

Experience in Manufacturing Nomex Composites Sandwich Structures

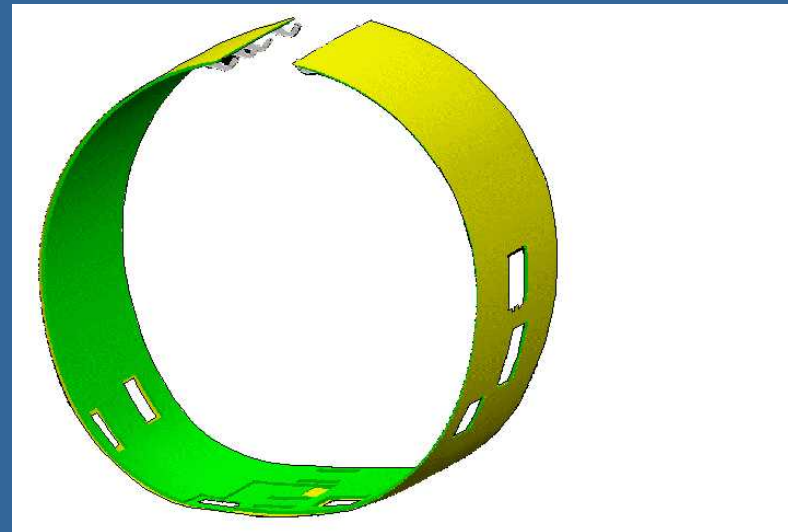
FAA Workshop on Adhesive Bonded Structures

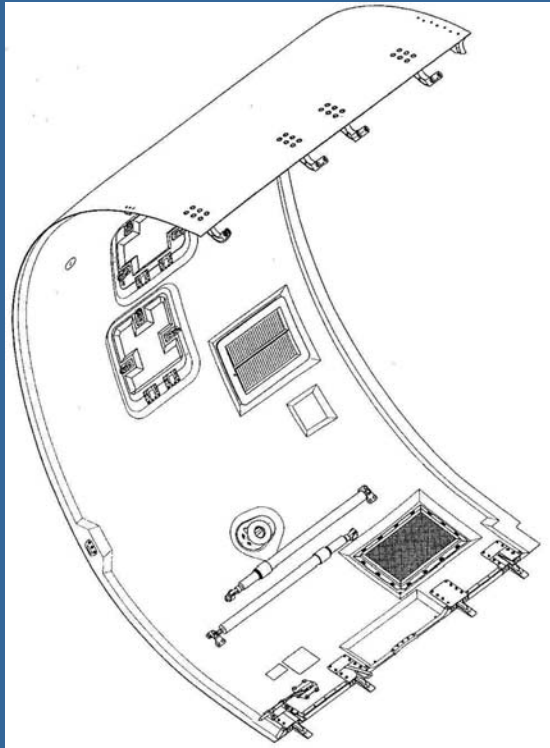
26th, 27th October 2004

UK Civil Aviation Authority, Aviation House, Gatwick Airport

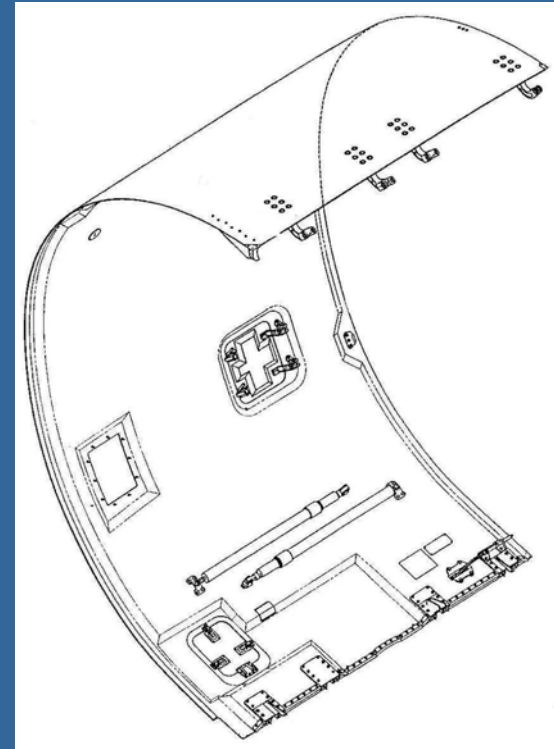


A330 Trent 700 Nacelle
Fan Cowl Door





Right Hand Fan Cowl Door

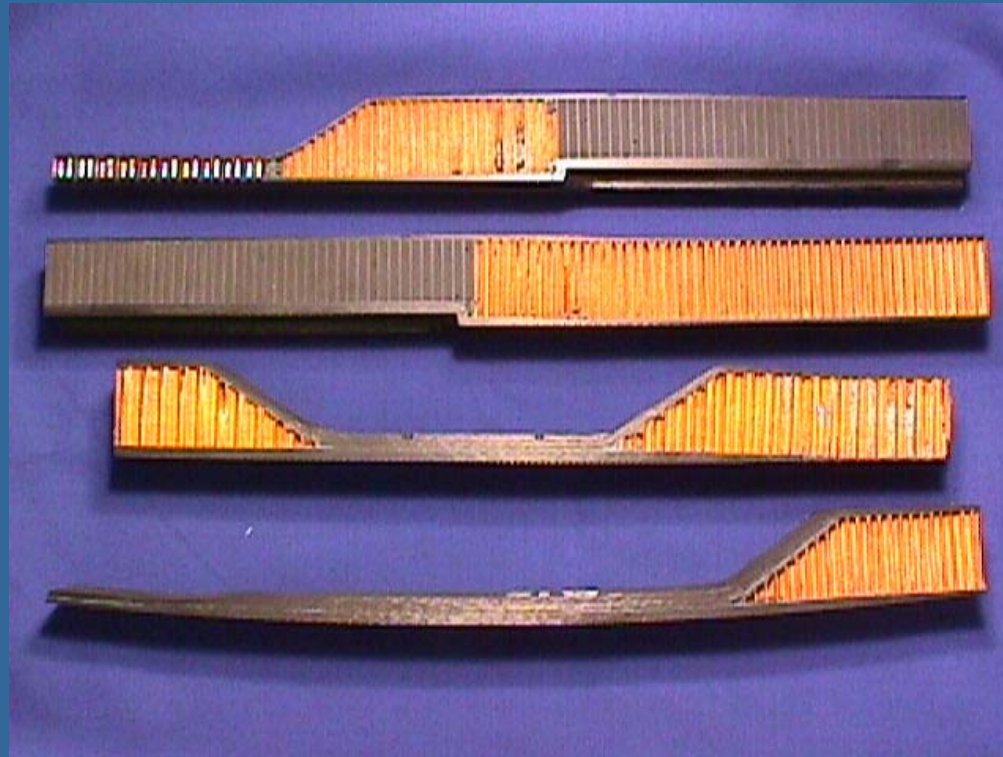


Left Hand Fan Cowl Door

Typical sandwich structure configuration

External Skin	Three Plies of Carbon Prepreg (Precured)
Film Adhesive	FM300M .03 psf
Core	HRH10- 1/8-4.0
Film Adhesive	FM300M .03 psf
Internal Skin	Two Plies of Carbon Prepreg (Secondary Stage Cured)

Typical A330 Trent 700 Fan Cowl Door Sandwich Structure Configuration



Challenges:

1. Materials Certification
2. Production Quality Control
3. Manufacturing Related Issues
4. Reparability

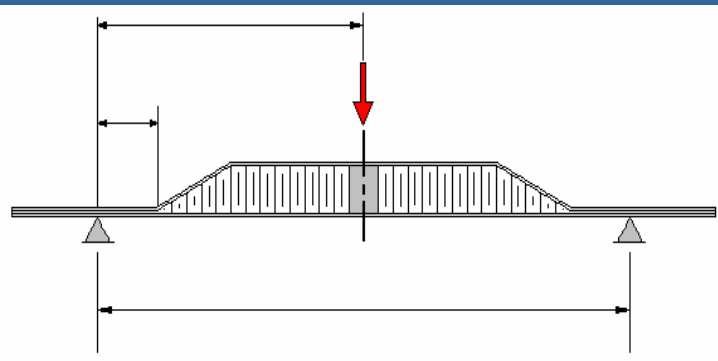
- Material certification activities have been planned since the beginning of the program due to their high time cost
- Test plans have been put in place to cover all the material configurations currently used in the A330 Trent 700 Nacelle Fan Cowl Door
- Test performed at the extreme environmental conditions experienced by the door during in-service life
- Test performed at coupon level and at structural element level
- Test details agreed with customers in advance



Generation of Material Design Allowable

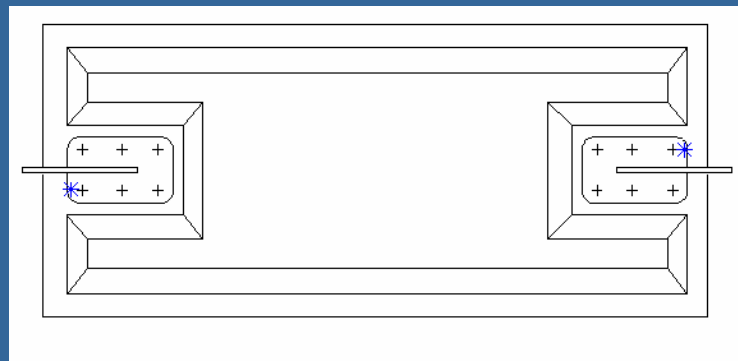
Coupon Level Tests

- Flatwise Tensile Test
- 3-Pts Bending Tests
- Climbing Drum Peel Tests
- Single Overlap Shear Tests



Structural Element Level Tests

- Residual Static Tensile Tests after Fatigue on Damaged Critical Areas of the Component (Hinge, Latch and Axial Locator Areas)
- Fire Resistance Test
- Pan-Down Region 3-Pts Bending Tests



The material certification test results have been analysed following the guidelines of MIL-HDBK-17 and multi-batch testing has been carried out to investigate key mechanical properties.

The set of material design allowables take in account a degree of damage tolerance in order to compensate for the presence of Beyond Visual Inspection Damages (BVID). This has been achieved by deriving the critical material allowable values from Open Hole (OH) specimens and impacted specimens.

Residual static strength after fatigue cycling on impacted and conditioned specimens has been used to prove the no-growth of BVID within the laminate.

- During the material certification test results analysis, the most sensitive tests have been identified with regards to the particular configuration of the structure.
- From the material certification test results a set of baseline values has been identified for purpose of production quality control.
- Procedures have been established to replicate the set of baseline test results during the production quality control process

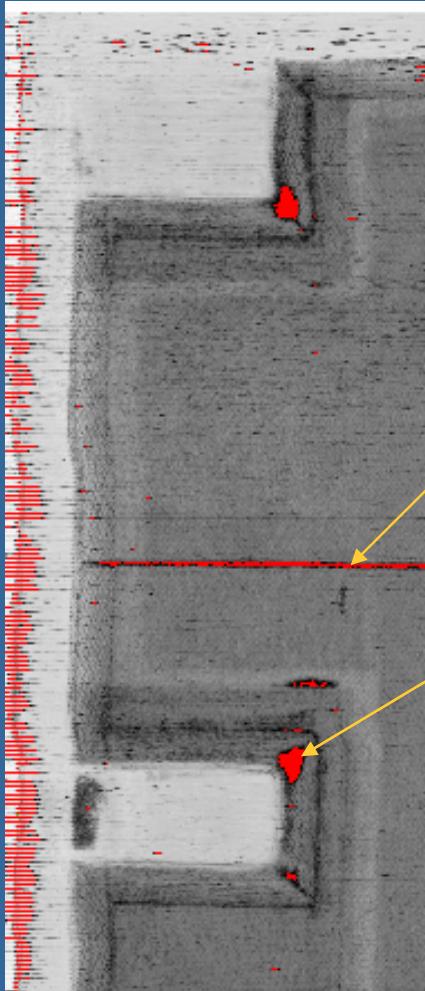


Generation of Production Quality Control Process

Production Control Tests include:

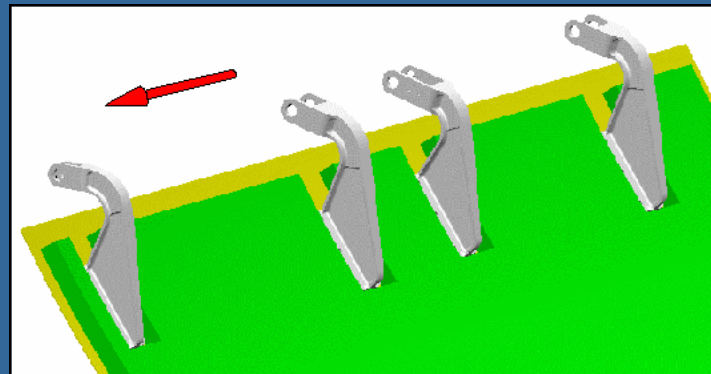
- > Fibre Volume Fraction on Monolithic Areas
- > T_G of Monolithic Areas of the Door
- > Micro-section Visual Inspection
- > Flatwise Tensile Test
- > Climbing Drum Peel Test
- > 3-Pts Bending Test
- > C-Scanning of the Entire Component

Typical Results of a C-Scan Quality Control



Line of Foaming Adhesive Joining Two Core Panels

Manufacturing Defect Due to Improper Positioning of Tooling



- Thermal survey of the set of tools, identified potential risk of over-curing some of the materials, therefore an investigation has been carried out to prove that the double cure cycle is not detrimental for all the materials involved and that their mechanical properties are not affected.
- Once the component has been manufactured for the first time (First Article Inspection) NDT and tear down tests highlighted area of potential problems due to the manufacturing technique.
- Consumable materials used during material certification cause delay in manufacturing. An investigation has been carried out to prove compatibility of consumable materials that improve the manufacturing cycle time.

- The customer is keen to have a robust product, but also one that can be easily and quickly repaired in the event of accidental damage
- Manufacturing defects repair and in-service damage repair considered
- Fly-on capability added to the component if damage is discovered in key areas
- In-the-field quick repair techniques developed alongside in-house repair techniques



Generation of Structural Repair Manual

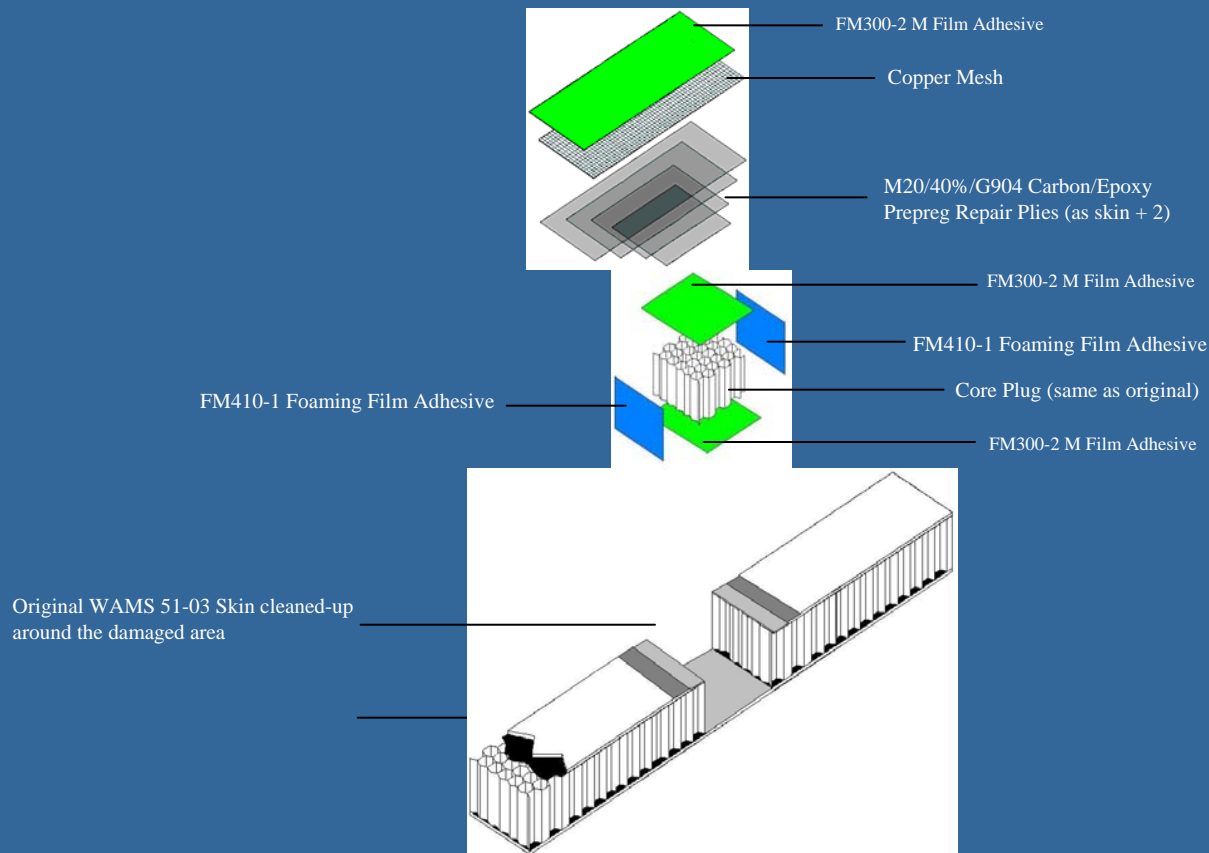
➤ The test activities related to the investigation of suitable repair techniques for the component are time consuming due to the environmental conditioning of the specimens and the presence of the simulated repair.

➤ The combination of original materials repaired with “repair material” has to be fully certified to prove material compatibility.

➤ Typical tests on repaired structure coupons are:

- 3-Points bending Tests (with repaired skin both in tension and compression, static and residual strength after fatigue)
- Single Overlap Shear Tests

Typical Repair Scheme



The overall certification of a composite bonded structure is a long and challenging task.

- Compatibility of all the different materials has to be proven in all the environmental conditions.
- Mechanical properties of the materials need to be established through extensive testing.
- Test definition needs to be part of the design loop from the very beginning in order to obtain material allowable data in time.
- First Article Qualification may still require changes in the design and/or materials.
- Previous experience on similar application play an important role in finding the best solution for all the design/manufacturing related problems