IAI ENGINEERING DIVISION
Commercial Aircraft Group
ISRAEL AEROSPACE INDUSTRIES LTD

SUBSTANTIATIONS OF AN AIRBORNE COMPOSITE RADOME MOUNTED ON AN AIRCRAFT DOME

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Israel Aerospace Industries

Substantiations of an Airborne Composite Radome Mounted on an Aircraft Dome

OUTLINE

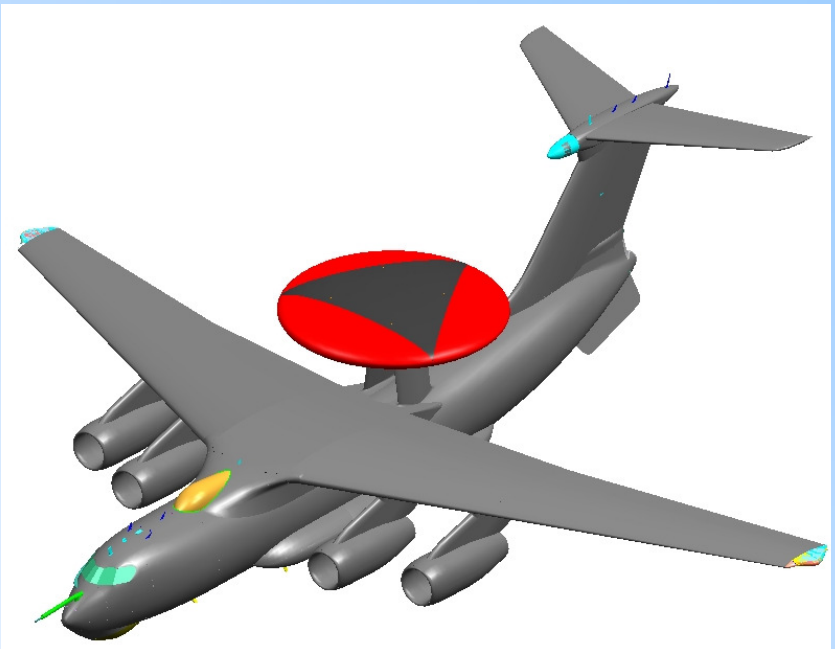
- Radome Design
- Radome Production
- Substantiation Method
  - Analysis
  - Elements Tests
  - Full Scale Static Test
- Summary

Radome trimming and inspection hangar

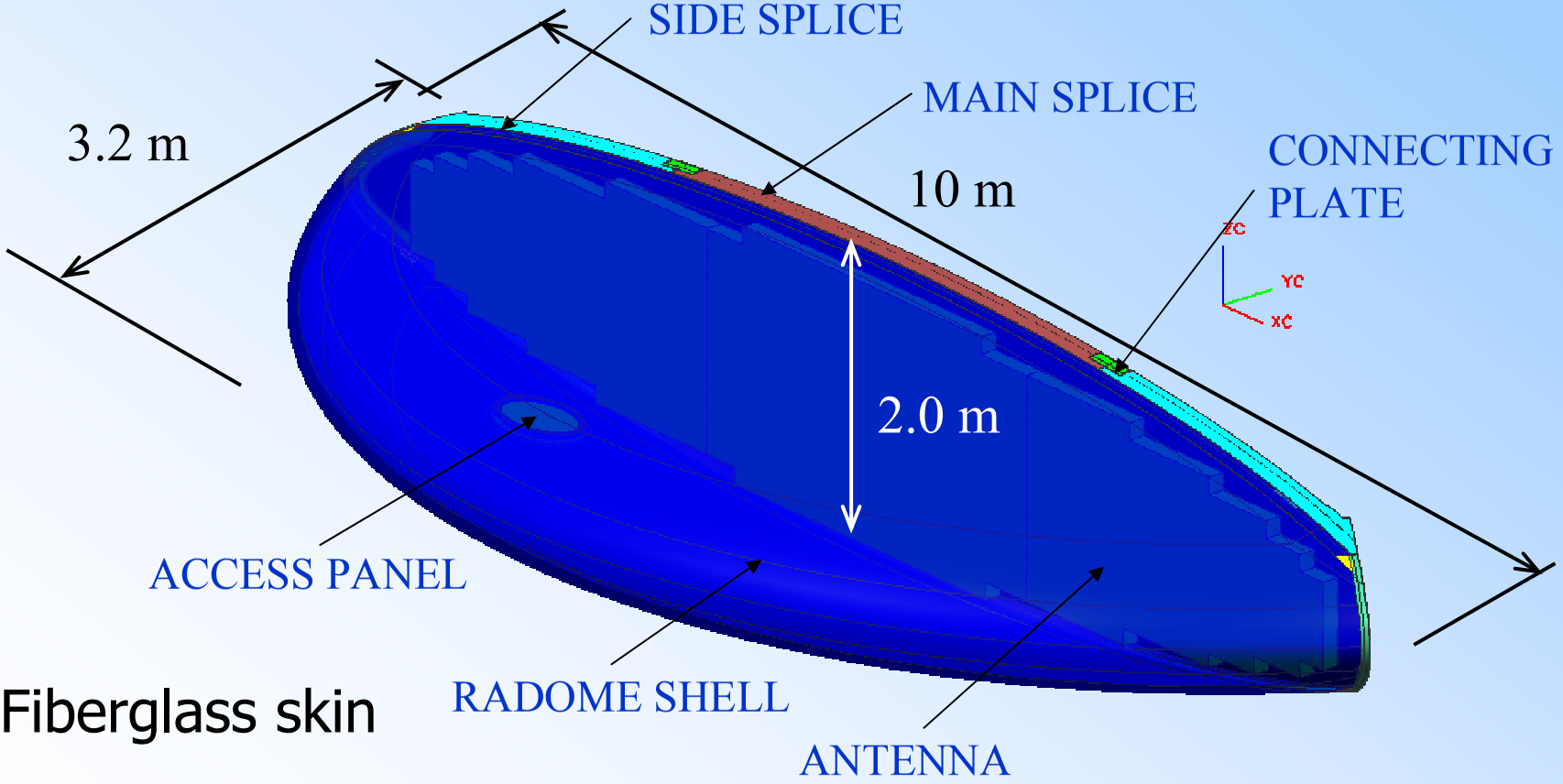
Design Concept

Each Radome was designed as a single, integral piece, thus ensuring:

- Minimal weight – no splicing, no rivets, etc…
- Optimal Electrical performance
- Reduction in No. of parts
- Elimination of assembly problems due to parts manufacturing tolerances
- Reduction in labor & assembly costs



Radome Design



- Fiberglass skin
- Honeycomb core

Structural Design Criteria

- Electrical requirements
- Minimal weight
- Environmental conditions: -55°C to 70°C/wet
- Damage tolerance
- Lightning strike protection
- Interchangeability

Radome Manufacturing

- Radome manufactured on a steel lay-up tool
- Challenge in ensuring: final geometry, uniform temperature distribution during curing process
- Automation in ply cutting, lay up using laser projector
- Honeycomb core formed & NC machined

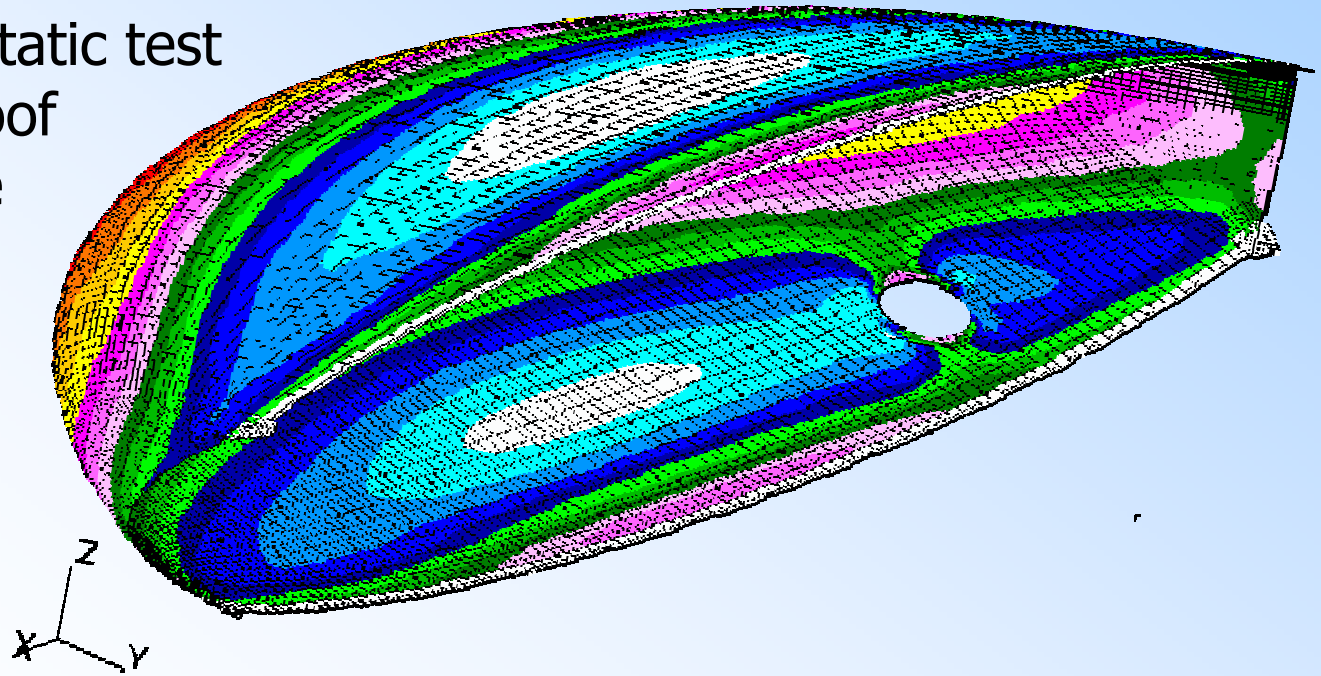
Radome lay-up tool in the clean room

Automated Inspection by Special "C" Scan Ultrasonic Machine

- Software developed at IAI for analysis of C-Scan data

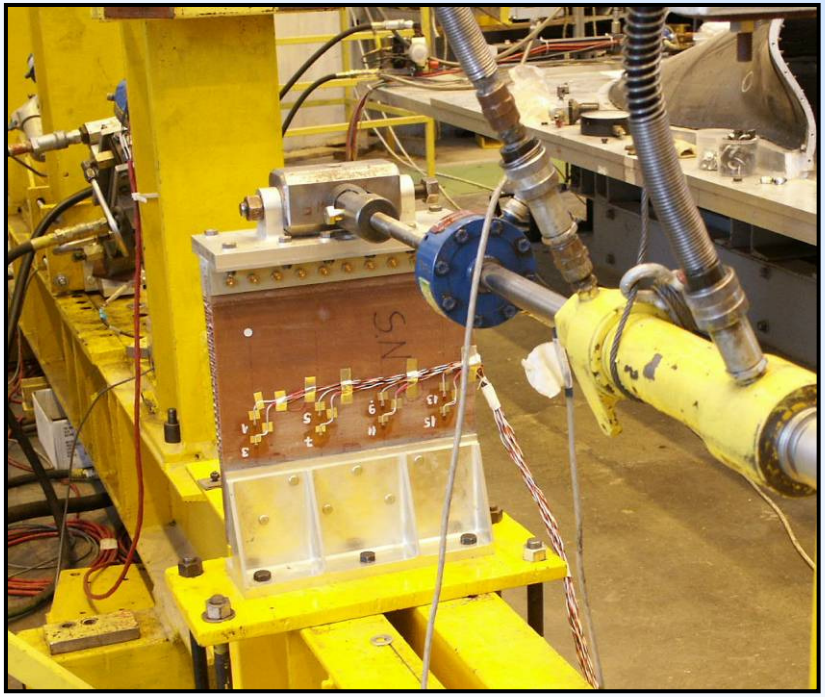
Substantiation Method

- Finite Element (FE) & detail stress analysis
- Building block approach:
  - Coupon tests for mechanical properties
  - Element tests for critical design details
  - Full-scale static test for final proof of structure

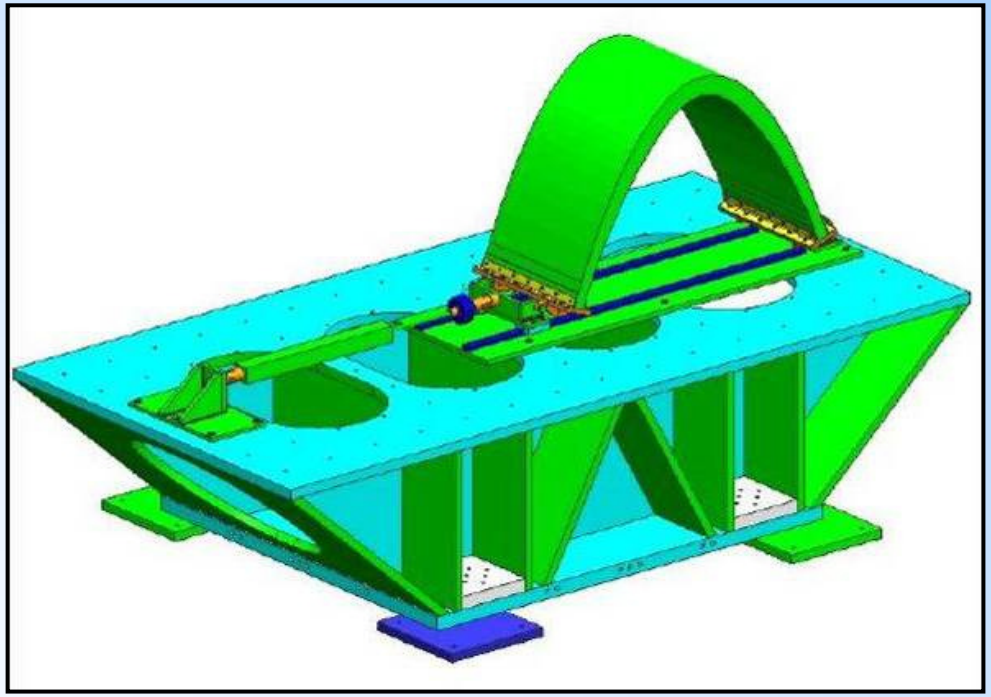


Element Tests

- Leading edge typical structure
- Edge specimen (for tension and bending tests)



Edge Specimen

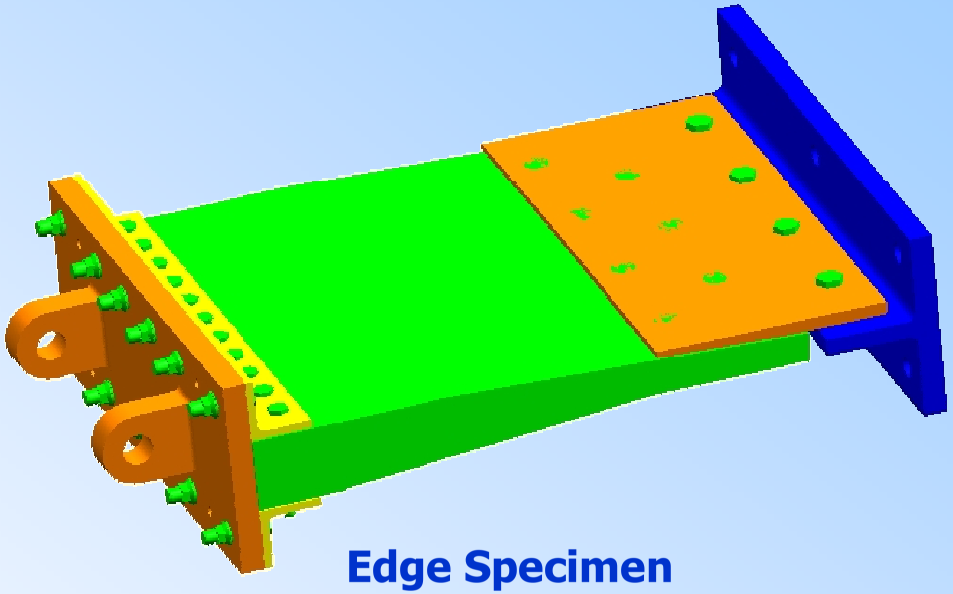


Leading Edge Test Specimen

Element Tests

Edge specimens - Tension Test

- Two static tests
  - Environmental knock-Up factor on loads
  - Embedded defects
- Loaded up to 220% ULT. **No failure**, test stopped



Edge Specimen
Tension Test

Element Tests

Edge Specimens - Bending Test

- Two static tests:
  - Environmental knock-Up factor on load
  - Loaded up to 260% ULT.
- Two fatigue tests
  - Environmental aging
  - Embedded defects
  - 20 lifetimes
  - Residual strength test up to 170% ULT at RTD, **No failure**, test stopped

Edge Specimen Bending Test

Element Tests

Leading Edge Specimen

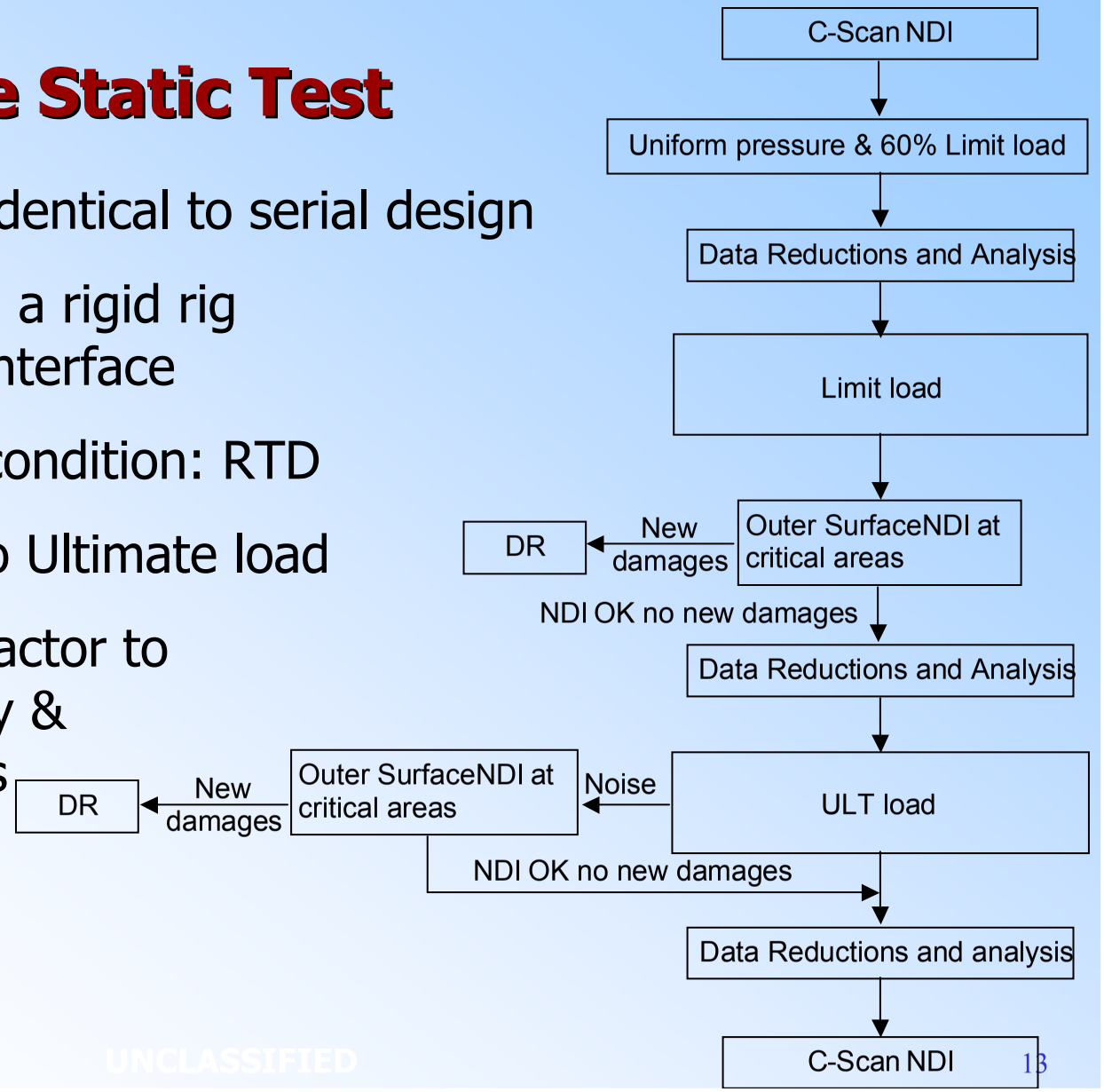
- Two static tests:
  - Environmental knock-Up factor on load
  - Loaded up to 440% ULT. **No failure**
- Two fatigue tests
  - Environmental aging
  - Embedded defects
  - 20 lifetimes
  - Residual strength test up to 170% ULT at RTD
    No failure, test stopped

Leading Edge Test

AEW Radome Design & Substantiation

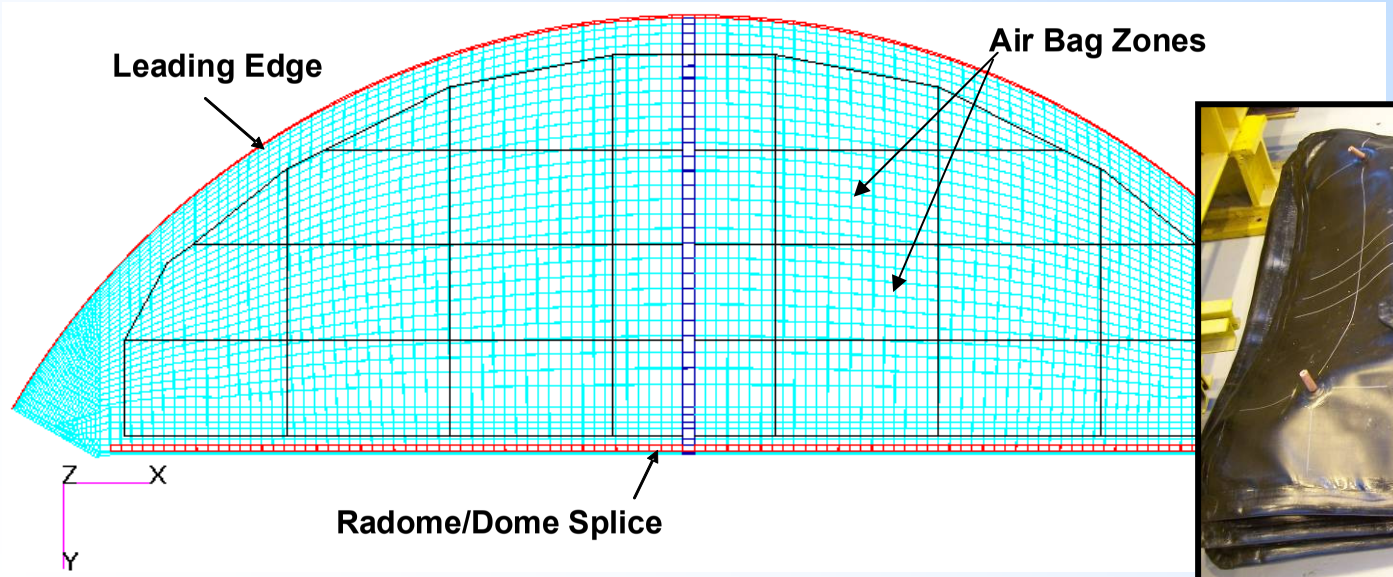
Full Scale Static Test

- Radome test article identical to serial design
- Radome mounted on a rigid rig representing Dome interface
- Test environmental condition: RTD
- Test performed up to Ultimate load
- Load enhancement factor to account for variability & environmental effects

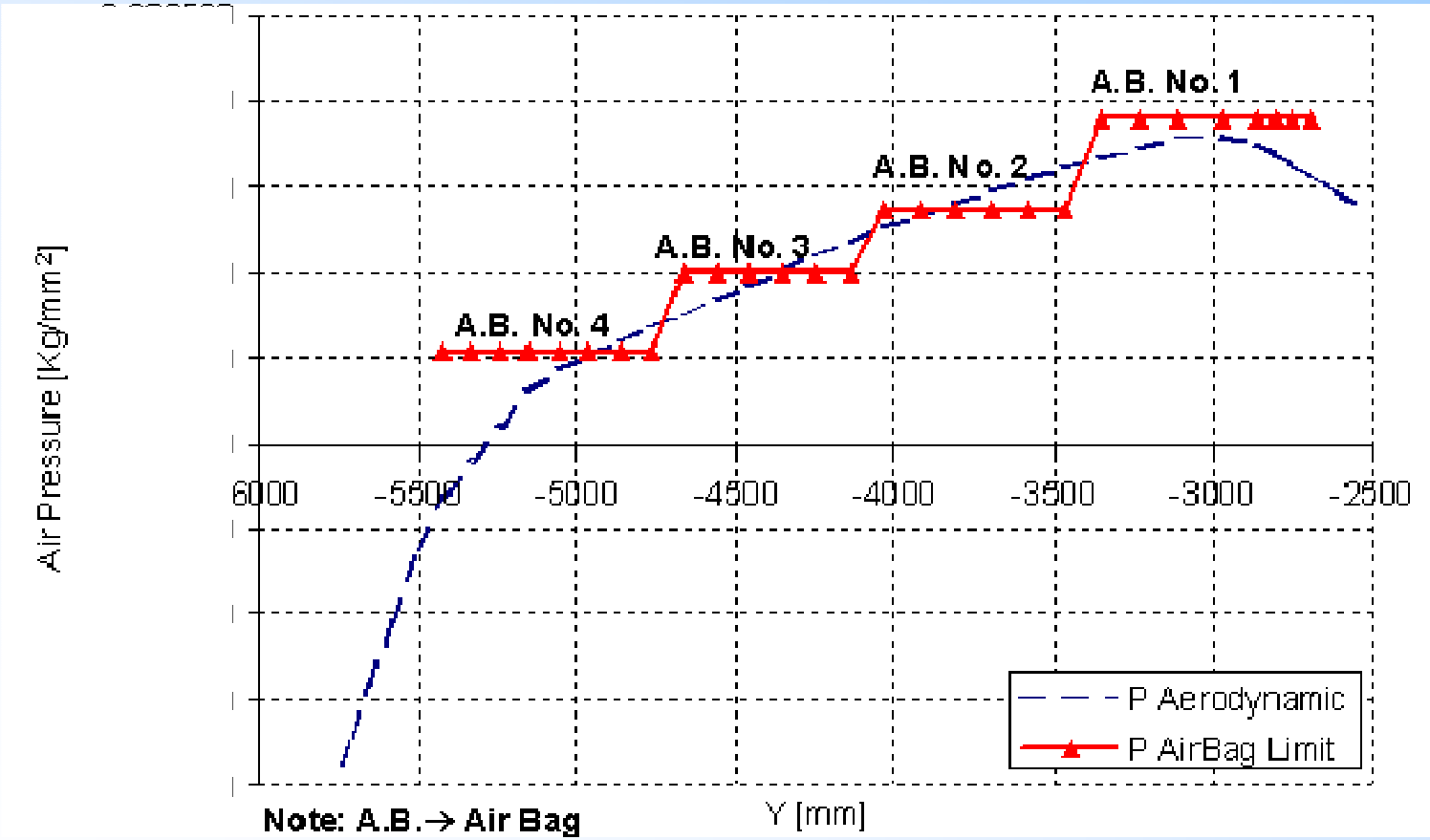


Full Scale Static Test Concept

- The Radome surface was divided into 52 cells
- Average aerodynamic pressure for each cell was calculated
- Internal pressure, on each cell, was applied by air-bags in order to simulate the actual air load distribution



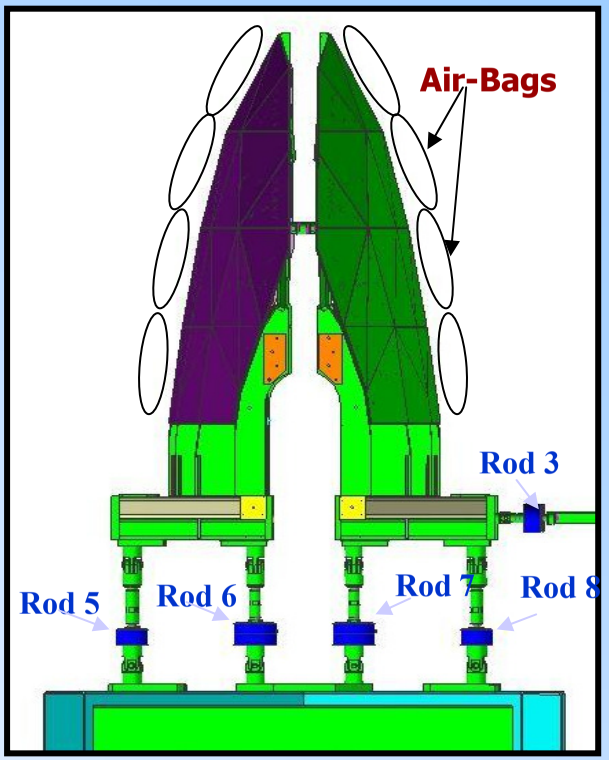
Comparison Between Air-Bags Pressure and Aerodynamic Loading

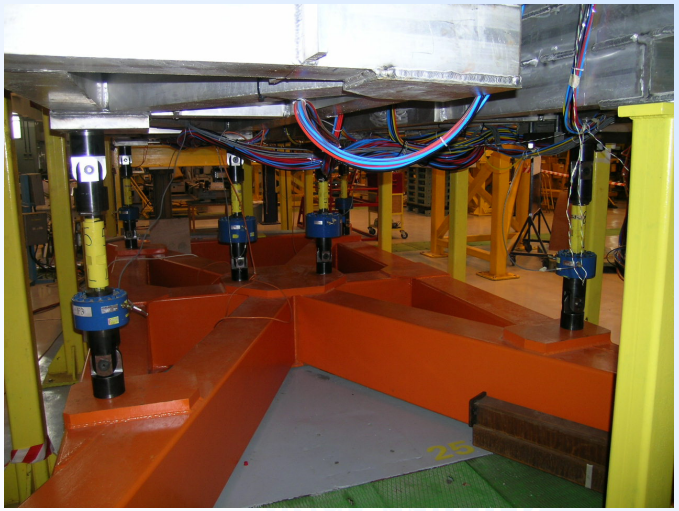


Full Scale Static Test Concept

Air-Bags Supporting Rig

- Each air-bag pressure is controlled separately
- Left Hand Side & Right Hand Side rig reactions measured separately, to allow pressure adjustment on each surface.
- 241 strain & 14 displacement channels.

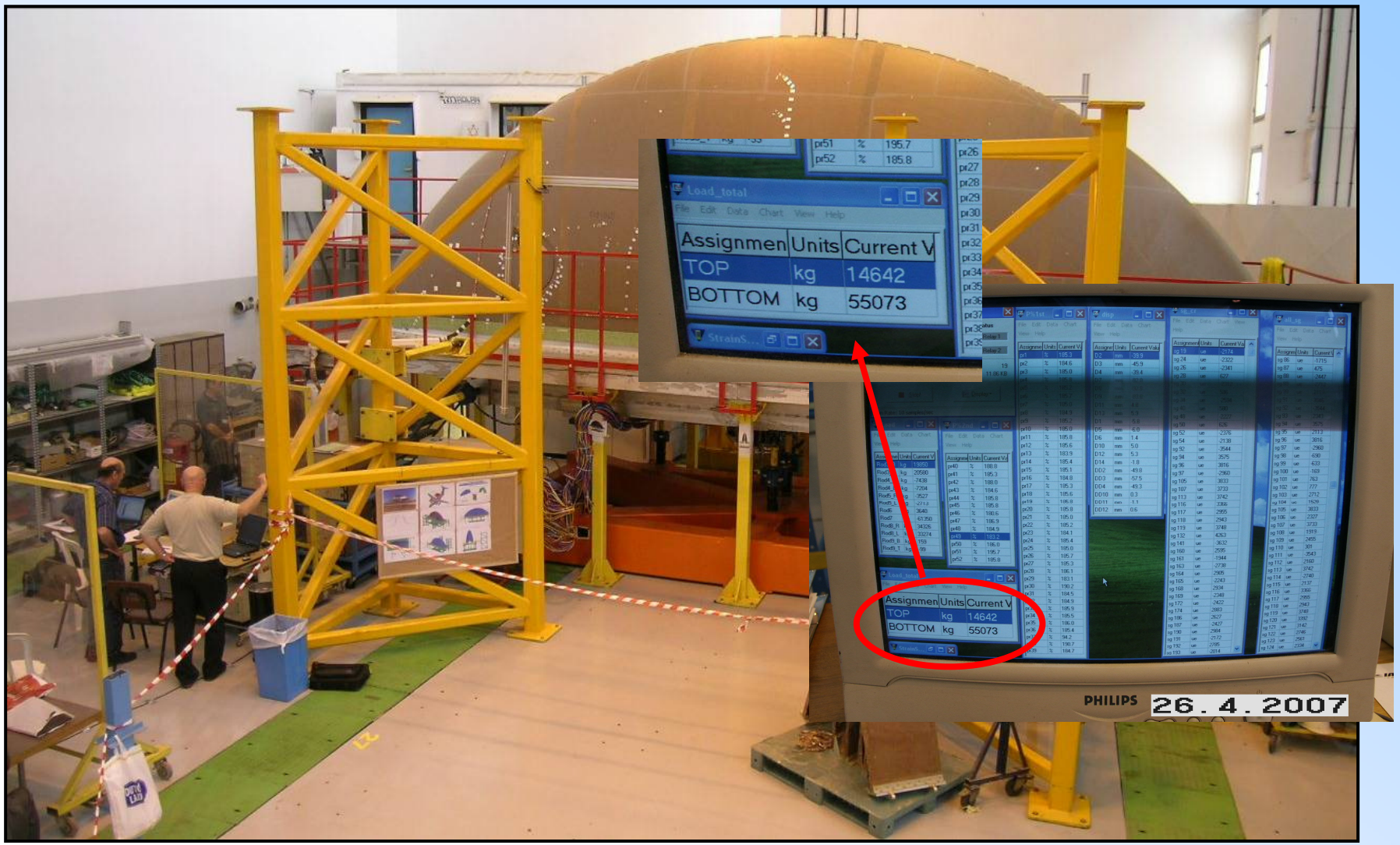




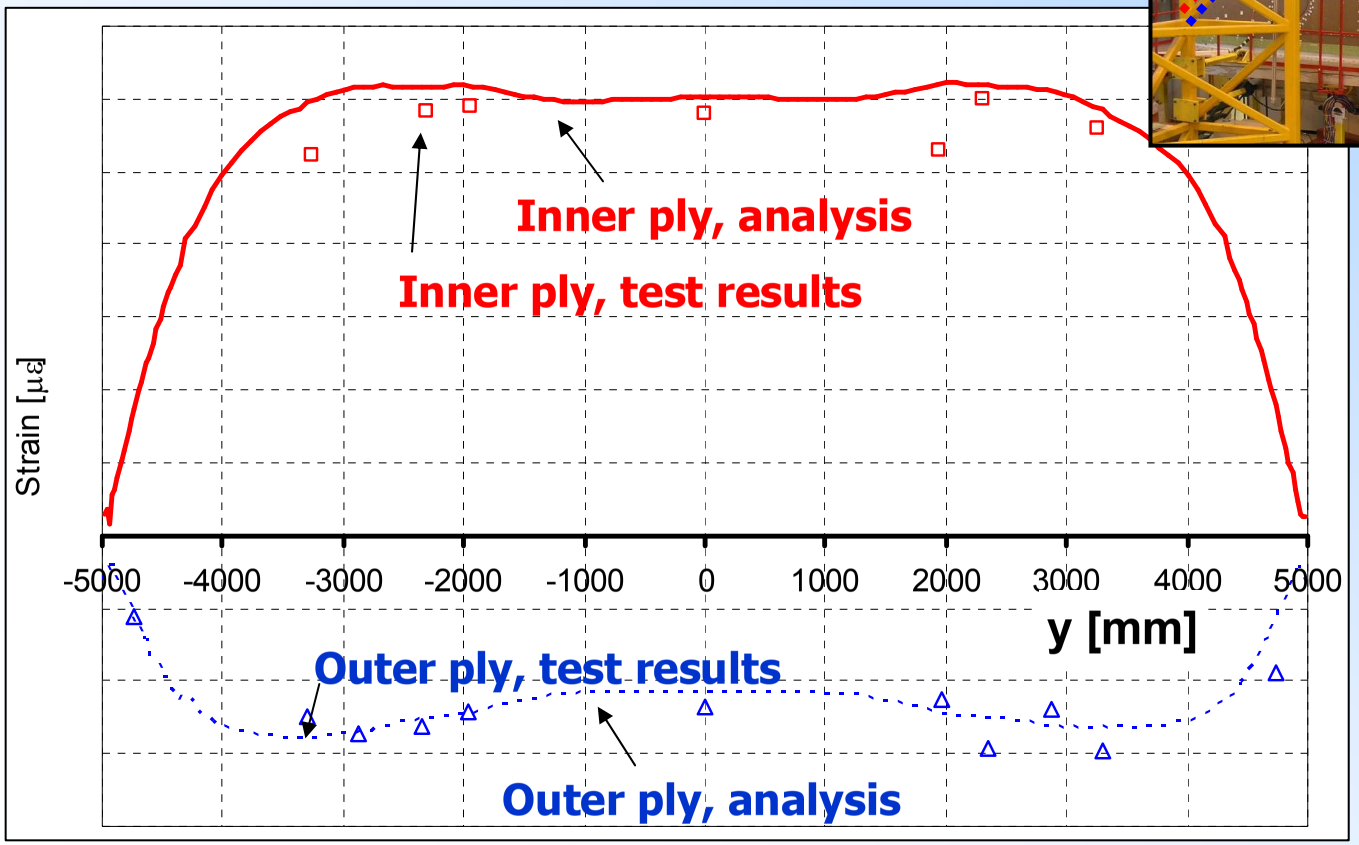
AEW Radome Design & Substantiation

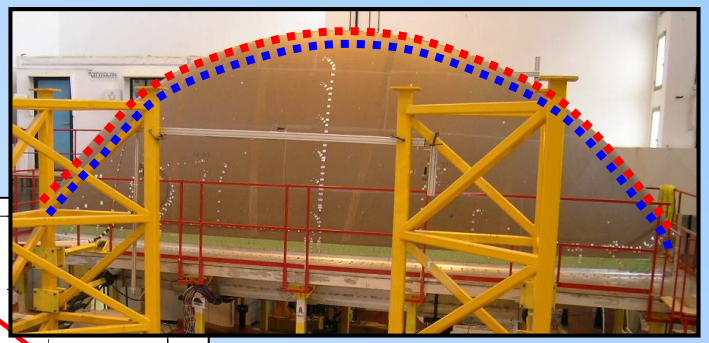
Test Setup

Full Scale Static Test Set UP



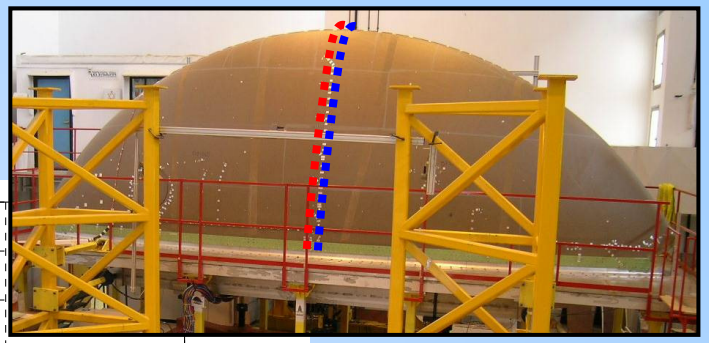
Radial Strain Distribution at Radome Leading Edge Ult. Test



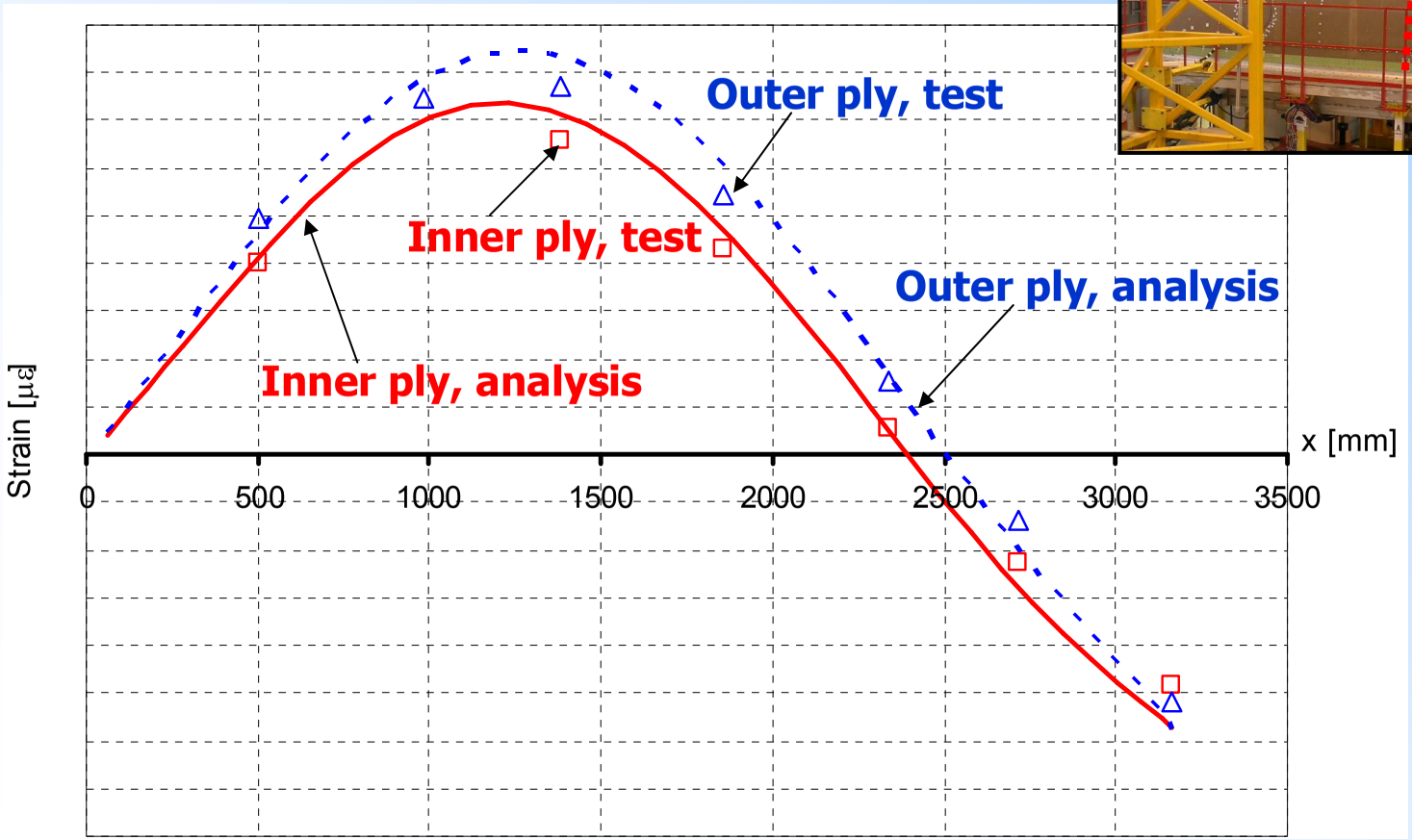


Leading Edge

Tangential Strain Distribution at Radome C/L Ult. Test



C/L



Summary

- A dome mounted composite Radome was designed and substantiated for an early warning surveillance system.
- Innovative design and manufacturing concepts allowed construction of this Radome as a single integral part, thus reducing cost and assembly problems.
- The substantiation method relied on analysis, supported by testing at component and full-scale level.
- The two primary damage tolerance requirements were addressed: damage growth characterization and residual strength-capability