

DEFENCE AND SPACE

# CRACK BRIDGING EFFECT IN HYBRID REINFORCED FUSELAGE STRUCTURE

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# General

## Mission capability

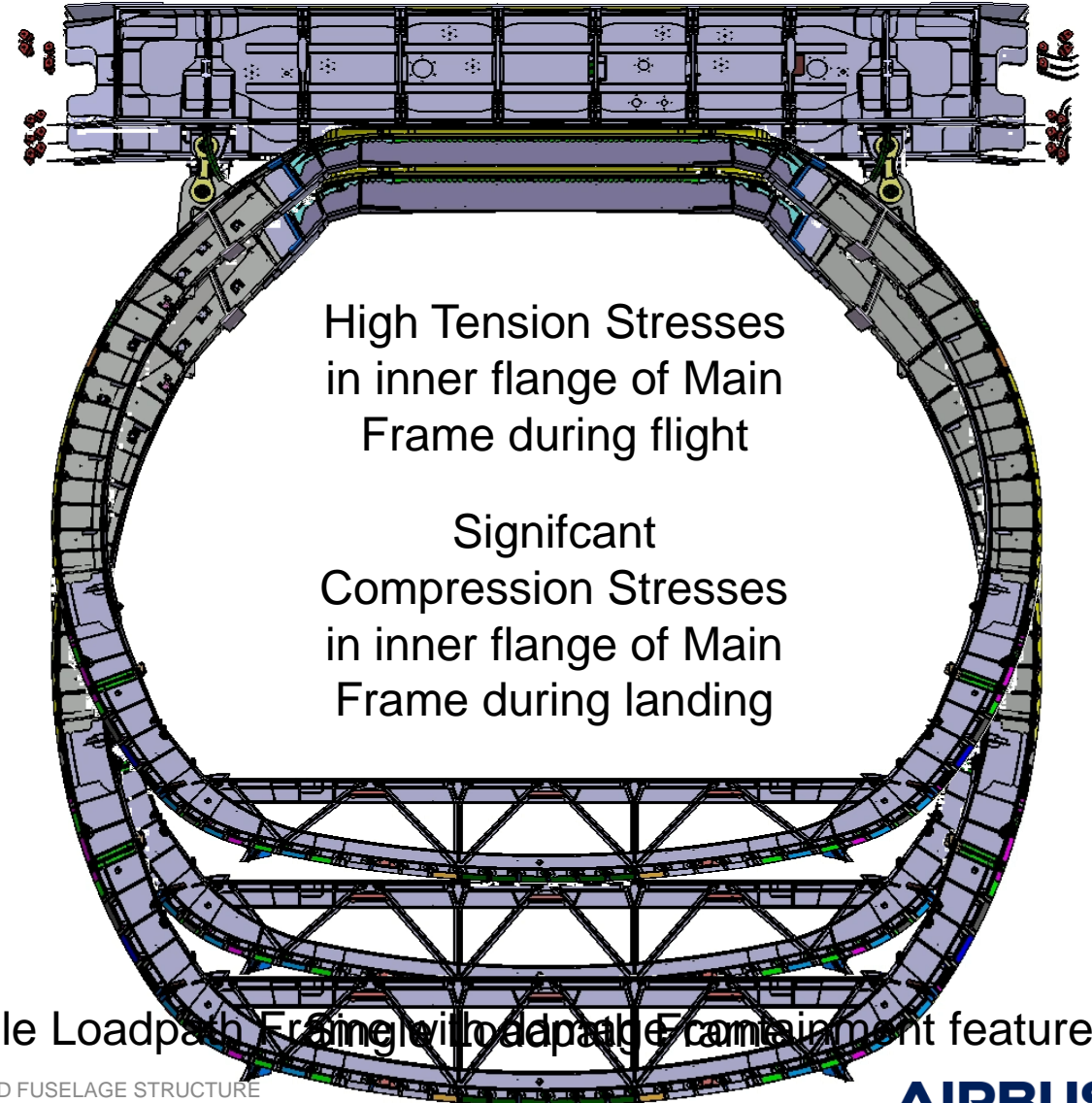
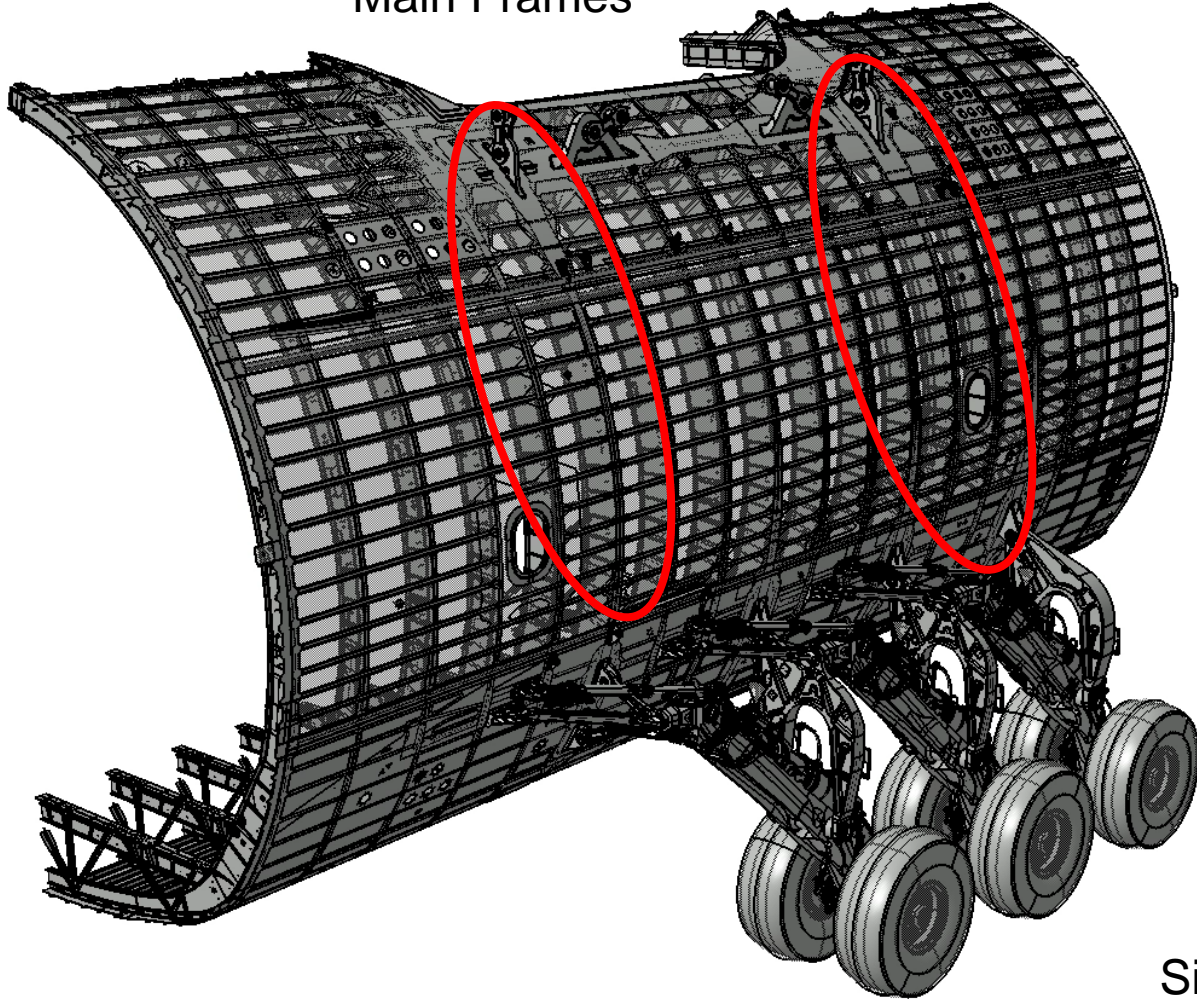
- Strategic airlift
  - Tactical airlift
  - Aerial tanker
- 
- Payload 37 t
  - MTOW 130 t
  - Range 6500 km
  - Design Life: 10000 FC / 30000 FH
- 
- Turboprop engines
  - T-Tail
  - High wing





# General

Wing attachment at Main Frames



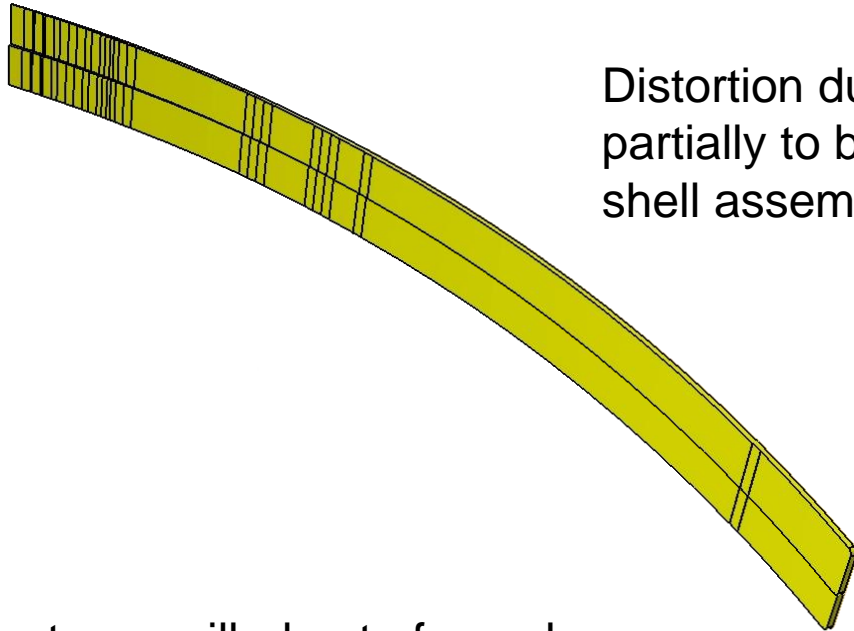
High Tension Stresses  
in inner flange of Main  
Frame during flight

Signifcant  
Compression Stresses  
in inner flange of Main  
Frame during landing

Single Loadpath Framing with loadpath containment feature

# Main Frame Production Process

1. Production of FML Panel

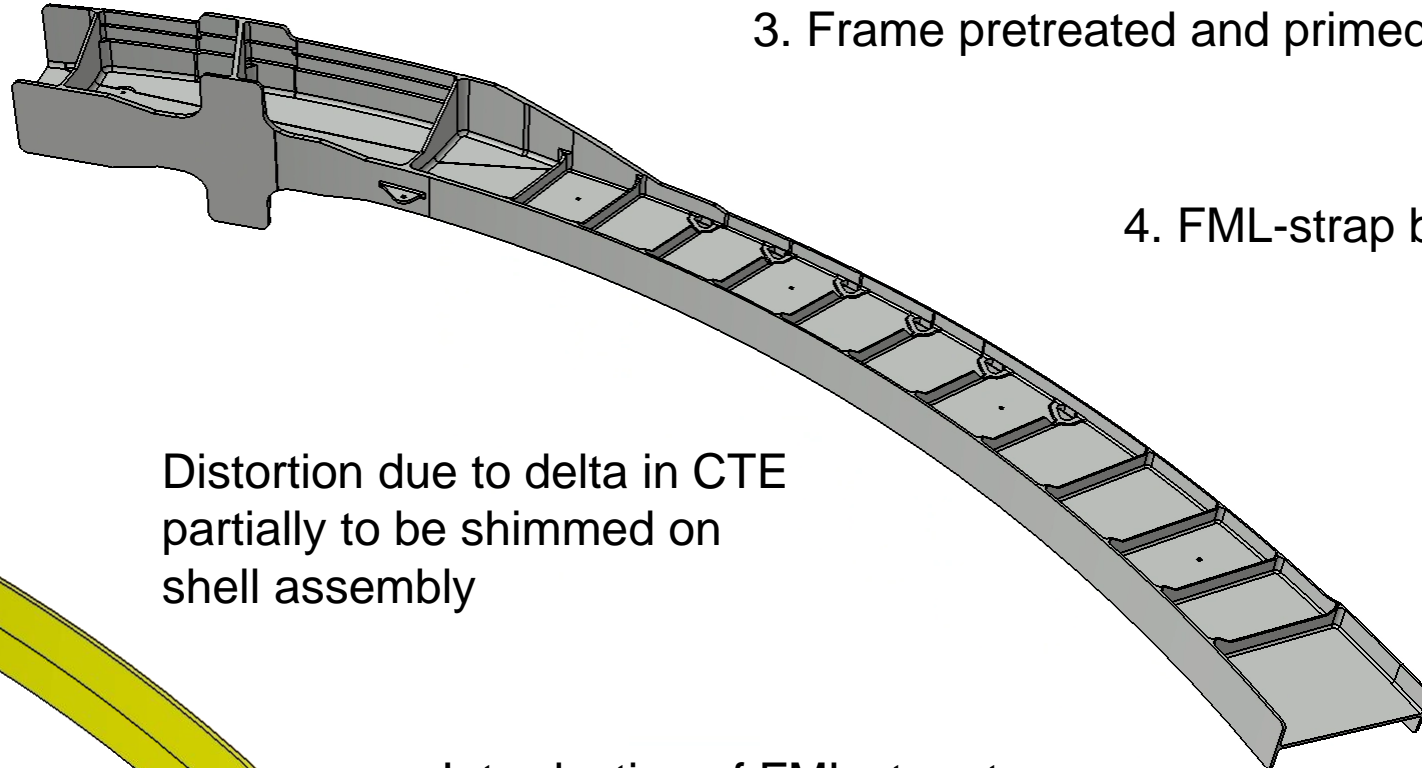


Distortion due to delta in CTE partially to be shimmed on shell assembly

2. FML-straps milled out of panel

Introduction of FML strap to retard or stop potential cracks\*1)

3. Frame pretreated and primed

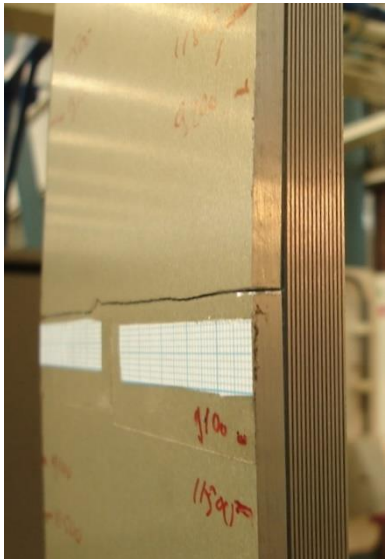


4. FML-strap bonded to frame

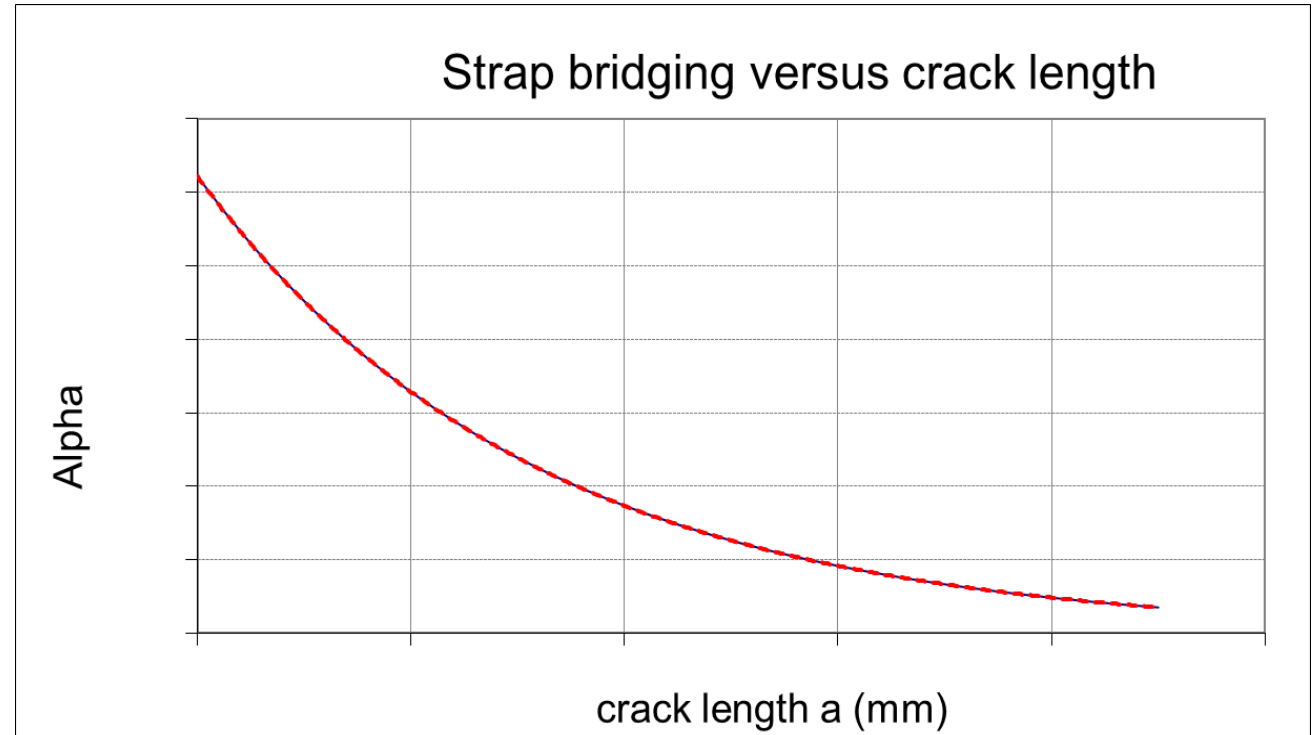
\*1) see Plokker, M., Daverschot D. and Beumler T. (2009), In: Hybrid structure solution for the A400M Wing Attachment Frames, Proceedings of the 25th ICAF Symposium

## Certification Tests

# Slowing down Crack growth



- Load transfer Strap vs Inner flange
- “crack bridging” correction function  $\alpha$
- Edge cracks and bore hole cracks



see Plokker, M., Daverschot D. and Beumler T. (2009), In: Hybrid structure solution for the A400M Wing Attachment Frames, Proceedings of the 25th ICAF Symposium

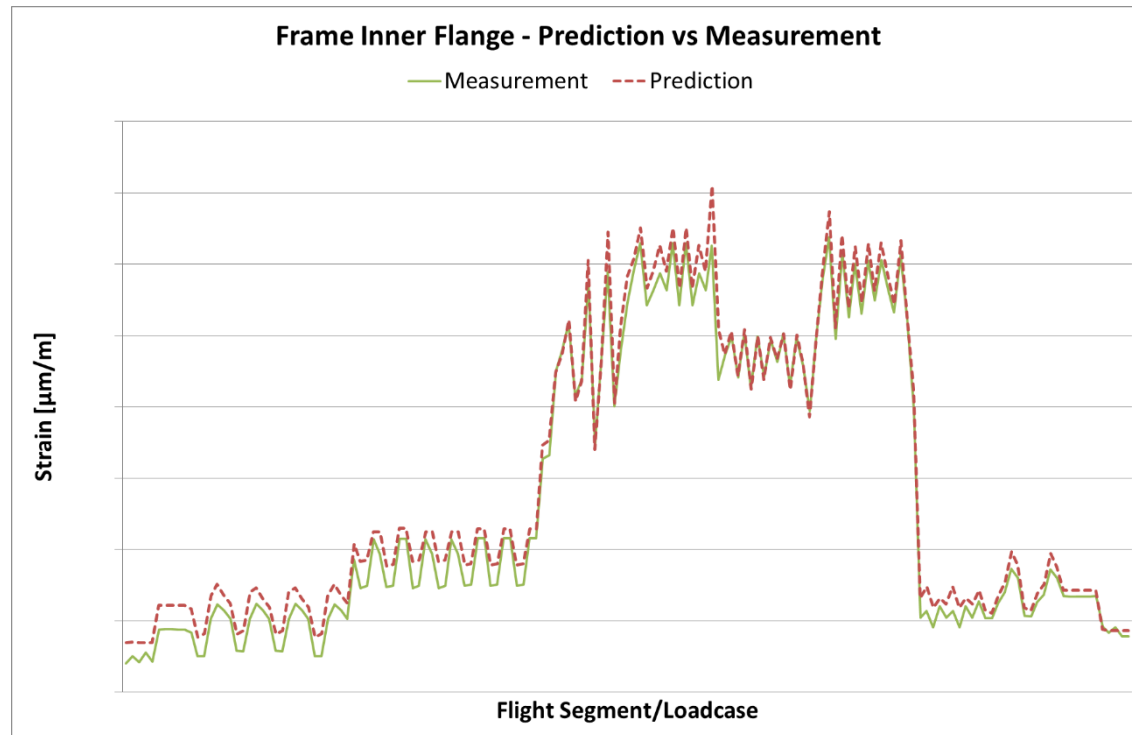
## Full Scale Test behaviour?



# Full Scale Test - Preparation

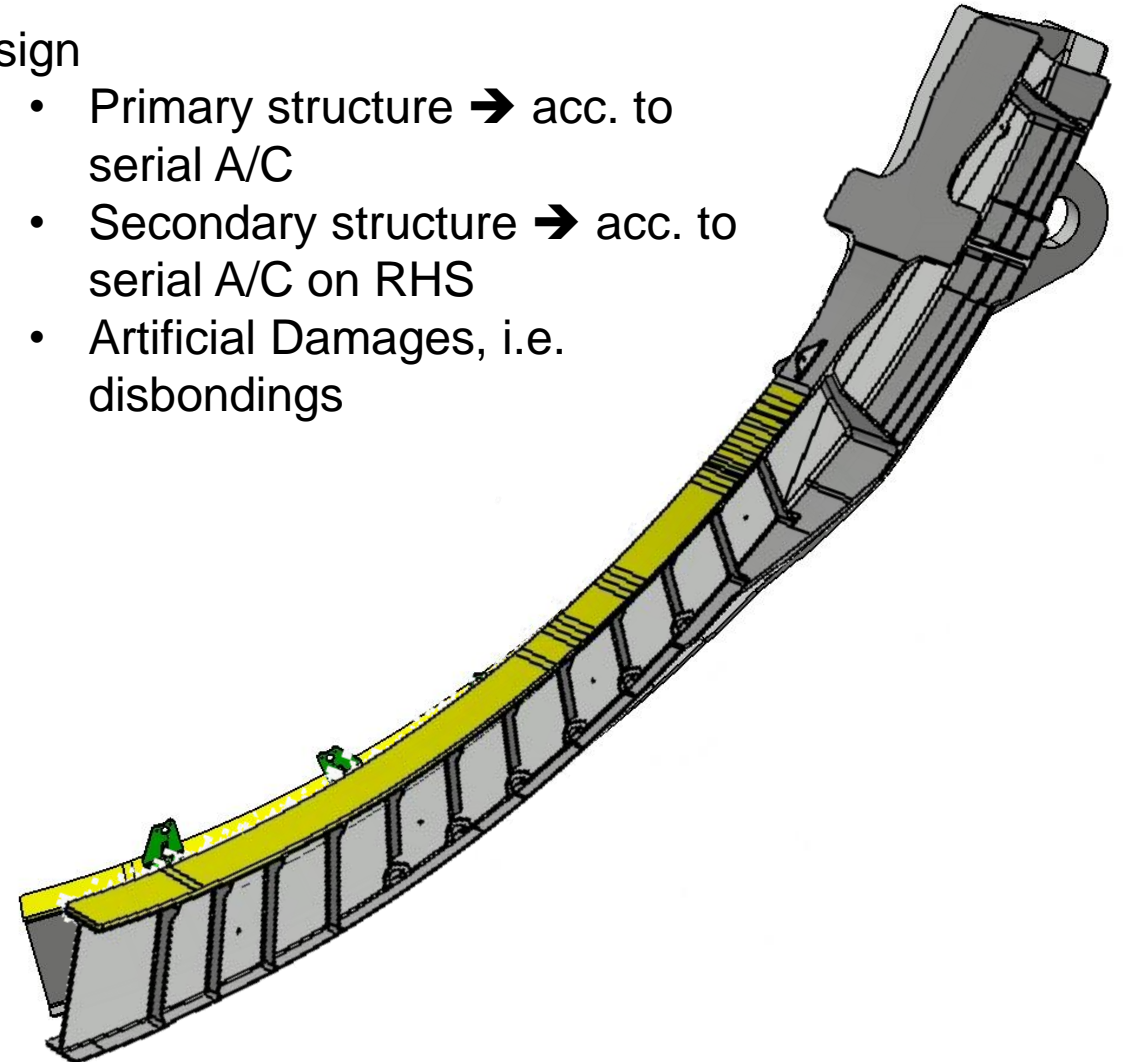
## Spectrum/Loading

- ➔ slight overload of 1-2%
- ➔ Theoretical stresses confirmed by strain gauge measurements
- ➔ Almost 3 Design Service Goals tested



## Design

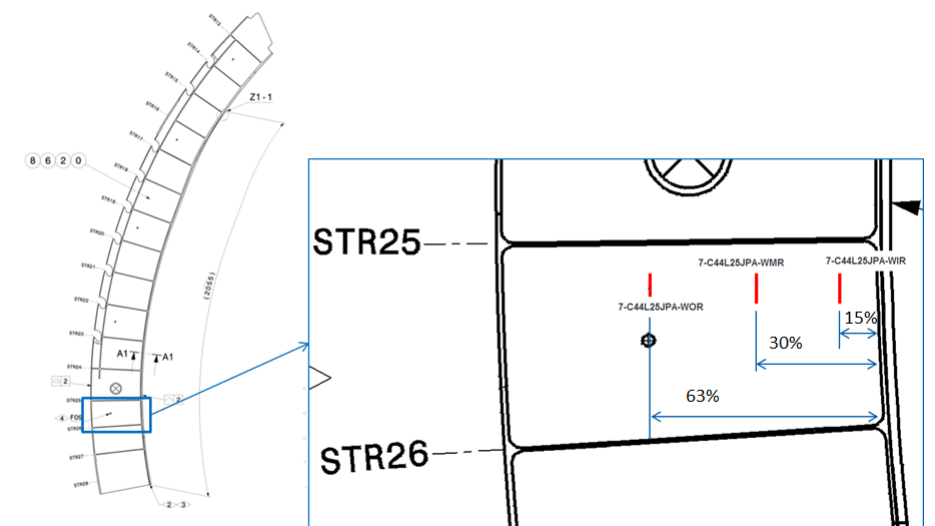
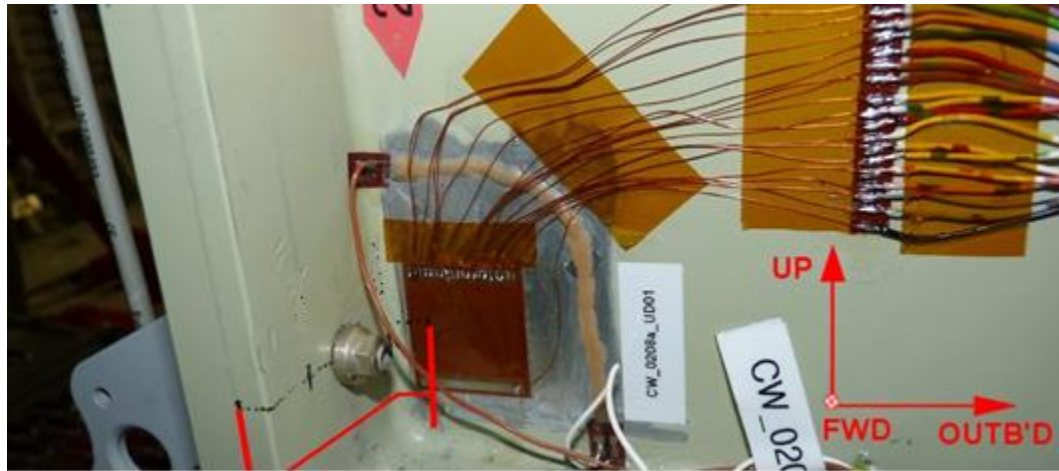
- Primary structure ➔ acc. to serial A/C
- Secondary structure ➔ acc. to serial A/C on RHS
- Artificial Damages, i.e. disbondings



# Full Scale Test - Execution

Natural crack initiations very late in the test

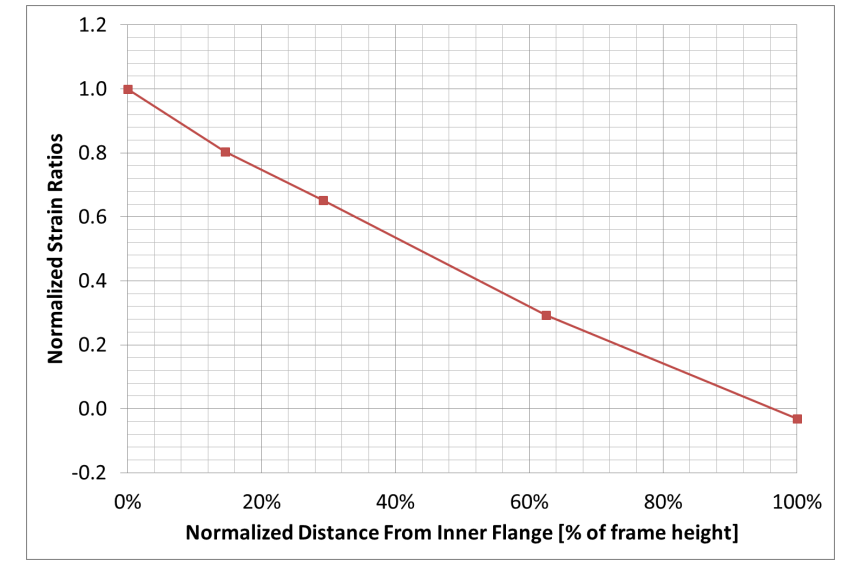
- At FML reinforced frame



- At non-reinforced frame



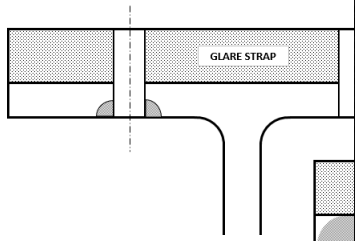
Measure as much as possible



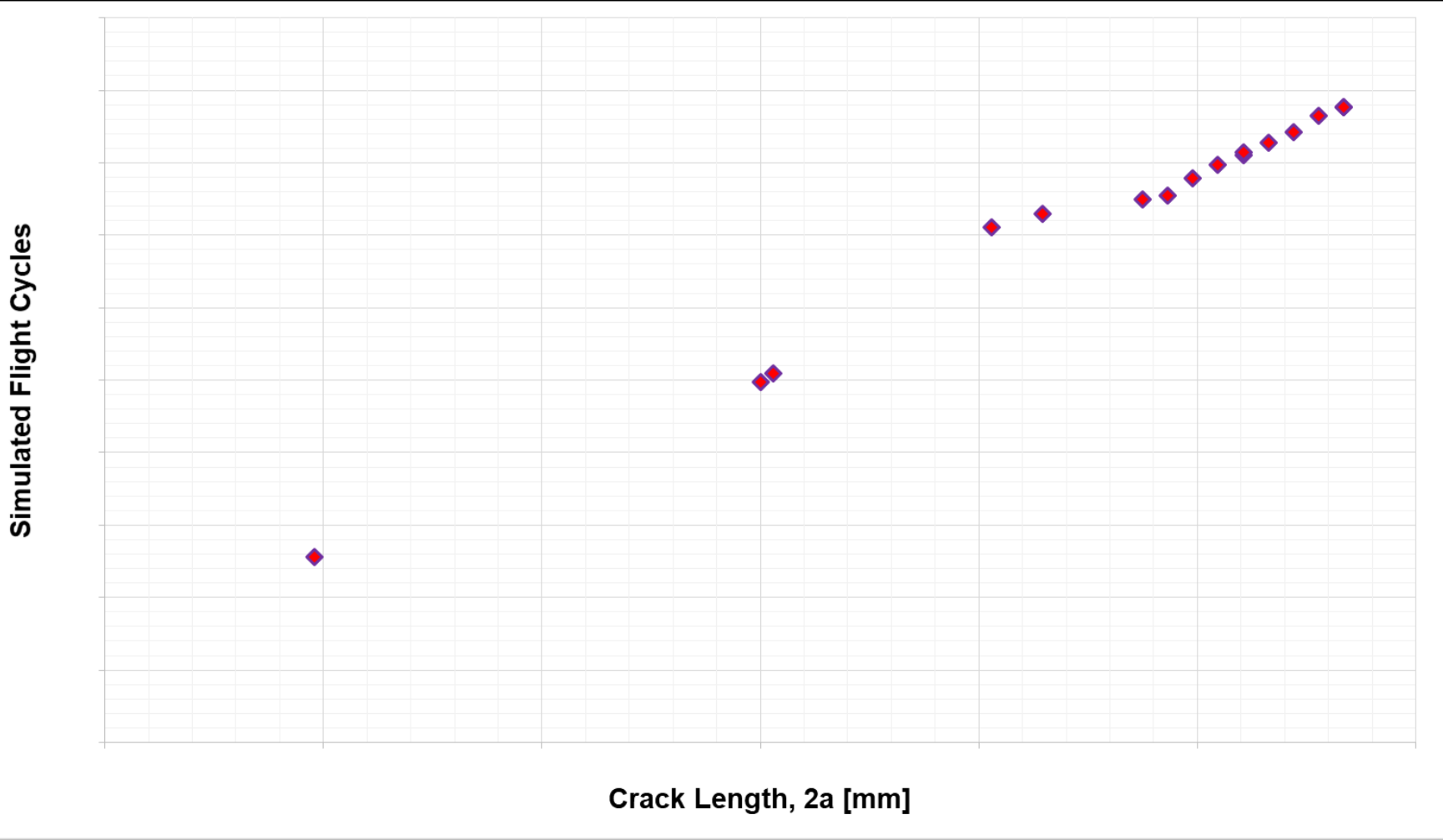
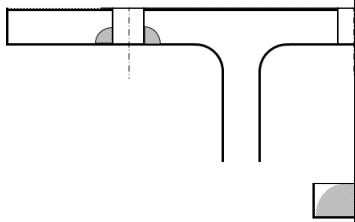
# Full Scale Test – Assessment

## Standard Crack Propagation models

Finding at FML reinforced



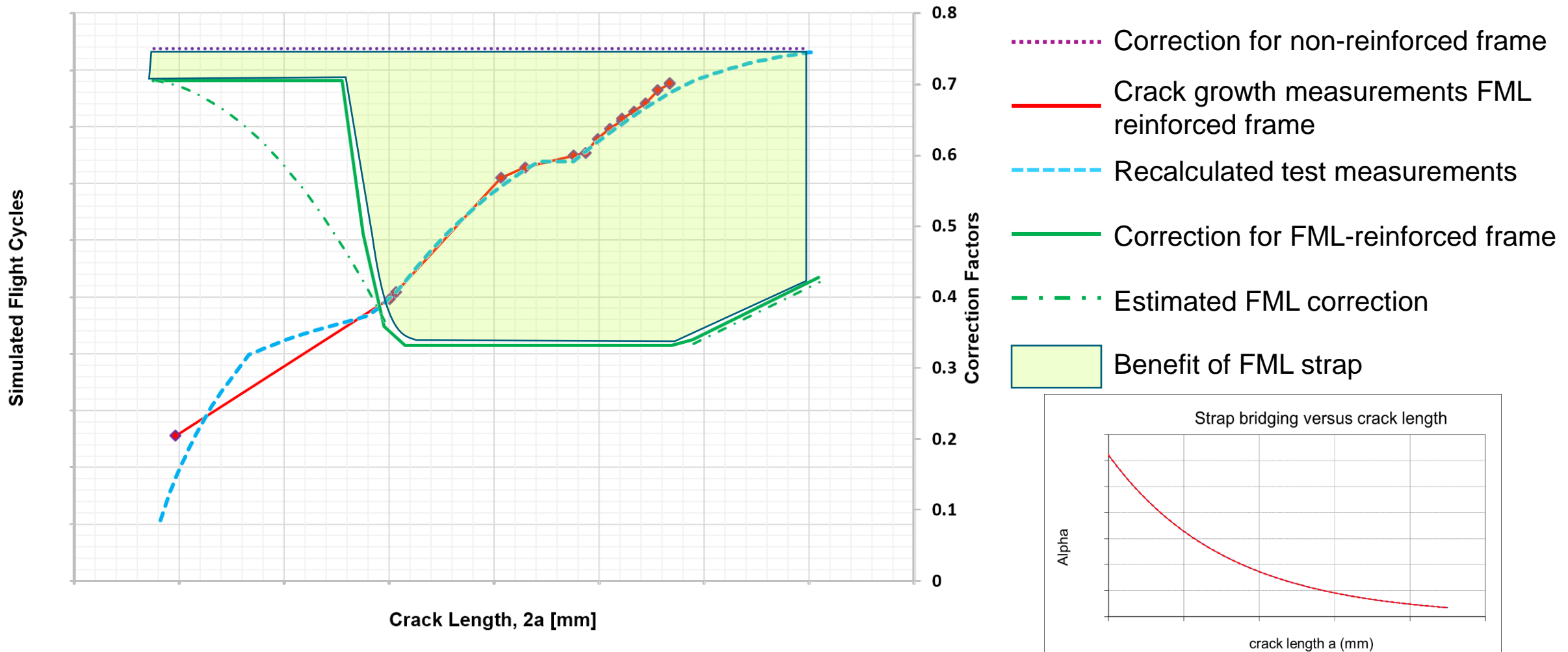
Finding at non-reinforced



ve crack  
ections function  
FML reinforced  
non-reinforced  
es



# Crack Bridging of FML strap



# Conclusion

- Expected outstanding benefit of the adhesively bonded GLARE® strap could be confirmed.
- Crack bridging feature has been illustrated by assessment of full-scale fatigue test.
- Detailed design features have an important influence
- Crack bridging effect could not be used to its full potential due these design features.

# Thank you

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