Australian Government
Department of Defence
Capability Acquisition and Sustainment Group

Ageing Aircraft Sustainment

Optimising Aircraft Availability

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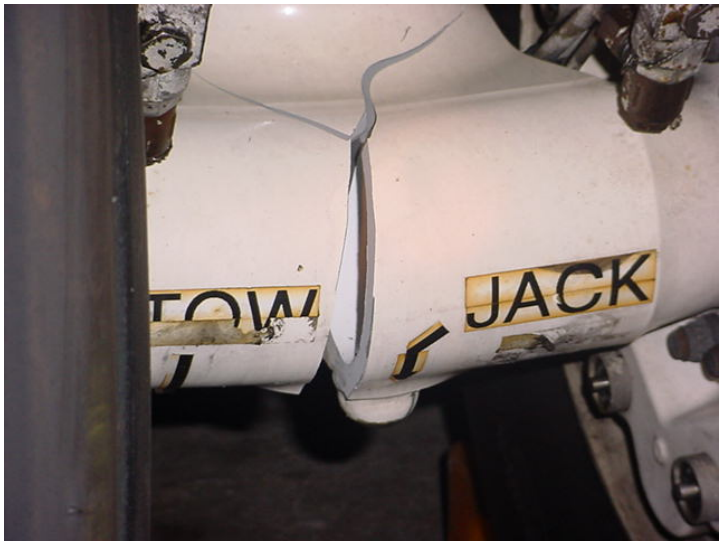
Scope

- Ongoing Issues with Sustainment of Ageing Aircraft
- Evolving role of Engineers in the Risk Assessment process
- Stress Corrosion Cracking on the AP-3C Orion
  - Degradation of routine inspections
  - Initial findings
  - Interim strategy development
  - Analysis of findings
  - Long term Strategy development
  - Development of specialist NDT methods
  - Physical testing for validation

Issues with Ageing Aircraft

- All organisations dealing with sustainment of aircraft can attest to the common issues surrounding ageing platforms
  - Corrosion
  - Fatigue
  - Parts obsolescence
  - Systems integrity
  - Personnel complacency, inadequate training



- Each of these issues can, separately, create larger issues which can impact aircraft serviceability and availability
  - Can also combine to create a ‘Swiss Cheese’ effect

Risk Based Engineering

- Engineers have had an evolving role in the Risk Assessment process over the years

- Mr Rick Ryan (Branch Head, Tactical Aircraft Strength, NAVAIR) discussed this topic as the Keynote speaker at the 2015 DGTA ASI Conference
  - Historically, any measurable risk of an in-flight failure was unacceptable
  - Cost of maintaining programs (among others) began to erode the authority – ageing aircraft?!

Risk Based Engineering

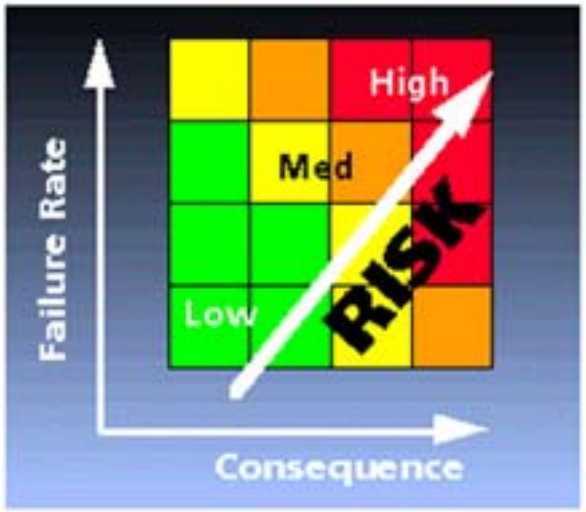
- Over time the concept of ‘Acceptable Risk’ began to gain ground

- A cumulative risk determination due to fatigue is relatively easy (for a tracked fleet)
  - Inspection of properly selected, statistically significant number of aircraft
  - Future risk assessed on projected usage and maintenance of the aircraft

- What about corrosion, wear, build quality – not so simple to quantify

Risk Based Engineering

- Risk appetite within the organisation has also recently shifted
  - Historically has been ALARP which is more conducive to acceptance of risk
  - New concept is SFARP mandating that everything that can be reasonably done to reduce the risk has been completed



Risk Based Engineering

- Risk based engineering is not a paradigm shift
  - Still make assessments IAW credible standards
  - Use relevant, credible standards to determine the level of non-conformance
  - Manage the non-conformance through risk analysis if deemed necessary

- All about managing the increase in risk compared to that inherent in the standard(s) or Certification Basis

- Primary responsibility remains making every effort to maintain safety and airworthiness

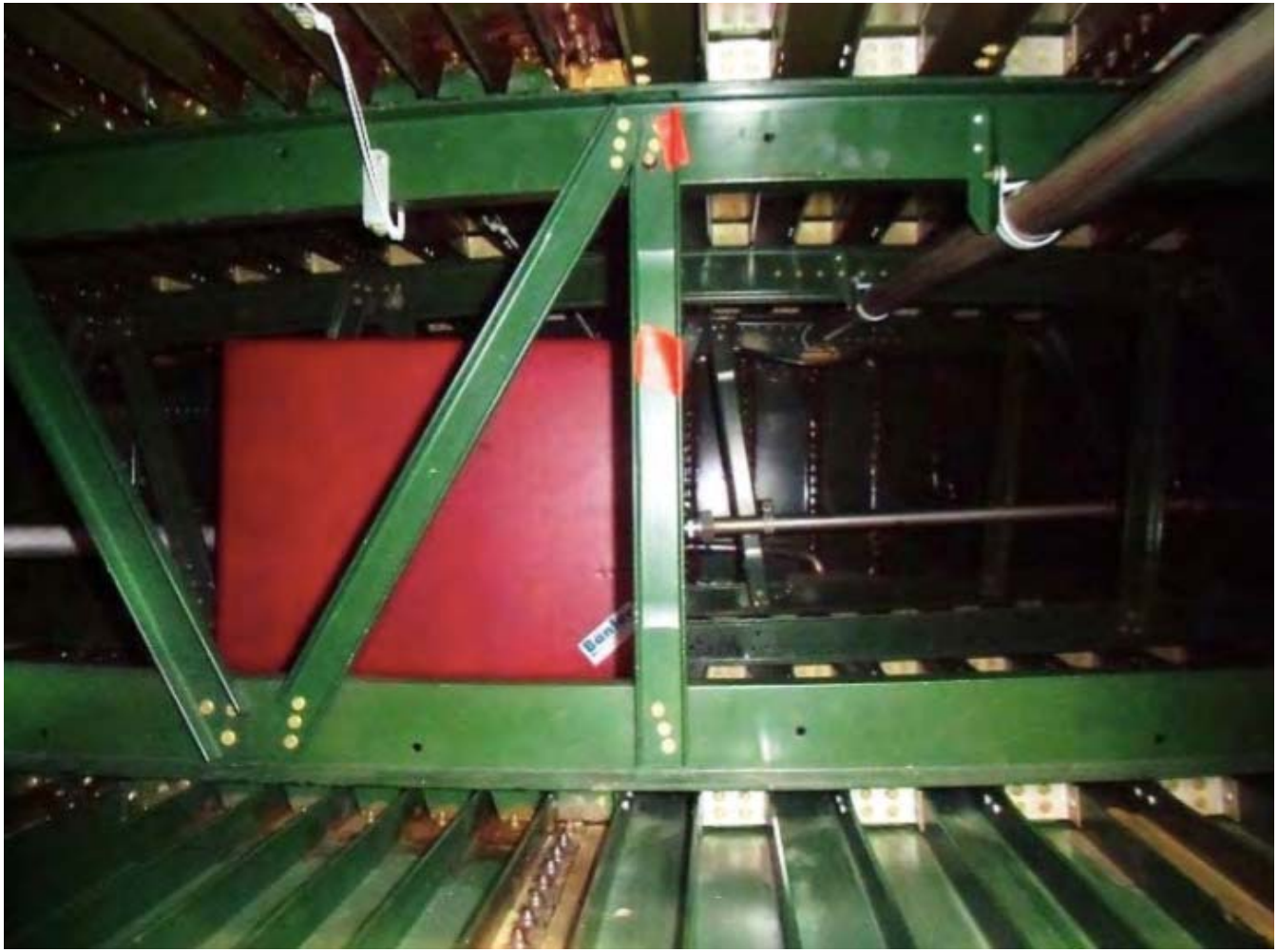
Risk Based Engineering

- Why is this relevant to ageing aircraft?
  - Financial viability to rectify issues when funding and resources on ageing aircraft is steadily reduced
  - Organisation becomes willing to accept a level of risk in exchange for continued aircraft capability
  - Utilisation of risk assessments to optimise aircraft availability through implementation of a well structured and approved risk management plan

Stress Corrosion Cracking

Wing Panel Rib H-Clips

AP-3C Orion



Stress Corrosion Cracking on the Orion

- Known ageing aircraft issue
  - International operators have detected the same issue
- Historically, internal tank SCC inspections conducted at every R3 with only limited indications found
- Safety By Inspection program inspects a number of the H-clip locations
- At recent R3 servicing, NDT performing inspections around the H-Clip area visually detected a potential crack indication post completion of the visual inspections

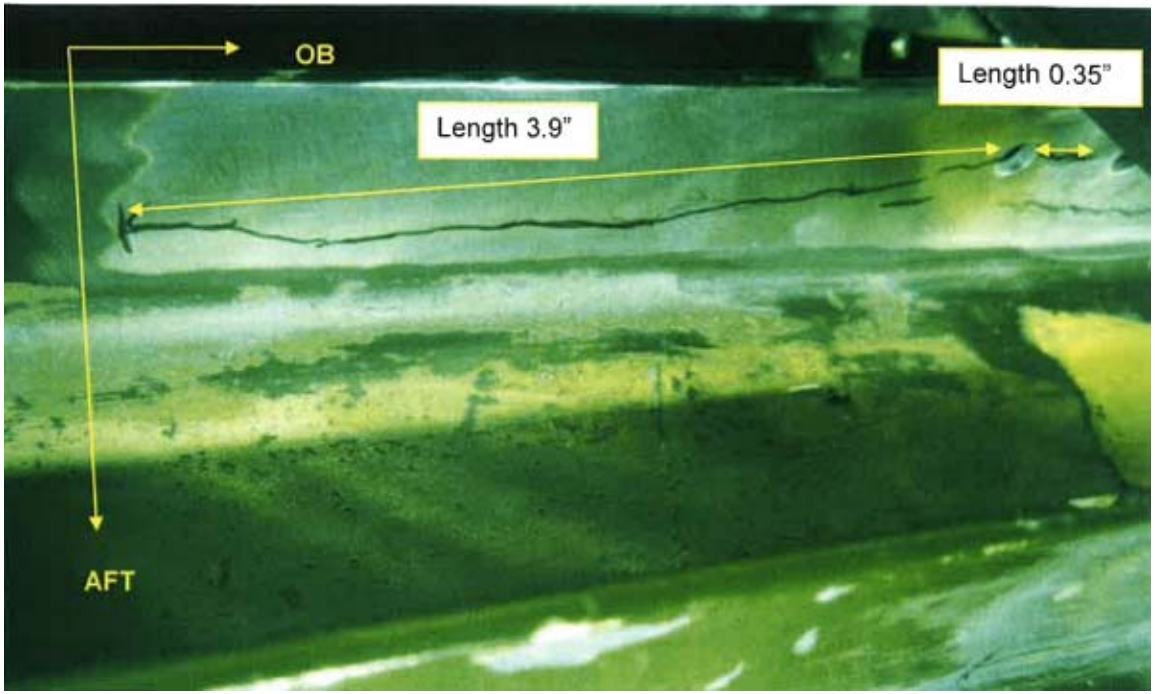
Stress Corrosion Cracking on the Orion

- Crack confirmed with surface scan
- NDT performed a visual sweep of the tank area
- Detected and confirmed a further 7 cracks

Stress Corrosion Cracking on the Orion

- Cracks were being dismissed as scratch/scribe marks potentially due to insufficient lighting

- Corrosion + Personnel complacency and inadequate training



Stress Corrosion Cracking on the Orion

- SMM and SDE directed a complete re-examination of both aircraft at the facility
  - Training delivered to mechanical workforce
  - Additional cracking detected
  - Increase in the number of ‘suspect cracking’ which all had to be confirmed by NDT – 10% (or less) were actually cracks

- Over conservatism due to cracks being missed on other aircraft

Stress Corrosion Cracking on the Orion

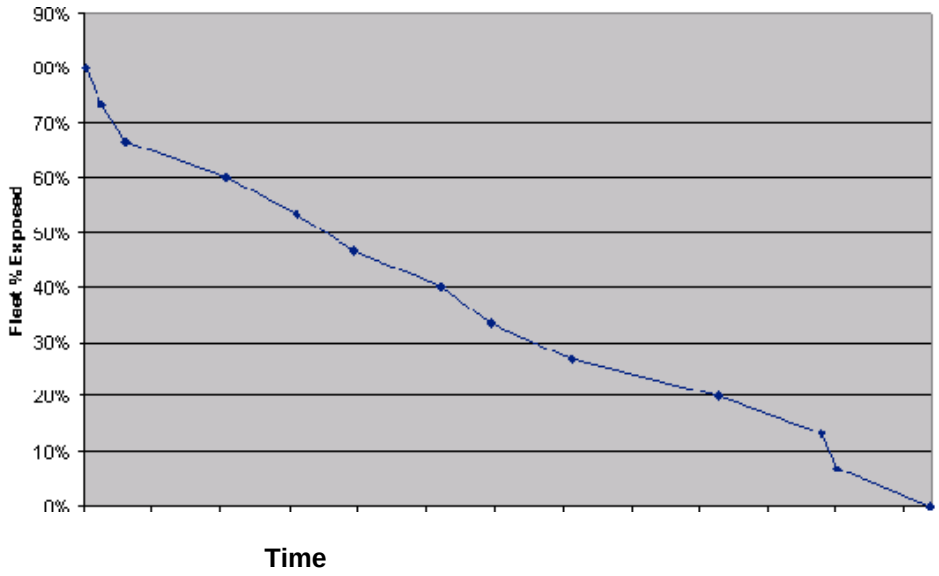
- Initiation of assessment at the SPO to determine immediate and ongoing management strategy(ies)

- During initial development there were a number of considerations
  - Availability of aircraft to inspect
  - Personnel effort for inspection
  - Time required for rectification actions
  - Ongoing inspection requirements
  - Impact to maintenance personnel availability
  - Impact to aircraft availability
  - Cause of cracking – fatigue initiated, material properties?

- Begin process of optimisation of aircraft availability through early consultation with stakeholders

Stress Corrosion Cracking on the Orion

- Involved the Maintenance Contract Manager and Fleet Planner early to ensure the section was using up-to-date information
  - Accurate picture for fleet exposure to the risk of structural failure due to SCC



Stress Corrosion Cracking on the Orion

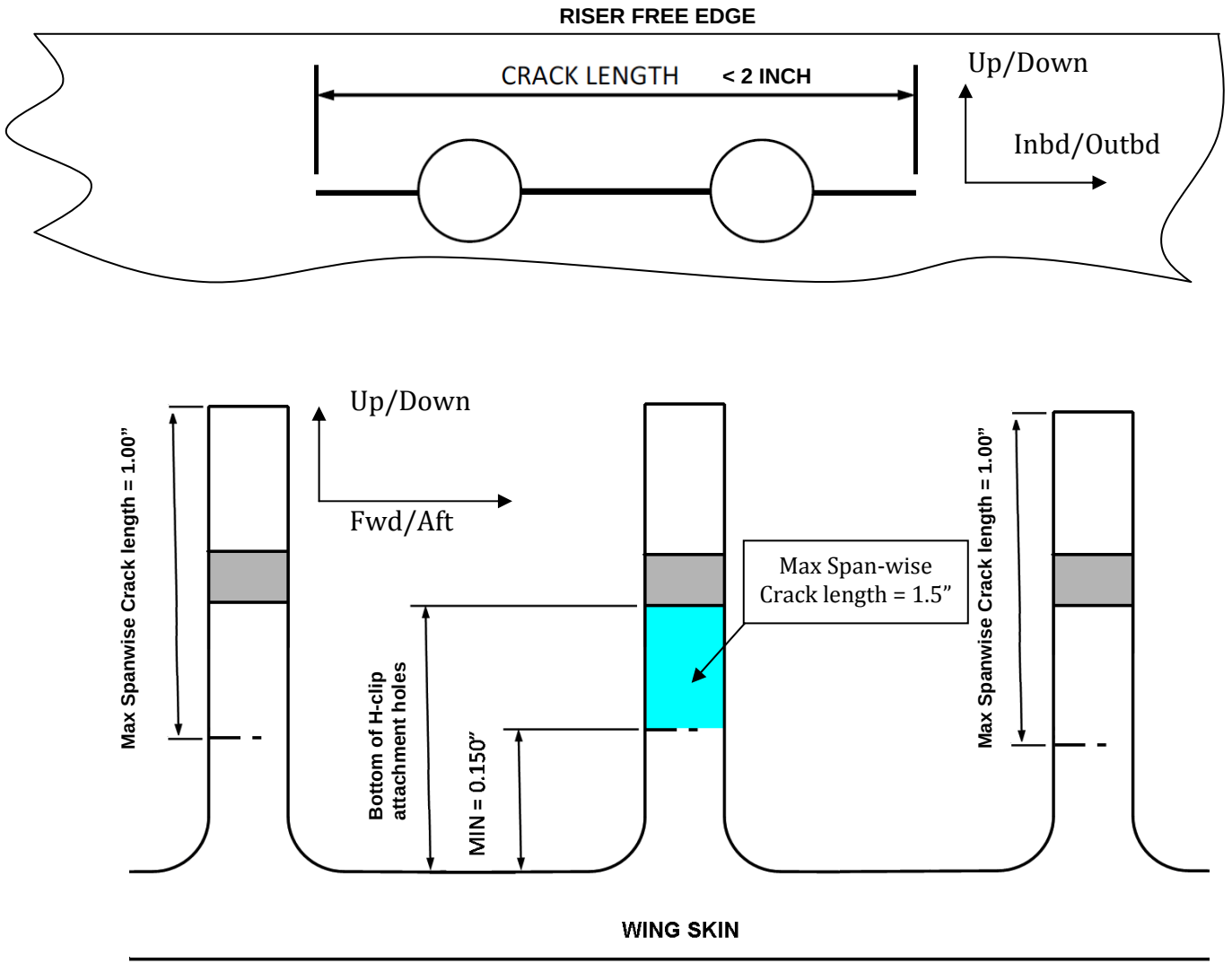
- Worked with the maintenance contractor to determine length of time to conduct inspections and any rectification actions
  - Impact on TMS and resources (personnel)

- Determined that full repair of each cracked site would create a heavy backlog for structural fitters and tank entry trained personnel

- Moved onto development of a more risk tolerant solution

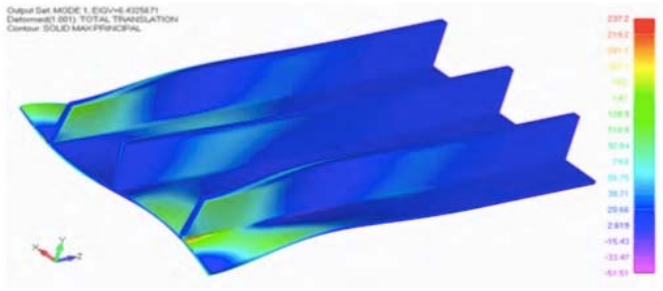
Stress Corrosion Cracking on the Orion

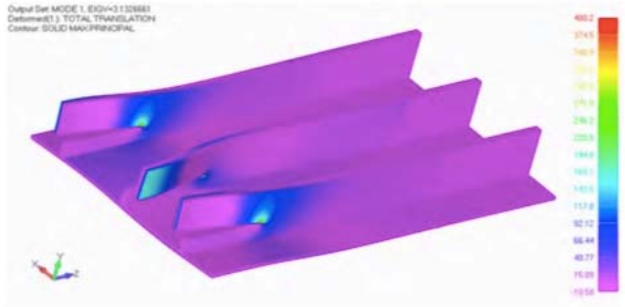
- Risk Based Engineering!
  - Had to determine an accurate, immediate and longer term failure risk and consequences with reasonable conservatism
- Engineering within the maintenance organisation developed FE model to determine failure characteristics of the ‘worst case’ found
  - Looked at buckling failure of the local riser region and the global panel buckling with multiple SCC sites
  - Different cracking configurations tested
    - Height up riser
    - SCC thickness through riser
- Development of a Special Technical Instruction (STI, Airworthiness Directive) to inspect all aircraft


RISER FREE EDGE
CRACK LENGTH
< 2 INCH
Up/Down
Inbd/Outbd
Up/Down
Fwd/Aft
Max Spanwise Crack length = 1.00”
Bottom of H-clip attachment holes
MIN = 0.150”
Max Span-wise Crack length = 1.5”
Max Spanwise Crack length = 1.00”
WING SKIN

Stress Corrosion Cracking on the Orion

- Initial compressive strength testing conducted to assist in validation of design behind the STI – single riser test only
  - Laboratory EDM slots in the riser
  - Results from FE model and test were in good alignment





Stress Corrosion Cracking on the Orion

- Inspection of properly selected, statistically significant number of aircraft
  - In this case, all aircraft inspected including a set of wings from a withdrawn aircraft
- All aircraft have been inspected with only a handful of repairs required IAW the developed strategy
- The inspection was incorporated with very limited affect to aircraft availability due to optimisation activities conducted
  - Enough forward planning to integrate requirements into standard servicing timeframes
  - Involved the correct stakeholders to result in the most effective outcome

- Job done, right?

https://memegenerator.net/High-Res-Success-Kid

Stress Corrosion Cracking on the Orion

- So Far As Reasonably Practicable

- This was only one part of the developed strategy to ensure airworthiness was maintained
  - Ongoing inspection requirements
  - Continued impost for entering all tanks at every R2/R3 servicing (R2 nominally has no tank entries)

- Investigated more efficient NDT options for inspection of the SCC

Stress Corrosion Cracking on the Orion

- Phased Array Ultrasonic inspection was identified as having significant potential
  - Successful on-aircraft trials have been conducted
  - Final approved NDT procedure yet to be released
  - Significant cost of equipment purchase is offset by the increased availability of aircraft once incorporated

Stress Corrosion Cracking on the Orion

- Aim is to completely negate the need for ongoing tank entries during the R2 servicing
  - Optimisation of aircraft availability through reduced maintenance effort

- Final step in the strategy is physical residual compressive strength testing of in-service wing panels with true SCC present
  - Wing panel samples removed from retired aircraft
  - Full NDT carried out to ensure accurate recording of presence of SCC
  - Develop testing plan to ensure panels are loaded and behave correctly

Stress Corrosion Cracking on the Orion

- Use FE models to perform the same testing
- Compare the two tests to assist with validation of the original FE analysis performed to authorise STI

- Long term strategy (yet to be implemented)
  - Track SCC growth using Phased Array Ultrasonic NDT equipment
  - Phased Array NDT procedure to detect new cracks
  - Confirm validity of original FE analysis
  - Any SCC outside of the original short term strategy to be repaired as per Standard Repair practices

Summary

- Significant Stress Corrosion Cracking issue identified
- Identification and rectification of root cause
- Development of well defined and structured management strategy with input from key stakeholders
  - Contract manager, maintenance organisation, regulator etc
  - Immediate actions – completion of inspections of aircraft in maintenance
  - Inspection of all aircraft
  - Development of Phased Array Ultrasonic NDT procedures
  - Validation of FE model using physical compressive residual strength testing of in-service wing panels
- Result – management of the risk of SCC to airworthiness of the aircraft all with minimal impact to aircraft availability

Comments

Questions