Reducing ASI risks: JSF case study on the benefits of integrated S&T engagement with the Program

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Outline

- Stakeholders
- Timeline
- Engagement and S&T
- Hits (and misses)
- Lessons learnt
Stakeholders - (current) partners-in-ASI

- Aerospace Division
  - Air Combat Capability Program - **K Sharp, A Zehetner**
  - Aircraft Structures Branch - **M Burchill, M McDonald (JPO CPP), T Mills**
  - Airframe Technology and Safety Branch - **A Rider, A Shekhter**
  - Aircraft Health and Sustainment Branch – **N Rajic**
  - Aircraft Performance & Survivability Branch - **D Conser, O Levinski**

- Maritime Division - **C Loader, M Ibrahim**

- Joint & Operations Analysis Division - **S Harrison**

- DASA, ASI
  - **WGCDR B Main, SQNLDR R Walker, SQNLDR Gordo, A Jackson (Q-Q)**

- CASG, JSF Division
  - **SQNLDR J Tagahode, SQNLDR M Gordon (JPO CPP)**
Timeline


- AIR6000 air combat capability
- AU joins JSF SDD phase
- 24 Super Hornet buy decision
- F-111 retired
- CTOL fatigue test start
- AU01 AU02
- 1st refuel with KC30
- 1st flight
- 1st pilot

- LM win the JSF competition
- 1st pass approval
- 2nd pass approval
- 2 year deferral of 12 JSF
- 2009 DWP 100 JSF
- PH2A/B pass 58 JSF
- IOC 2020
- FOC 2023
- AUS & JAP regional support hub

CTOL - conventional take off and landing  SDD - system design & devel.  LM - Lockheed Martin
## Strategy - to mitigate risks to RAAF JSF ASI

### Engagement
- with Joint Program Office
  - Cooperative Partner Positions
  - technical meeting contributors
- with International partners
- with US services
  - USAF, USN
- with contractors
  - prime - OEM Lockheed Martin
  - subs - BAE Systems

### S&T
- Ensure S&T to support the JSF
- Inform and support JSF Program
- Technical Risk Assessment
- S&T insertion JSTAB (then)
- S&T insertion Modernisation (now)
- Legacy experience
  - classic Hornet, F-111
  - testing, teardown, interpretation
  - service, environment
Just a few JSF ASI achievements ....
PASIWG

- CASG/DASA/DST Group instigated the partner ASI working group (PASIWG)
- Initial meeting chaired in AU in 2009, with reps in attendance from Denmark, Italy, the Netherlands, UK and USA
- Yearly PASIWG & Service Life Management (including Structural Prognostic Health Management SPHM) meetings held at Lockheed Martin, Ft Worth TX
- Bi-monthly PASIWG telecons run by Joint Program Office

POC - SQNLDR J Tagahode - JSF Division - CASG

note - DGTA, DMO & DSTG stood up first RAAF JSF ASIWG in 2006
Tracking buffet loads

- DST wind tunnel model to generate VT buffet data
- Gained support from partners and program to undertake the development of a direct strain-based buffet load monitoring methodology and incorporate into SPHM
- Transitioning DST developed algorithms for Multi-Variable Frequency Response Analysis (FRA)
- Enhances Individual Aircraft Tracking to improve Fleet Management for condition based maintenance
- POC - Dr O Levinski - Aircraft Performance and Survivability - DST Group

**note - DST input also led to enhanced testing of buffet induced dynamic loads**
Composite Repairs and JSTAB

- JSF Science and Technology Advisory Board (JSTAB) funded (2005-09) DST to consider how bonded repairs can be designed to meet strength requirements
- DST designed and substantiated a novel scarf-doubler repair concept
- Materials, adhesives and curing processes identified as well as new surface treatment methods to enable reliable vacuum cure of composites in the field
- Ongoing work includes how the combination of environment and mechanical loading affects the structural integrity of the composite structure

POC - Dr A Rider - Airframe Technology & Safety Branch - Aerospace Composite Technologies

Note - out of 280 JSTAB bids from partners, 21 were funded and 6 went to DST
Three Lifetimes of Type (3LOT) Testing

- Original fatigue test duration planned 2LOT of design loading
- Through PASIWG and partner engagement (i.e. USAF, USN) DST led the discussion on the benefits of a test extension to 3LOT, such as risk mitigation for usage variation
- 3LOT currently underway on CTOL variant test article AJ-1 (RAAF variant).

POC - WGCDCR Ben Main - DASA - ASI

*note - all three variants HTs have already completed 3LOT testing*
Marking cracks on the fatigue test

- Presented a case for the benefit of marker band (MB) load sequences as a fatigue test enhancement - to aid post test & teardown interpretation activities
- Accurate crack growth data from MB can be used to validate fatigue predictions
- DST developed, tested and delivered MB load sequences to aid post-test analyses on: all variants HT and CTOL AJ-1

POC - M Burchill - Aircraft Structures Branch - DST Group

note - JPO have instructed LM to develop MBs for USN JSF Carrier Variant test
Strain-life curves updated: surface treatment

- DST identified current design knockdowns did not account for fatigue reduction due to surface treatment.
- DST developed a rigorous program to perform a detailed evaluation of LM surface treatment design curves for main airframe alloys.
- DST comprehensive test contributions were used by LM to develop the final lifing curves.

POC - Dr A Shekhter - Aircraft Technology and Safety Branch - DST Group

Fatigue crack origins

Anodising conducted by LM-authorised manufacturer to F-35 specification.
Correlating fatigue hotspots in-situ

- Data from local strain gauges are used to correlate large scale stress analysis models
- Presented DST test enhancement methodology that enables direct wide area measurement of stress fields (c.f. gauges) during cyclic fatigue testing
- LM has adopted the system to aid correlation and investigate suspect hotspots

POC - Dr N Rajic - Aircraft Health and Sustainment Branch - DST Group

Note: TSA (Thermoelastic Stress Analysis) has also successfully applied to other full scale test articles – Hornet, Hawk & C-130

LM adopt TSA MiTE
On demand corrosion inspections

- JSF Corrosion Prognostic Health Management (CPHM) uses a BAE Sentinel Sensor
- DST developed a Prognostic Algorithm (PA) of atmospheric pitting corrosion that is based on electrochemical noise
- Further, DST is providing direct support to BAE Systems through incorporation of chromate free inhibitor into diffusion controlled primer depletion model
- The corrosion state predictions can be used to plan more effective and efficient corrosion inspections in difficult to access internal bays

POC - C Loader – Non Acoustic Signature Management Branch - DST Group
Non-destructive inspection enhancements

- Developed NDI reliability software to determine POD from inspection data (JSTAB)
- Production NDI: DST reliability analysis used to determine the effect of non-etching prior to liquid penetrant testing (LPT)
- Determination of 3-D damage characterisation in composites using ultrasonic inspection
- In-field composite repair qualification demonstrated
- Effects of inspection through thick composite layers analysed

POC - M Ibrahim – Acoustic Signature Management Branch - DST Group
Lessons Learnt

- early engagement is key - airframes are designed early
- learning from legacy - i.e. ASIWG V glossy brochures
- active collaboration: knowledge, data and resources
- needs commitment from leadership
- keep pushing: engineering time and money constraints
Questions
References


N.Rajic, D.McSwiggen, M.McDonald and D.Whiteley (2015) In Situ Thermoelastic Stress Analysis of the F-35 - An Improved Approach to Airframe Structural Model Validation. Aircraft Structural Integrity Program Conference, San Antonio, TX, USA

M.Christian (2014) Overview of the Full Scale Durability Tests on F-35 Lightning II Program, 2014 Aircraft Structural Integrity Program Conference, December San Antonio, TX USA
Backup videos


Joint Strike Fighter S&T Advisory Board (JSTAB)

- 280 proposals from partner nations in 2003
- 21 projects awarded (<1/13) and 7 awarded to AFRL
- 6 awarded to DST and received a level of funding
  - Advanced Airframe Repairs (AAR) - i.e. composite repair
  - Shape Optimisation for Structural Detail Design - i.e. fatigue hotspots
  - Improved Methods of Validation of Non-destructive Inspection Reliability
  - Non-Chromate Conversion Coatings for High Strength Aluminium Alloys
  - Cold Spray Metal Coatings for Corrosion Protection & Repair
  - Vibration-based Prognostics and Health Management (VPHM)