AMCOM CBM+
Program Overview
for the
DoD Maintenance Symposium

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Director, Condition Based Maintenance
AMCOM CBM+

**Key CBM Enablers**
- Digital Source Collectors
- Health Monitoring Units
- Flight Line Diagnostics
- Data Fusion/Analysis

**CBM Program Objectives:**
- Decrease Maintenance Burden on the Soldier
- Increase Platform Availability and Readiness
- Enhance Safety
- Reduce Operations & Support (O&S) Costs

**The purpose of Army Maintenance is to generate Combat Power.**

AR 750-1

**Warfighter Will Not Deploy Without CBM**
## Enabling the Weapon System

For Every 20 CBM-Equipped Aircraft, Equivalent to 1 More Available for Missions

<table>
<thead>
<tr>
<th>Aircraft Type</th>
<th>Total # of Aircraft</th>
<th>DSC Equipped</th>
<th>Percent Complete</th>
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<th>Percent Complete EOY FY12</th>
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<td><strong>TOTAL</strong></td>
<td><strong>3546</strong></td>
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### CBM Generating Combat Power

- 4-12% NMC Reduction
- 12-22% Class IX Cost Reduction
- 5-8% Increase in Readiness

- 1-4% Reduction in Maintenance Test Flight
- 1 Less Mission Abort Per 100 Flt Hrs
- Avoided 4 Class A (Major) Mishaps

For Every 20 CBM-Equipped Aircraft, Equivalent to 1 More Available for Missions
Enabling the Maintainer

Platform Data

Diagnostics & Decision Support

Corrective Maintenance Action

User’s Must Transmit Data in Order for CBM to be Effective

Provides Recommended Corrective Actions to Maintain Vibration Levels at a Minimum

Minimizes the Number of Dedicated Maintenance Test Flights, Aircraft Down Time, and Mission Aborts Due to Excessive Vibrations

Monitors the Status or Health of Dynamic Drive System Components and Advises When a Limit Has Been Exceeded
**CBM Operational Environment**

**In Theater**
- CAISI – Combat Support Systems Automated Information System Interface
- DSC – Digital Source Collector
- IVHMS – Integrated Vehicle Health Maintenance System
- JTDI – Joint Technical Data Integration
- ULLS-A – Unit Level Logistics System – Aviation
- VSAT – Very Small Aperture Terminal

**At National**
- IMMC
- Top-Tier Server at Redstone Arsenal
- CBM Data Warehouse
- PM and OEM File Server
- Analysis and Decision Support

- CI Development
- Failure Analysis
- Flight Regimes
- Part Re-engineering
- Airworthiness Release (AWR)
Net Centric Maintenance Process

1. Digital Source Collectors (DSC)
   1. Suite of Sensors and LRU (MSPU, ECA, IV-HMS)
   2. Monitor Component Health ("EKG" of Systems Health)

2. At Platform Work Stations
   1. Transfer DSC Data & Processed Information to ULLS-A(E)
   2. Immediate Action Information

3. BN Production Control
   1. Plans Maintenance Activities
   2. Collates Unit Data
   3. Portal Into STAMIS

4. Data Loaded
   Into CBM Data Warehouse

5. Engineering Analysis
   Component Health and Remaining Life

6. Actionable Maintenance & Supply Information Returned to Unit

A Net Centric Maintenance Environment Supports the Collection, Transmission, and Storage of Important Health Data to Improve Maintenance
Data Analysis Method

Diagnostics for the Connected Maintainer: Begins with Analyzed & Correlated Data

- **Failure Mode 1**: Spalling
- **Failure Mode 2**: Corrosion
- **Failure Mode 3**: Crack
- **Failure Mode 4**: Oil Debris
- **Failure Mode 5**: Pressure

**RCM Data Analysis**
- **Failure Mode 1**: Spalling
- **Failure Mode 2**: Corrosion
- **Failure Mode 3**: Crack
- **Failure Mode 4**: Oil Debris
- **Failure Mode 5**: Pressure

**CBM Data Analysis**
- Sensors: Vibration, Temp, Oil Debris, Pressure
- Algorithms: Condition Indicators & Health Indicators
- Actions: Do Nothing, Inspect, Repair, Replace

**FMECA**
- QDR (SF-368)
- Form 2410

**RIMFIRE Depot Teardown Data**

**Data Analysis**
- **Data Analysis Method**: Begins with Analyzed & Correlated Data
- **Field Inspection**
- **FMECA**: Failure Modes, Effects and Criticality Analysis
- **QDR (SF-368)**
- **Form 2410**
- **RIMFIRE Depot Teardown Data**

**Data Analysis is Important to Develop A National Level Knowledge Foundation to Give Actionable Information to Maintainers in the Field**
PM CBM Working Groups
Direct Connection: Maintainer/PM

CBM Working Groups Provides Feedback to the Unit

- MSPU
- IVH MU
- TeleCom with WG
- DSC Data Transmit

PM, AED, ED, IMMC, OEM

Watch List
- Continue Operation
- Remove / Replace
- Order Component
- Tear Down Analysis
- Remove at Scheduled Maintenance
- CI Refinement

Maintenance Recommendation

CBM Working Groups Provides Feedback to the Unit
Implementing Tactics, Techniques & Procedures

Challenge to Implementing Net-Centric Maintenance: TRAINING

Availability of Training will Make CBM More Useful to the Soldier in the Field
Where Are We Going

We are working to:

• Take Advantage of the CBM Momentum to Derive Solutions to Benefit the Soldier
• Facilitate Data Exchange from the Field After Each Mission Day
• Communicate with Field Maintainers
• Relate Benefits to Metrics and ROI
• Institutionalize RCM
Challenges

You Can Help By:

• Sending Data on a Regular Basis
• Calling Into PM/CBM Working Groups
• Soliciting your LAR Support to Assist with CBM Issues, Questions, or Concerns
• Point of Contact at IMMC CBM Office:

   James D. Webster
   jdwebster@us.army.mil
Questions
Backup
The purpose of Army Maintenance is to Generate Combat Power (AR 750-1)

Over 62% of the Aviation fleet (2121 of 3434 aircraft) CBM equipped.

Program Objectives:
- Decrease Maintenance Burden on the Soldier
- Increase Platform Availability and Readiness
- Enhance Safety
- Reduce Operations & Support (O&S) Costs

Key CBM Enablers
- Digital Source Collectors
- Flight Line Diagnostics
- Data Fusion/Analysis

CBM is Transforming Maintenance

**CBM+ Overview**

### Program Objectives
- Decrease Maintenance Burden on the Soldier
- Increase Platform Availability and Readiness
- Enhance Safety
- Reduce Operations & Support Costs

### Success Stories
- 4 aircraft Class A Accidents Avoided ~ $49M
- 57 UH60/AH64 engines not replaced ~$27M
- 6-9% decrease in aircraft maint non-avail
- Reduced Operations & Support Costs
- Abrams TIGER Project – 1400 hours between Depot repairs, fewer new parts, less disassembly/assembly, reduced Depot time
Five CBM Domains

**Collection 1**
- DSC Data
  - UH-60
  - AH-64
  - CH-47
  - OH-58
- ULLS-A (E)
- Component Historical data (2410)

**Transmission 2**
- Satellite
- Fed Ex
- Mail
- NIPR

**Warehousing 3**
- CBM DWH
- T&E
- IMMC
- PM Flt Mgt Sys
- OEM
- LOGSA
- Academia

**Action/Decision 5**
- Maintenance TTP
- Inspection Remediation
- Part Re-engineering
- Airworthiness Release (AWR)
- Supply Optimization

**Transmission Pipeline**
- Extract
- Transform
- Load

**Analysis 4**
- Supply Engineering
- Other

**Overarching Architecture Compliance**

**Flight Line Decisions**
- Improved diagnostics
- Maintenance actions based on component health
- Reduced MMH
- Planned maintenance
  - Unscheduled vs. Scheduled

**Direct Funding and S&T Leverage**

**U.S. Army**

**U.S. Air Force**

**U.S. Navy**

**U.S. Marine Corps**

**U.S. Special Operations Command**

**U.S. Army National Guard**

**U.S. Army Reserve**

**National Guard Bureau**

**Army Corps of Engineers**

**Additional Notes:**
- DSC Data
- Component Historical data (2410)
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**OIF/OEF**

**CONUS**

**OCONUS**

**OEM**

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What Does it Do?

**Digital Source Collector**

**Diagnostics Decision Support**

**Corrective Maintenance Action**

User’s Must Transmit Data in Order for CBM to be Effective

- Provides Recommended Corrective Actions to Maintain Vibration Levels at a Minimum
- Minimizes the Number of Dedicated Maintenance Test Flights, Aircraft Down Time, and Mission Aborts Due to Excessive Vibrations
- Monitors the Status or Health of Dynamic Drive System Components and Advises When a Limit Has Been Exceeded
The Six CBM Functions

1. **Rotor Smoothing**
   Continual assessment/correction of rotor induced vibrations to ensure a smoother flying aircraft, limiting component damage and aircrew fatigue. Reduces maintenance burden by reducing the frequency of maintenance test flights, increasing mission readiness.

2. **Drive Train Health**
   Provides increased awareness of drive train health, increasing flight safety and aircrew confidence. Enables more accurate maintenance management and enhancing logistics planning to always be ready for the mission.

3. **Engine Health**
   Pre-Flight Power Assurance check utilizing engine data already recorded on the aircraft. Increased accuracy and repeatability for mission planning, reduction in routine engine performance checks, and data trending to optimize scheduled engine maintenance.

4. **Structural Health**
   Fatigue Life Management / Damage Fraction for component re-lifing based on actual usage and remediation to extend TM/DMWR damage limits.

5. **Exceedance Monitoring**
   Post-flight data analysis of parametric data (vibration, torque, speed, temperature, and pressure). Provides more accurate assessment of actual exceedance values, reducing human error.

6. **Logbook Interface**
   Automated population of computerized forms and records, downloading CBM data to flightline analysis software.
### DSC Fielding Through 7 SEP 11

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1 – End of Year FY11 Fleet Density
2 – 75% (3624 DSC aircraft) of total fleet based on end of year FY12 fleet inventory (3624)
* AH-64A will be equipped when modified to AH-64D Block III configuration.
** CH-47F DSC installation will begin 2013
DCO Connect Utility

- DCO Connect is a lightweight, two-way, audio-visual tool
- Enables communication with Engineering Technical Support.
- ETS personnel are able to provide maintenance assistance, helping to return the system to an operational status.

Screen shot using chat, video and white board

Screen shot using chat, and desktop sharing
Army Aviation System Impact

- 573 (92% of AH-64D Fleet) DSC Equipped
  - 93 Monitored Components
  - 58 Maintenance Tasks Eliminated
  - 9.1% Fewer Mission Aborts / 100 Flight Hours

- 189 (40% of C/MH-47D/G Fleet) DSC Equipped
  - 163 Monitored Components
  - 4.0% Reduction in Flight Hours Dedicated to MTF

- 174 (52% of OH-58D Fleet) DSC Equipped
  - 14 Monitored Components
  - Significant MMH Reduction in RTB and Engine Vibration

- 1314 (68% of M/UH-60A/L/M Fleet) DSC Equipped
  - 108 Monitored Components
  - 9.2% Reduction in NMC-M
  - 59 Maintenance Task Changes Increasing Aircraft Availability

For Every 20 CBM-Equipped Aircraft, Equivalent to 1 More Available for Missions

Decrease in Maintenance Cost & Soldier Burden
- Maintenance Test Flight Reduction 1-4%
- Over 127 Maintenance Procedures Improved or Eliminated

Gains in Readiness and Combat Power
- Experienced 3.8%-12.4% NMCM Reduction
- 1 Less Mission Abort Per 100 Flt Hrs
- 5-8% Increase in Readiness

Enhanced Safety
- Avoided 4 Class A (Major) Mishaps
- Predicted To Avoid 11-12 Additional Class A Mishaps Over Next 10 Years

CBM+ Generates Combat Power
Army Missile System Impact

Army Missile Systems (AGM-114 Hellfire)

Pareto Plot of Defects - HFII

Based on repair data from 86 HELLFIRE II RESET missiles (145 failure modes)

$14.9M Cost savings over 3 years
= Potential to Eliminate Many $M in Unnecessary Guidance System Replacements

“Captive Carry hours impact HELLFIRE performance and drive repair and RESET activities by replacing Guidance Systems only when usage indicates.

HELFIRE II Sensor Group Replacement

$14.9M Cost Avoidance by not replacing

<table>
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<th>AMCF Cost (Millions)</th>
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<td>FY07</td>
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<td>PlannedCost</td>
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<td>Actual Cost</td>
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<tr>
<td>Planned SG QTY</td>
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Technology Improvements

AMRDEC S&T is Working Technologies Across Entire Fleet

Purpose: Develop and demonstrate diagnostic, prognostic, and system health assessment technologies to enable transition to Condition Based Maintenance

Propulsion
- Continuous power assurance
- PHM for rotating components
- Power management

Drive and Mechanical Systems
- Gear fault detection
- Wear detection prognostics
- Non-metallic debris monitoring
- Corrosion detection

Structures
- Corrosion detection
- Damage detection

Flight Controls and Hydraulics
- Mechanical controls prognostics
- Pump and Actuator prognostics
- Hose chafing detection

Rotors & Hub Components
- Hub component diagnostics
- Blade damage detection
- Usage monitoring-direct load measurement
- Acoustic rotor blade delamination robot

System Integration

Electrical/Electronic Systems
- Wiring prognostics/chafing
- Electrical component prognostics
- Electronic power supply prognostics
<table>
<thead>
<tr>
<th>Item</th>
<th>Action / Benefit</th>
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<tr>
<td>Main Rotor</td>
<td>AVA installation for main rotor smoothing. Allows for minor adjustments without requiring MTF</td>
</tr>
<tr>
<td>Tail Rotor</td>
<td>Eliminates AVA installation for tail rotor balancing. Allows for minor adjustments without requiring MTF.</td>
</tr>
<tr>
<td>Main Rotor Swashplate</td>
<td>AWR eliminates 50 Hr bearing inspection. Eliminates Maintenance Test Flight required after 50 hr bearing inspection</td>
</tr>
<tr>
<td>APU Clutch</td>
<td>Eliminates AVA installation for vibration check at APU installation and phase and increases APU mount special inspection from 250 to 500</td>
</tr>
<tr>
<td>Fwd Hanger Bearing</td>
<td>Safety Improvement w/Continous Diagnostic Monitoring. Increase TBO from 2500 to 2750</td>
</tr>
<tr>
<td>Aft Hanger Bearing</td>
<td>Safety Improvement w/Continous Diagnostic Monitoring. Increase TBO from 2500 to 2750</td>
</tr>
<tr>
<td>Main Trans Primary Acc Clutch</td>
<td>Safety benefit: Can tell if Primary acc clutch has failed and operating on secondary clutch</td>
</tr>
<tr>
<td>Nose Gearbox</td>
<td>Safety and Maintenance planning benefit. Provides early warning of failure, can remove NGB prior to chip light, preventing internal damage and Precautionary Landing</td>
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## How Does IVHMS Help?

<table>
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<tr>
<td>Oil Cooler Axial Fan Bearing</td>
<td>Eliminates AVA Installation Requirement for 120 Hour Inspection. Extends TBO of oil cooler fan assembly from 2500 to 3240 hours.</td>
</tr>
<tr>
<td>Engine Output Drive Shaft</td>
<td>Eliminates AVA Installation Requirement for 120 Hour Inspection. Eliminates AVA installation for high speed shaft balancing procedure. Replace w/ Continuous Diagnostic Monitoring. MMH Saved per Inspection 3.3 hours. Downtime Saved per Aircraft 1.8 hours.</td>
</tr>
<tr>
<td>Main Rotor, Nose Absorber</td>
<td>Eliminates AVA installation for main rotor smoothing and nose absorber tuning procedure. MMH Saved 17.2 Hours</td>
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<tr>
<td>Tail Rotor</td>
<td>Eliminates AVA Installation Requirement for 120 Hour Inspection. Eliminates AVA installation for tail rotor balancing procedure. MMH Saved 2.0 Hours</td>
</tr>
<tr>
<td>Cabin Absorber</td>
<td>Eliminates AVA installation for cabin absorber tuning procedure. MMH Saved 2.0 Hours</td>
</tr>
<tr>
<td>Accessory Gearbox Spline Adapter</td>
<td>Identifies potentially cracked splines reducing probability of generator, or gear damage due to adapter chips migrating into the gearbox.</td>
</tr>
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How Does It Work?

Correlate Hardware Condition to Sensor Data via RIMFIRE

RIMFIRE: Record of Observation

Correlation of equipment condition to indicators such as vibration sensors and metal chip detectors is necessary to improve confidence in the Health Monitoring System.

RIMFIRE: Inspection Lifecycle

RIMFIRE data is utilized to Correlate Health/Condition Indicators with actual observed hardware condition.

RIMFIRE identifies and tracks root removal cause, helps validate condition indicator thresholds and subsequently aids RCM in determining which components should be identified as candidates for corrective action thru CBM.
How Does It Work?

Analyze & Correlate Data: Prognostics

Supply Chain
Demand Chain

Data & Parts Flow

Retrograde
Forward Pipeline

Platform

Component Data
- Comp. #1
- Comp. #2
- Comp. #3

Unit

Electronic Logbook

ULLS-A(E)

SARSS

SARSS

Component #1 (TBO = 2,000 hrs)

Vibration NRG

Date Range

Hours / Days / Weeks

vs.

Component #1 (Transactions)

Priority

Date Range

12-Months

Demand Signal Type

- #1 (Transaction)
- #2 (Component LoS)

Acquired Component

Repaired Component

OEM

Depot

DLA

LMP

Objective: Improved Class IX (Air) forecasting.

Hypothesis: Sampling aggregate component LoS from DSC will produce more accurate forecasting than sampling aggregate transaction history.