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Ageing Gas Turbine Issues. C-130J Case Study

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HISTORICAL OVERVIEW

- The RAAF AE2100D3 Fleet consists of 58 Engines. (48 Installed, 10 Spare / above fit)
- AE2100D3 has an “On Condition” maintenance philosophy.
- On Condition philosophy managed by the RAAF as a “fly to failure” approach till 2010, then from 2014 through to 2016. Engines were still removed during this period for sustainment maintenance as well.
- High removal rate attributed to:
  - Lack of Engine Fleet Planning.
  - Poor MGT Margin
  - Reduction in Preventative Maintenance actions
  - Ageing engine components.

RESULT….

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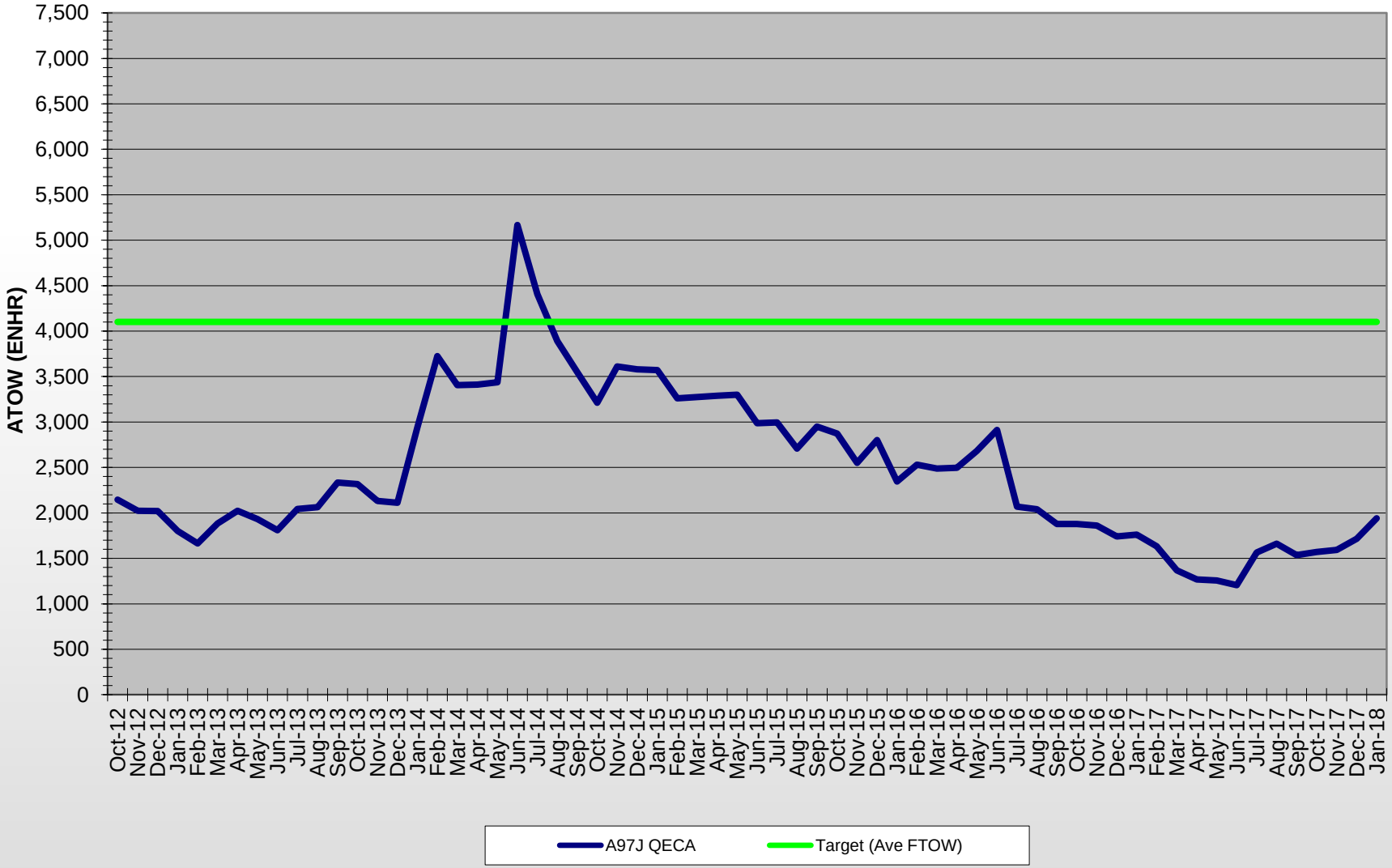
- In flight events increased year over year culminating in 5 In Flight Shutdowns (IFSD) across a 5 week period in 2016 (Dual IFSD 5468)
- Inherent engine removal rate greater than repair turn around time.
- Unmanageably low serviceable engine asset levels.
- Budget overruns
- C-130J Powerplant operational confidence all time low.

ROOT CAUSE ANALYSIS

- During the root cause investigation, StandardAero concluded that poor engine MGT health and worn compressor module components enabled the engine to be more susceptible to failure with aircraft anti-ice engaged.
- Five resultant factors were discovered;
    1. Weather. (Dual IFSD)
    2. Operations in Middle East exposes the engines to High Pressure Altitude operations, in extreme temperatures; as well as dusty and sandy environments, leading to accelerated wear on engine components.
    3. The effects of Preventative Maintenance on the bleed air system has on the overall performance of the engine.
    4. No OEM limits on compressor blade Chord dimensions
    5. Divergent Aircrew Behavior.

Propulsion System Maintenance Support

OPM-01: Average Time on Wing (ATOW) - A97J QECA



INHERENT OFF WING DRIVERS

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Reason	2005-2009	2010-2014	2015-2017
Low MGT Margin	14	10	4
Vibration	18	4	6
P/S Oil Pressure	8	5	1
1st Stage Turbine Distress	7	4	3
PGB Metal on Mag Plug	5	3	3
#2 Bearing Rivets	4	8	3
Compressor Flooding	5	0	0
Integral Oil Leak / Impending Bypass	4	3	4
2nd Stage Turbine Distress	3	1	0
Smelly Bleed	2	0	0
4th Stage Turbine Smash Plates	2	2	0
Over Torque	1	0	2
QEC (Sheetmetal)*	29	16	6
High MGT Event	0	2	9
Total Removals **	103	58	43
Average Removals Per Year **	21	11	14
Total Removals for Performance Related Fault	49	26	23
Percentage of Removals for Performance Related Fault	47.57%	44.83%	53.49%
Percentage of Engine Fleet Removed	177.59%	100.00%	74.14%

* Maybe not Primary Reason for Removal, but Discovered during Removal / Inspection.

* * Excludes Removed for Access, Sustainment Maintenance, FOD, Serviceability Checks, etc.

HI MGT Event – 5468 – Compressor Blade Erosion

HI MGT Event – 5467 – Comp Blade Deformation

Compressor Blade Limits

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- Rolls Royce released Service Bulletins following the recent surge events as they were attributed to eroded compressor airfoils.
- AE2100D3-72-311 – 1st thru 14th Stage compressor blade chord inspection.
- AE2100D3-72-312 – 1st thru 5th stage Variable vane chord inspection.

- All RAAF engines that return to the AMC will have the compressor split and blades measured, inspected and replaced IAW the SB limits.

- 28 Engines have already been through the Compressor Remediation Program.

Propulsion System Maintenance Support
AE2100D3 Compressor Blade Chord Analysis

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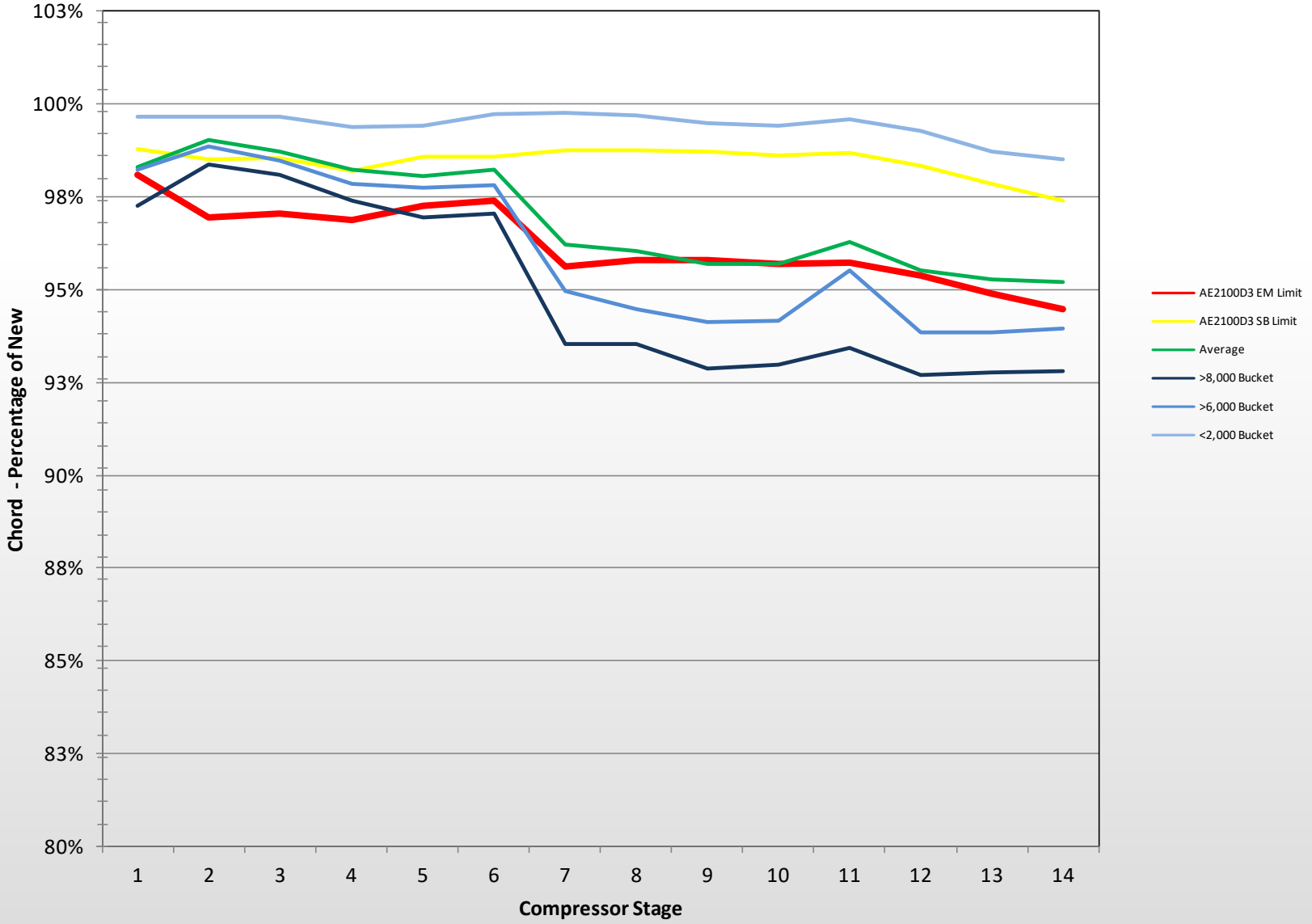

Middle East Operations

HI MGT Event – 5464 – Compressor Blade Erosion

Compressor Vane Erosion

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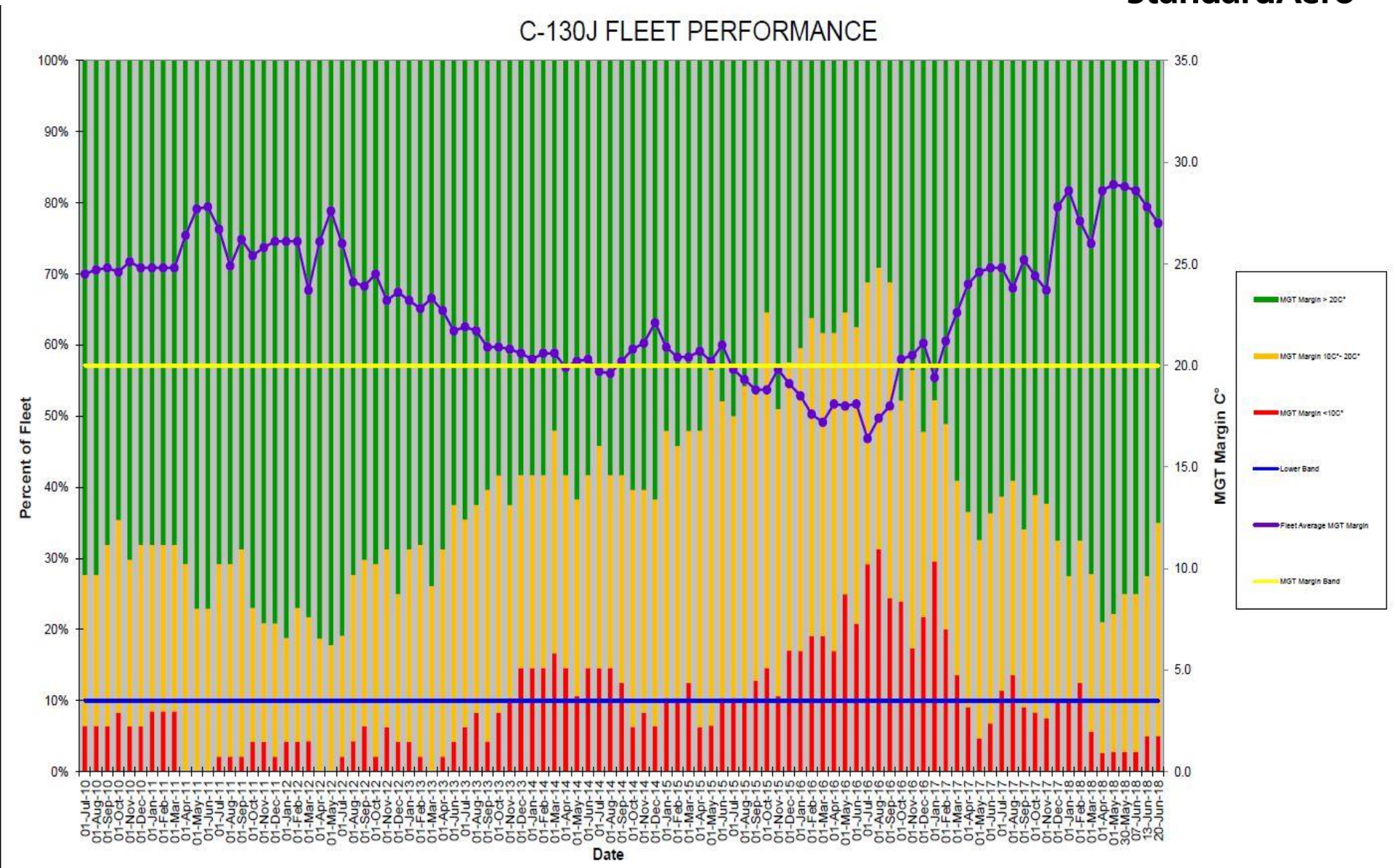
C-130J Fleet Health



Gas Generator Case Baffle Damage

2nd Stage Turbine Vanes – Distorted

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Low MGT Margin – 1st Stage Turbine Damage

HI MGT Event – 5467 – 1st Stage Turbine Damage

Goals

- **Fundamental Change required in the fleet management of the AE2100D3**

- **Goals**

- Maximize / Optimize time on wing
- Reduce in flight events.
- Contain / Reduce sustainment costs
- Increase serviceable spare asset levels
- Plan engine removals prior to failure or in-flight event.
- Restore C-130J Power Plant operational confidence.

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QUESTIONS