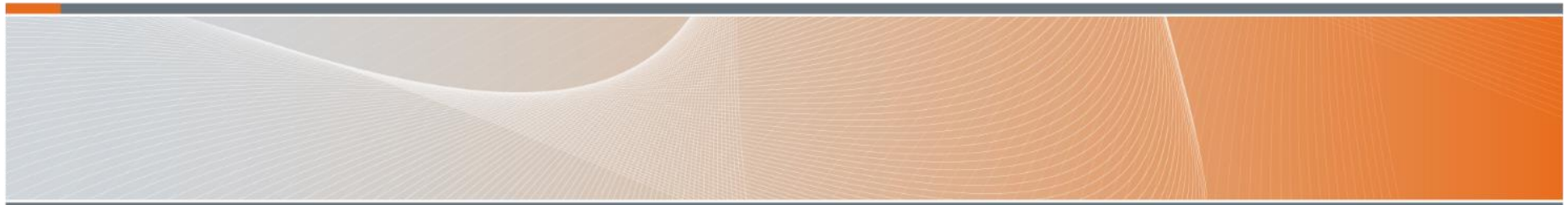




Reliability-based Maintenance to achieve Capability & Cost of Ownership Objectives

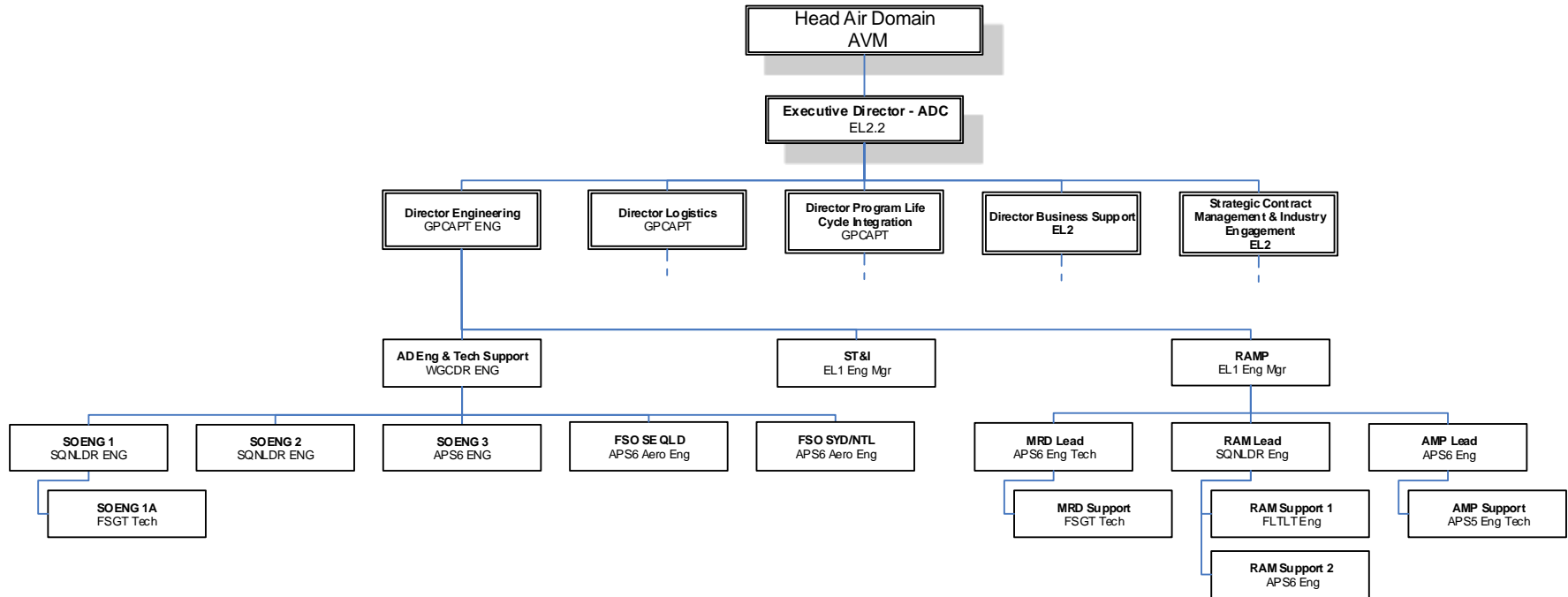
Aircraft Airworthiness & Sustainment Conference – Australia 2019



Overview

- CASG Air Domain Directorate of Engineering
- Reliability, Availability & Maintainability 101
- Reliability-based Maintenance Essentials
- Reliability-based Maintenance Benefits
- Current Air Domain Initiatives

CASG Air Domain Centre



Reliability-based Maintenance Principles

- Reliability, Availability & Maintainability (RAM) - 101
 - Reliability inextricably linked to ‘failure’
 - Maintainability = ease of conducting maintenance
 - Availability results from the combined effects of failure & maintenance
- RAM Engineering Processes:
 - Help ensure safety
 - Influence Capability
 - Optimise Operating & Sustainment (O&S) Costs
 - Ensure supportability for Life of Type (LOT)



Safety

- Systems are designed to be safe; & **maintenance** aims to ensure the continued functionality of the system without unforeseen failures
 - Based on assumed Configurations, Roles, Environments & **Use** (CREUs)
- CREUs can affect how 'reliable' a system will be in service



Safety

- Systems are designed to be safe; & maintenance aims to ensure the continued functionality of the system without unforeseen failures
 - Based on assumed Configurations, Roles, Environments & **Use** (CREUs)
- CREUs can affect how 'reliable' a system will be in service
- RAM processes enable the **verification of design assumptions** for equipment when operated within a given CREU
 - Ensure safety-critical items/systems do not fail unexpectedly

Capability

- RAM characteristics influence **initial capability planning**
 - Reliability (how often something fails) will affect the likelihood of an asset completing a mission
 - Maintainability (the ease to conduct maintenance) will affect how long it will take to fix an asset
 - The resulting Availability will dictate how many assets we need to fulfil a Capability requirement
- RAM characteristics **influence the support** required for a capability
 - Failure types dictate maintenance skill sets
 - Failure frequencies & maintainability dictate maintenance workforce size
 - Failure types & frequencies dictate spares & maintenance facility requirements

O&S Costs

- Reliability is correlated to Failures
 - Responding to Failures requires **personnel, equipment, facilities, spares**
 - Majority of O&S budget
- Maintainability is correlated to time & effort to maintain an asset
 - Corrective Maintenance (CM)
 - Preventive Maintenance (PM)
- RAM Processes can enable:
 - Optimised CM & PM
 - Informed decisions wrt balancing Capability & Costs Objectives
 - Optimised spares holdings
 - Optimised fleet sizes
 - Improved mission efficiency & effectiveness
 - Improved Availability & Safety

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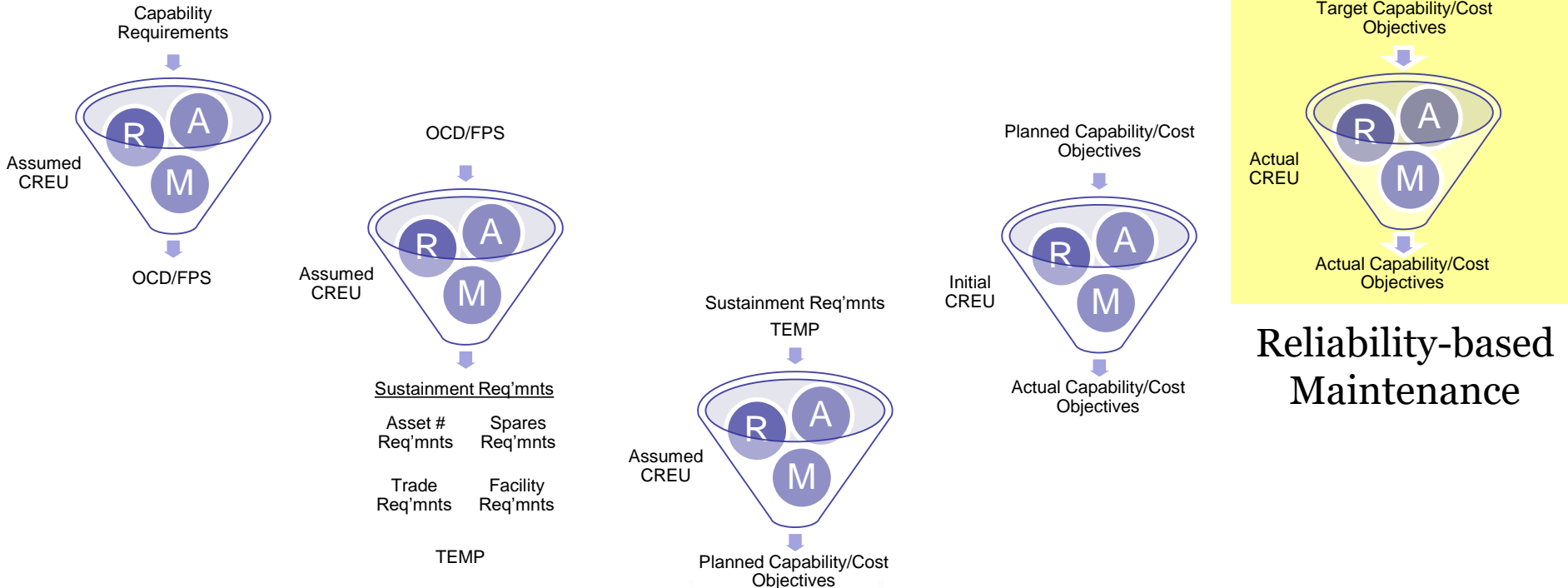
**Reduced Cost of
Ownership**

Supportability for LOT

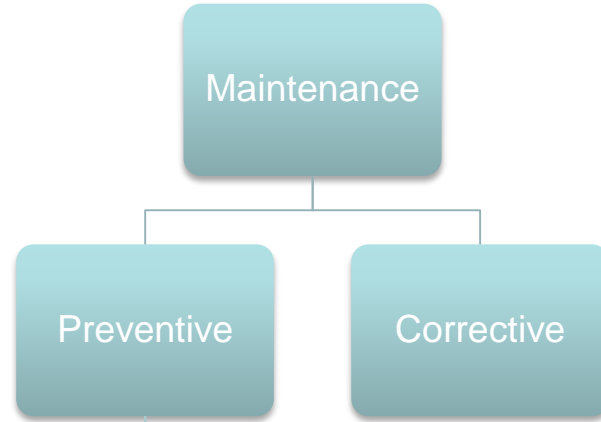
- **RAM performance will change** with time due to the ageing of an item/system & changes in CREU
- RAM processes can be utilised to make informed Capability decisions wrt:
 - Cost effectiveness
 - Platform to Item level
 - Logistics Support
 - Upgrades/Mods/Replacements



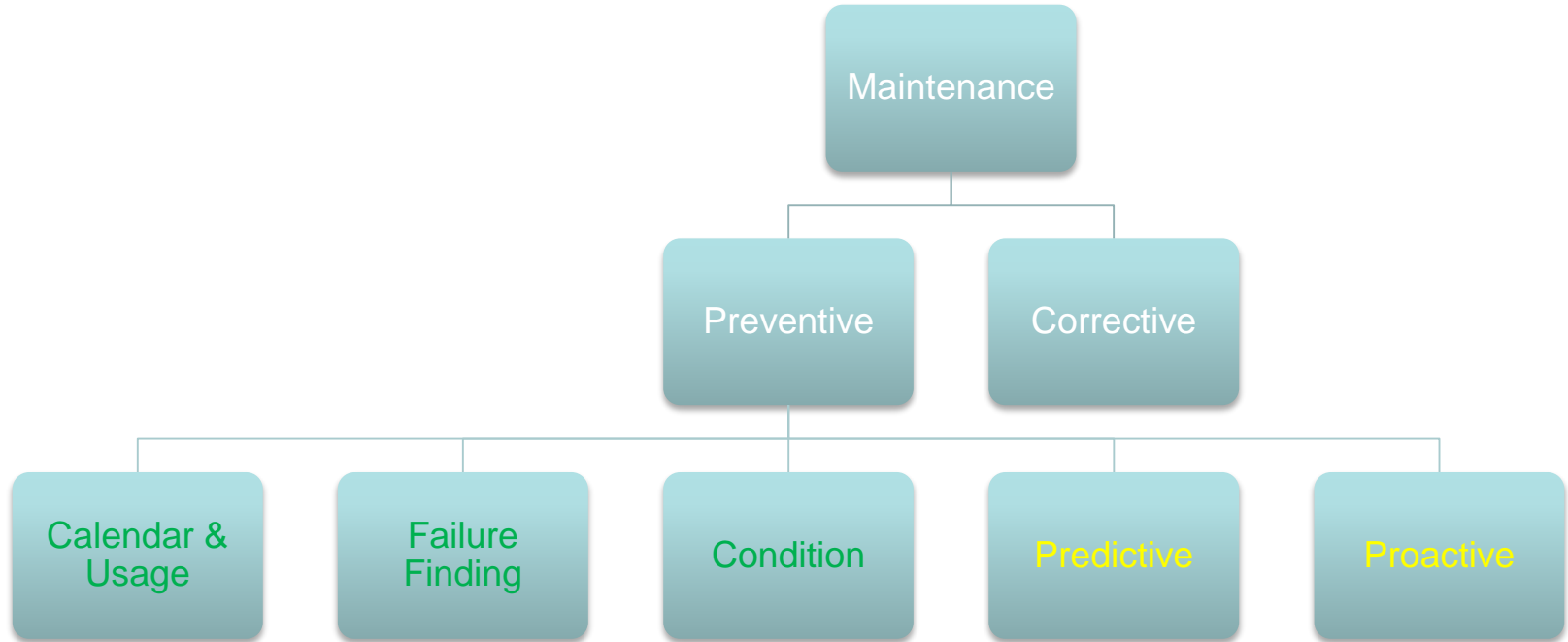
RAM Capability Life Cycle Watershed Effect



Maintenance



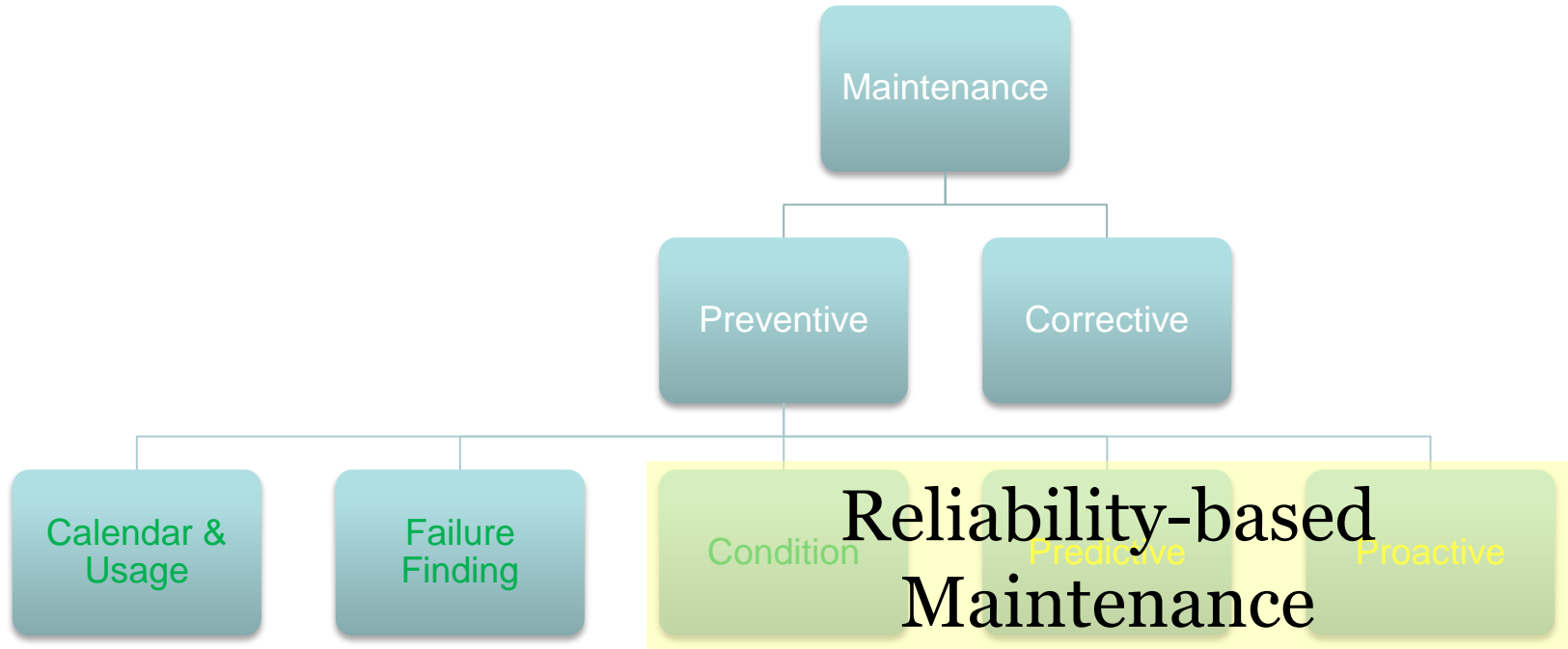
Maintenance



Maintenance

- **Calendar/Usage Based:** Maintenance conducted at specific intervals to replace/renew reliability regardless of condition
- **Failure Finding:** Maintenance conducted to ensure the availability of a 'hidden function'
- **Condition Based:** Maintenance conducted based on the condition of the item
- **Predictive:** Maintenance conducted based on analysis of condition trends
- **Proactive:** Maintenance based on predictive methods to identify failure root causes

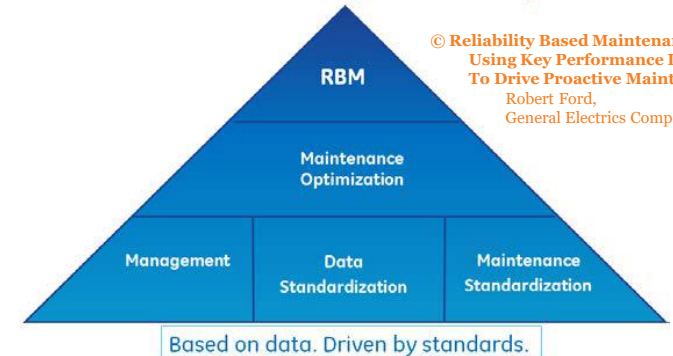
Maintenance



Essential Elements

- **OPPDT**
 - Organisational commitment
 - People with requisite Qualification, Training & Experience
 - Processes that are repeatable and provided consistent outcomes
 - Data that is accurate and relevant
 - Tools that are reliable and effective

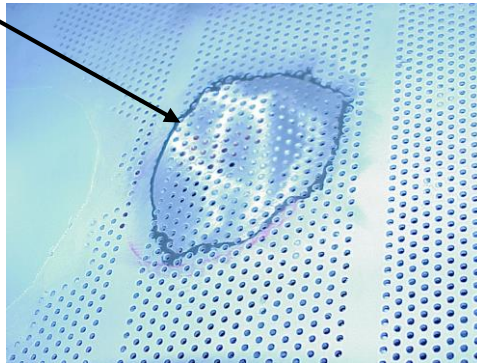
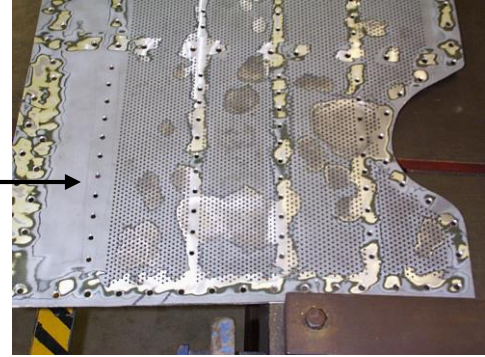
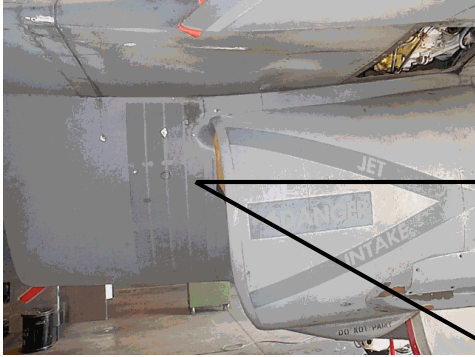
RBM ... Building a solid foundation
To maximize the benefits of Enterprise Asset Management



RbM Benefits

- **Safety:** RbM can help ensure that the maintenance conducted is applicable and effective for a given CREU
 - ensure safety-critical items/systems do not fail unexpectedly
- **Capability:** RbM can realise the latent reliability of an item/system
 - optimise 'down-time'; ensure capability is available when needed
- **Cost of Ownership:** RbM can tailor maintenance program for CREU
 - do the right maintenance, at the right time, for the right reasons
 - optimise personnel, equipment, facilities & spares requirements
- RbM is applicable to items & systems

RAAF F/A-18A/B Splitter Plate



RAAF F/A-18A/B Splitter Plate

■ Problem

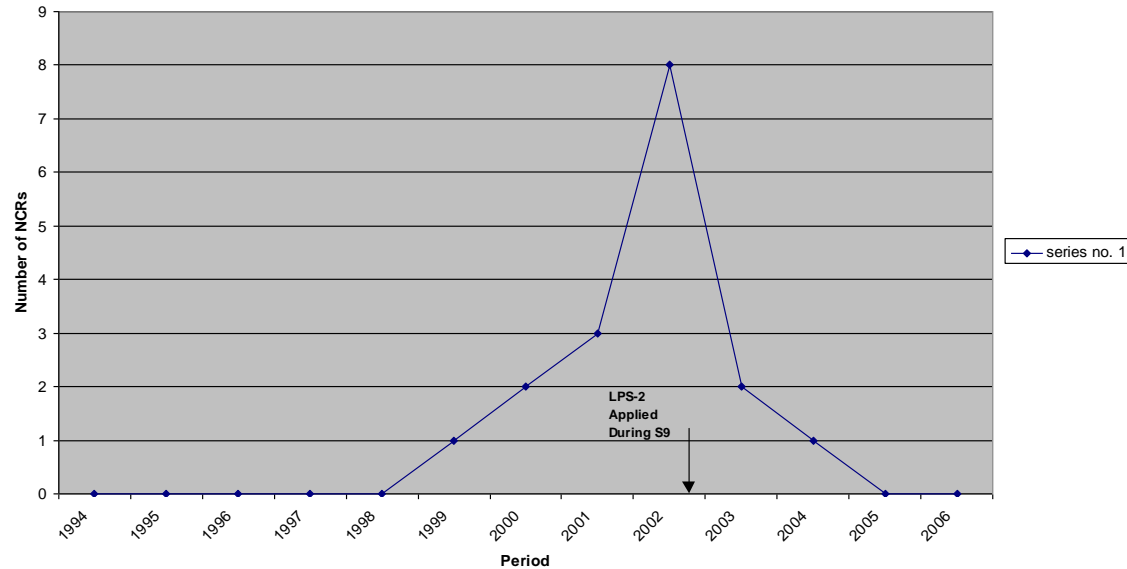
- Two week A/C down-time
- High cost to repair: 63 hrs
- Occurrences seem to be increasing

■ Strategy

- Research the problem & gather data
- Task DST to determine corrosion mechanism
- Develop engineering solution
- Implement solution - LPS-2 during S9 servicing
- Monitor success of Maintenance action through Fleet data

RAAF F/A-18A/B Splitter Plate

Number of NCRs over time
Criteria series no. 1:
Part no in (74A322114) Splitter Plate



Black Hawk Maintenance Optimisation

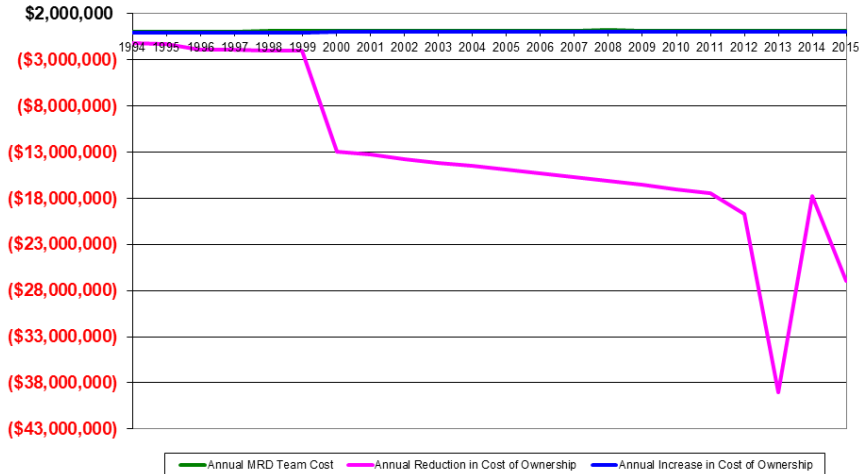
- Objective: Assess all tasks to extend 500 AFHR Major Servicing
 - Conduct 100% Major Component Review
 - Failure, Modes, Effect & Critical Analysis
 - Reliability Centre Maintenance
 - Utilised US Army & ADF In-Service data
 - Assessed applicability & effectiveness of tasks

Black Hawk Maintenance Optimisation

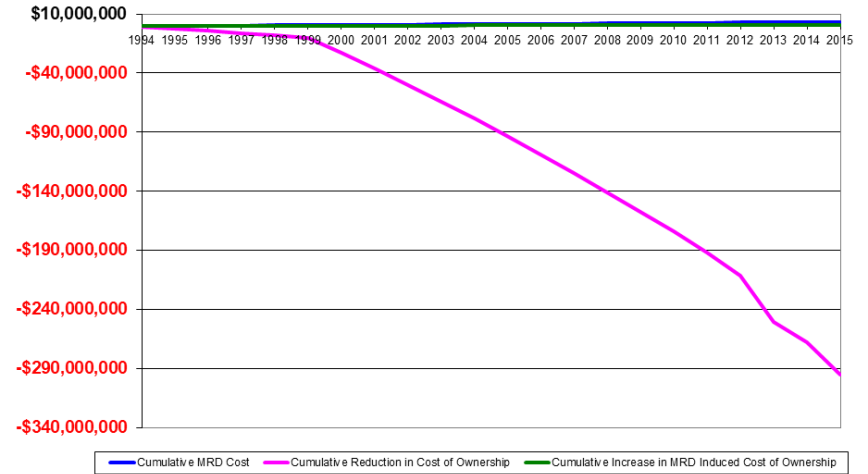
- Results:
 - Increased the Major Servicing Interval from 500 to 600 AFHR
 - 20% increase of Major Service Interval
 - Reduction of 12 Major Services P/A
 - Introduced 65 new tasks to address emergent failure modes
 - Removed 285 ineffective tasks
 - 30% Reduction in task content
 - A Two-fold Savings in the Cost of the Major Servicing
 - Reduced Number of Servicing
 - Less Servicing Content

Black Hawk Maintenance Optimisation

Annual Return on Investment A25A
Annual Costs V's Savings



A25A Black Hawk
Cumulative Costs V's Savings

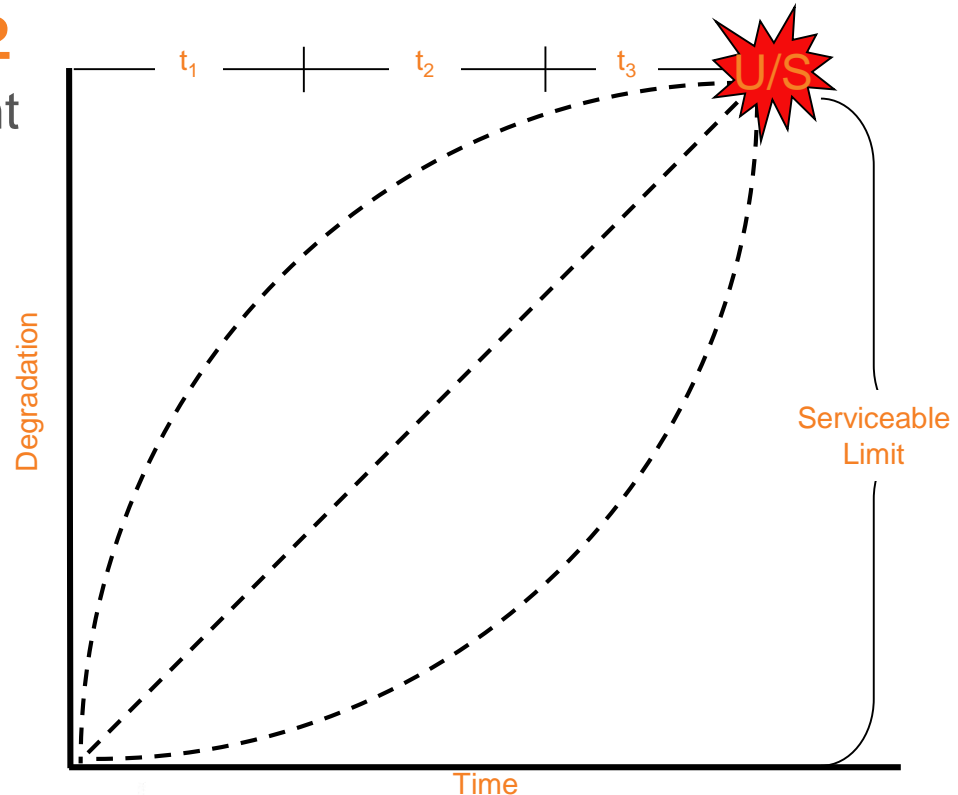


RAMP Working Groups

- Biannual Working Groups
 - Invite ADF & Industry RAMP Practitioners
 - RAMP Community of Practice
- Address/Resolve RAMP-related issues through the collective knowledge/experience
- Influence the development of Corporate Tools for RAMP Practitioners

FRR Codes in CAMM2

- Failure Reporting Requirement (FRR) Codes have been updated within CAMM2 utilising Alpha-Numeric codes
 - Alpha code: Type of Degradation
 - Numeric code: Degree of Degradation



FRR Codes in CAMM2

Code	Description
A	Scratch/Gouge
B	Bent/Distorted
C	Corrosion
D	Dented/Nicked
E	Erosion
F	Surface Finish / Paint
G	Lubrication

Code	Description
H	Hardening/Brittle
K	Delaminated / Debonded
L	Leaking
M	Movement
N	Contamination
Q	Overheating
R	Replenishment

Code	Description
S	Security
V	Visibility/Clarity
W	Worn, Frayed, Chafed
X	Calibration, Check/Test
Y	Cracked/Split
Z	General Condition

FRR Codes in CAMM2

Severity Ratings (excluding Corrosion)

Rating	Description
0	No Degradation
1	$\sim \leq 30\%$
2	$30\% < \sim \leq 60\%$
3	$60\% < \sim \leq 90\%$
4	Unserviceable

Severity Ratings for Corrosion

Rating	Description
0	No Corrosion
1	Light Corrosion
2	Rework $\leq 50\%$
3	$50\% < \text{Rework} \leq 100\%$
4	Beyond Repairable Limits

Severity Ratings for Cal/Check/Test: **Pass-Fail**

FRR Codes in CAMM2

- FRR Codes can enable
 - Collection of Maintenance Condition Data (MCD) prior to item being U/S
 - Trending a given A/C across successive servicings
 - Trending across a fleet of aircraft
 - Predictive and Proactive Maintenance
- Candidate Maintenance Tasks to be identified
- Training of Maintenance Personnel

Training

- Maintenance Requirements Determination (MRD) Practitioners Course
- Defence Reliability Management (DEFRELMAN) Course
 - Executive Course
 - Practitioner Course
- Maintenance Condition Data Continuation Training
 - Maintenance and MCS personnel

Defence Aviation Asset Management Program

- Enable journey to LOT with capability intact, risk attenuated & cost contained
- Creates a framework for the collection, reviewing and responding to MCD
 - Ageing Aircraft Program
 - Addresses all Systems
 - Based on RbM principles
 - Utilise System Condition & Health Monitoring

Key Take Aways

- RbM
 - Safety; Capability & Cost
 - Not ‘Set & Forget’
 - Requires Organisational Commitment
 - Fits within Ageing Aircraft Program
- Air Domain support is available
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References

- **Reliability Management Fundamentals Course (DEFRELMAN)**
Notes
- **NASA Reliability-Centered Maintenance Guide for Facilities And Collateral Equipment**, NASA, September 2008.
- **Reliability Based Maintenance, Using Key Performance Indicators To Drive Proactive Maintenance**, Robert Ford, General Electrics Company 2014.

Questions/Discussion

RAMP Team

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