



HOW THE HOLISTIC APPROACH FOR GLARE DEVELOPMENT STILL BRINGS BENEFITS

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AIRBUS

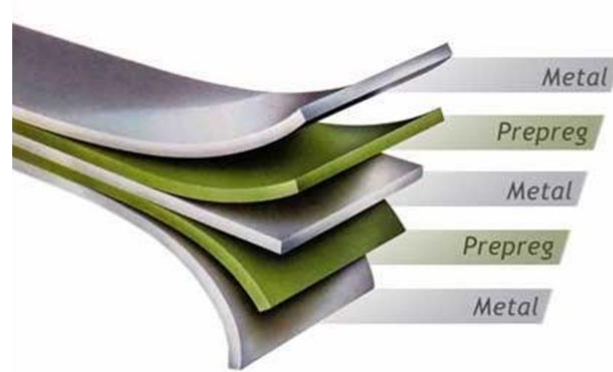
Introduction holistic approach

Development philosophy:

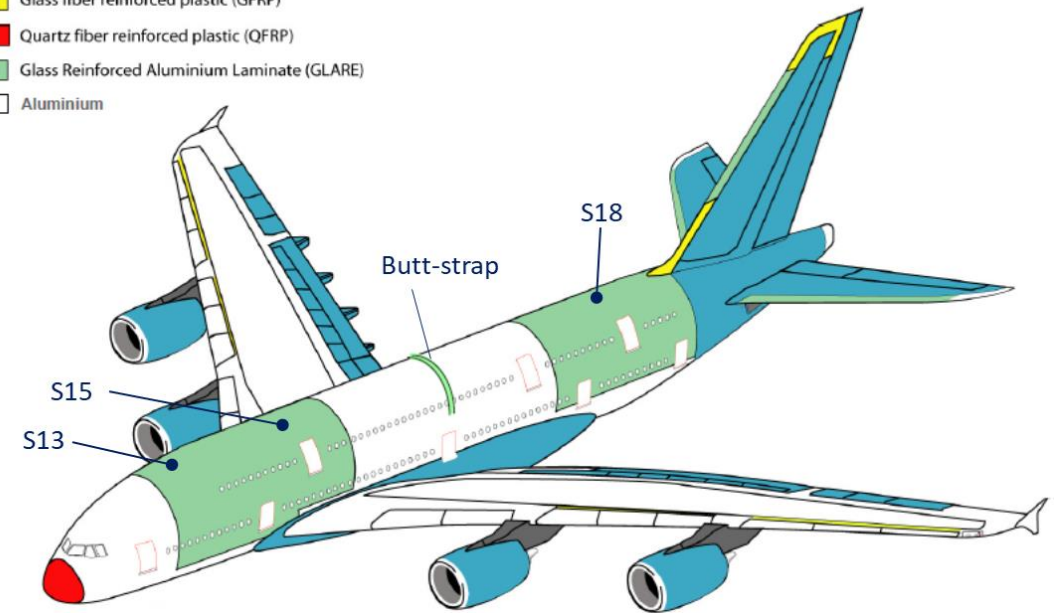
- Combine the advantages of fibres and metals
- Design against Ultimate load after 1 DSG
- Multiple Side Damage analysis baseline for F&DT analysis

Bridging fibres:

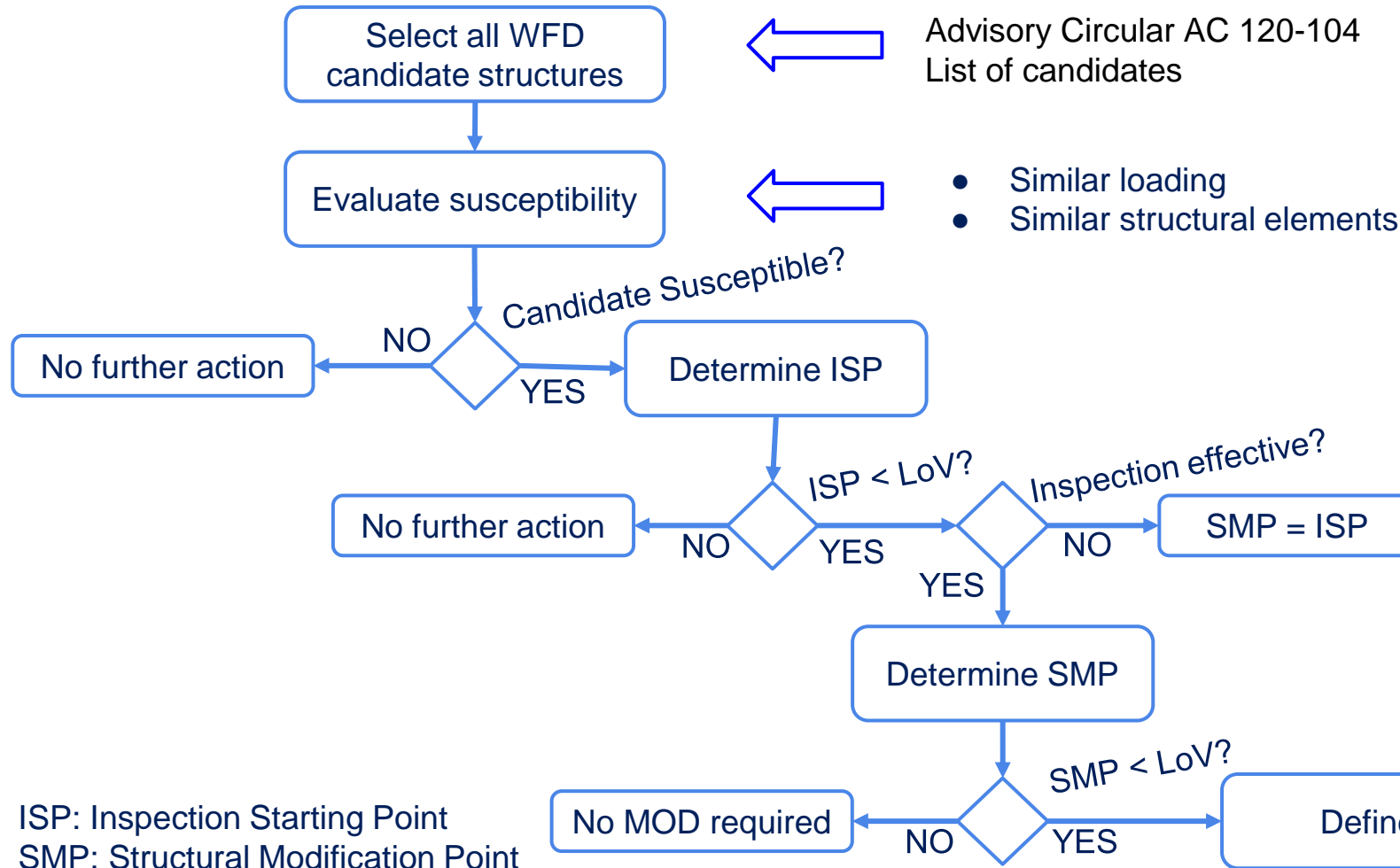
- Constant & low crack propagation rate
- High residual strength



- Carbon fiber reinforced plastic (CFRP)
- Glass fiber reinforced plastic (GFRP)
- Quartz fiber reinforced plastic (QFRP)
- Glass Reinforced Aluminium Laminate (GLARE)
- Aluminium



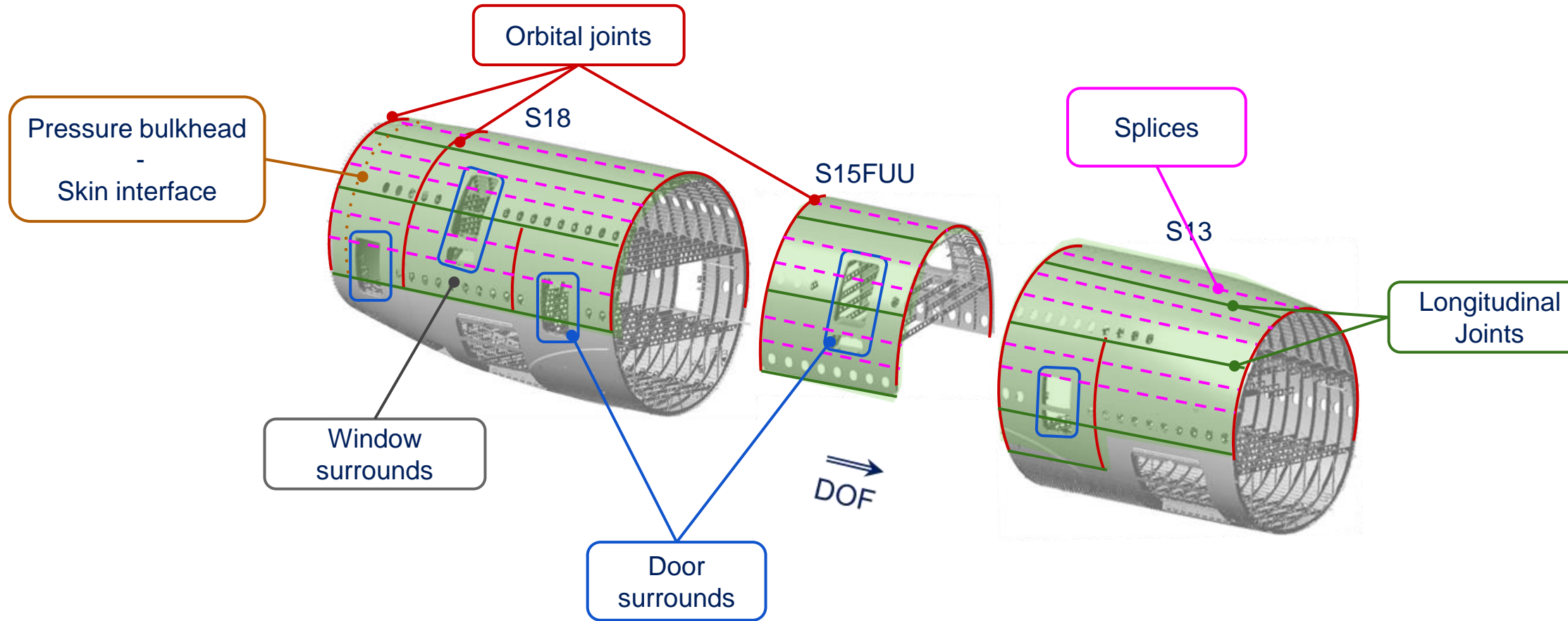
Widespread Fatigue Damage FAR26.21 Certification



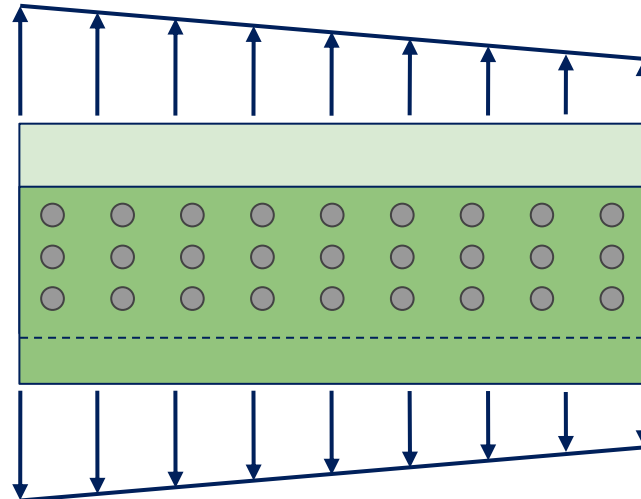
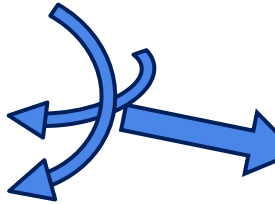
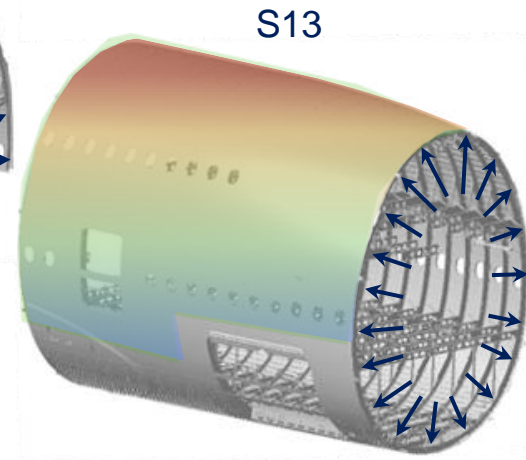
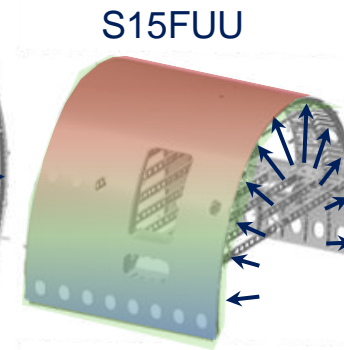
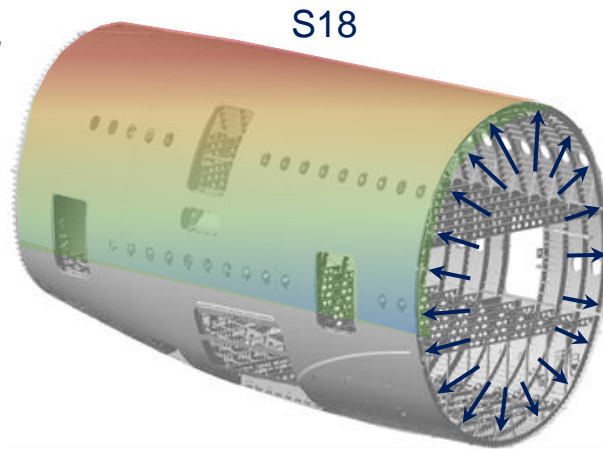
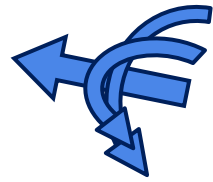
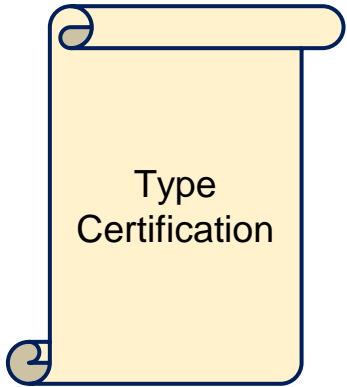
- **Longitudinal Skin Joints**, Frames, and Tear Straps (MSD/MED)
- **Circumferential Joints** and Stringers (MSD/MED)
- Lap Joints with Milled, Chem-milled or Bonded Radius (MSD)
- Fuselage Frames (MED)
- Stringer to Frame Attachments (MED)
- **Shear Clip End Fasteners on Shear Tied Fuselage Frames** (MSD/MED)
- **Aft Pressure Dome Outer Ring and Dome Web Splices** (MSD/MED)
- **Skin Splice at Aft Pressure Bulkhead** (MSD)
- Abrupt Changes in Web or Skin Thickness — Pressurized or Unpressurized Structure (MSD/MED)
- **Window Surround** Structure (MSD, MED)
- Over-Wing Fuselage Attachments (MED)
- Latches and Hinges of Non-plug Doors (MSD/MED)
- Skin at Runout of Large Doubler (MSD)—Fuselage, Wing or Empennage
- Wing or Empennage Chordwise Splices (MSD/MED)
- Rib-to-Skin Attachments (MSD/MED)
- Typical Wing and Empennage Construction (MSD/MED)

ISP: Inspection Starting Point
 SMP: Structural Modification Point
 MOD: MODification

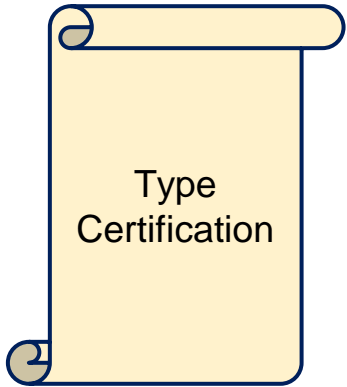
Relevant selected areas



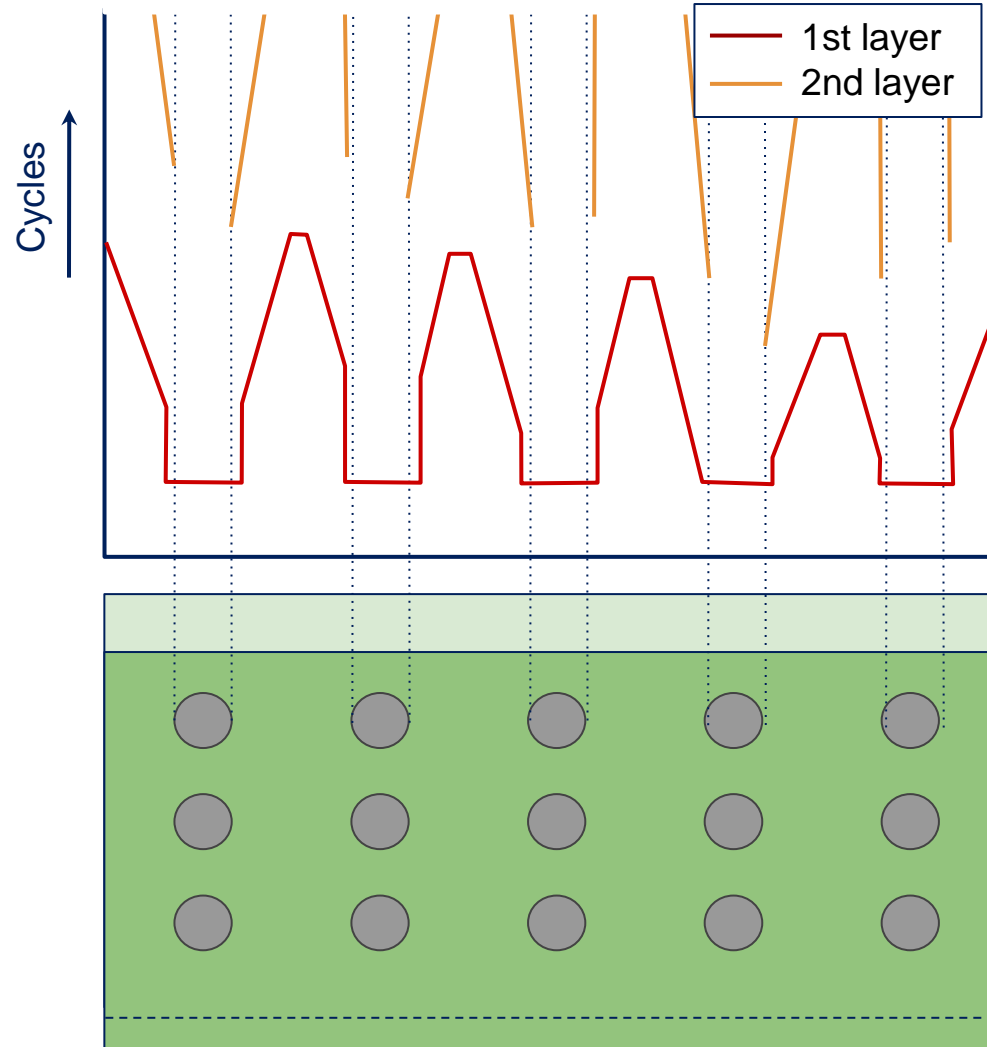
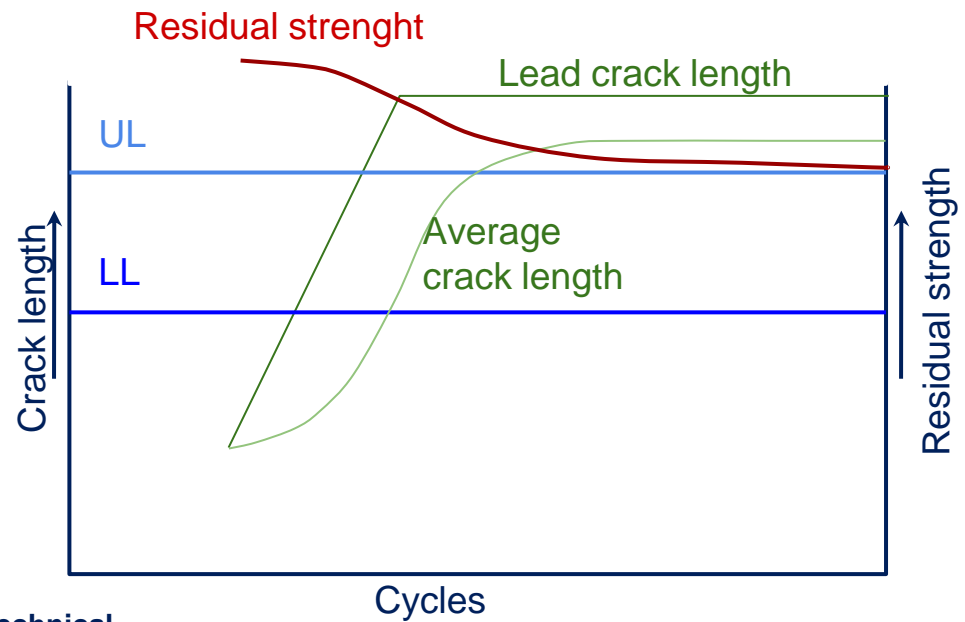
Analysis approach



Analysis approach



- Multiple Side Damage:
- Monte-Carlo analysis (200 MSD scenario's)
 - Crack propagation



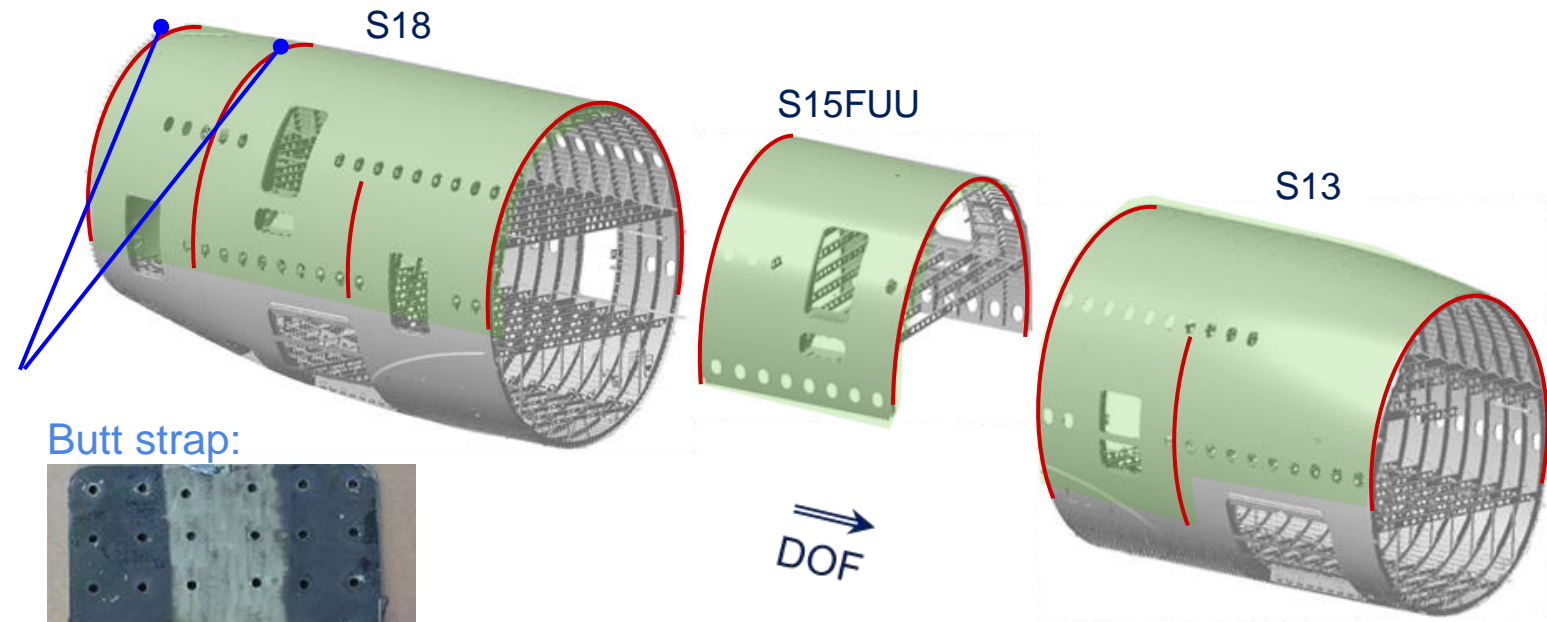
Orbital Joints

Full Scale Fatigue Test:

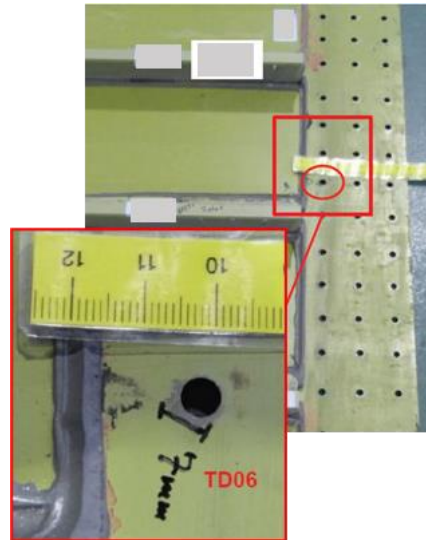
- No damages detected in test
- Few cracks in Tear-Down
- Longest crack = 7 mm
- Coupon test: **RF > 1.5 UL**

Type Certification:

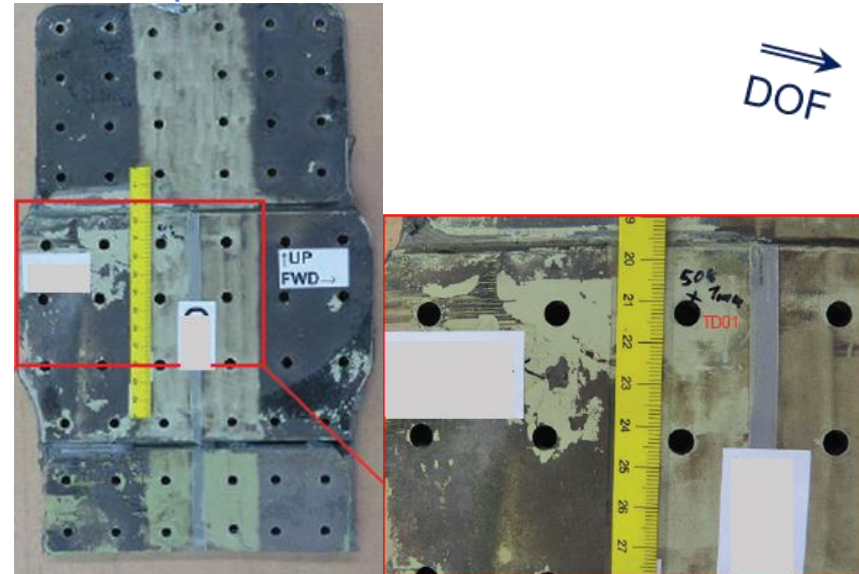
- Life > 100 * DSG



Skin:



Butt strap:



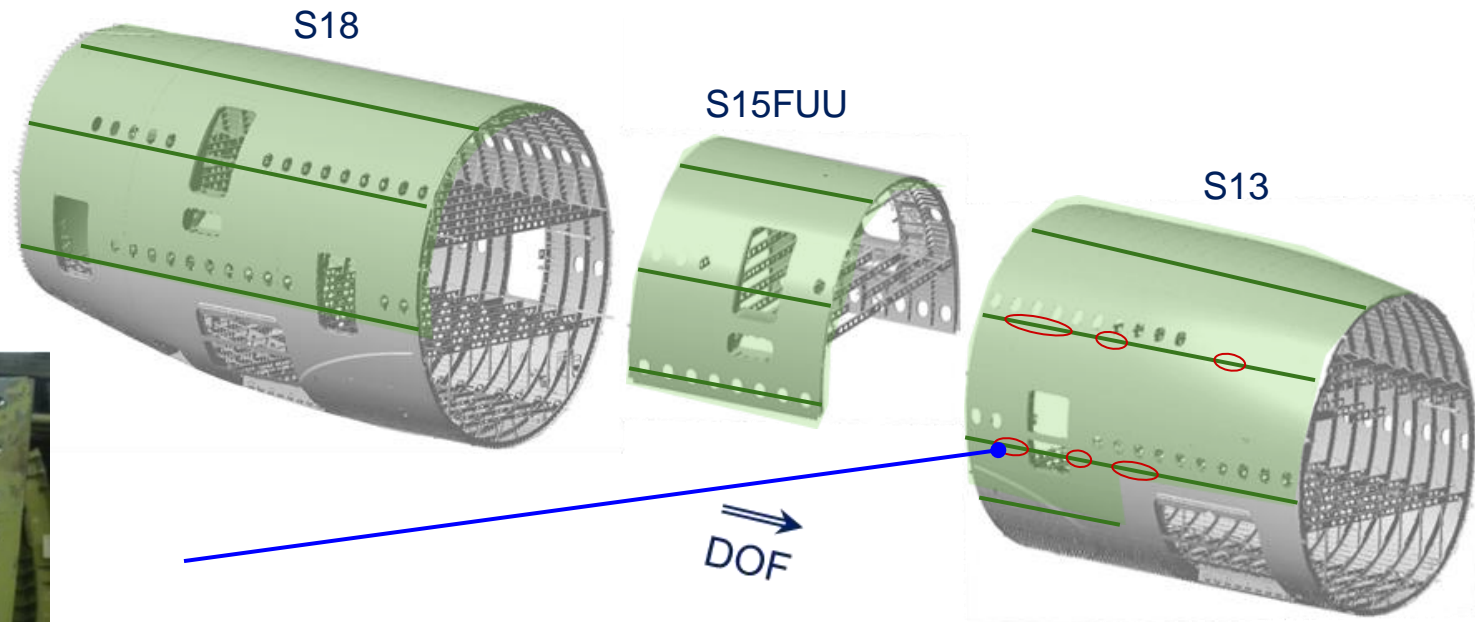
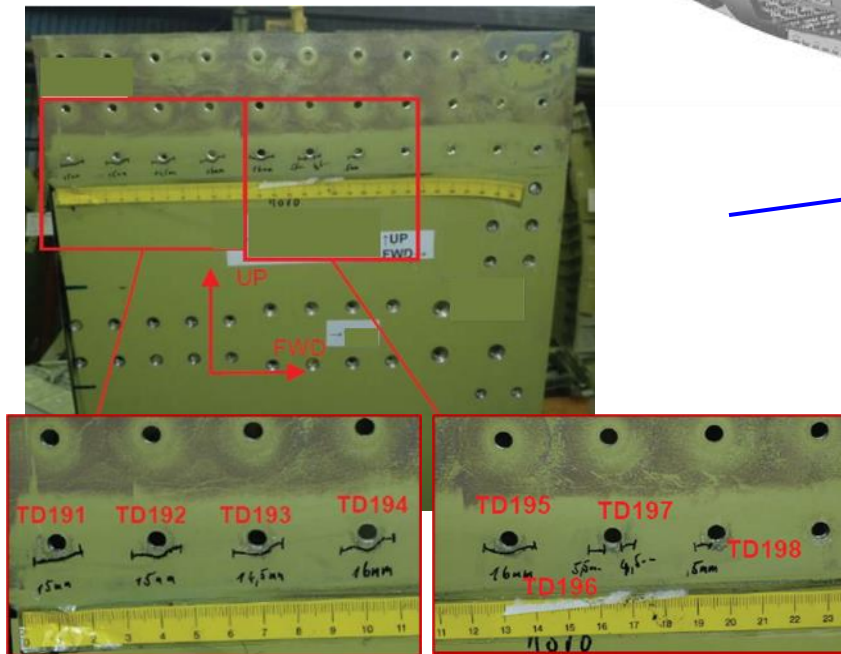
Longitudinal Joints

Full Scale Fatigue Test:

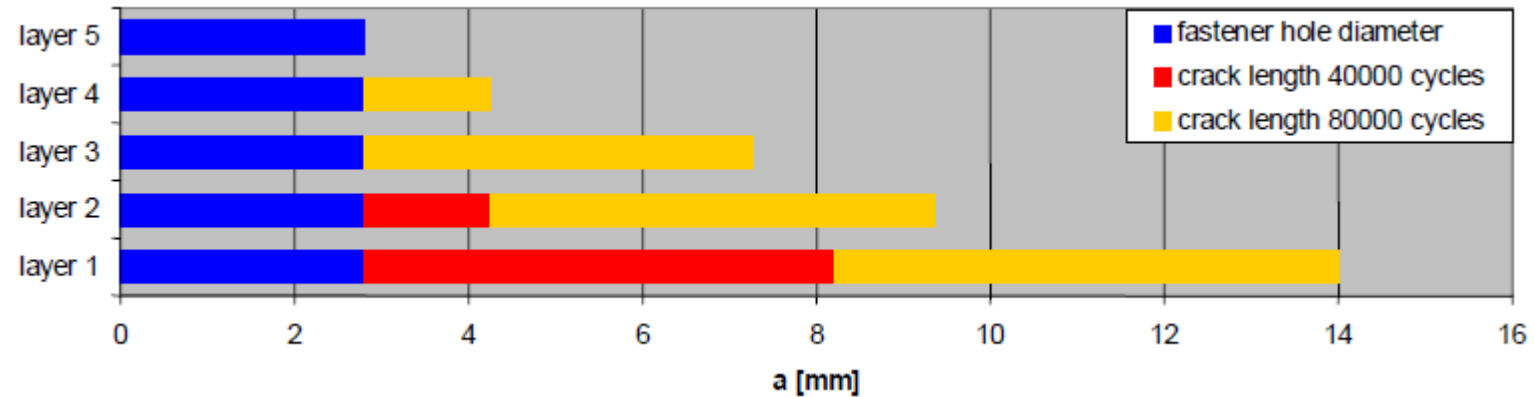
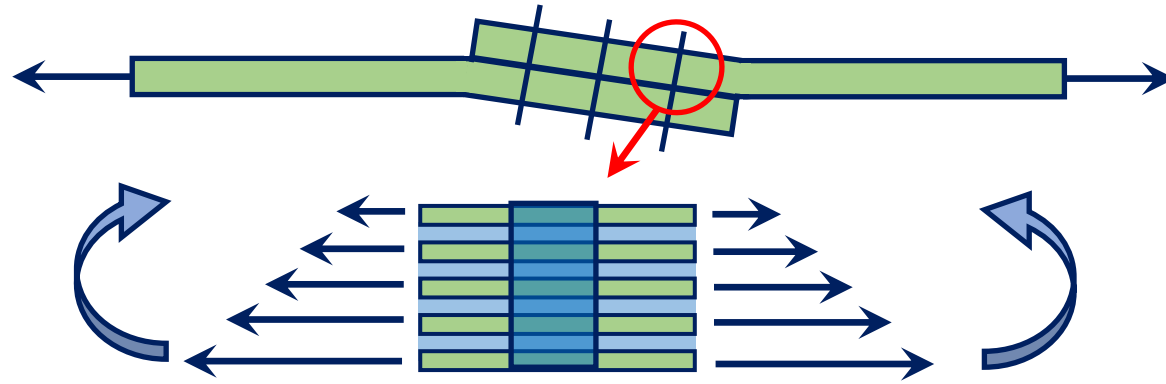
- No damages detected in test
- >100 cracks in Tear-Down
- 95% cracks < 3.0 mm
- Longest crack = 16.0 mm
- Coupon test: **RF > 1.5 UL**

Type Certification:

- Life = infinite



Lap joints through thickness

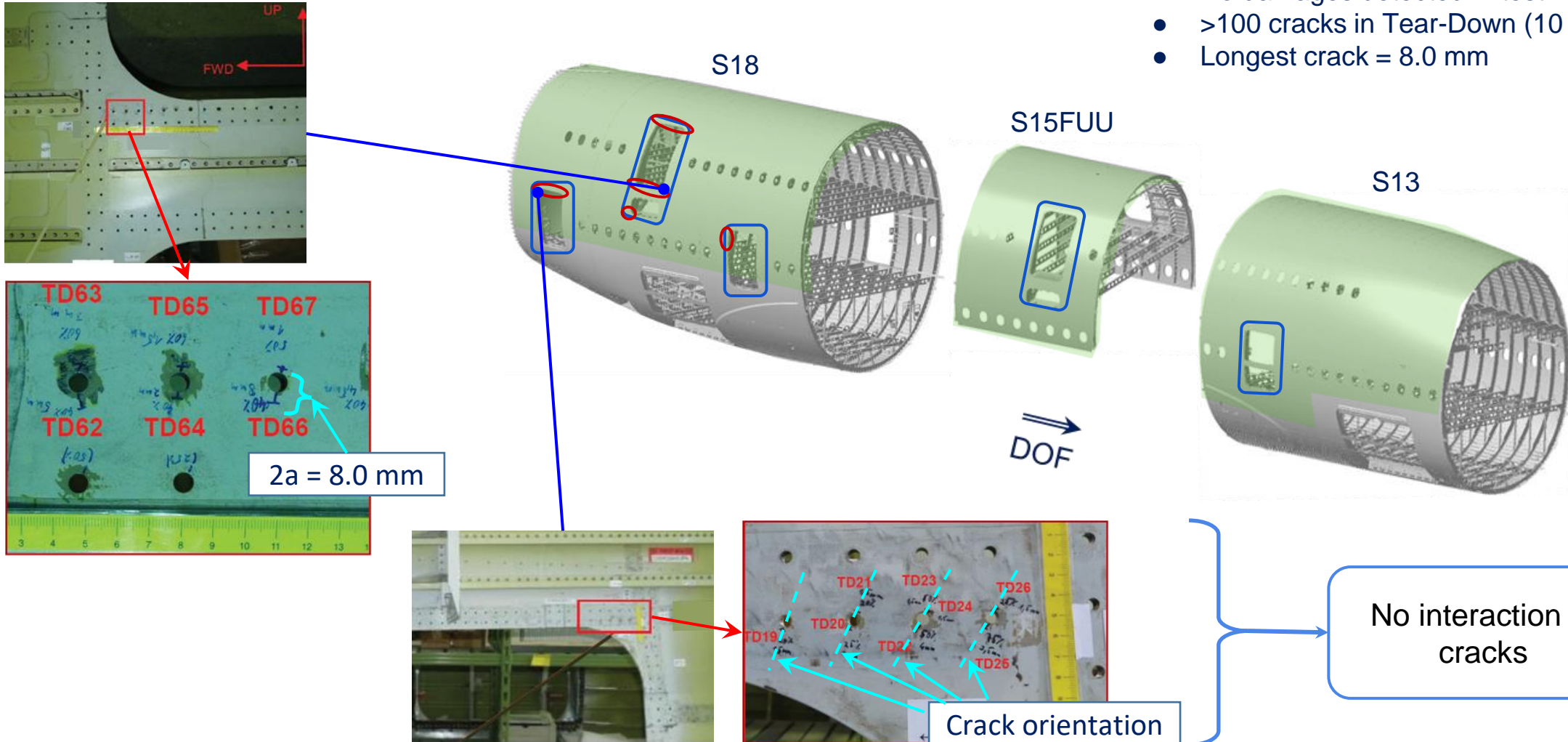


Each layer is a fence for crack propagation.

Door surrounds

Full Scale Fatigue Test:

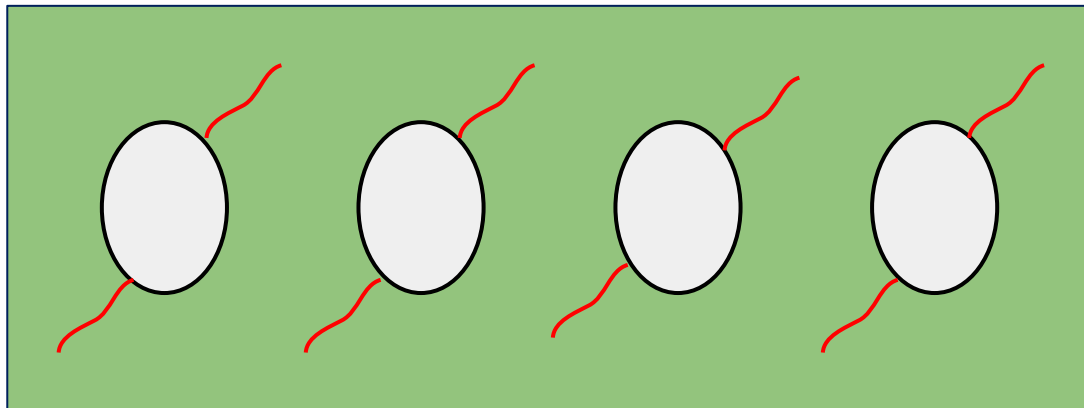
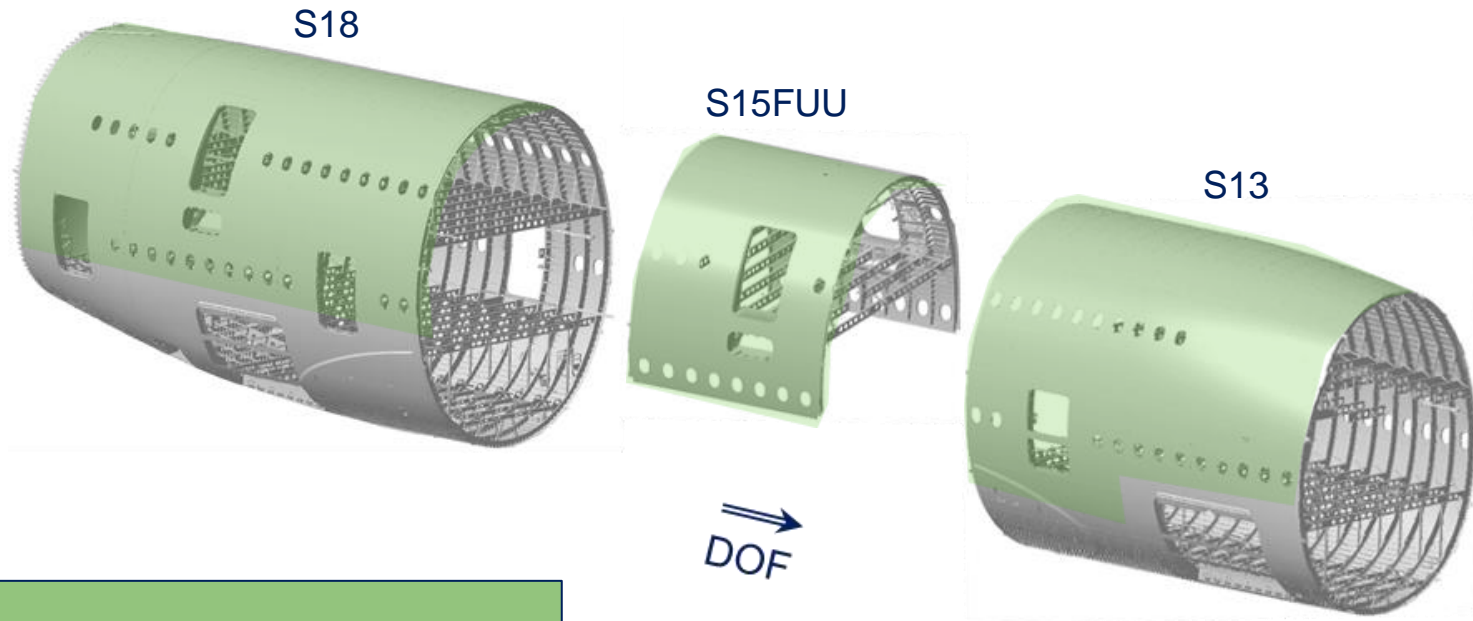
- No damages detected in test
- >100 cracks in Tear-Down (10 doors)
- Longest crack = 8.0 mm



Pax window surrounds

Full Scale Fatigue Test:

- Only 3 windows with damages



No interaction of cracks

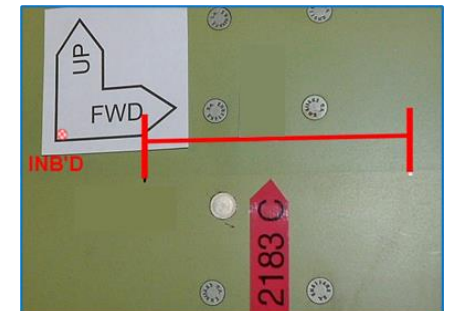
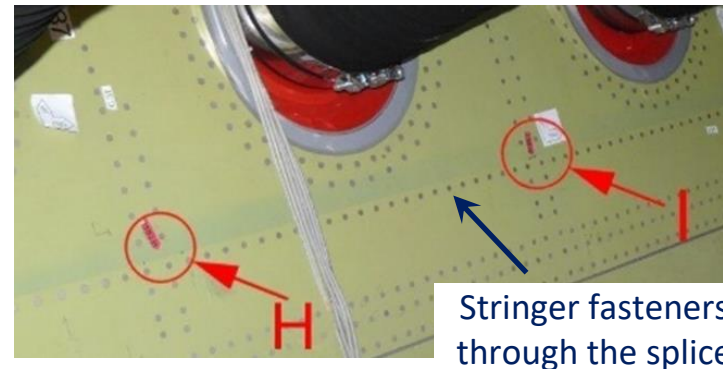
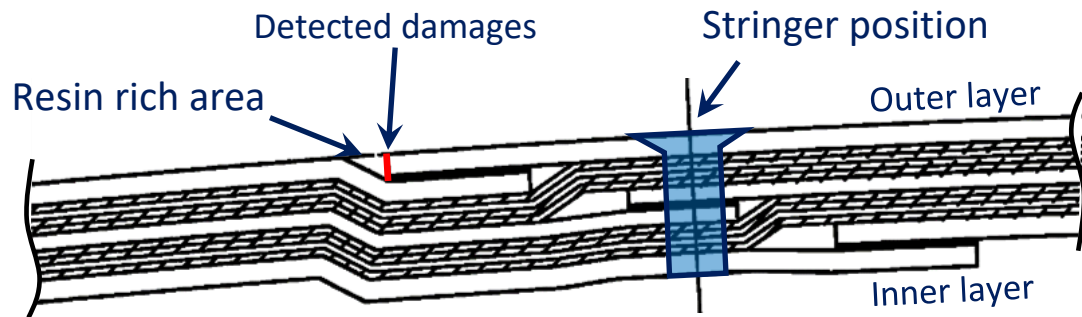
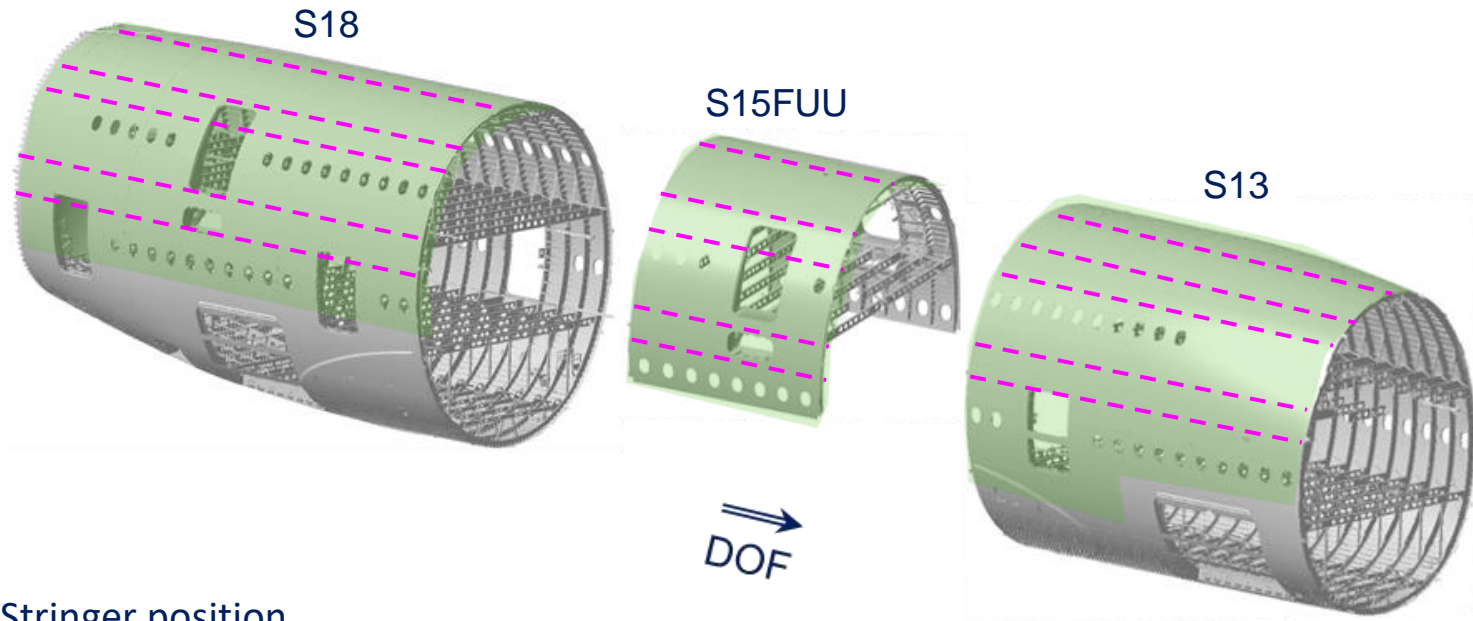
GLARE splices

Full Scale Fatigue Test:

- Damages > 80% of test
- RF > 1.5 UL

Type Certification:

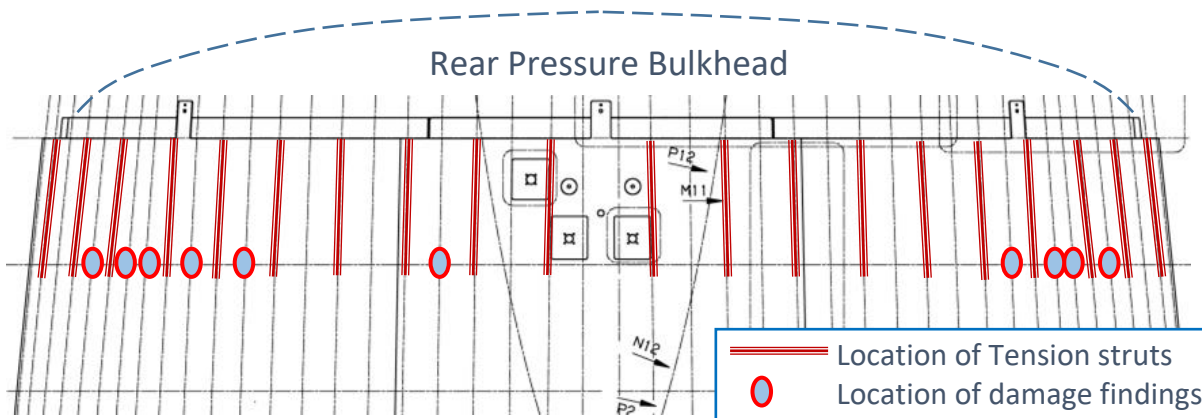
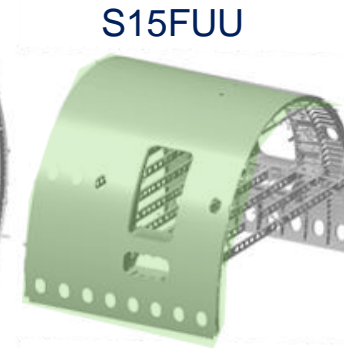
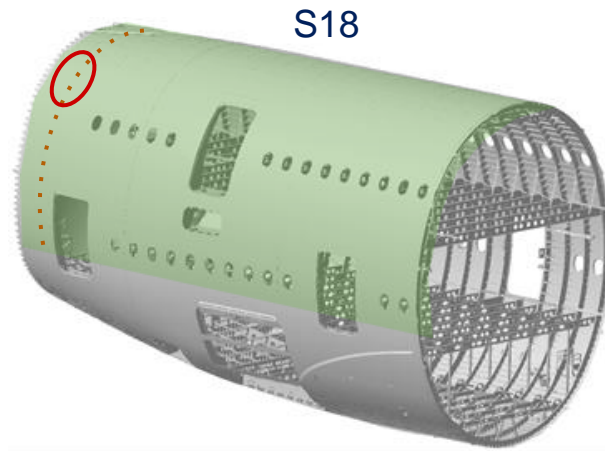
- Life = infinite



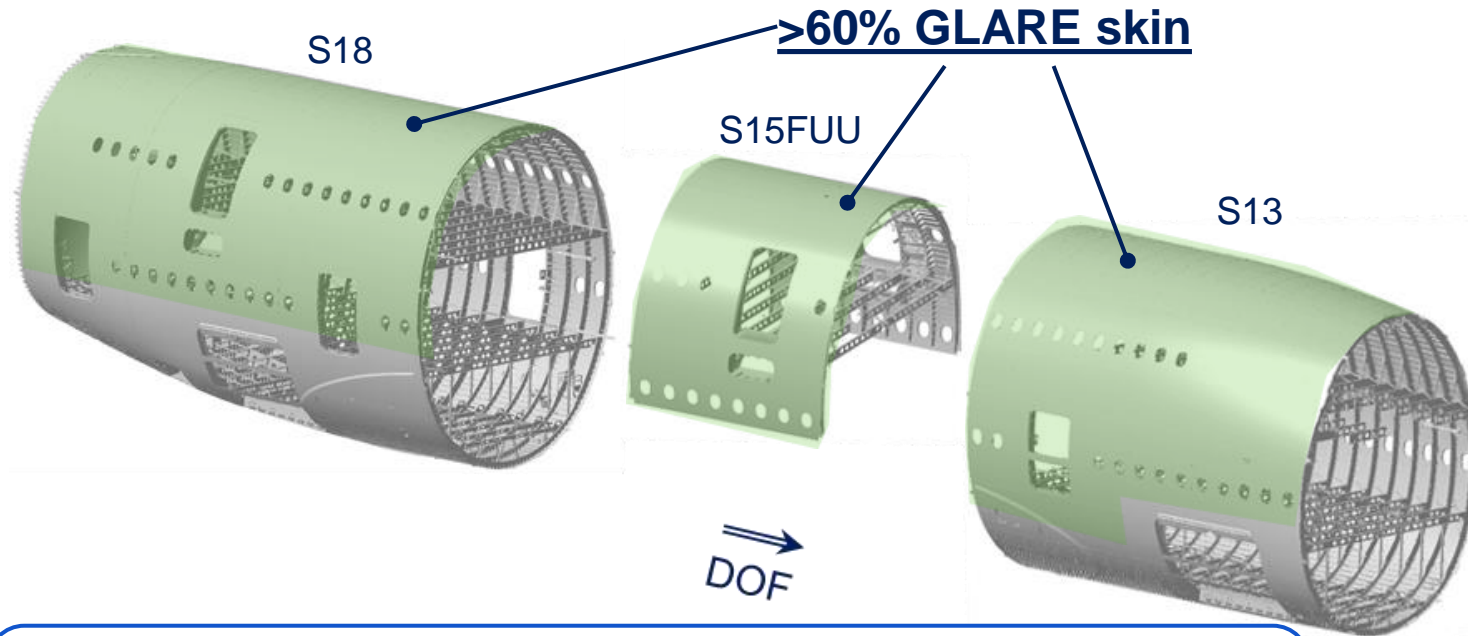
Pressure Bulkhead - skin interfaces

Full Scale Fatigue Test:

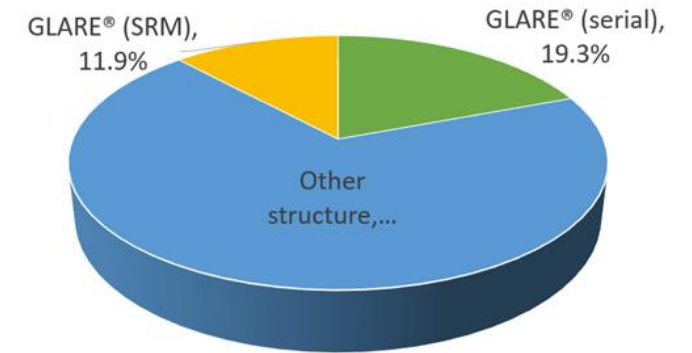
- Damages at stringer-frame intersection
- Limited delamination below cracks



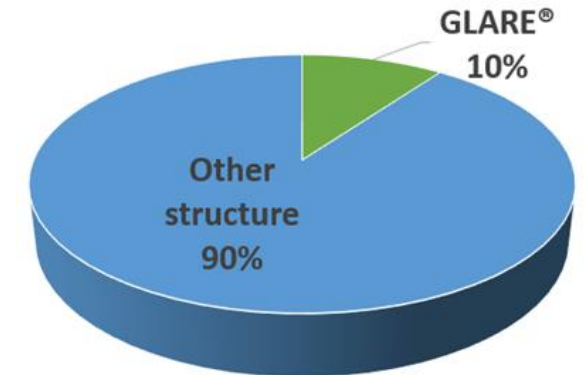
How the holistic approach helped the WFD campaign



Full-scale Fatigue Test findings:



Natural Damages¹⁾



Tear-Down findings¹⁾

Full-scale Fatigue Test:	WFD campaign ¹⁾ :
- Coverage > 2 LoV	- 25 Stress dossiers
- LEF = 1.1	- 2 related to GLARE
- GLARE RF > 2.0 UL	- No new calculations
	- < 3% activity for GLARE skin

¹⁾Only section S13, S15FUU, S18

Conclusion

- It is confirmed; a holistic approach considering all requirements early in the development process saves significant effort and costs later
- GLARE can not develop a WFD critical damage
- No additional analysis is performed because MSD scenario is baseline for the F&DT analysis @ type certification
- By applying all requirements to all design solutions, the whole structure exhibits the same standard and robustness.

Thank you

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