearing

Normal Bearings
Proof of Principle Demonstration Scenarios
Conducted July – August 2005

- Demonstrate the Use of CBM at the Soldier Level
  - Converted Vibration Data Into Maintenance and Supply Actions
  - Integrated Vibration Condition Indicators (CIs) and Maintenance Data

- Demonstrate Engineering Methodology for CI Development
  - Explained How Vibration Data Becomes Condition Indicators
  - Used Integrated Vibration and Maintenance Data From the Warehouse

- Demonstrate the Benefit of a Analytical Data Warehouse
  - Explained How Data of Different Types From Disparate Systems Is Correlated
  - Displayed Correlated Vibration and Maintenance Data With a Single Query

- Prognostics for UH-60 Intermediate Gearbox (GTRI)
  - Explained How Vibration Data Is Turned Into Prognostics
  - Used Mathematics and Data From Bench Tests
  - Provided Production Control Officer With Estimates of Remaining Useful Life

- Prognostics on CH-47 T55 Engine
- Prognostics on AH-64 Laser Transceiver Unit (LTU)
- UH-60 HUMS in 4-101, 101st AASLT Division
CBM at the Soldier Level

- Vibration Monitoring
- Enhanced Diagnostics
- Planned Maintenance
Condition Indicators
CIs occurring for AH64D:01-05276 Drive Shafts fault 'AFT hanger bearing' on flight 09/24/2004 12:51:52

Vib Peak FPG100 AFT HB Drive Shaft

1x Brg Fault Aft HB

Yellow = Alert
Planned Maintenance Vs. Unscheduled Maintenance

<table>
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<tr>
<th>INSNO</th>
<th>WUC</th>
<th>NEXT DUE DATE</th>
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Condition Indicators

CIs occurring for AH64D:01-05276 Drive Shafts fault 'AFT hanger bearing' on flight 02/12/2005 08:28:58

- Maintenance Corrected the Fault
- Maintenance Performed Correctly
CBM For Soldiers Summary

Demonstrated Capabilities:

• Crew Chief Monitored Component Health Via Condition Indicator (CI)
• CI in Yellow Zone Implied a Maintenance or Supply Action May Be Required
• Crew Chief Ordered Replacement Part; Production Control (PC) Officer Validated
• PC Officer Scheduled Bearing Replacement at Next Planned Maintenance Period
• Crew Chief Replaced Bearing
• PC Officer Used CI to Verify Problem Corrected

Benefits to the Warfighter:

• Decisions Based on Component Condition Rather Than Overt Failure
• Convert Unscheduled Maintenance to Planned Maintenance
• Minimize Maintenance Downtime
• Improve Aircraft Availability
• Minimize Parts Wait Time
Aviation PoP Data Warehouse

- Integral Part of the Engineer’s Analytical Support System
- Near Real-Time Access to Multiple Sources of Data for Data Fusion
- Integrated Analytical Tools

**Data Sources**
- AMCOM
- EDRS
- IMMC
- LOGSA
- AC Logbooks
- AH HUMS
- ARH HUMS
- CH HUMS
- UH HUMS
- LUH HUMS

**Subject Areas**
- Aircraft
- Usage
- State
- Condition
- Failure Modes
- Configuration
- Parts
- Cost
- OEMs

**Customers**
- AMCOM
- AMRDEC
- IMMC
- MFAB Units
- PEO-AV
- PM Apache
- PM Cargo
- PM Utility
- PM AS
- GCSS-ARMY

**Meta Data and Access Layer**
- 1. User interfaces
- 2. Efficient Queries
- 3. Plain Language

**Extract, Transform, Load**
- 1. Loading
- 2. Normalization
- 3. Cleansing

- 1. Optimal storage
- 2. Change mgmt
- 3. Periodic Refresh
What Caused the CI Value to Decrease?
Data Warehouse Summary

Demonstrated Capabilities:

- Data Fused in a Relational Data Warehouse From Separate Sources
- Accessed From a Single Query
- Changes in CIs Correlated to Maintenance Activity

Benefits to Engineers/PMO’s Supporting Warfighters:

- Avoid Independent Queries of CI Database and Maintenance Records
- Identification of the Corrective Action That Actually Solved the Problem
- Eliminates Unnecessary Steps in Diagnosis and Troubleshooting
- Provides Engineering With a Single Source of Comprehensive Data
Prognostics for Electronic Components
AH-64 Laser Transceiver Unit (LTU)

- Fault Data From Aircraft Buss Used to Predict Component Failure
- Algorithms Validated By Existing Test Equipment and Procedures
Fault Isolation

Bit Fault Mapping Is Used to:
- Reduce the Ambiguity Group
- Isolate the Failing Component
**LTU Hard Failure**

### Army Laser Transceiver Unit

#### System Level Reasoner - ReasonPro On Board or At Wing

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<th>Select Maintenance Instance</th>
<th>Run ReasonPro</th>
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#### Health Index

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#### Health Index

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- **RUL**: 0.1

#### Confidence

- **Confidence**: 0.95

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