Australian Government
Department of Defence
Defence Aviation Safety Authority

# The Role of Propulsion System HUMS in Maintaining Aircraft Availability & Safety


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# Outline

- Career Background
- Role of PSI
- HUMS
  - Health
  - Usage
  - System
- Past, Present & Future
- Case Study 1 – Availability
- Case Study 2 – Availability & Safety
- Case Study 3 - Safety
- Conclusion

# Career Background

- Bachelor of Aerospace Engineering from RMIT
- Joined RAAF in 2009
- Engine Structural Integrity Manager – C130H, C130J & AP-3C Orion
- MRH90 Acquisition Project Certification Engineer
- Hawk 127 Flightline Maintenance Officer
- MSc Thermal Power – Cranfield University, UK
- PSI in DAVENG-DASA

# Role of Propulsion Systems Integrity (PSI) in DAVENG-DASA

- ~30 engine types
- Subject matter experts in propulsion systems integrity for the Australian Defence Force (ADF)
- Performs Authority functions for all ADF propulsion systems
- 21J Design Organisation
- Typical Tasking
  - Acquisition advice
  - Approval of changes to type design
  - Approval of Unsafe Condition Assessments
  - Component lifing review coordination
  - Management of technical risks & life reductions
  - Overview of platform management
  - Development of HUMS specifications
  - Verification & Validation of HUMS

# HUMS

| | |
|---|---|
| **Health** | • Condition Monitoring (Wear Debris, RVI)<br>• Vibration Monitoring<br>• Diagnostics<br>• Prognostics<br>• Environmental Degradation Management |
| **Usage Monitoring** | • Cycle counting<br>• Hours counting<br>• Flight records<br>• Engine run history<br>• Operating parameters |
| **System** | • More than just the hardware!<br>• Onboard/Offboard<br>• Data Validation<br>• Procedures & Training<br>• Analysis, Support |

# Past, Present & Future

| Past | Present | Future |
|---|---|---|

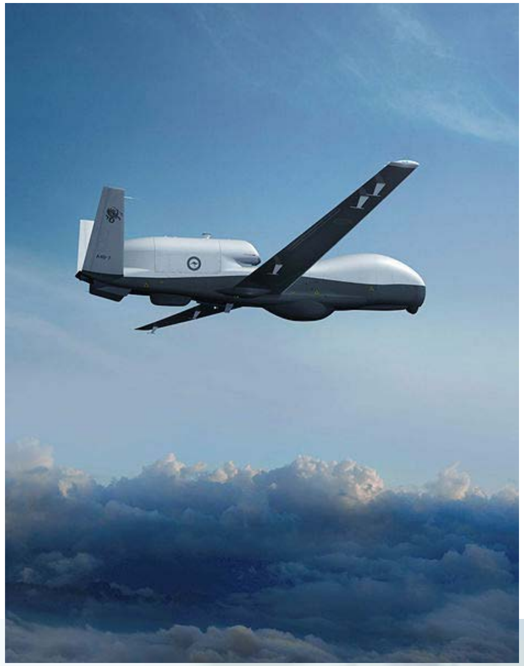
- Paper based, manual, first generation systems
- Minimal OEM involvement
- Minimal automation or data capture
- Local systems developed - FAMIS/CAMM/CAMM2
- Some basic level of condition monitoring

# Past, Present & Future

## Present

- Full digital transition (mostly)
- Increased OEM involvement
- Increased automation & data capture
- Use of commercial & bespoke recording systems
- Large quantities of data

# Past, Present & Future

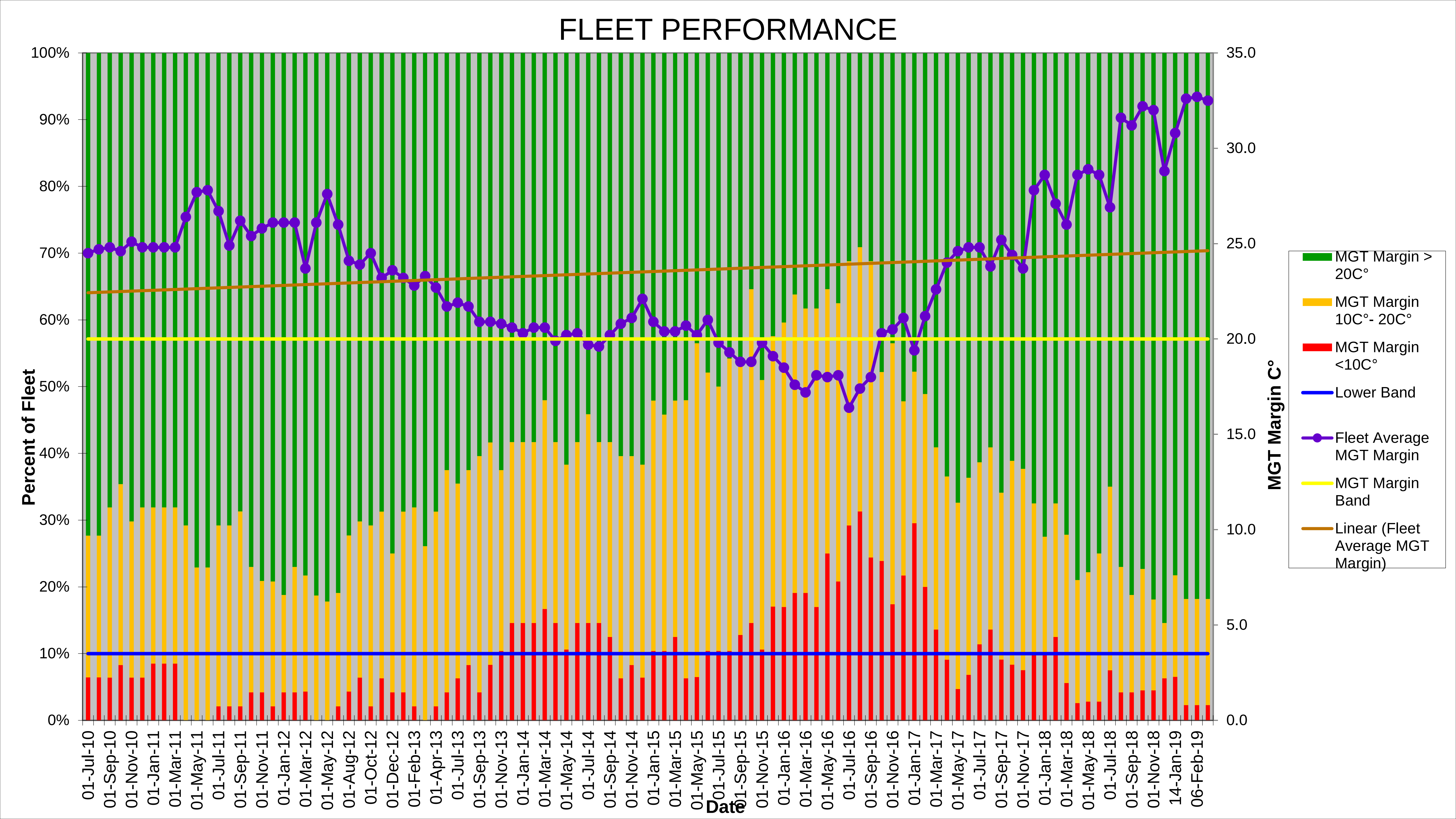


## Future

- Automated data analytics
- Significant OEM involvement
- Exponential increase in data capture
- Automated prognostics
- Physics based algorithms
- More accurate lifing
- Automated condition monitoring & maintenance initiation
- Increased use of machine learning

# Case Study 1 – Availability - HUMS

- Squadron started to use an engine health monitoring system in 2009
  - Monitored the vibration characteristics, measured gas temperature (MGT) margin
  - Significant improvements in availability
- Due to posting cycles in 2014 no dedicated Engine Health Monitoring specialists at the SQN or the CAMO
  - Reduction in engine performance
  - increase in unscheduled removals, and
  - reduction in TOW. (Fly to failure approach…again)
- Mid 2016 saw 5 IFSD in 5 weeks as a result of worn compressors and low MGT margin
  - Root cause – Loss of adequate health monitoring:
    - poor preventative maintenance
    - worn compressors
    - weather
- Aug 2016 saw a resurgence in engine health and condition monitoring
  - Fleet planning to schedule engine removals
  - Preventative maintenance to maintain engine health
  - Introduction of additional limits to components
  - Marked improvement in engine health (comparable to new engines)
  - Unscheduled removals has improved back to levels that were seen in 2013.


FLEET PERFORMANCE
Percent of Fleet
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
MGT Margin C°
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Date
01-Jul-10
01-Sep-10
01-Nov-10
01-Jan-11
01-Mar-11
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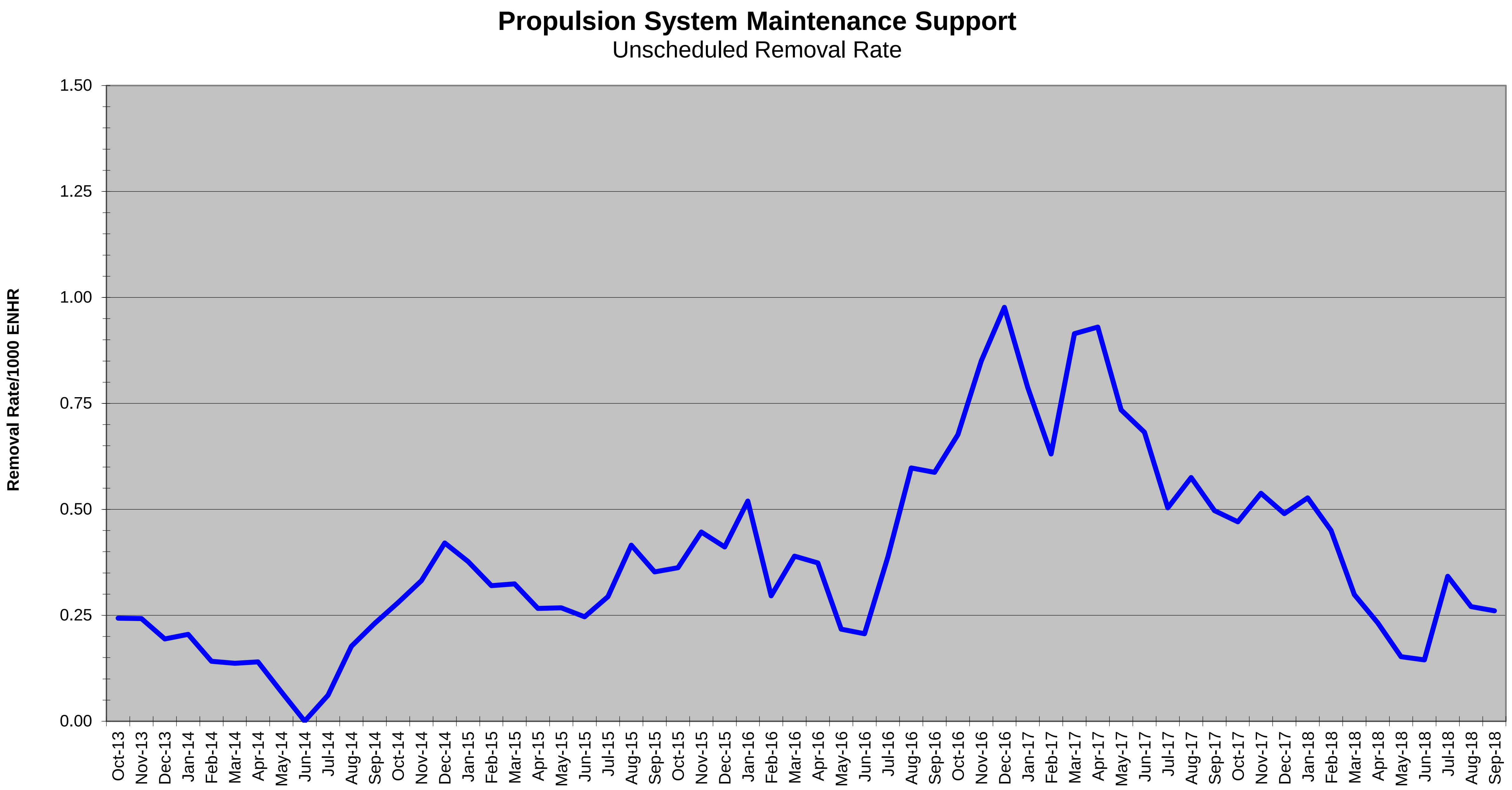
01-Nov-17
01-Jan-18
01-Mar-18
01-May-18
01-Jul-18
01-Sep-18
01-Nov-18
14-Jan-19
06-Feb-19
MGT Margin > 20C°
MGT Margin 10C°- 20C°
MGT Margin <10C°
Lower Band
Fleet Average MGT Margin
MGT Margin Band
Linear (Fleet Average MGT Margin)



Propulsion System Maintenance Support
Unscheduled Removal Rate
Removal Rate/1000 ENHR
0.00
0.25
0.50
0.75
1.00
1.25
1.50
Oct-13
Nov-13
Dec-13
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14
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Sep-18

# Case Study 2 – Availability & Safety – Wear Debris Analysis

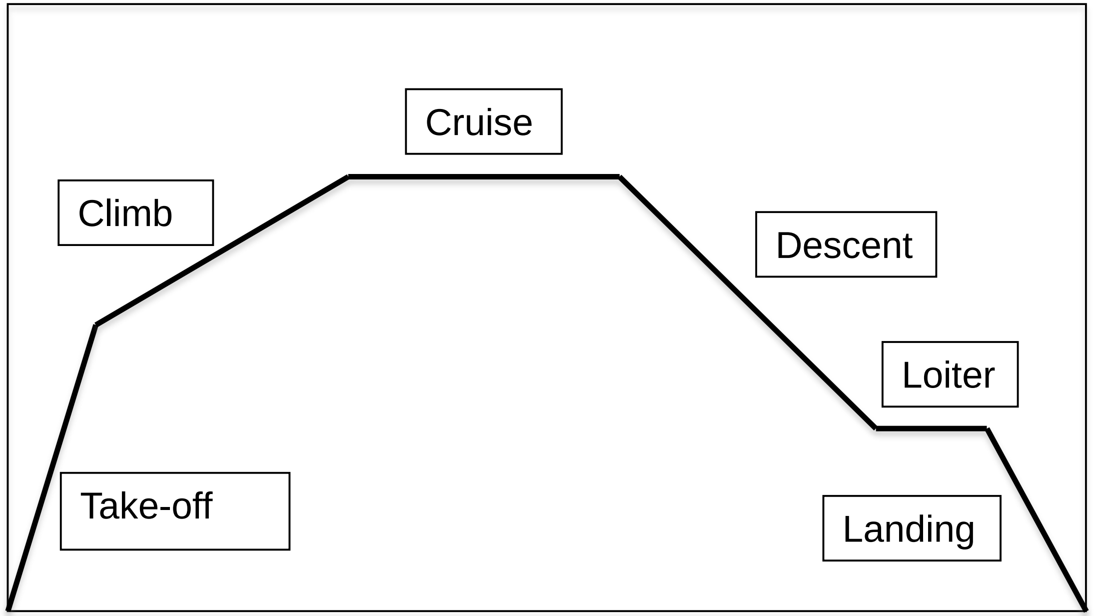
- Prior to WDA
  - Engines being removed for chip indications
    - Expensive exercise & limited availability
  - Aircraft on-ground awaiting OEM advice

- Introduction of WDA (DST Group & PSI in DAVENG-DASA)
  - Allowed for analysis of debris – quick turnaround
  - Allowed for prioritisation of aircraft going on deployment

# Case Study 3 – Safety – Mission Analysis

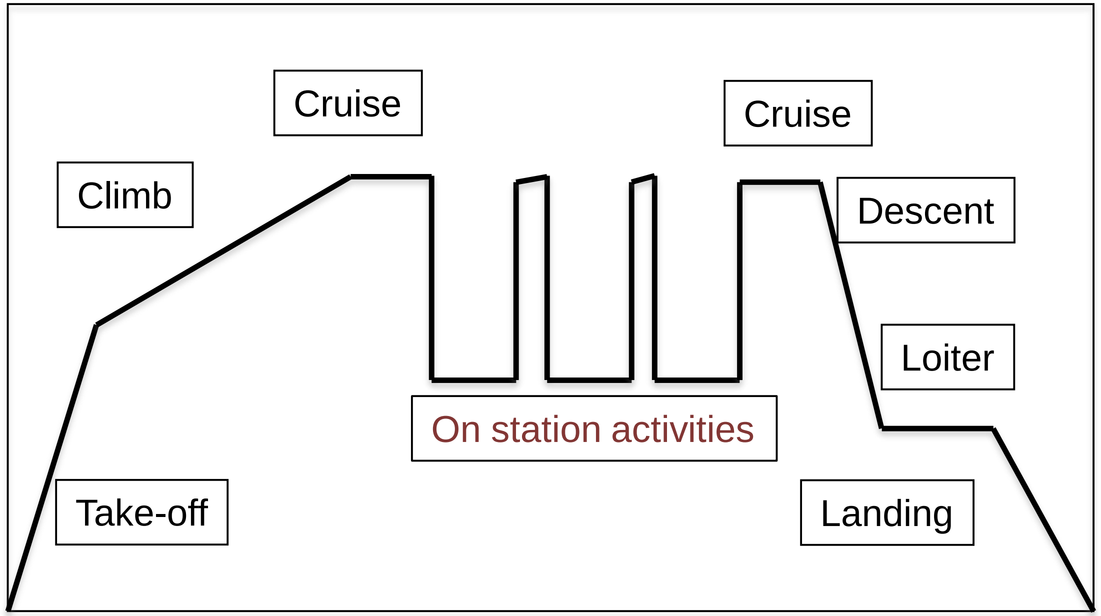
- ADF Missions
  - Multiple Missions
  - Complex Mission Definition
  - OEM development of lives based on assumed cycle definition
  - Availability of high fidelity usage monitoring systems
  - Australian usage has been shown at times up to 50% more severe than OEM design assumptions

# Case Study 3 – Safety – Mission Analysis




DURATION

Civil Design Mission/Flight




DURATION

Military Mission/Flight

Note: Not actual mission profiles

# Case Study 3 – Safety – Mission Analysis

- Review OEM assumed mission profile with accurate UM data
- Review identified usage more severe than original assumptions
- Life reduction imposed

- So what?
  - Credible first-order effects of failure:
    - Uncommanded engine shutdown
    - Non-containment of high energy debris, fire
    - Severe vibrations
  - Invalidation of Type Certification Basis

# Conclusion

- HUMS
  - Sometimes an afterthought
  - Minimal certification requirements
  - Very important tool to maintain availability & safety
  - Extremely useful to the ADF due to varying mission profiles

When all elements of HUMS work as one, significant improvements in availability, cost of ownership & safety can be made

# QUESTIONS


Safety Authority