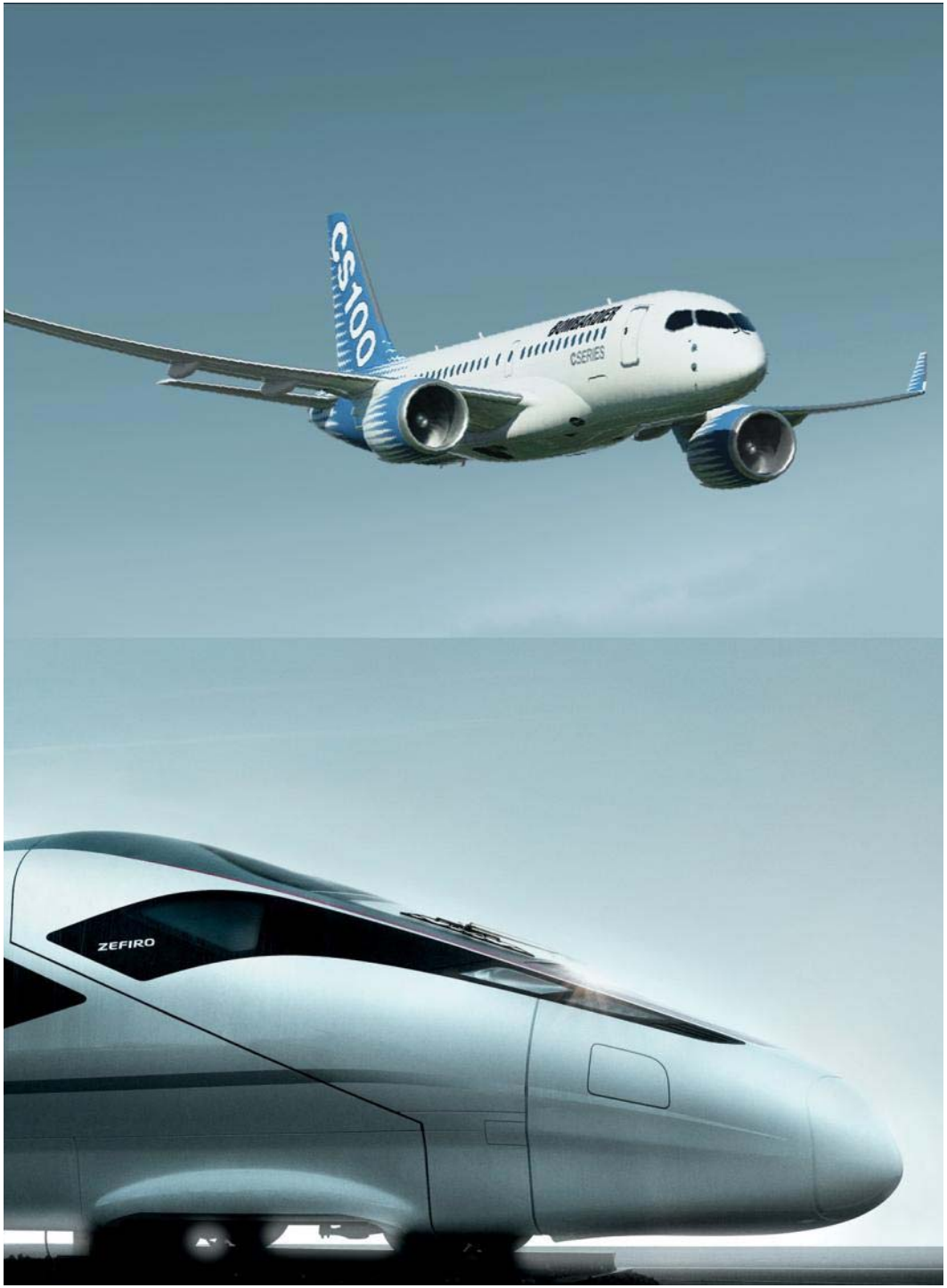

Rear Pressure Bulkhead: Large Damage Capability Demonstration

Composite Transport Damage Tolerance and Maintenance Workshop, Montreal
September 2015

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Product Development Manager

Bombardier Aerostructures & Engineering Services

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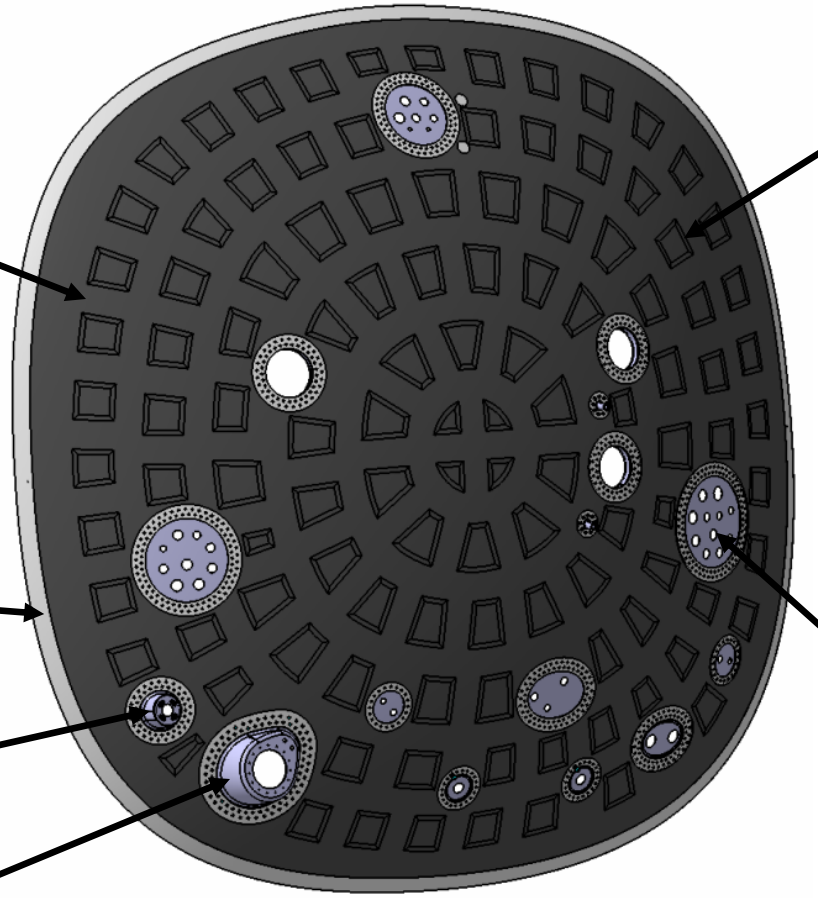
CSeries RPB: Design overview

RPB is a fiber placed tear strap design with an objective of large damage capability as per design principle.



CSeries RPB: Advanced Process

Automated processes brings repeatable optimized part and quality

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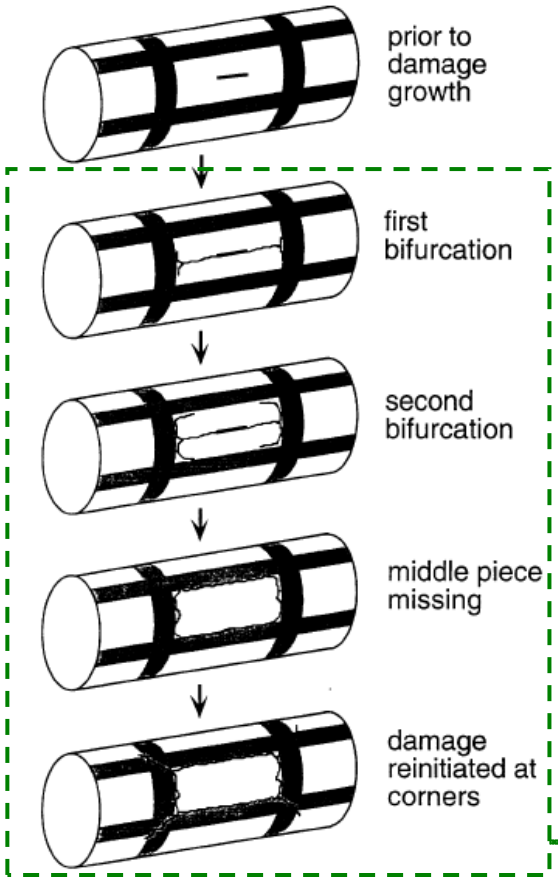
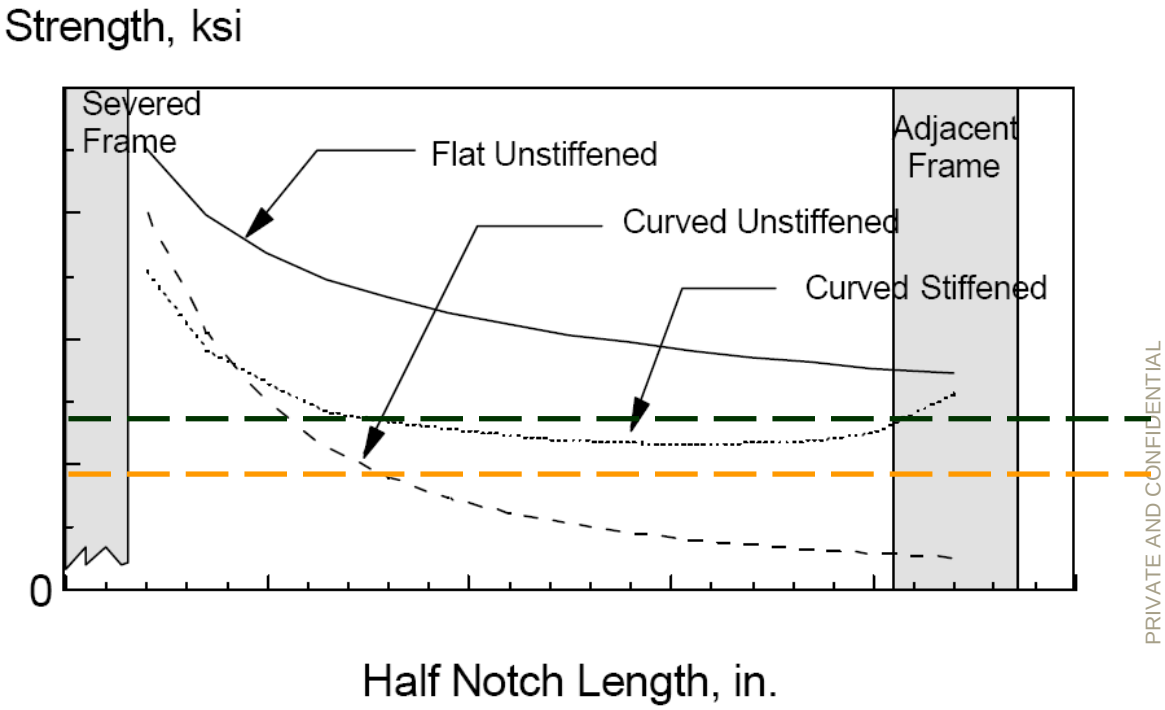
CSeries RPB: Tear Strap design





Not applied for CSeries RPB

Strap are used to demonstrate residual strength capability (orange curve)
Mar-Lin curve associated to a Point-Stress approach with non-linear FEM for final analysis.

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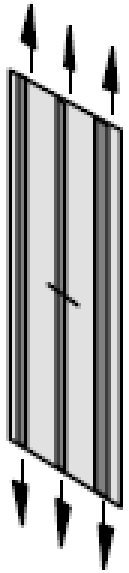
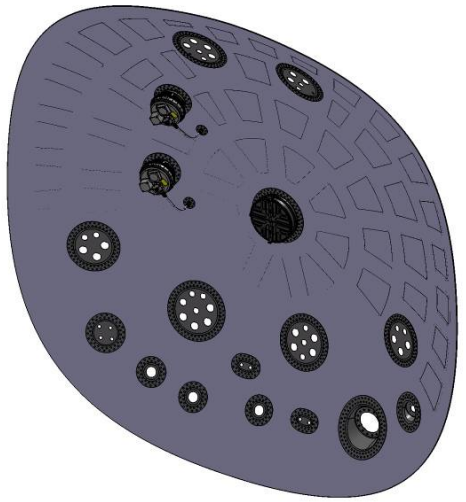
CSeries RPB: Tear Strap design

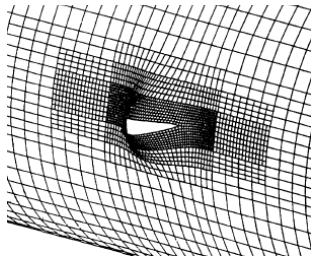
Intensive bibliography studies performed to defined preliminary and detail sizing of RPB. BA worked with NSE Composites

Level 2:
Un-configured tests
Derive Tolerance to Notch



Level 3:
Tear strap tests
Validate Methodology





Level 4:
Pressurized Bulkhead
Validate Bulging, Bi-axial loading and Curvature Effects

Test conducted with production lay-up at each stage

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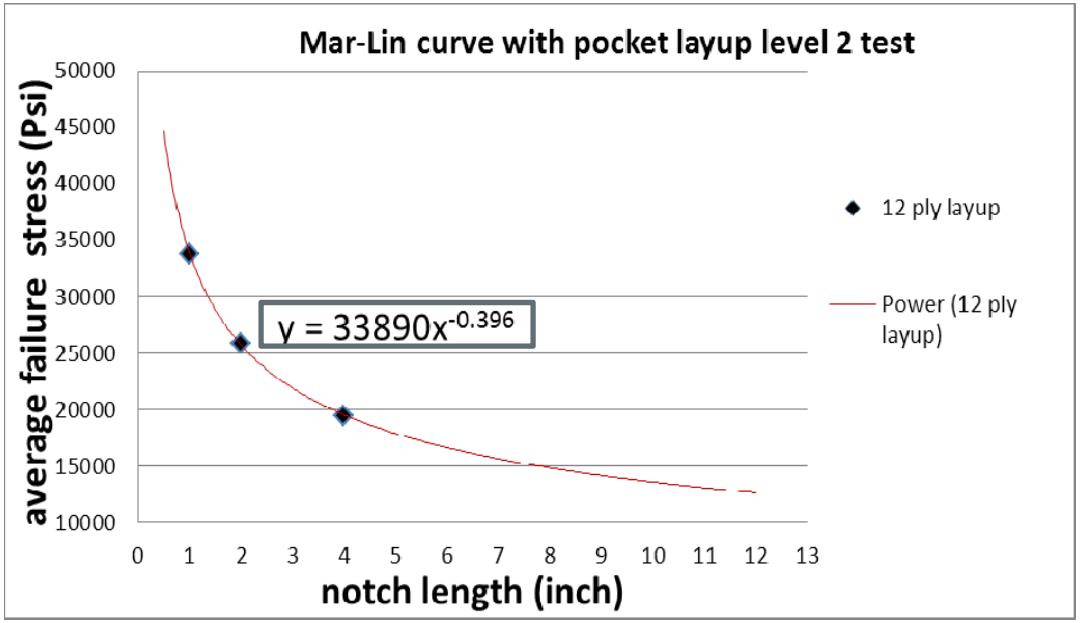
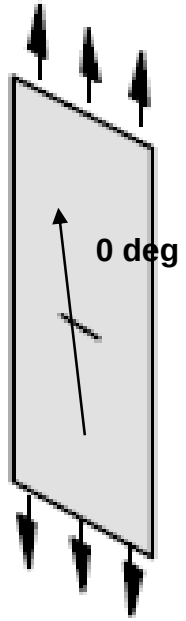
CSeries RPB: Level 2 un-configured

There is a benefit on residual strength capability with notch of using AFP process rather than hand lay-up validated with small notches (up to 4 inches)

Final production lay-up and off-axis notch / load need to be validated by tests.

Effect of overlap and gap density on notch capability is validated by tests.





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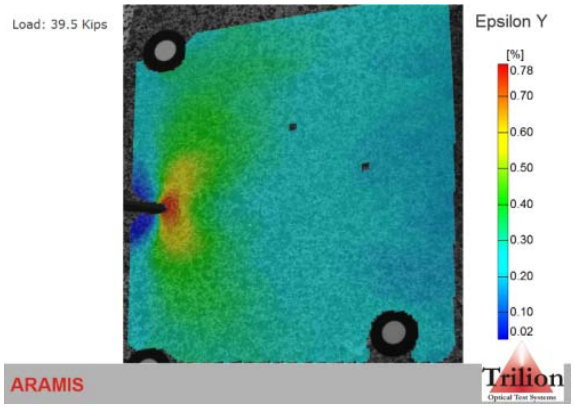
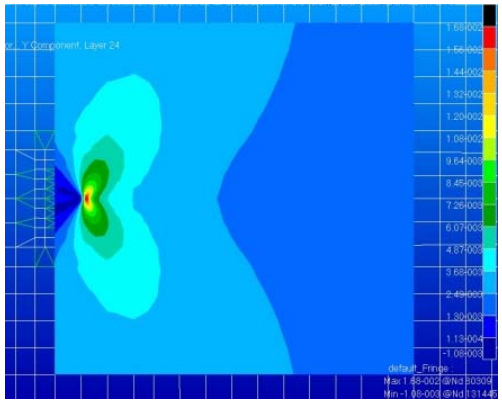
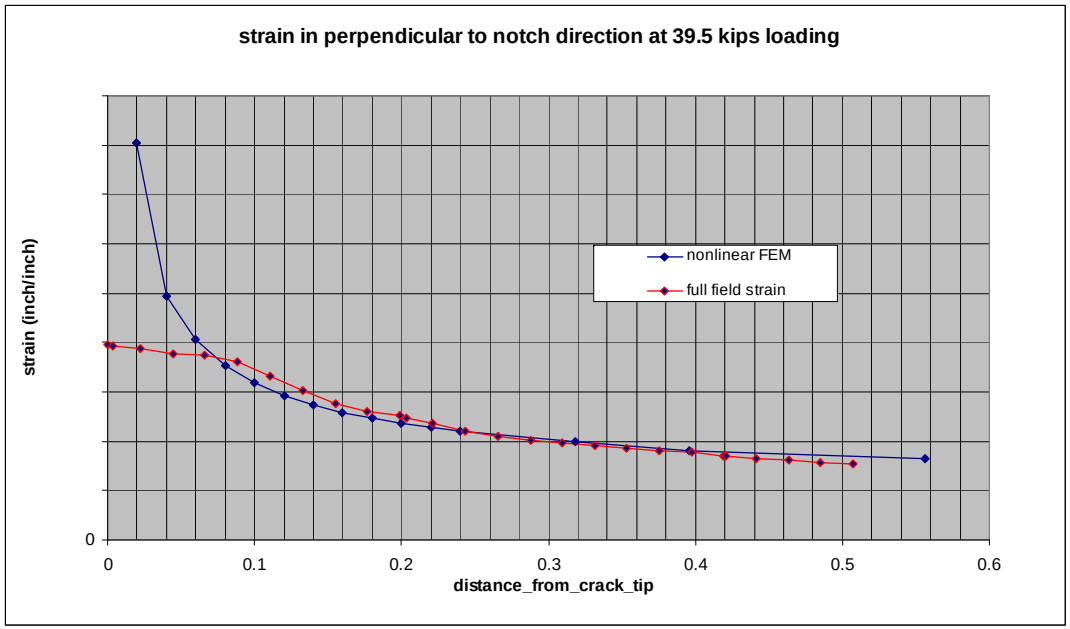
CSeries RPB: Level 3 Tear Strap Test







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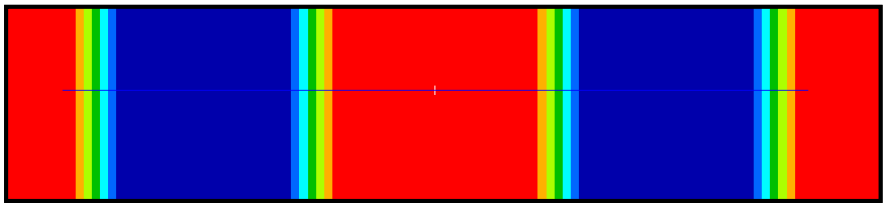
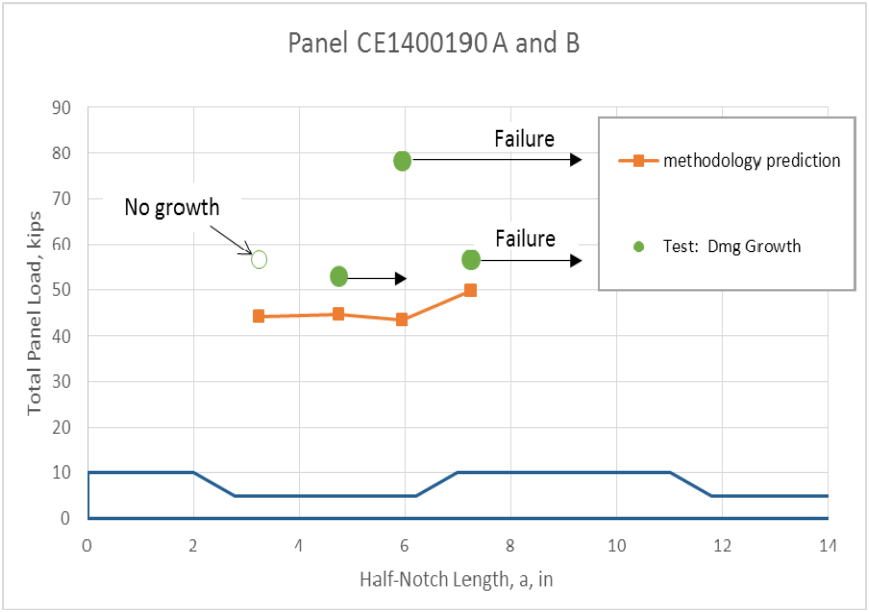
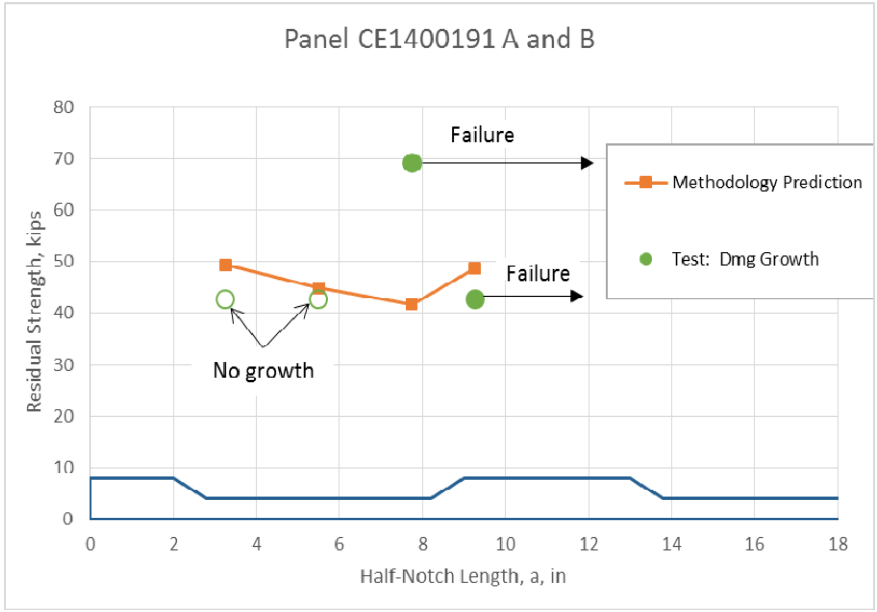
CSeries RPB: Level 3 Tear Strap Test







Methodology show conservatism but removing it on a RPB shall be done also with other design consideration including inherent robustness criteria and fire resistance.

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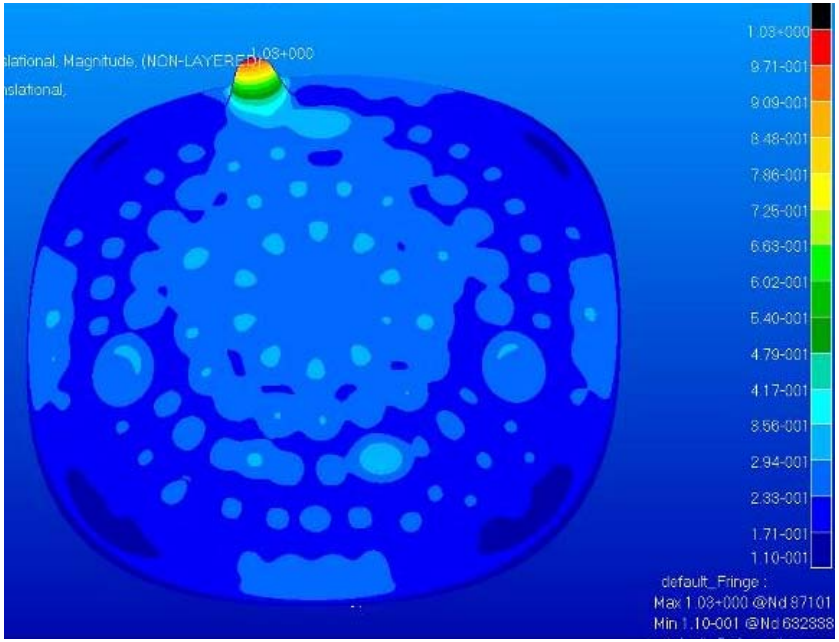
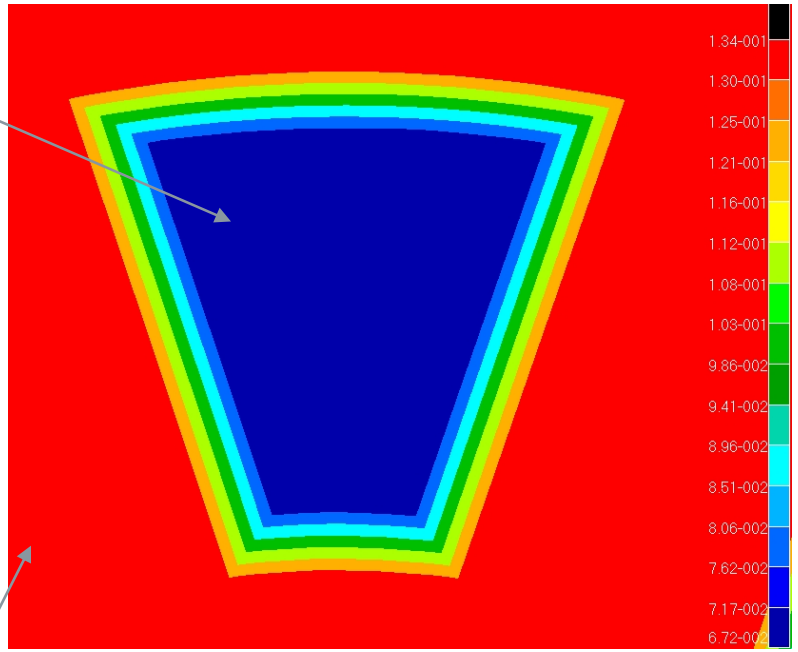
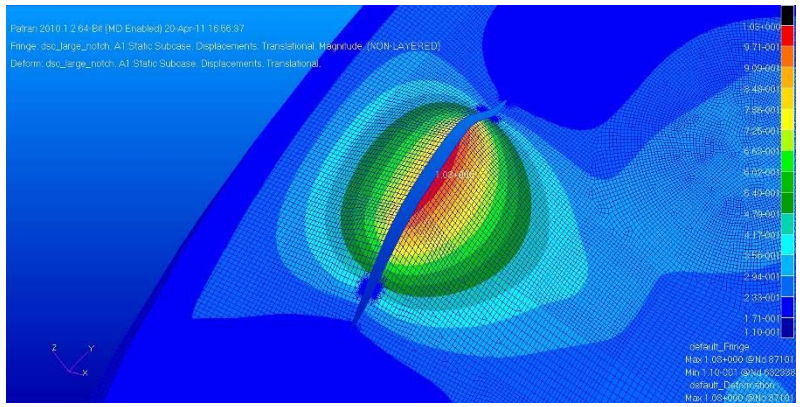
CSeries RPB: Level 4 Pressurized Bulkhead

Minimum gage





Reinforcement



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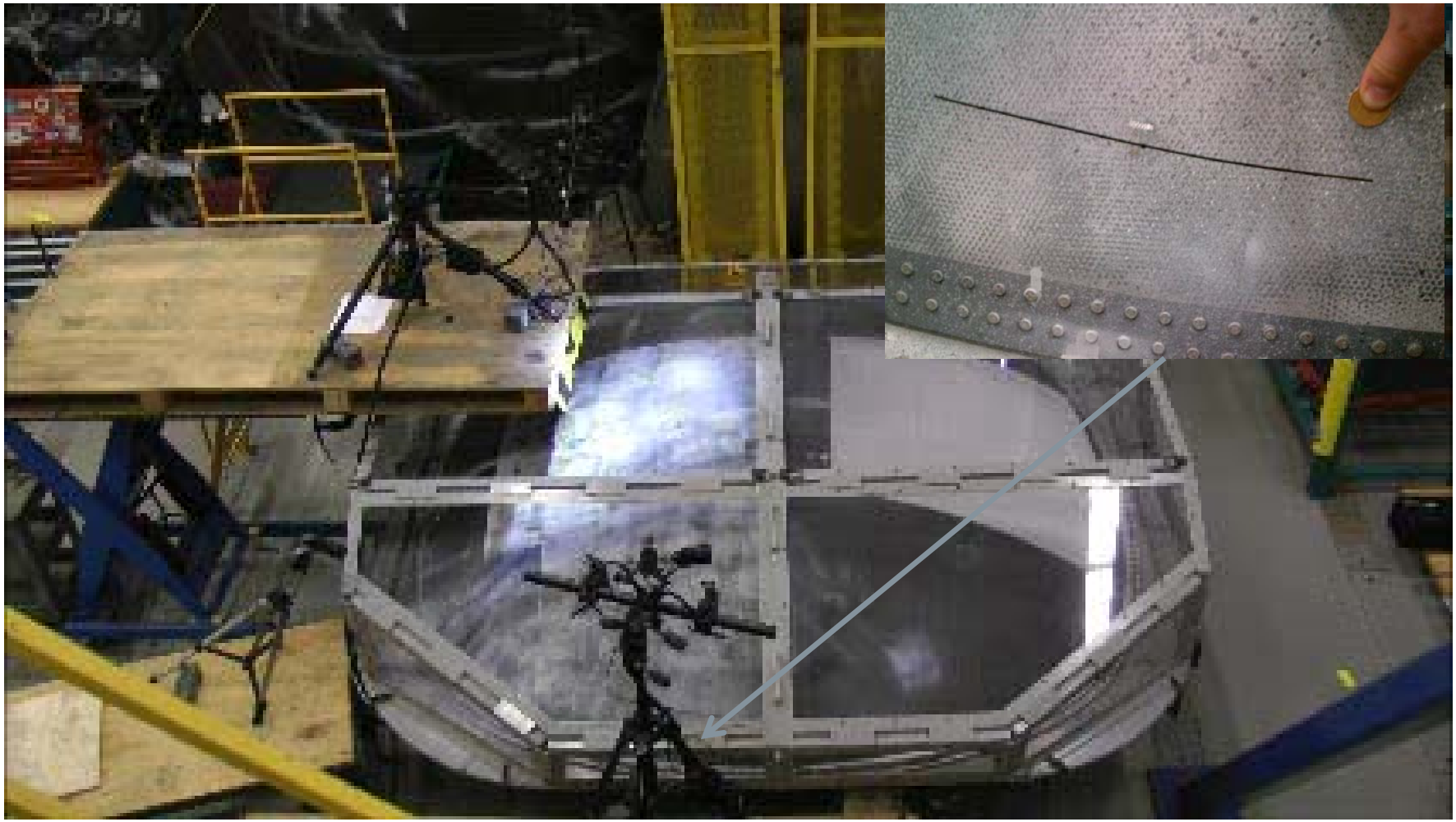
CSeries RPB: Level 4 Pressurized Bulkhead – Pre-Production



12 inch notch on the side of RPB (critical area) and in the middle

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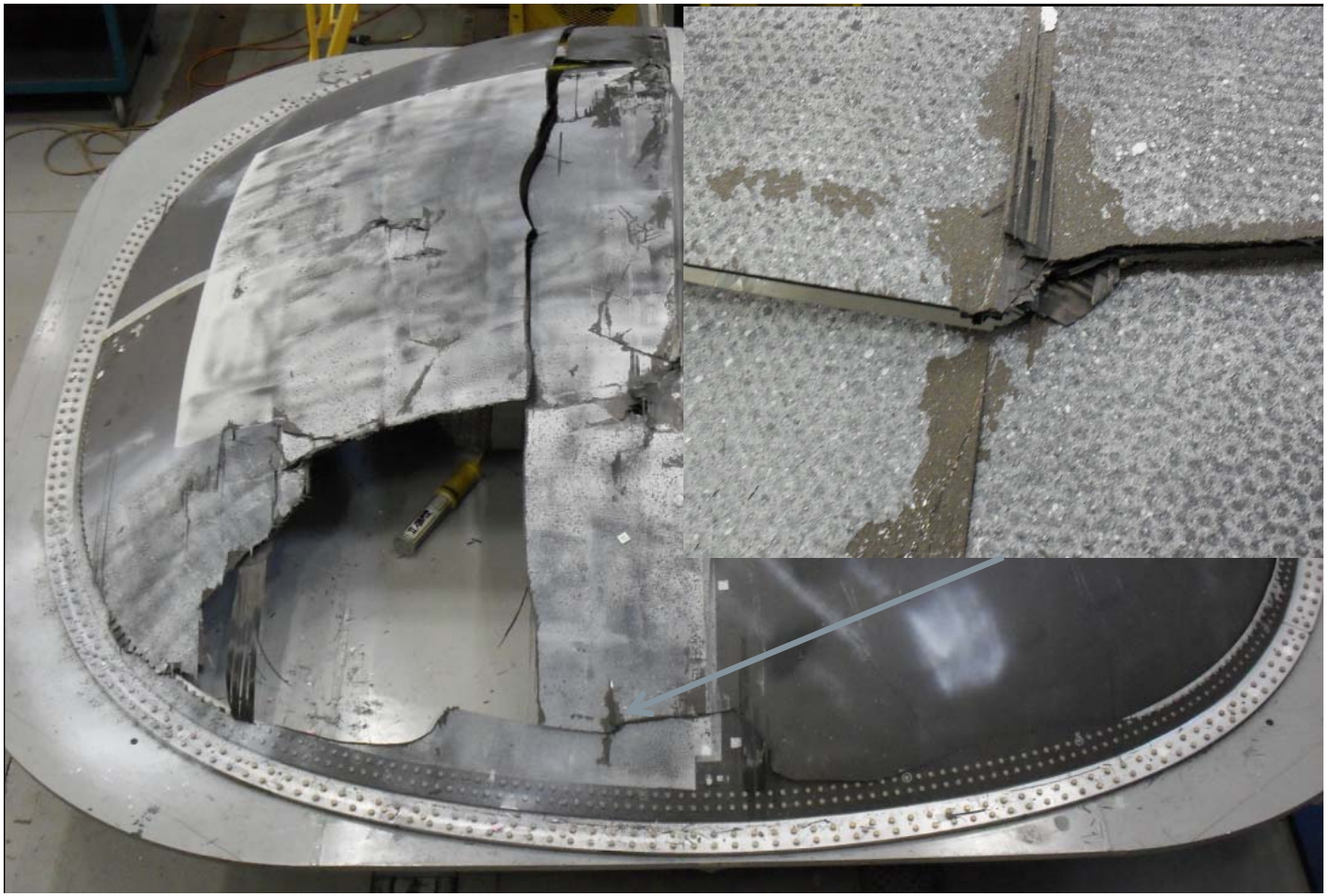
CSeries RPB: Level 4 Pressurized Bulkhead – Pre-Production Test to failure



Similar failure mode on un-configured plate

Conclusion

RPB is designed as a large damage capable structure demonstrating product robustness associated to a complex damage scenario for this critical part.

Large Damage Capability is also applied to other primary structure (skin/stringers) on Aft Fuselage

Methodology demonstrate conservative approach but interaction with other design criteria shall be considered (fire, robustness, bearing/by-pass).

Nevertheless, improving our simulation capabilities for complex failure mode like notch is future interest:

- Inter-action between stiffening ratio/lay-up and propagation
- Softening law
- Progressive Failure Analysis

Objective is to maximise simulation validated by coupons tests rather larger complex one

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