U.S. Navy Condition-Based Maintenance Program
Briefing Outline

- Reliability Centered Maintenance (RCM) and Condition Based Maintenance (CBM) Overview
- U.S. Navy Surface Ship RCM Processes
  - Classic RCM (Initial maintenance requirements development)
  - Backfit RCM (SURFMER Program)
- Institutionalizing RCM
- Discussion
RCM Is the Hub of CBM

CBM is a Maintenance Strategy

RCM Provides Rules of Evidence

RCM Provides
Evidence of
Preventive
Maintenance

Corrective
Maintenance

Alternative
Maintenance

Condition-Based Maintenance

Doing the Right Maintenance — Doing Maintenance Right

the Need for Maintenance
US NAVY MAINTENANCE DEFINITIONS

DoD Directive 4151.18 – dated 31 March 2004

“Maintenance programs shall consist of (RCM) applicable and effective tasks for addressing the failure modes and effects using Reliability-Centered analysis…”

OPNAVINST 4700.7K – dated 11 July 2003

“Maintenance procedures... are to be developed and performed in accordance with CBM.... This will be determined in accordance with RCM.”

Class Maintenance Plans “will be based on CBM methodology using RCM principles.”

OPNAVINST 4790.16 – dated 6 May 1998

“CBM – A strategy that stipulates the performance of maintenance only when there is objective evidence of need.”

“RCM – A method which identifies applicable and effective maintenance tasks needed to maintain the inherent reliability of systems or equipment at minimum cost. RCM provides rules for determining appropriate objective evidence of need.”
Two RCM Processes

Initial PMS Development
(Classic Approach)

- Interfaces
- Risk Assessment
- Risk Management
- Age Exploration

Partitioning → FMEA → RCM Logic → Continuous Improvement

Failure Modes & Effects Analysis

Maintenance Effectiveness Review (MER) -
(“Backfit” Approach)

Requirement

Age Degradation

“Does Failure Mode Occur?”

Benefit

Applicability

“Hardware Feels Better”

Task Value

Effectiveness

“Pays for Itself”
Road Map for applying CBM to Maintenance Tasks

**Step 1:** Identify Failure Mode (e.g., seized bearings)

**Step 2:** Does a Significant Rate of Age Degradation Exist?
- No
  - No or Acceptably Slow Rate of Degradation
    - No task
- Yes
  - Significant Rate of Degradation

**Step 3:** Determine/Classify Type Task
- TIME. CONDITION. FAILURE- SERVICING LUBE
- DIR. (TD) (CD) (FF)

**Step 4:** Is the Existing Maintenance Task Applicable?
- Apply Rules for Applicability
  - TD: Life Renewal Replace/Restore
  - CD: Health Monitoring
  - FF: Hidden Failure (Find/Repair)
  - S/L: Servicing and Lubrication
  - Task Does Satisfy Applicability Rules
  - Task Does Not Satisfy Applicability Rules

**Step 5:** Identify Failure Consequence
- Task Does Not Satisfy Effectiveness Rule
  - Redesign
  - Improve task
  - “Fix when failed”
- Task Does Satisfy Effectiveness Rule

**Step 6:** Improvement Option Goals
- Continuous Improvement: Periodic re-evaluation and adjustment of tasks
- Develop Recommendations for Change
- Schedule Task

**Effectiveness**
- Third Filter
  - Is Task Worth Doing?
  - Apply Rule for Effectiveness
    - Safety or the Environment (Law)
    - Operational performance (Mission)
    - All other failures
    - Task Does Not Satisfy Effectiveness Rule
      - Extend periodicity
      - Sample Vs 100% inspection
      - Make situational
      - Redesign task
      - See other options
    - Task Does Satisfy Effectiveness Rule
      - Schedule Task

**Applicability**
- Second Filter
  - Task Restores/Maintains Original Reliability?
  - Apply Rules for Applicability
    - No or Acceptably Slow Rate of Degradation
    - Significant Rate of Degradation

**Age Degradation**
- First Filter
  - Does Failure Mode Occur?
SURFMER Results

Baseline

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<tr>
<th>Year</th>
<th>Fleet Manhours</th>
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Percent Reduction (to date): 46.6 %
I & D Level Maintenance

- Qualified Repairs *
  - unscheduled
- Assessments leading to Maintenance Decisions *
  - scheduled & unscheduled
- Mandatory Deep Maintenance*
  - scheduled
- Alterations
  - scheduled
  - Fleet
  - Program

O - Level Maintenance

PMS RCM Based – MER Validated

ICMP

Library of Specs (e.g. MSC, TRS)

Waterfront Maintenance Team

MRS*

3M History

OPNAV 4700 Note

$
RCM Training

■ US Navy Engineers
  ● Level I - Navy Backfit RCM for Practitioners
  ● Level II - Classic RCM for PMS Developers
  ● Level III - Navy Backfit RCM Trainer

■ Sailors
  ● 3 computer based training courses
  ● Classroom training at junior and senior technical schools

■ Naval Officers
  ● Training for all Officers at Surface Warfare Officer and Engineering Duty Officer Schools
Summary

- U.S. Navy employs two RCM processes in Surface Ship planned maintenance:
  - Classic (Maintenance requirement development) and
  - Backfit (Continuous improvement)

- RCM training and certification are enabling cultural change at the deckplates

- Application of RCM-Based Condition Based Maintenance at O, I and D-levels to optimize surface ship readiness
Backup Slides
RCM Criteria for CBM-Enabling Technology

■ Failures Happen: Dominant Failure Modes
  ● Failure mode is reasonably likely to occur

■ Applicability
  ● Monitored parameter really correlates to the failure mode; and
  ● Measures the parameter consistently and accurately; and
  ● Measurements serve as an accurate indicator of required repair action; and
  ● There is adequate time for corrective action before functional failure.
RCM Criteria for CBM-Enabling Technology (cont.)

**Effectiveness**

- **Safety:** Identifies repair threshold in time to reduce probability of failure to acceptable level; or

- **Mission:** Identifies repair threshold in time to reduce risk of failure (probability times severity) to acceptable level; or

- **Economics:** Identifies repair threshold in time to reduce cost to identify and prevent failure at less cost than repairing after run to failure.
Surface Ship Maintenance Effectiveness Review (SURFMER)

SURFMER is an RCM-based process for conducting system-level engineering review of surface ship preventive maintenance requirements

**Objectives:**

- Perform the right maintenance tasks – those that preserve equipment reliability
- Perform those tasks only on equipment that NEEDs it – i.e. on equipment that actually fails during service life
- Perform these maintenance tasks at the right time – when the equipment really needs it
Age-Reliability Curves

Evidence of Wearout

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<th>Age-Related</th>
<th>1973 UAL</th>
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Random

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