PM/FM Matrix & CBM Gap Analysis in Reliability Centered Maintenance

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CBM Analysis Tools – Tools to Define Where and How to Apply CBM but do not by themselves make the System Failure Strategies go to CBM
- RCM
- FMECA
- Business Case Analysis

CBM Enablers – Technologies Applied to System that Drive Failure Strategies to CBM
- Built-In Test
- HUMS
- IETMS

CBM Ancillary Enablers – Technologies/Tools Applied to System that do not Drive Failure Strategies to CBM but Reduce Overall Failure Occurrence and/or Maintenance Resource Burden
- Reliability Improvement
- Diagnostic Improvements
- Maintenance Training
- Seeded Fault Testing
- Data Collection, Scoring & Warehousing
- Diagnostics/Prognostics
- Data Warehouse Algorithms/Analysis
- Maintenance Improvement
- Supply Chain Maintenance
- Asset Visibility
CBM+ Initiatives

Failure Strategy Associated with a Failure Mode

Failure Strategy with Potential to go to CBM (With CBM Enablers Applied)

CBM Analysis Tools

CBM Enablers

CBM Ancillary Enablers
RAM CBM/RCM Analysis Process

Aviation System Assessment Program (ASAP)
- Scored & Scrubbed Data to Warehouse
- RAM Metric Analyses

Preventative Maintenance / Failure Mode Analysis
- PM/FM Matrix
  - Input to Component Map

RCM Analysis
- RIP Business Cases
  - CBM Gap Analysis

Feedback and Attack

RCM Analysis Report

RCM DoD/DA Policy
RAM CBM/RCM Analysis Process
(PM/FM Analysis)

CBM PM/FM Analysis

- Identifies Opportunities to Reduce Inspection Requirements.
- Quantifies Potential Value of New Prognostic Technologies.
- Identifies Future Prognostic Needs.

CBM Inspection Analysis Work

- We have completed linking the 2410 removals and Navy IRCMS failure modes to schedule maintenance for all UH-60 Rotor components.
- This information is driving the UH-60 component mapping effort.
- The UH-60 Drive System and Sub Systems components are currently being generated.
- FY07 Begin Analysis of AH-64
### Preventive Maintenance Failure Mode Matrix

**AH-64 IGB**

#### Intermediate Gear Box
- NSN: 1615-01-074-5152
- WUC: 06F
- Total Inspections: 6

#### Component Failure Modes

<table>
<thead>
<tr>
<th>Mode</th>
<th># Occurred</th>
<th>%</th>
<th>Existing BIT Detection Capabilities</th>
<th>06F</th>
<th>06F01</th>
<th>06F03</th>
<th>06F04</th>
<th>06F</th>
<th>06F01</th>
<th>06F03</th>
<th>06F04</th>
<th>06F</th>
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<tr>
<td>Corroded</td>
<td>100</td>
<td>37.59%</td>
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<tr>
<td>Impending/Incipient Failure</td>
<td>26</td>
<td>9.77%</td>
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<td>Sudden Stoppage, Blade</td>
<td>15</td>
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<tr>
<td>Metal on Magnetic Plu</td>
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<tr>
<td>Internal Failure</td>
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<td>Leaking (Liquid)</td>
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<td>Bearing or Bushing Failed</td>
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<td>Contamination</td>
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<td>Pitted</td>
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<td>Worn Excessively</td>
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<td>Chipped</td>
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<td>Others</td>
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<td>Cracked</td>
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<td>Grooved</td>
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#### Inspection Failure Modes
- PMS (40 hr)
- 120 hr
- PMI 1 (700 hr)
- PMI 2 (700 hr)
- 90 Day

#### Modes & WUC Inspected
- 06F
- 06F01
- 06F03
- 06F04

RAM CBM/RCM Analysis Process

(RCM Analysis)

- Facilitated Group Approach
- Pilots/Maintainers on Staff
- Established ALNG Contacts for RCM Support

Systems Engineer

Test Pilot

Flight Engineer

Mechanic

Depot Rep

Equipment Manufacturer

Other Expert

RAM Facilitator
CBM Gap Analysis

• Classical RCM
  – Captures Existing Design and Maintenance Structure
  – Decision Tree Tool Optimizes Maintenance Practices to Component Needs
    
    Results – Optimized Maintenance Strategy Mix (CBM, Inspection, Replace at Failure, etc.)

• CBM Gap Analysis (Add on tool)
  – Force Decision Tree to CBM
  – ID Points Where Existing Design Branches Off CBM
  – Address Gaps in Design

    Results – CBM Requirements
Traditional RCM Analysis

Failure Mode
Effect on safety
or Mission?

Impending
FM Detectable?

FM Detectable
before effect?

FM evident
To crew during
operation?

Replace/Repair
at Failure

Scheduled Maintenance

Replace/Repair
upon detection of
Impending Failure

Scheduled
Replacement

FM-Fatigue

TBO

Scheduled
Condition Check

120 Hr
Inspection

Scheduled
Condition Check

40 hr Plug
Inspection

Every SM Requirement Driven
by Technology/Design Gap

FM–Fatigue

FM–Bearing

FM–Oil/Grease
Contamination

040506-Erickson-ED CBM
CBM Gap Analysis
Drive Design to CBM

 Identified design gaps required to drive RCM decision toward CBM

CBM Gap Analysis

Gap 1 - Change in Answer
Requires:
-TBD Structural Sensors

Gap 2 - Change in Answer
Requires:
-Vibration Monitoring

Gap 3 - Change in Answer
Requires:
-Real Time Plug Analysis

Failure Mode Effect on safety or Mission?

Impending FM Detectable?

FM Detectable before effect?

FM evident To crew during operation?

Replace/Repair at Failure

Replace/Repair upon detection of Impending Failure

Replace/Repair at Failure

FM - Fatigue

FM - Bearing

FM - Oil/Grease Contamination

YES

YES

YES

Failure Mode Effect on safety or Mission?

Impending FM Detectable?

FM Detectable before effect?

FM evident To crew during operation?

Replace/Repair at Failure

Replace/Repair upon detection of Impending Failure

Identified design gaps required to drive RCM decision toward CBM