



**Lifecycle Cost Optimization  
through Maintenance Engineering:  
Reliability Centered Maintenance (RCM)  
&  
Condition Based Maintenance (CBM)**



# The Goal of RCM

**Deliver sustained equipment readiness while minimizing total ownership cost for owners of capital assets.**

## **RCM Supports:**

- Material Availability (KPP)
- Material Reliability (KSA)
- Lifecycle Ownership Cost (KSA)



# The Challenge:

- DoD needs sustainment solutions which can affordably facilitate extended weapon system life, enhancing legacy equipment availability, relevancy and/or viability.
- At NAVSEA, surface ship maintenance and lifecycle sustainment are critical to the surface warfare enterprise.
- The average cost of maintaining a Navy Destroyer over a 35 year lifecycle is over \$ 213 Million, this is in addition to the procurement cost for this ship ~ 2.7 Billion.
- The average age of a navy ship is nearly 28 years



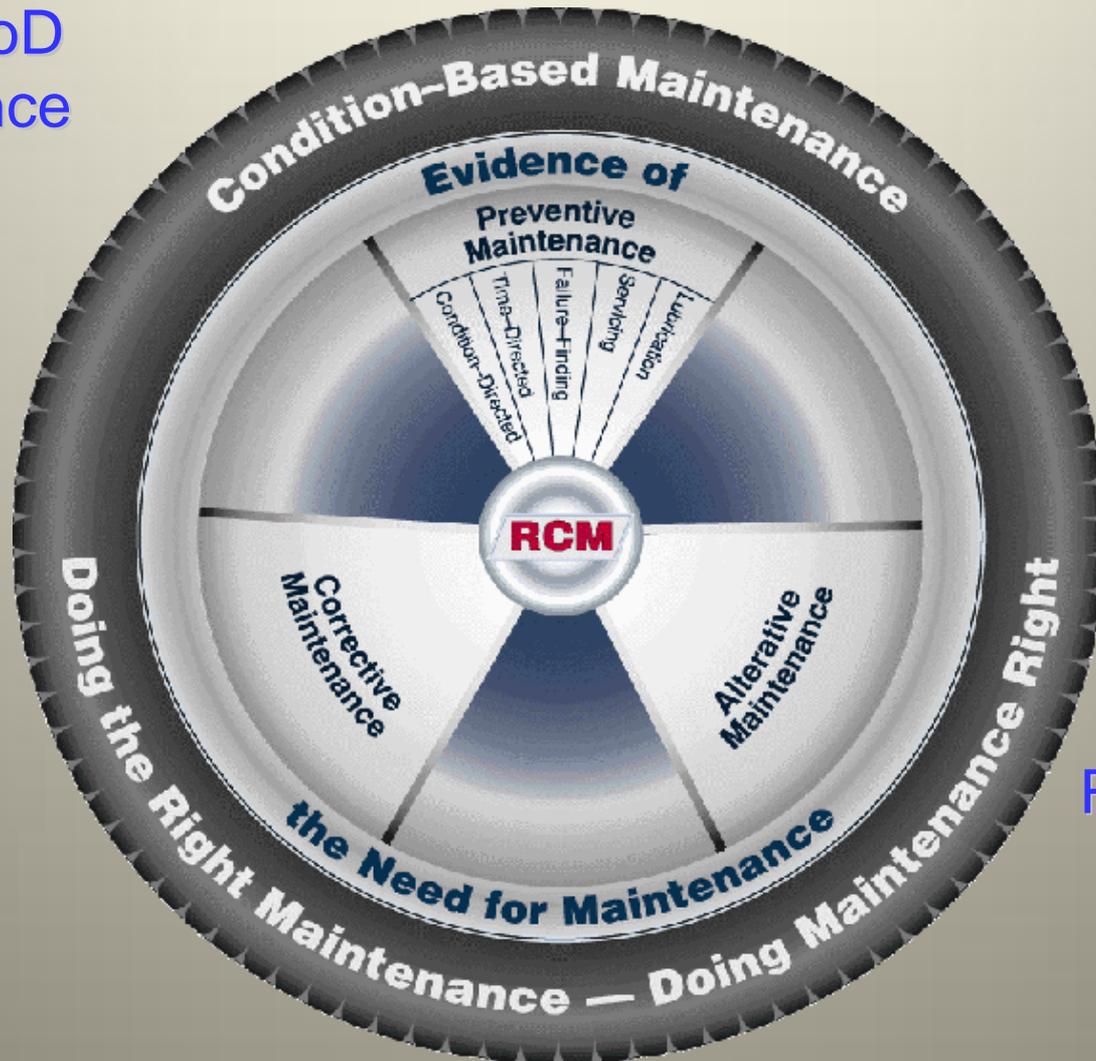
# Powerful Solutions

**Reliability-Centered Maintenance (RCM)** - A defined process which identifies the 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.

**Condition-Based Maintenance (CBM)** – A strategy that stipulates the performance of maintenance only when there is objective evidence of need (e.g. sensors, good data). It begins with RCM.

# RCM Is the Hub of CBM

CBM is DoD maintenance policy.



RCM provides the means to implement CBM



# What is CBM+ ?

*CBM+ Consists of three basic elements:*

- 1. A rigorous methodology for developing maintenance requirements employing a structured decision logic process known as Reliability Centered Maintenance.*
- 2. Tasks derived from the RCM methodology to monitor operating equipment to identify impending failure.*
- 3. Infrastructure to make use of sensor-based maintenance information.*

*Source: US ARMY CBM+ Roadmap (G-4, HQDA, December 2007)*



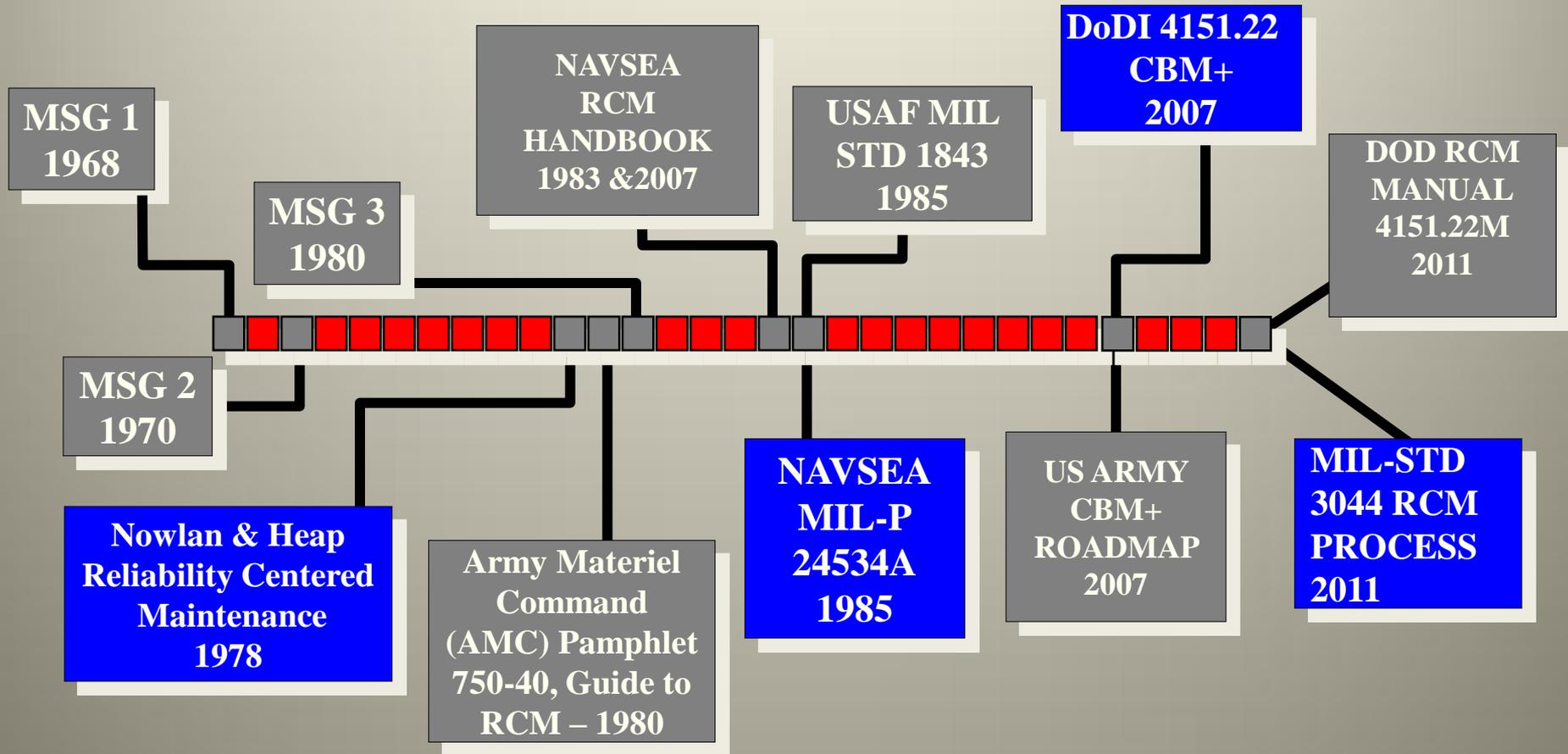
# RCM & CBM+ are DoD Policy

- DoDI 4151.22, Condition Based Maintenance Plus (CBM+) of 2 Dec. 2007 states...
  - “CBM+ is the application and integration of appropriate processes, technologies and knowledge-based capabilities to improve the reliability and effectiveness of DoD systems...”
  - “CBM+ be implemented into current weapon systems, equipment and material sustainment programs where technically feasible and beneficial.”
  - “CBM+ is maintenance performed on **evidence of need** provided by **reliability centered maintenance (RCM)** analysis and other enabling processes and technologies...”



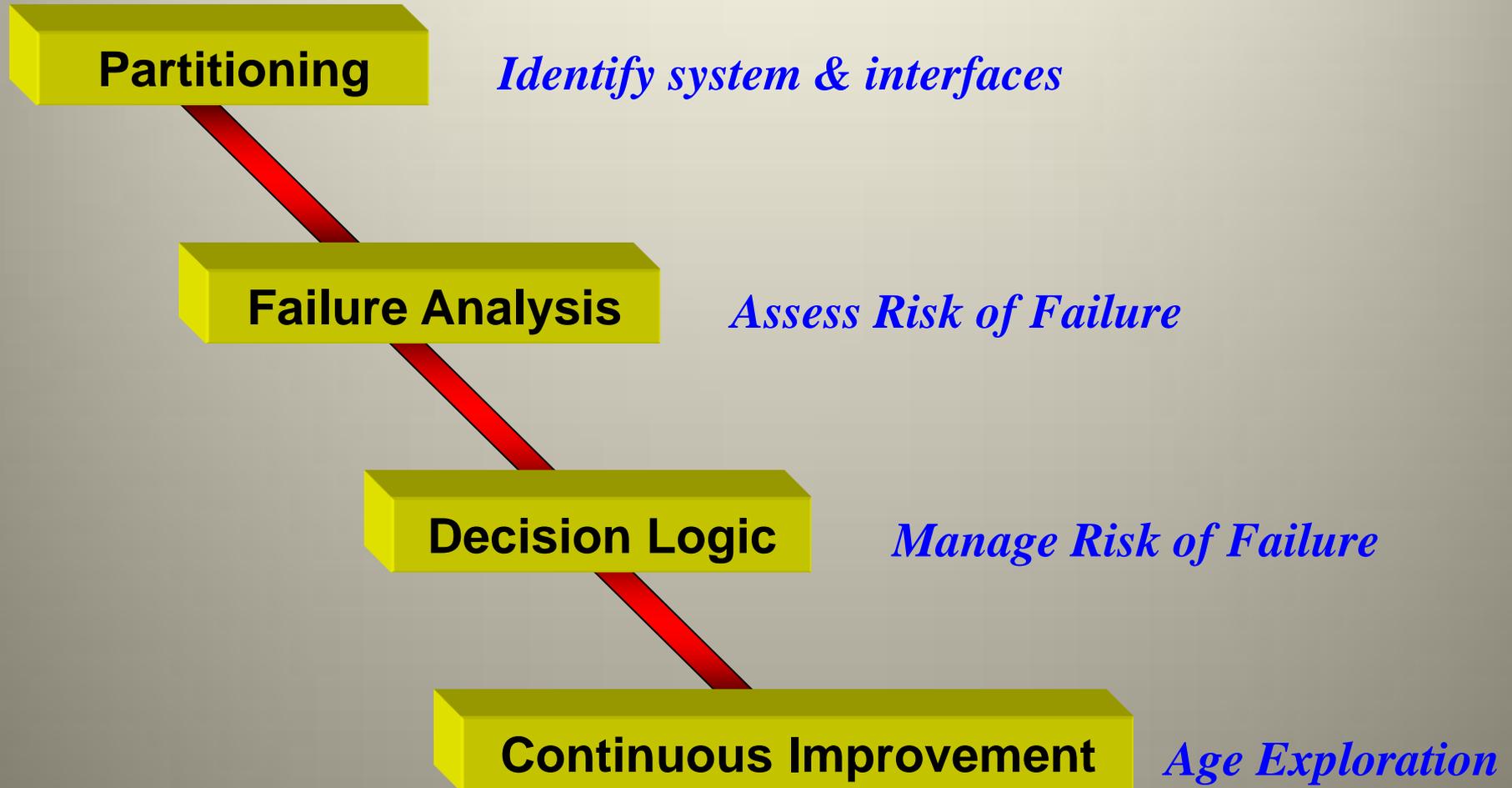
# History of RCM

RCM began with the Airline Industry in the 1970s and was adopted by the various Defense Department agencies in the 1980s and later by commercial industry.





# The NAVSEA Classic RCM Process





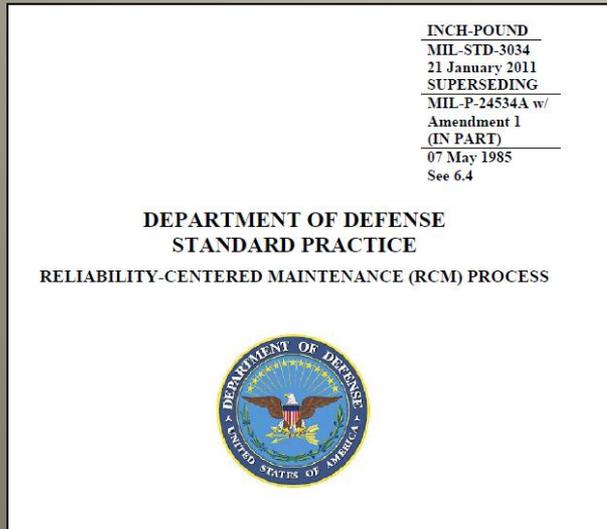


# NAVSEA RCM Tools

## MIL-STD 3034

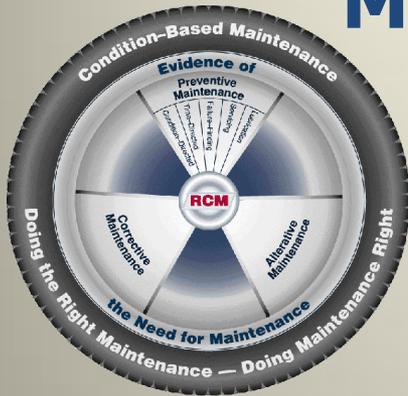
### “Reliability Centered Maintenance Process”

- Released in January 2011
- Navy standard, but available to all services
- 12 Phase fully detailed RCM process
- Associated Data Item Descriptions (DIDs) for each Phase

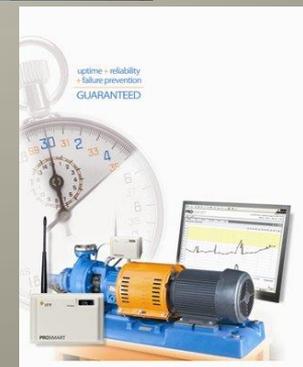
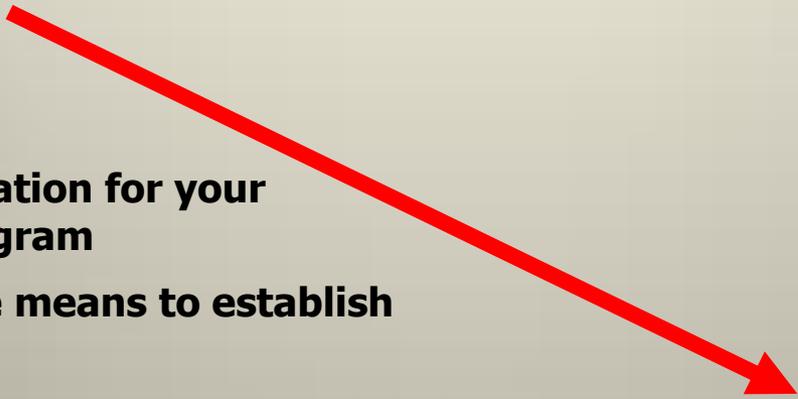


<https://assist.daps.dla.mil>

# RCM's Role in Predictive Maintenance (pM)

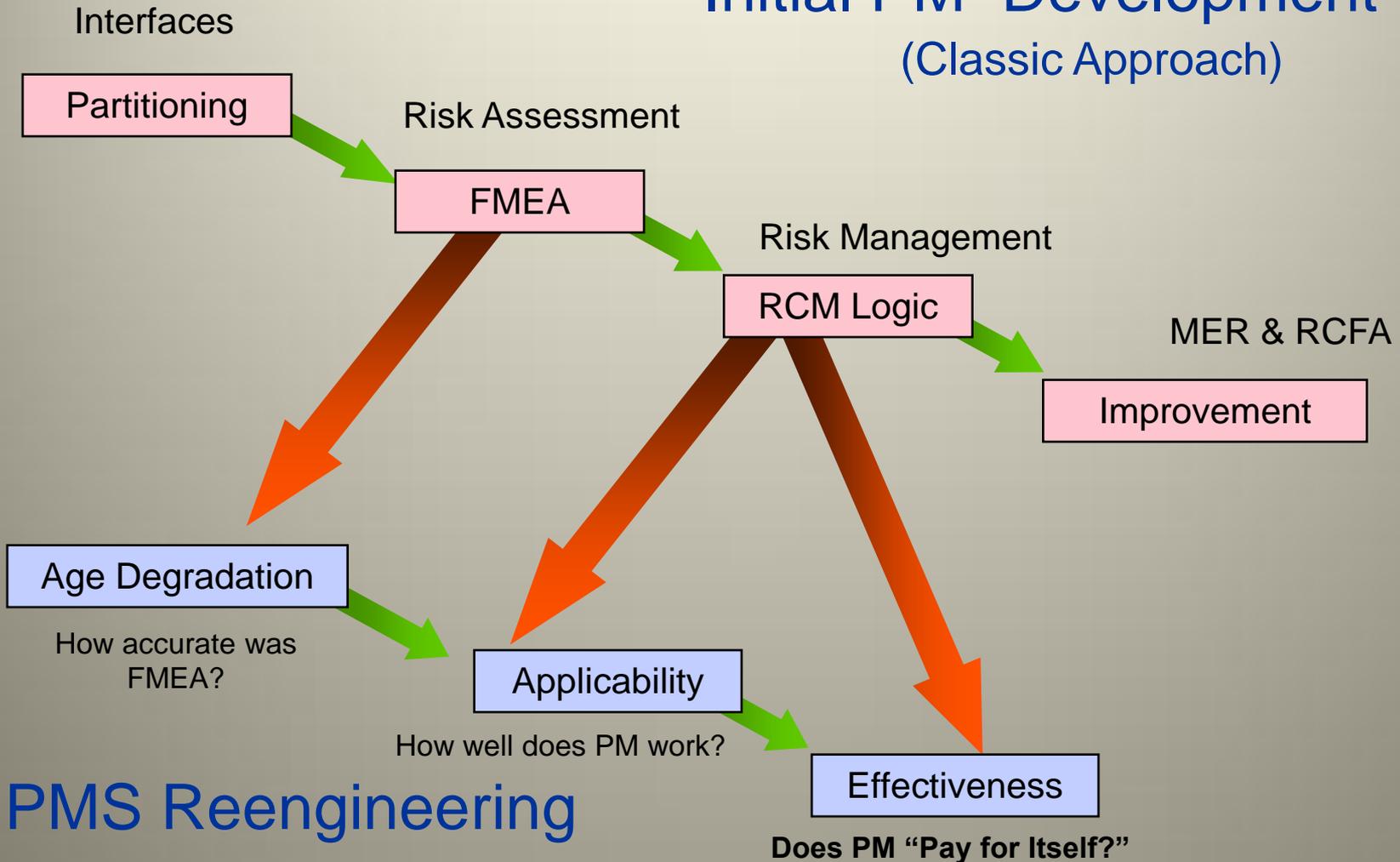


- **CBM is the foundation for your maintenance program**
- **RCM provides the means to establish CBM**
- **All RCM derived PM tasks are scheduled**
  - **By calendar**
  - **Visual inspection**
  - **Predictive maintenance technology**
    - **Wireless monitoring**
    - **Oil Analysis**
    - **IR technology**
    - **Vibration Analysis**



# Two RCM Processes

## Initial PM Development (Classic Approach)

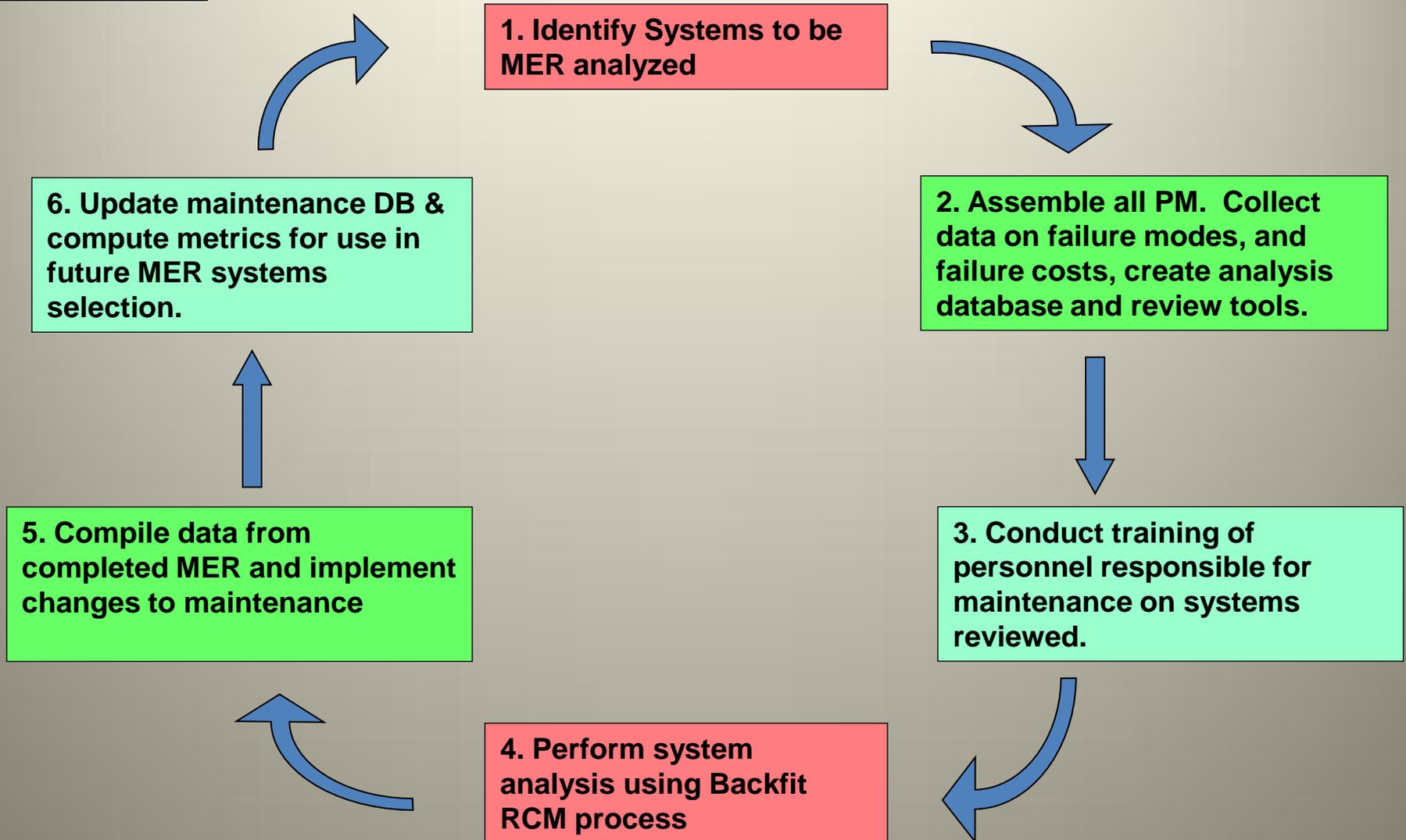


## PMS Reengineering

("Backfit" Approach)

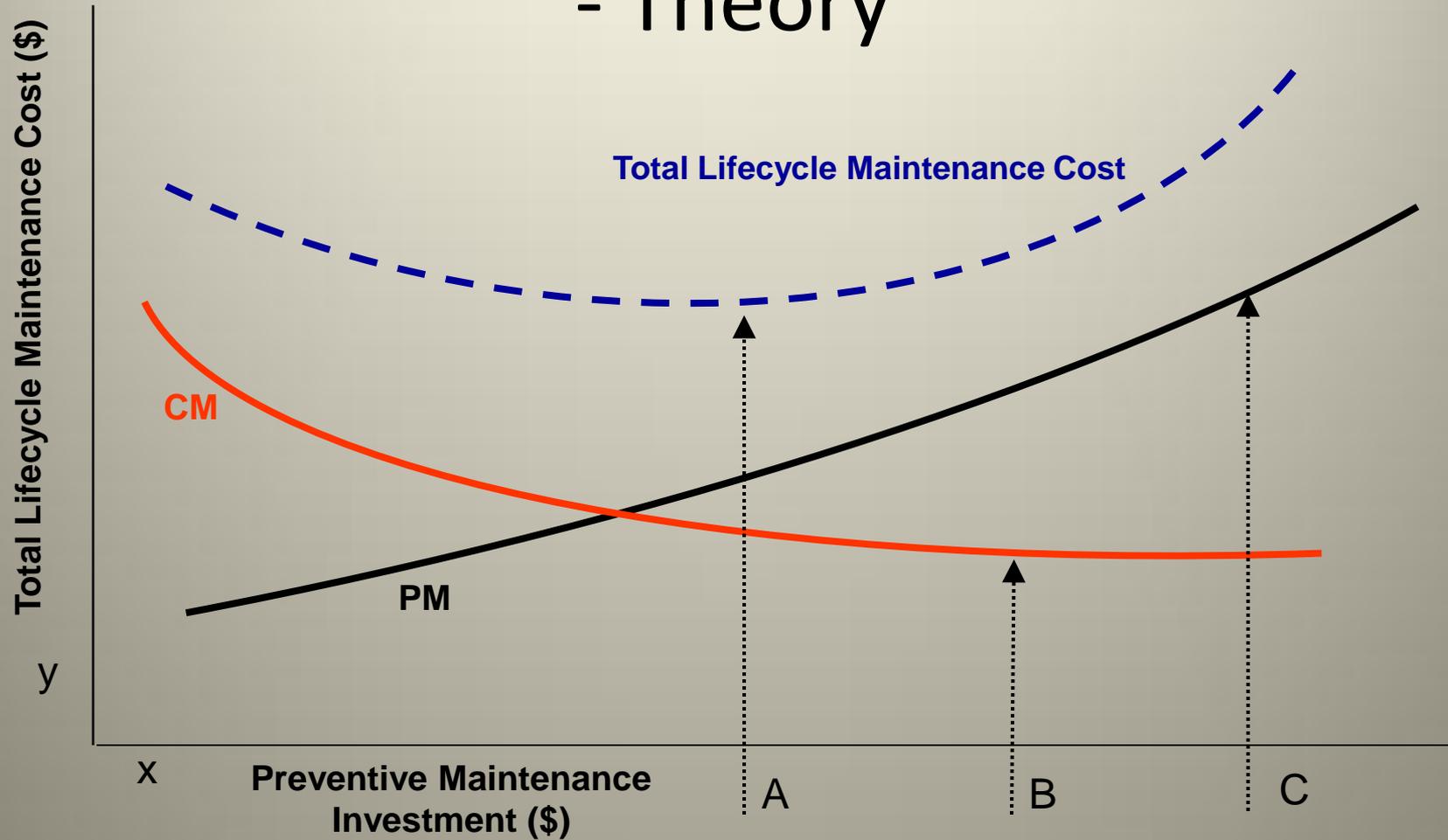


# RCM Tools in Practice: MER Process





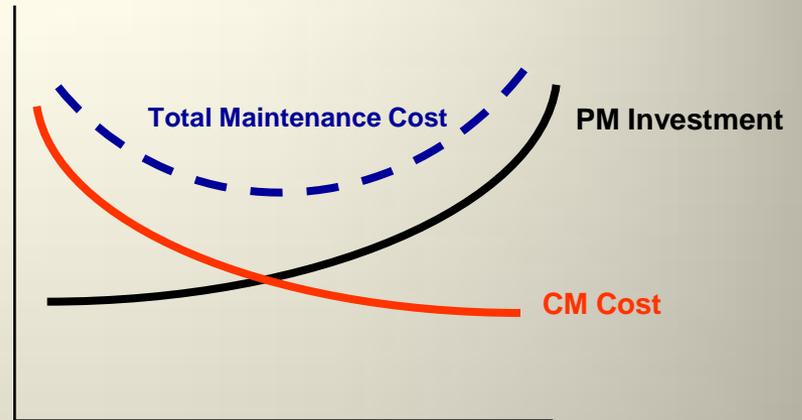
# Lifecycle Maintenance Cost - Theory



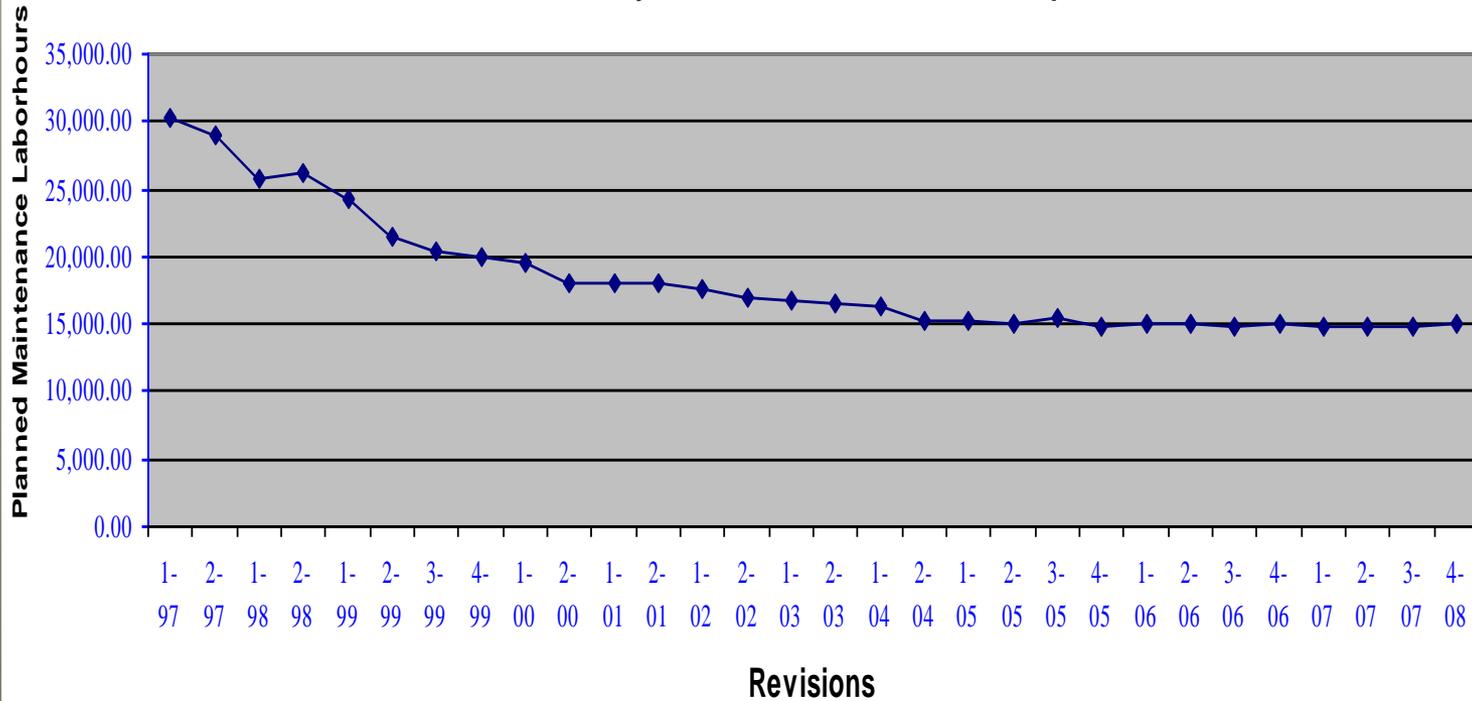


# MER Results

Cost \$



### US Navy Labor Hour Reduction Per Ship





# RCM Certification at NAVSEA

- *RCM Training & Certification Program*
  - **Level I** – Basic fundamentals and “Backfit RCM” process
    - Two day course of instruction – “intro to RCM”
  - **Level II** – “Classic RCM”
    - One week course of instruction
    - How to develop maintenance requirements
  - **Level III** – Train the trainer
    - Government Only,
    - Two week course of instruction
    - Level I and Level II plus experience



# RCM Certification at NAVSEA

- *RCM Training & Certification Program*
  - All Certifications are valid for three years
  - Classes taught once per month (L2) and once per quarter (L1)
  - Training team can travel offsite from Fairfax, VA
  - Recertification available online via ePMS Gateway
- *DAU RCM Training*
  - Fundamentals of RCM (2 hour course)
  - DAU Continuous Learning Module CLL-030 ([www.dau.mil](http://www.dau.mil))



# NAVSEA RCM Summary



## *People*

- RCM Certification & Training Program
  - Classic RCM Course (Level II)
  - RCM Intro/Backfit Course (Level I)
  - Three Year Certification
  - Recertification available online
  - Available to all Services & Government agencies

## *Policy*

- NAVSEAINST 4790.8B
  - Requires RCM Certification for Maintenance Developers
  - Requires RCM for maintenance development
- NAVSEAINST 4790.27
  - Delineates CBM & RCM Policy at NAVSEA

## *Process*

- MIL-STD 3034 RCM
  - Step by step RCM Process
  - Associated DIDs for contracting
  - Available for all Services use
- NAVSEA RCM Manual
  - Describes fundamentals of Level 1 and Level 2 RCM

## *Payoff*

- >40 % Average maintenance manhour reduction since Backfit RCM enacted in 1997
- Since 2001, over 6000 RCM Certified
- Best Manufacturing Practices Center of excellence award 2007
- Consistent, repeatable, auditable process for maintenance development



Please Visit... <https://altair.seajax.navy.mil/epmsgateway>





**BACK-UP**



**Evident Failures**

**Hidden Failures**

1

Is occurrence of a failure evident to operating crew in performance of normal duties?

Yes

No

2

Does Failure cause loss of function or secondary damage that has direct and adverse effect on operating safety?

No

3

Does failure have a direct and adverse effect on operational capability?

No

Critical Safety Class A

Yes

Scheduled maintenance is required and must be able to reduce risk to an acceptable level or item must be redesigned unless basic design constraints require acceptance of the identified risk

4

Is there an effective and applicable preventive maintenance task (or combination of tasks) that will prevent functional failures?

**Safety**

Yes

No

Describe and classify task(s)

Submit a safety related design change

Operating capability (economics) Class B

Yes

Scheduled maintenance is desired if it is effective in reducing probability or operational consequences to an acceptable level

5

Is there an effective and applicable preventive maintenance task (or combination of tasks) that will prevent functional failures?

**Mission**

Yes

No

Describe and classify task(s)

No task required

Other regular functions (economics) Class C

6

Scheduled maintenance is desired if it is cost effective in reducing corrective maintenance

Is there an effective and applicable preventive maintenance task (or combination of tasks) that will prevent functional failures?

**All Other**

Yes

No

Describe and classify task(s)

No task required

Scheduled maintenance is required to reduce risk of multiple failures or unavailability of function to an acceptable level

Hidden or infrequent functions Class D

7

Is there an effective and applicable preventive maintenance task (or combination of tasks) that will prevent functional failures?

Yes

Describe and classify task(s)

No

8

Is a scheduled Failure Finding task available and justified?

Yes

No

Describe and classify task(s)  
Submit Safety related design changes if appropriate

No task required  
Submit Safety related design changes if appropriate



# Road Map for "Backfit" RCM

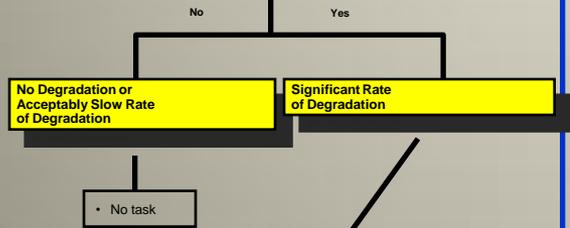
**AGE DEGRADATION**  
(First Filter)  
**Does Failure Mode Occur?**

**APPLICABILITY**  
(Second Filter)  
**Task Restores /Maintains Original Reliability?**

**EFFECTIVENESS**  
(Third Filter)  
**Is Task Worth Doing?**

**Step 1:** Identify Failure Mode (material condition of an item after failure, e.g., seized bearings)

**Step 2:** Does a Significant Rate of Age Degradation Exist?



**Step 3:** Determine/Classify Type Task

Name	TIME-DIRECTED (TD)	CONDITION-DIRECTED (CD)	FAILURE-FINDING (FF)	SERVICING (S)	LUBRICATION (L)
<b>Action</b>	"Renew life" (Restore or replace) condition	"Renew Life" (Restore or replace) Based on measured condition compared to standard	Determine whether failure has occurred	Add/replenish consumable (e.g. windshield washer fluid)	Oil, grease, or otherwise Lubricate Regardless of
<b>Circumstance</b>	wearout	Imminent Accelerated characteristic corresponding to failure mode	Equipment off-line or "hidden" function (e.g. safety/protective devices)	Failure of consumable	Reduced level wear
<b>Evident</b>	Yes/No	Yes/No	No	N/A	N/A
<b>Scheduling</b>	All tasks SCHEDULED on calendar time or situational basis				

**Step 4:** Is the Existing Maintenance Task Applicable?

**Apply Rules for Applicability**

**TD: Life Renewal (Replace/Restore)**

- Probability of failure increases at a specific age for all units in population (evidence of WEAROUT)
- Large portion of population survives to that age
- Task restores original resistance to failure (no infant mortality)

**CD: Health Monitoring**

- An equipment characteristic corresponding to the specific failure mode can be identified
- That characteristic can be measured accurately with consistency
- Enough time exists between potential and actual failure to take corrective action

**FF: Hidden Failure (Find/Repair)**

- Failure not evident to operating crew
- No applicable and effective preventive task exists

**S/L: Servicing and Lubrication**

Task Does Not Satisfy Applicability Rules

Task Does Satisfy Applicability Rules

• Redesign to permit maintenance (change failure mode/features)

• Improve maintenance procedure

• Accept "fix when failed"

• See other options

**Step 5:** Is the Maintenance Task Effective?

**Apply Rule for Effectiveness**

**Safety or the Environment (Law)**

- Reduces probability of failure to an acceptable level

**Operational performance (Mission)**

- Reduces risk of failure to an acceptable level

**All other failures**

- Cost of PM is less than cost of repair plus cost of lost capability

Task Does Not Satisfy Effectiveness Rules

Task Does Satisfy Effectiveness Rules

• Extend periodicity

• Sample vs. 100% inspection

• Make situational vs. calendar-based

• Redesign to permit effective task

• See other options

Schedule Task

**Step 6:** Improvement Option Goals

• Develop Recommendations for Change

**Continuous Improvement:** Once this process is applied, tasks need to be periodically re-evaluated and adjusted based on operating experience.

**Identify Failure Consequences**

**Safety or the Environment**

- Personnel safety (life or limb) or Law

**Operational performance**

- Ability to perform ship's mission

**All other failures**

- Not impacting safety, law, or mission