Large Scale Composite Testing at Airbus Filton Site
Outline

• Background

• Research Tests
  ‣ Butt joint with bypass loading
  ‣ Simple stiffened panel
  ‣ Shear panel
  ‣ Large stiffened panel
  ‣ Composite/metallic joint panel
  ‣ Composite/metallic joint
  ‣ Wingbox tests

• Aircraft Tests – A340-500/600 J-nose
  ‣ Structural proof
  ‣ Leading edge impact
The Airbus Family – A Complete Range of Aircraft

<table>
<thead>
<tr>
<th>Seats</th>
<th>Range (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>16000</td>
</tr>
<tr>
<td>500</td>
<td>13000</td>
</tr>
<tr>
<td>400</td>
<td>11000</td>
</tr>
<tr>
<td>300</td>
<td>9000</td>
</tr>
<tr>
<td>200</td>
<td>7000</td>
</tr>
<tr>
<td>100</td>
<td>5000</td>
</tr>
<tr>
<td>2750</td>
<td>4000</td>
</tr>
<tr>
<td>2500</td>
<td>3500</td>
</tr>
<tr>
<td>2300</td>
<td>3000</td>
</tr>
<tr>
<td>2100</td>
<td>2500</td>
</tr>
<tr>
<td>2000</td>
<td>2000</td>
</tr>
<tr>
<td>1500</td>
<td>1500</td>
</tr>
<tr>
<td>1400</td>
<td>1400</td>
</tr>
<tr>
<td>1300</td>
<td>1300</td>
</tr>
<tr>
<td>1200</td>
<td>1200</td>
</tr>
<tr>
<td>1100</td>
<td>1100</td>
</tr>
<tr>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>900</td>
<td>900</td>
</tr>
<tr>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>700</td>
<td>700</td>
</tr>
<tr>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Airbus Fleet: More than 3300 aircraft
Composite Materials in Airbus Aircraft

Progressive Introduction of Composite Materials

- **CFRP primary structures:** Fin, flaps, HTP
- **CFRP primary structure:** Fin
- **CFRP flight controls:** Spoilers, Airbrakes, Rudder
- **CFRP Spoilers:** In service trial
- **GFRP fairings**
- **CFRP primary structures:** Fin, flaps, HTP as fuel tank, rear pressure bulkhead, keel beam, centre wing box, ribs, tail cone
- **CFRP primary structures:** Fin, flaps, HTP as fuel tank
- **CFRP primary structures:** Fin, flaps, HTP as fuel tank, Rear pressure bulkhead, keel beam
- **CFRP primary structures:** Fin, flaps, HTP as fuel tank

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Aircraft Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970 - 1979</td>
<td>A300, A310-200</td>
</tr>
<tr>
<td>1972</td>
<td>A310-300, A320</td>
</tr>
<tr>
<td>1970 - 1979</td>
<td>A300-600</td>
</tr>
<tr>
<td>1980 - 1989</td>
<td>A310-300, A320</td>
</tr>
<tr>
<td>2000 - 2006</td>
<td>A319, A340-600, A380-800</td>
</tr>
</tbody>
</table>
Composites on Airbus A320 Family
Large Scale Testing

• “Large Scale” =
  ‣ Component
  ‣ Sub-component
  ‣ Detail

• Purpose
  ‣ Validate structural analysis
  ‣ Support certification

• Approach
  ‣ Test article design is specific to a particular structure/aircraft
  ‣ Consider multiple/complex load cases
  ‣ Environmental effects through Load Enhancement Factors

“Pyramid of Test” from MIL-HDBK-17
Research Tests

• Large scale testing carried out under various projects:

  ▸ TANGO (Technology Application to Near Term Business Goals and Objectives)
  ▸ CASCADE (Civil Aircraft Structural Composites – Application Development & Exploitation)
  ▸ HLIE (High Load Input Element)
  ▸ AMCAPS II (Affordable Manufacture of Composite Aircraft Primary Structure)
  ▸ Airbus internal test programmes

• Objective:

  ▸ Gather data to validate and enhance structural analysis methods and tools
Butt Joint With Bypass: Tensile Test
(TANGO Research Project)

Metallic panel

Composite panel

Metallic splice plate

Composite bypass panel

Test article in tensile load frame
Butt Joint With Bypass: Tensile Test
(TANGO Research Project)

In-plane strain (photoelastic) response of composite face (left) and metallic face (right)

After test - composite face (left); side view (right)
Simple Stiffened Panel: Compression Test
(Airbus Internal Research Project)

Test article showing anti-buckling guides
Simple Stiffened Panel: Compression Test
(Airbus Internal Research Project)

Out-of plane displacement (Moiré fringe) response of flat face showing development of buckling modes
Shear Panel: Cantilever Bend Shear Test
(TANGO Research Project)

Shear panel in cantilever bend rig – plain panel (top left) and panel with access hole (left and above)
Shear Panel: Cantilever Bend Shear Test
(TANGO Research Project)

In-plane strain (photoelastic) response of plain shear panel

Out-of-plane displacement (Shape Measurement System) response of plain shear panel
Shear Panel: Cantilever Bend Shear Test  
(TANGO Research Project)

In-plane shear strain (Image Correlation) response of panel with access hole

Out-of-plane displacement (Shape Measurement System) response of panel with access hole
Large stiffened panel – flat and stiffened faces
Large Stiffened Panel: Tensile Test
(CASCADE Research Project)

Panel ready for proof test (above) and with artificial damage and repairs (right)
Composite / Metallic Panel Joint: Compression Test
(Airbus Internal Research Project)

Front and rear views of test article in compression load frame
Composite / Metallic Panel Joint: Compression Test
(Airbus Internal Research Project)

In-plane strain (photoelastic) response of flat face (left) and stiffened face (right)
Composite / Metallic Joint: “Glyn Jones” Shear Test
(TANGO Research Project)

Steel load transfer fitting
Alignment arm

Composite
Load
Metal
Load

Joint zone
(butt joint with single splice plate)
Composite / Metallic Joint: “Glyn Jones” Shear Test
(TANGO Research Project)

Test article in loading rig
Composite / Metallic Joint: “Glyn Jones” Shear Test
(TANGO Research Project)

In-plane strain (photoelastic) response of butt joint (left) and splice plate (right)
Composite / Metallic Joint: 3 & 4 Point Bend Tests
(TANGO Research Project)

Front and back views of test article
Composite / Metallic Joint: 3 & 4 Point Bend Tests
(TANGO Research Project)

Test article in three point bending rig
Composite / Metallic Joint: 3 & 4 Point Bend Tests
(TANGO Research Project)

In-plane strain (photoelastic) response of splice plate – three point bend loading
Composite / Metallic Joint: 3 & 4 Point Bend Tests
(TANGO Research Project)

In-plane strain (photoelastic) response of splice plate – four point bend loading
Partial Wingbox: Structural Test
(High Load Input Element Research Project)

Load frame and test article design

Partial wingbox under construction
Partial Wingbox: Structural Test
(High Load Input Element Research Project)

Partial wingbox in loading jig
Partial Wingbox: Structural Test
(High Load Input Element Research Project)

In-plane strain (photoelastic) response of selected areas of upper skin (left) and lower skin (above)
Outer Wingbox: Structural Test
(TANGO Research Project)

Metallic diffusion structure and support rig design

Schematic of outer wingbox with upper cover removed

Detail of joint between outer wingbox and metallic diffusion structure
Outer Wingbox: Structural Test
(TANGO Research Project)

Assembly of outer wingbox
Outer Wingbox: Structural Test
(TANGO Research Project)

*Outer wingbox in loading frame (above) and with loading jacks attached (right)*
Aircraft Tests

• Testing carried out to support A340-500/600 J-nose design:
  ‣ Glass fibre / thermoplastic resin leading edge structure

• Objective:
  ‣ Demonstrate satisfactory structural static strength
  ‣ Demonstrate satisfactory impact response
Composite J-Nose Tests
(A340-500/600)

“J-nose” is fixed leading edge structure.

J-nose structure for A340-600
Composite J-Nose: Structural Test
(A340-500/600)

J-nose structural test
Composite J-Nose: Impact Test
(A340-500/600)

First upper panel test

Second upper panel test

1.81 Kg Bird at 313 knots (161 m/s) TAS
Direction of Flight

With Slat 1 Deployed at 23° - Upper Panel Impact
Conclusions

• A selection of large scale composite tests carried out at Airbus Filton site have been presented, including
  ‣ Research tests from TANGO, CASCADE, HLIE and AMCAPS II
  ‣ A340-500/600 leading edge structure

• Structural tests are carried out to the highest possible standards using state of the art instrumentation and data acquisition techniques

• Research and certification testing is on track to support aircraft projects

• Future work includes
  ‣ Further testing on the TANGO wingbox including fatigue, repair etc.
  ‣ ALCAS main landing gear support structure, pylon and supporting tests
Acknowledgements

• TANGO is funded by the participants and the European Union under the GROWTH RTD programme

• AMCAPS II, CASCADE and HLIE were funded by the participants and the UK Department of Trade and Industry under CARAD (Civil Aircraft Research And Demonstration)
This document and all information contained herein is the sole property of AIRBUS UK LTD. No intellectual property rights are granted by the delivery of this document or the disclosure of its content. This document shall not be reproduced or disclosed to a third party without the express written consent of AIRBUS UK LTD. This document and its content shall not be used for any purpose other than that for which it is supplied.

The statements made herein do not constitute an offer. They are based on the mentioned assumptions and are expressed in good faith. Where the supporting grounds for these statements are not shown, AIRBUS UK LTD will be pleased to explain the basis thereof.