The Way to Assure Maturity of Hybrid Wing Technology

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Guidelines for Preparation of Maturity

- Materials: Select proven materials with known long-term behavior
  - Select an adhesive from a family of adhesives with excellent life cycle records
  - Select fibers with proven performance
- Design: Integrate “lessons learned” from metal bonded structures
  - Apply state-of-the-art damage tolerance design principles
  - Assure predictability of acceptable delaminations in the vicinity of cracks
- Scheduled Maintenance: Assure care-free approach
  - Base inspection programs on reliable visual inspections of external surfaces
  - Ensure that cracks will not grow *to critical size* during the design service goal
  - Select alloys and tempers to virtually eliminate corrosion
- Manufacture: Full-scale demonstrators for prove of manufacturing readiness
- Qualification/Certification:
  - Qualify materials separately
  - Verify hybrid performance through testing of structural design details

Ref: Hinrichsen, J., Airbus: The Way to Ensure Technology Maturity for New Materials; GLARE Conference, “GLARE the New Material”, Delft, The Netherlands, September 24th – 26th, 2001.

Certification Approach for A380 with Glare Introduction

Qualification: each material *separately*	Design for specific geometry/loading	Concept validation	Aircraft certification

Composites

Prepreg:

Resin
FM94

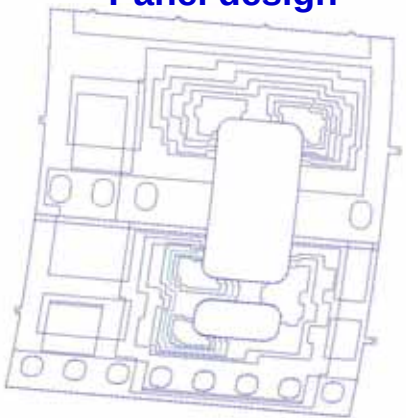
Glass-fibers
S2-glass

Metal

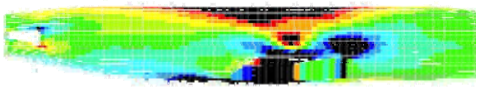
Aluminum sheet, Al2024

Initial sizing

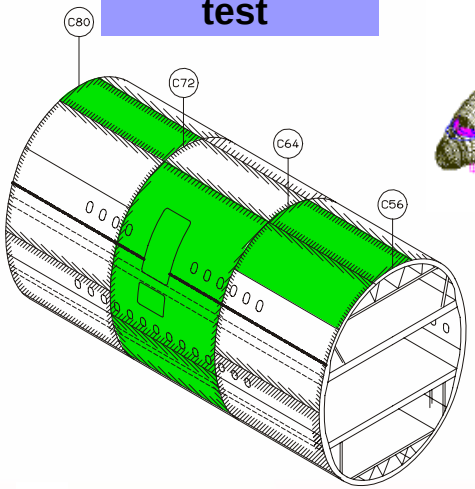
Panel design



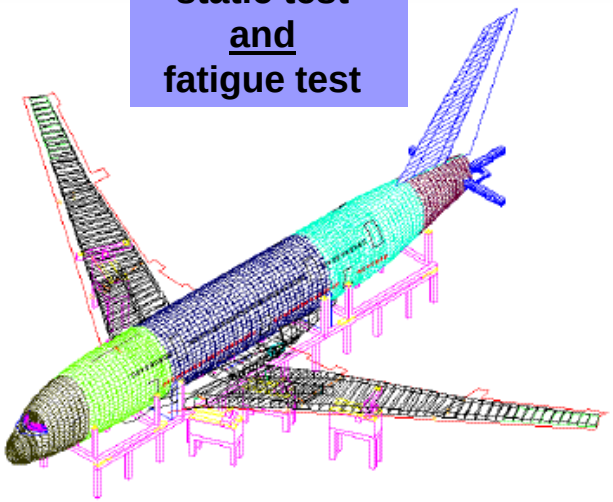
FEM & Stress



Full-scale barrel fatigue test

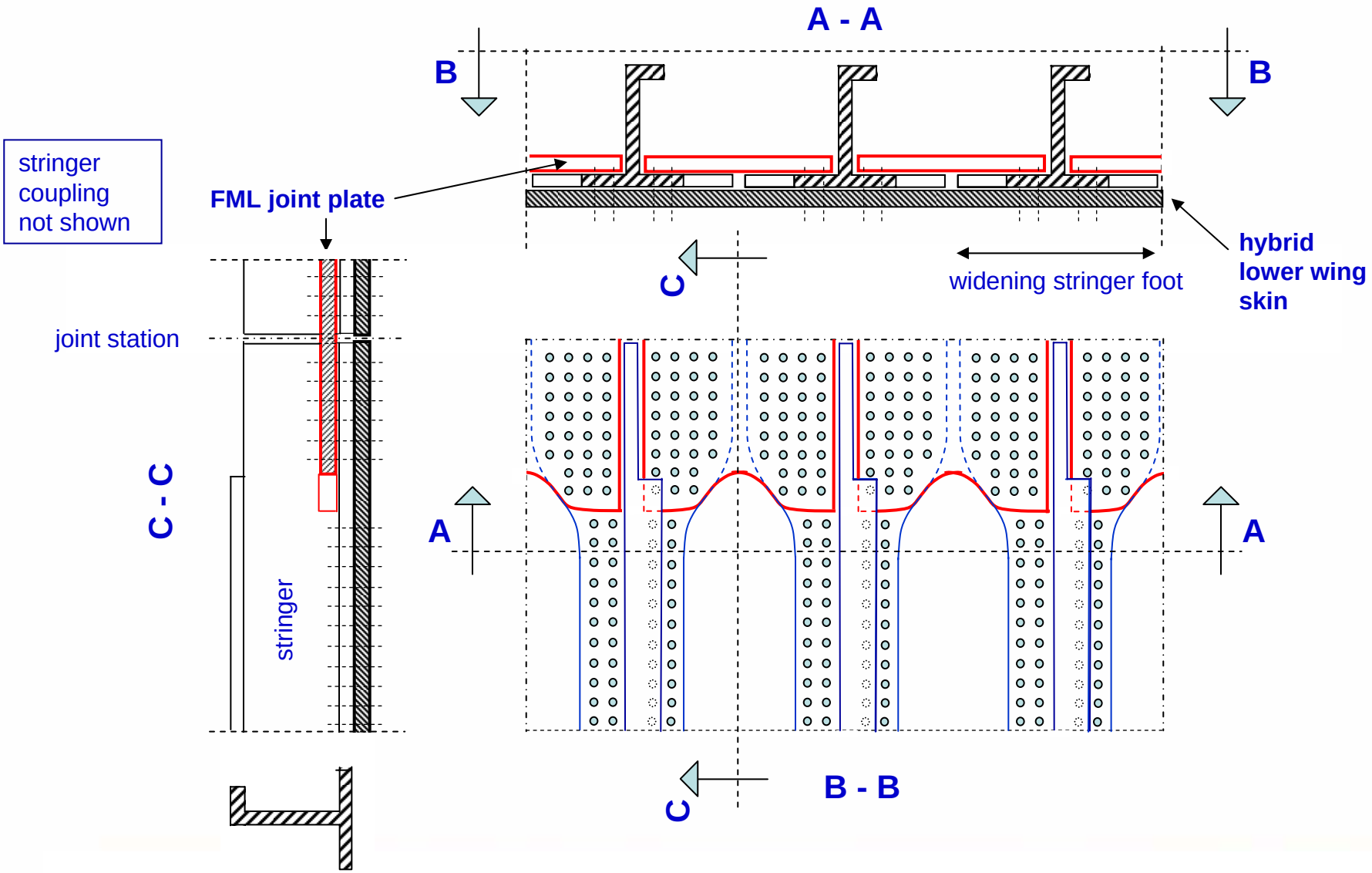


Airframe static test and fatigue test



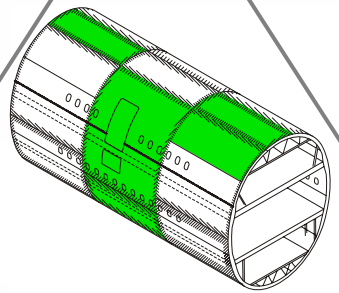
Ref: Hinrichsen, J., Airbus: The Way to Ensure Technology Maturity for New Materials; GLARE Conference, "GLARE the New Material", Delft, The Netherlands, September 24th – 26th, 2001.

An Example for Specific Design: C130 Wing Joint



Material and Design Readiness: Development Test Principles

Full-scale A/C section

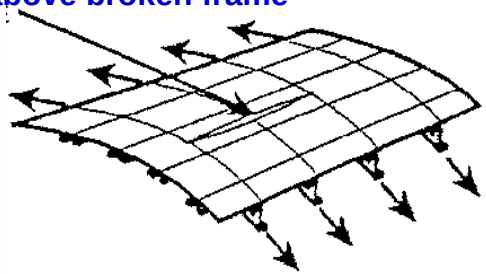


Proof of design concepts

Sub-assemblies

Sea coast exposure

Two-bay skin crack above broken frame



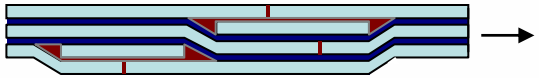
Corrosion, delamination, lightning strikes, paint stripping, Manufacturing processes, etc.

$\sigma_{\textbf{longitudinal}}$ (crack propagation)

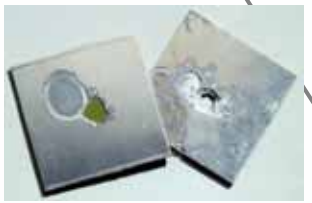
$\sigma_{\textbf{Circumferential}}$ (residual strength)

Coupons

Splice Concepts



FOD

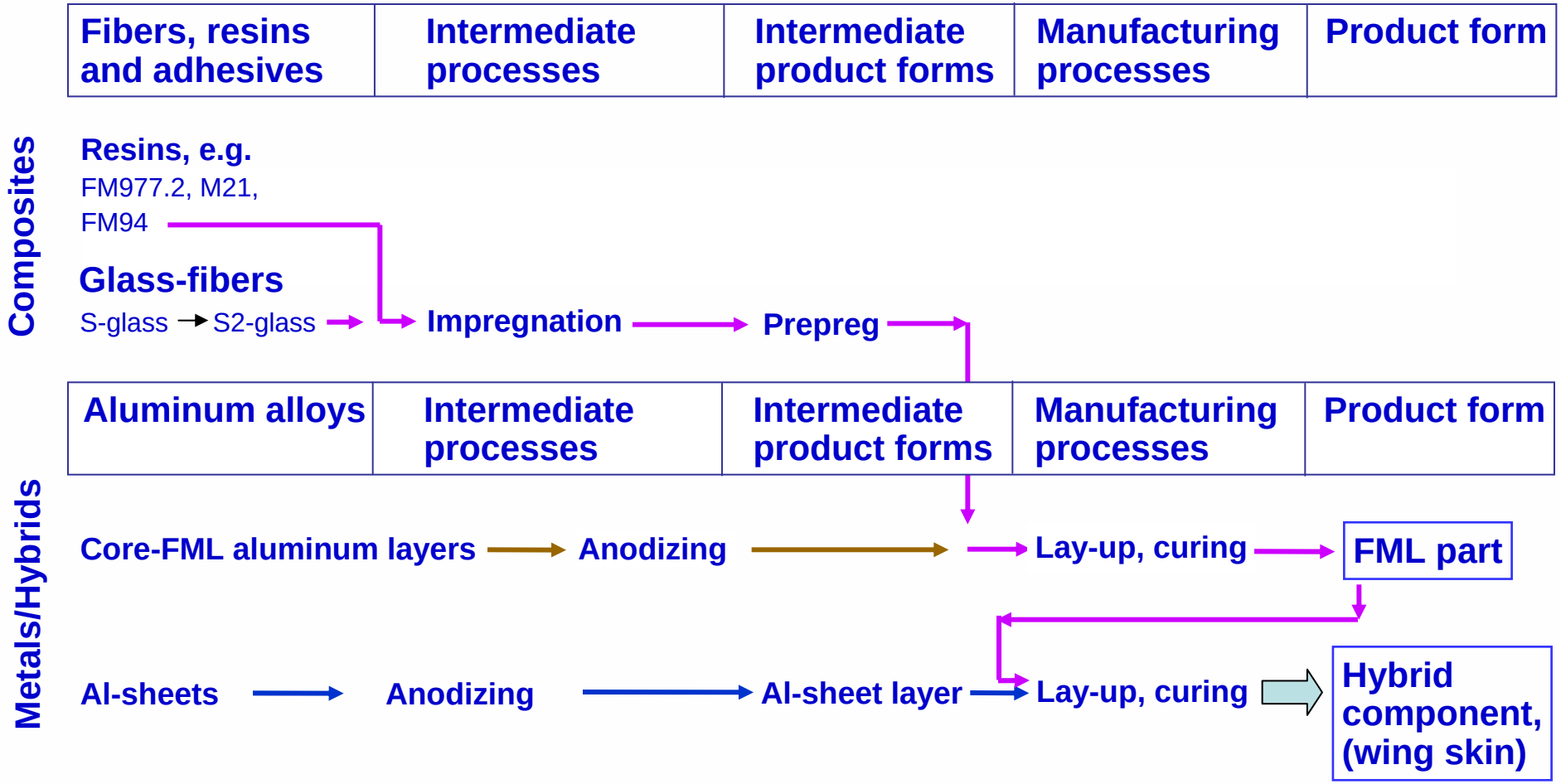


Corrosion, impacts, delaminations, moisture, temperature, etc.

$\sigma_{\textbf{ultimate}}$ $\sigma_{\textbf{yield}}$ $E_{\textbf{tension}}$

Ref: Hinrichsen, J., Airbus: The Way to Ensure Technology Maturity for New Materials; GLARE Conference, "GLARE the New Material", Delft, The Netherlands, September 24th – 26th, 2001.

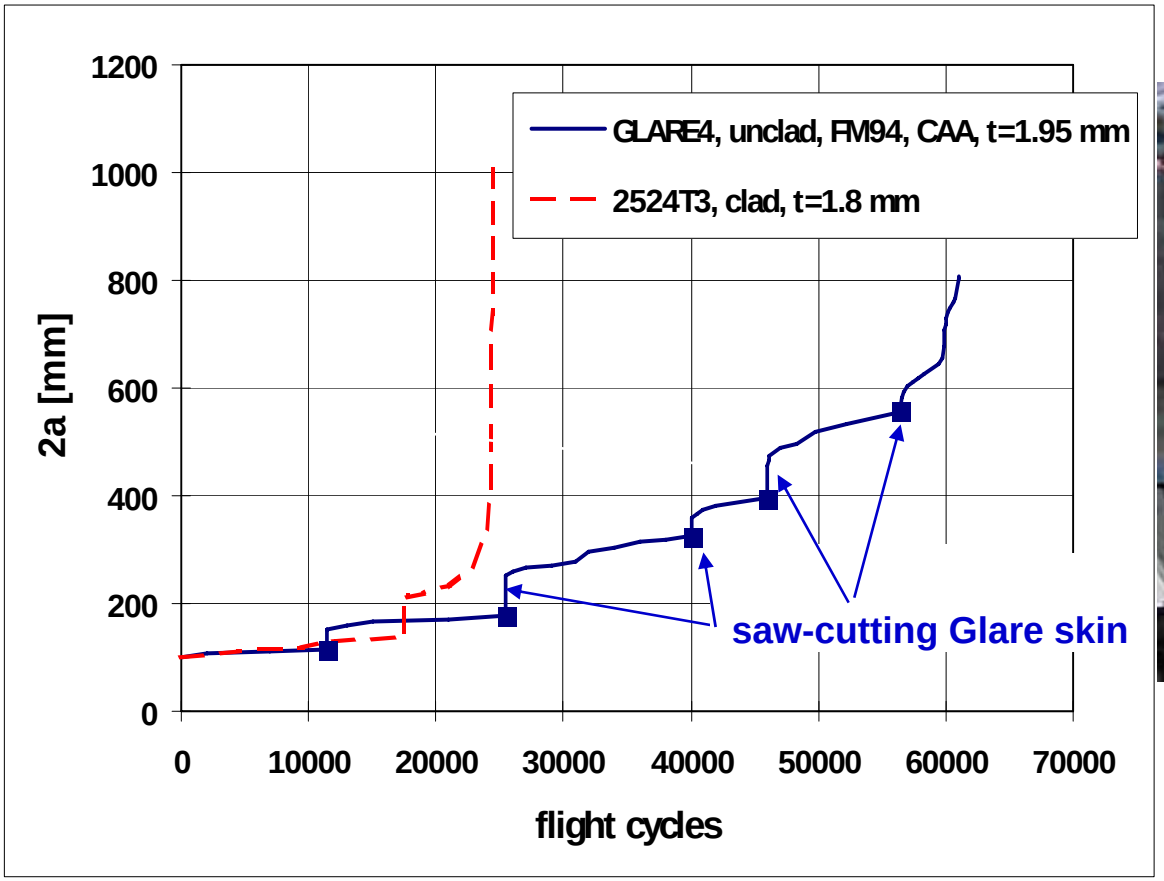
Composites and Aluminum meet for Hybrids



Critical Issues Specific to Hybrid Wing Skins

- Validate bonding technology for Al-sheet with thickness > 1mm:
  - Verify acceptable delamination zones around crack tips
- Exposure to temperature:
  - Define range of temperature in operations (e.g. sun light reflection in a desert)
  - Assure that the glass transition is well above maximum temperature
- Damage tolerance design
  - Apply state-of-the-art damage tolerance design principles
  - Assure predictability of acceptable delaminations in the vicinity of cracks
- Assure a balanced DT design:
  - Provide sufficient crack resistance for monolithic spar caps and stringers, so that these elements do not become the fatigue critical elements

Damage Tolerance Testing (full scale)



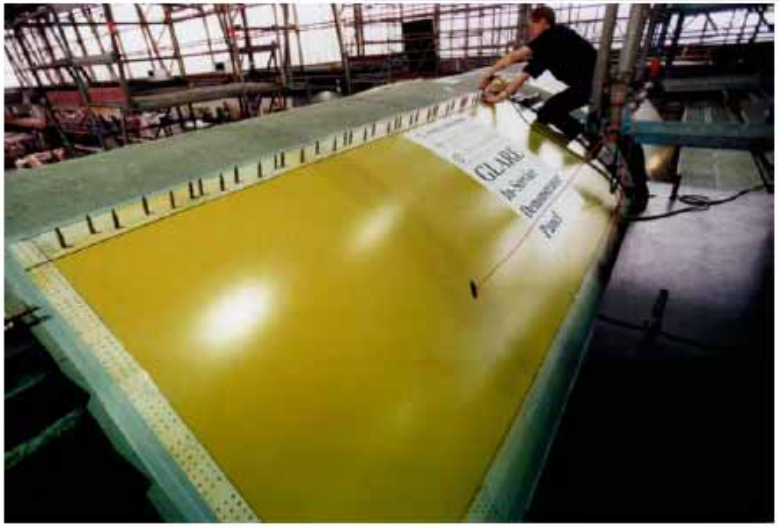
Large Fuselage Panel Tests

Through-the-thickness crack

Ref: Hinrichsen, J.: The Material Down-selection Process for A3XX; Keynote Address to the "19th European Conference on Materials for Aerospace Applications", Confederation of European Aerospace Societies (CEAS), Munich, Germany December 6th – 8th, 2000.

Thank You for Your Attention!

Glare Panel Installation on an Airbus A310 at Lufthansa



Positioning at a longitudinal joint

Fastener installation

Conclusion: Standard procedures/tools and metal-based skills on the shop floor

Ref: Hinrichsen, J.: The A380 Materials Technology Platform – Contributions from Metal Material Technologies and Processes; Keynote at NIMR Congress “Building Bridges in Metallurgy”, Netherlands Institute for Metals Research (NIMR), December 16th – 17th, 2002, De Leewenhorst, Noordwijkerhout, The Netherlands.