

# RCM Applied to the CH-47 Chinook Heavy Lift Helicopter



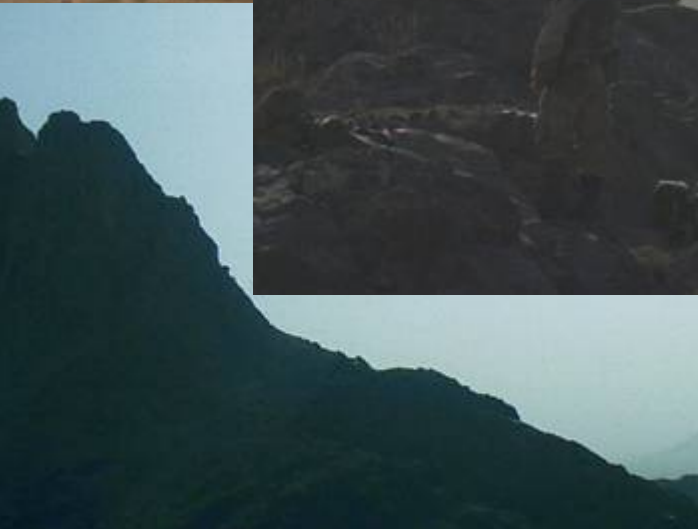
*For the Warfighter – With the Warfighter*



# Presentation Agenda



- Application of Reliability Centered Maintenance (RCM)
- RCM Principles Applied to:
  - Special Tools and Test Equipment (STTE)
  - Unique Identification (UID)
  - Condition Based Maintenance (CBM+)



# **Application of Reliability Centered Maintenance**



# Application of RCM to the CH-47



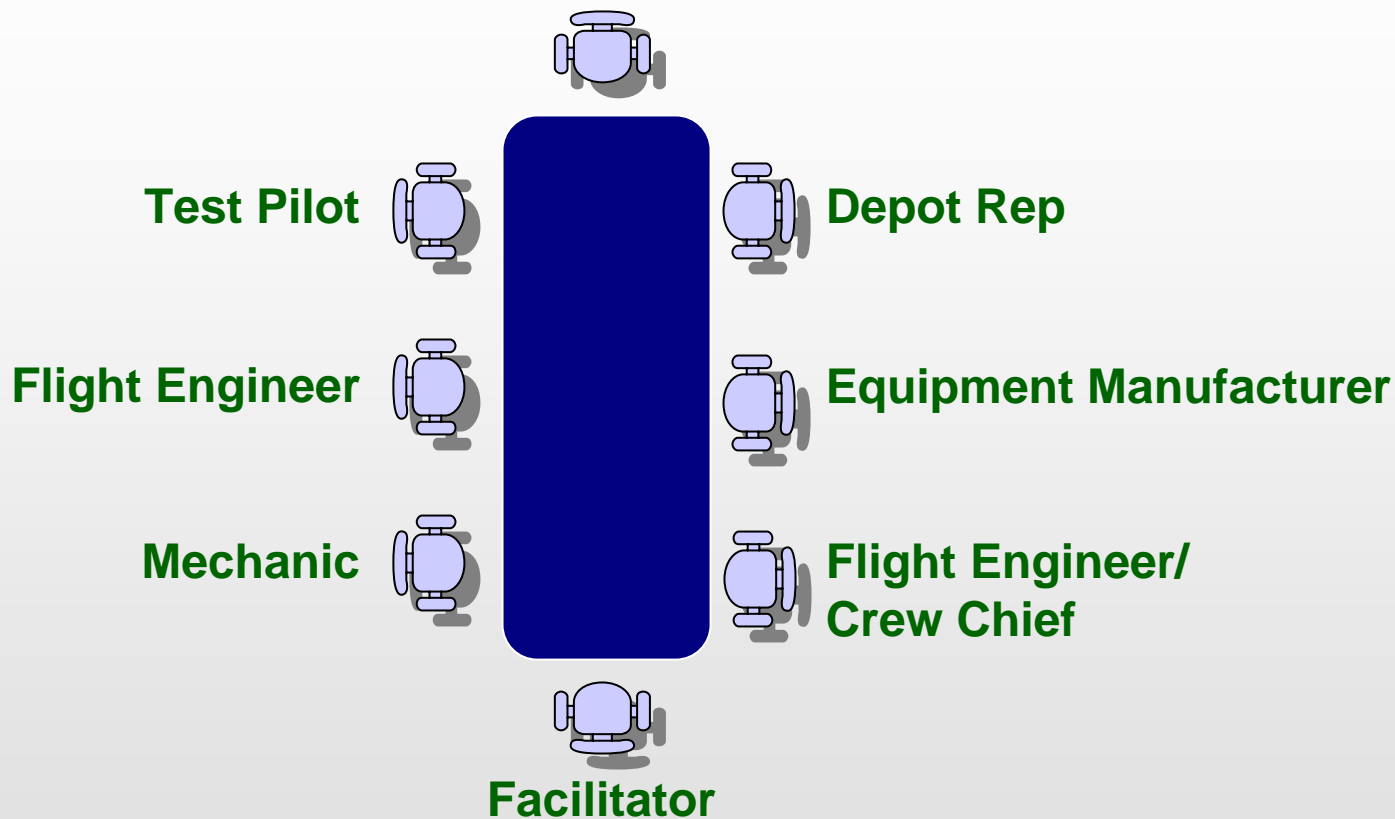
- **To reverse the trend of increasing Operation and Support costs**
- **Chief focus of maintenance had been on the prevention of failures**
  - Common assumption that, in most cases, equipment “wears out” and inevitably becomes less reliable with age
- **With RCM analysis, focus began to shift from preventing failures to managing the consequences of failures as they affect the aircraft as a whole.**



# RCM Working Group



## Systems Engineer



**In the absence of specific data on failure rates and characteristics, intervals are largely determined based on service experience.**



# Maintenance Transformation



## BEFORE RCM

200 Hour Phase maintenance

## AFTER RCM

400 Hour Cycle Service Plan  
200 Hour Servicing/Inspection

- Number of Phase Maintenance tasks reduced by **73%**
- Phase Maintenance requires **50% fewer** man hours to complete with an increase in readiness.



# Application of RCM to the CH-47



- Eliminated unnecessary tasks
  - Eliminated Duplication of Effort
    - 200 Hour Phase Maintenance Program: Independent Activities
    - 400 Hour Cycle Service: Supportive Activities
  - Technical Justification
    - Pitot Static System Check
  - In response to single events
    - Retorque droop stop bolts (due to bad lot of hydrogen embrittlement)
  - Extended intervals
    - Wheel bearing repacking (Extended from 200 to 400 hours)
  - Move to On-Condition Maintenance
    - Brake pad replacement

Maintenance  
Pre-Flight  
Daily  
Corrosion Inspection  
Special Inspections





# 200 Flight Hour Phase Maintenance to 400 Flight Hour Cycle Service Plan



	# of Tasks <u>Before</u> RCM
200 Flight Hour Phase	428

	# of Tasks <u>After</u> RCM
200 Flight Hour Servicing and Inspection	68
400 Flight Hour Cycle Service Plan	48
<b>Total</b>	<b>116</b>



# Default Strategies

RCM applied to electronic system:

*T55-GA-714A Engine Full Authority Digital Electronic Control (FADEC) system*



- Improved understanding
- Developed accurate and useable fault code matrix
- Capitalized on -714A technology to increase readiness and reduce mission aborts
  - More than 18 new operating/emergency procedures added to Operator's manual
- Simulator software changes



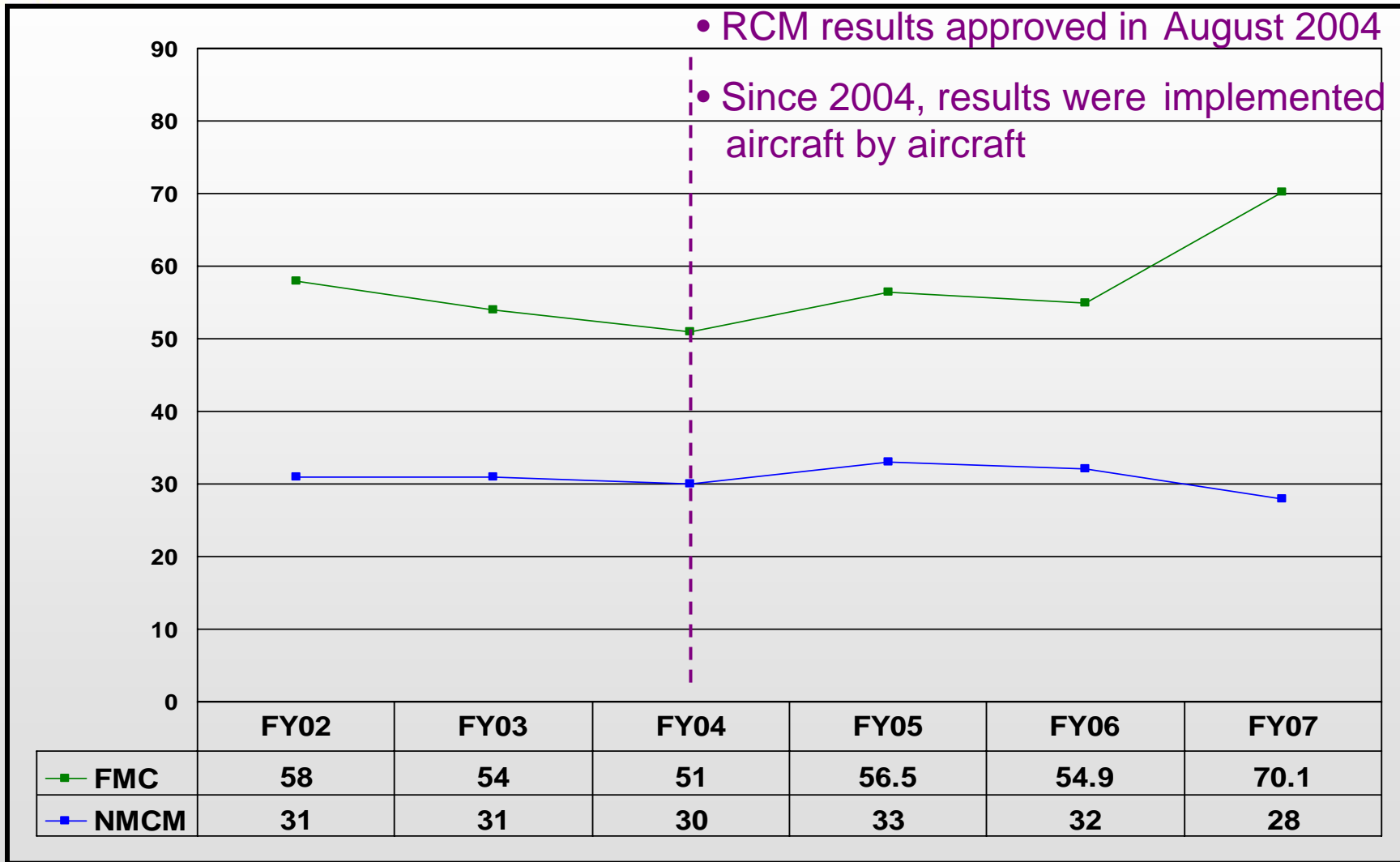
# Application of RCM to the CH-47



- RCM results implemented in 2004.
  - CH-47 achieved readiness goal of 75% FMC in August 2007 for the first time!



# CHINOOK (CH47D) TOTAL ARMY



DA GOAL 75% FMC

**FY02 – FY07**

SOURCE OF DATA: RIDB

# **RCM Principles Applied to Special Tools and Test Equipment (STTE)**



# STTE



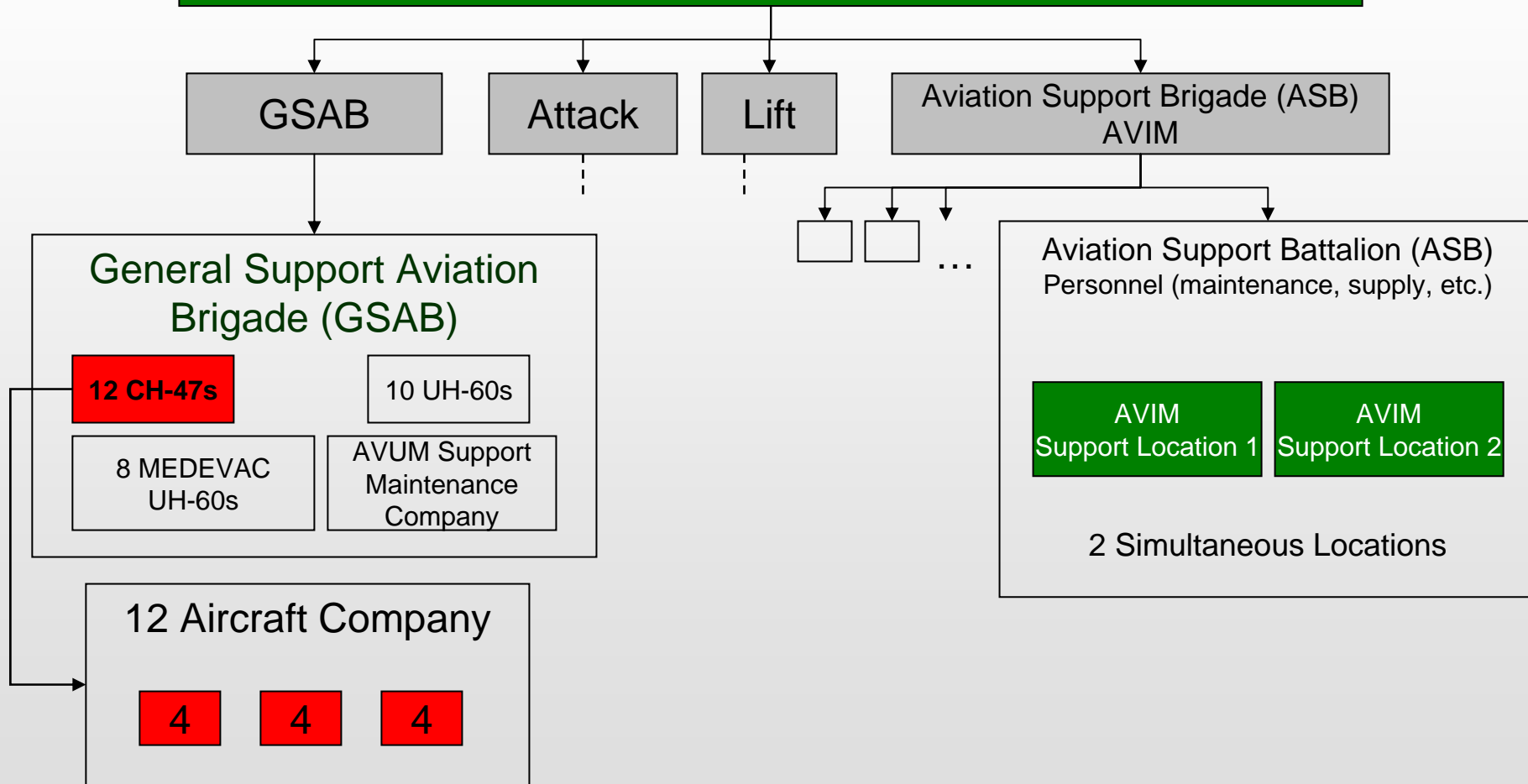
- Analysis initiated to determine suitable Basis of Issue (BOI) to support Army Transformation
- BOI for STTE that was being used estimated by Boeing ~1960s
  - Assumption that units stayed together
  - 1 of every applicable Tool was allotted per 25 Helicopters
- Needed to determine suitable BOI so the Field could operate under the new doctrine of Split Based Ops



# Army Transformation Affect on STTE



## Combat Aviation Brigade (CAB)





# STTE



- How do RCM Principles apply to STTE?
  - Allows a clear understanding of the Operating Context
  - Reviewed all tasks and analyzed STTE
    - What tools were currently recommended versus what was needed
  - Functions, Functional Failures, Failure Modes and Effects, and Consequences
- Determined new BOI to support Army Transformation





# RCM Principles Applied to STTE



## "The Big List" Before

- 422 STTE line items

## CH-47 STTE After

- 224 STTE line items

- Purged obsolete STTE
  - All -712 engine tools purged (~120)
- Many items that were identified as STTE but were common tools
  - Dial Indicator
- Purged unnecessary STTE
  - STVA (Self Tuning Vibration Absorber) Trailer Adapter



# RCM Principles Applied to STTE



- Increased BOI in most cases
  - *Example: Actuator Safety Blocks and Rotor Head Lockout Pins from 1 set per 25 aircraft to 1 set per aircraft*
  - Field will be supplied with what they need
- Established Accountability
  - In process of putting all STTE on the MTOE (Modified Table of Organization and Equipment)
    - Means it must be inventoried and accounted for
    - Most STTE before this process were not required to be inventoried.



# RCM Principles Applied to STTE



- Acquisition of additional STTE began 1½ years ago
- First two units equipped in May and June 2007
- Analysis results justified an increase in STTE funding
  - As a results, the PM awarded \$6M additional funding per year for the next 10 years
    - Funds 2 Combat Aviation Brigades
- Guy in the Field has the tools he needs!!

# Unique Identification



# DoD UID Mandate: Parts Marking



- Approximately 1,000 components are required to be marked
  - Conform to 1 or more of the 5 criteria
- Independent study performed on 300 components



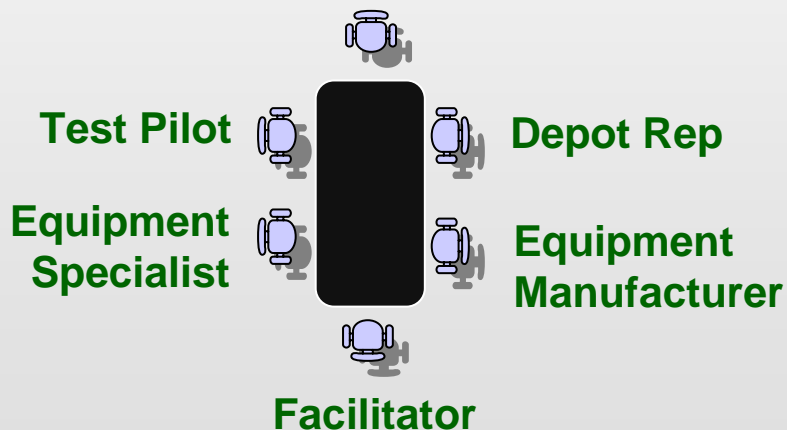


# DoD UID Mandate: Parts Marking



- Realized that Parts Marking Decisions in such a critical environment require analysis
- Parts marking solutions identified using RCM Principles
  - Systematic review of all failure modes, failure effects, and consequences of each marking opportunity

## Systems Engineer



- Facilitated Group Approach
  - Ensures the right people who are sensitive to the hazards of the equipment in its operating environment are the decision makers

- Incorporates safety and operating context into the core of the parts marking decision making.



# DoD UID Mandate: Parts Marking



## Results:

- ~280 items approved for label marking
- 100 items under review for marking approval
- 167 Direct Part Marking Candidates
- Over 13,000 items marked in the DoD UID registry



**CBM+**



# CH-47 CBM+

- 49 specific CH-47 components selected for CBM+ analysis.
- Acknowledge that a FMEA is required to properly implement CBM+ strategy
- Components evaluated to identify Failure Modes that could be monitored.
  - Forward Transmission: 13 Failure Modes such as
    - Stationary ring gear wears due to normal use.
    - FWD transmission 1st stage planetary carrier splines wear due to normal use.
    - FWD transmission spiral bevel pinion gear wears due to normal use.
- Each Failure Mode prioritized for CBM+ Implementation based upon
  - Failure consequences
  - Frequency of failure
  - Effort required for implementation (ex. cost of equipment, training, etc.)
- 161 Failure Modes were identified as candidates for Condition Based Maintenance



# What RCM Achieved



- *“RCM makes you take a real hard look at what you’re doing.”*
- RCM offers results to better support the Warfighter
  - Reduced Downtime and improved Readiness
  - Reduction of workload to the soldier
    - Relieves unnecessary burdens
  - Improved Health of Aircraft
  - RCM has the ability to change the maintenance philosophy



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