



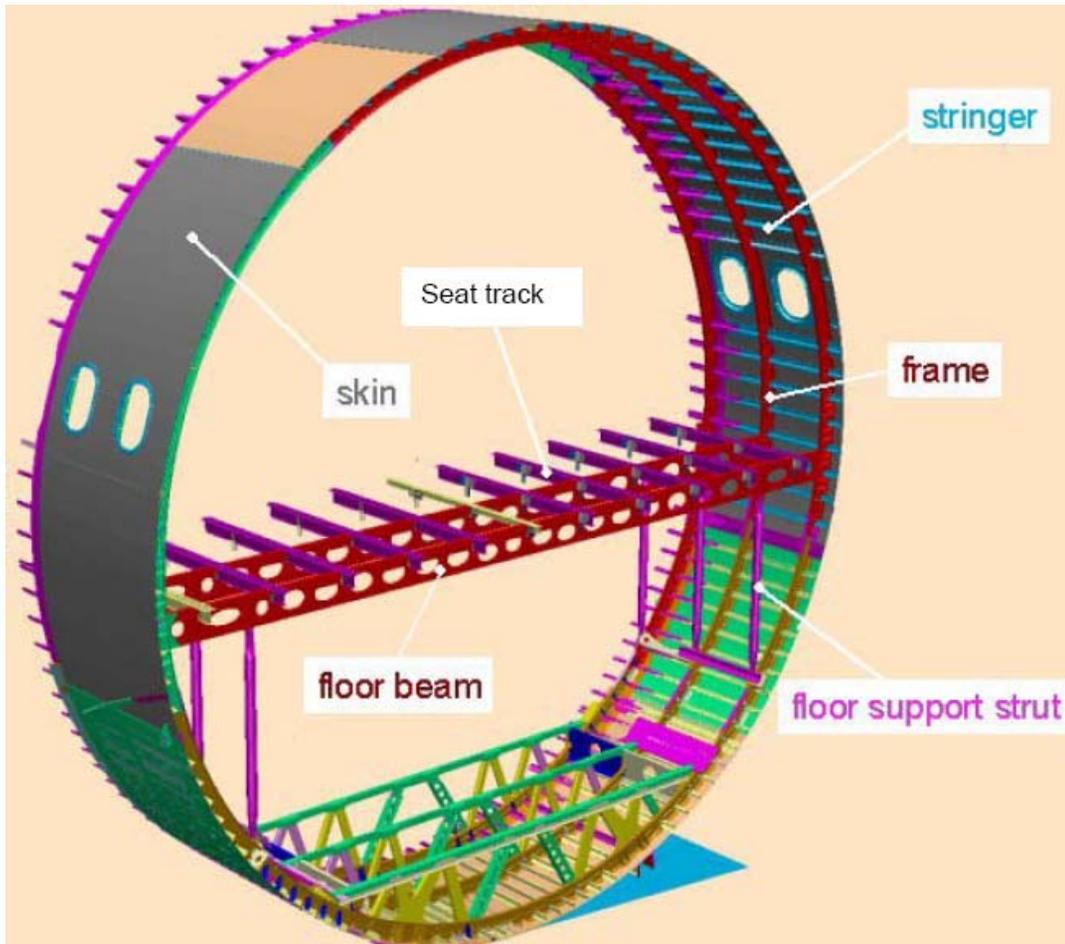
Event / Department (optional)

Fuselage Structural Integrity Forum

Panel 3: Design Requirements and Objectives

Presented by
Nikolaus Ohrloff

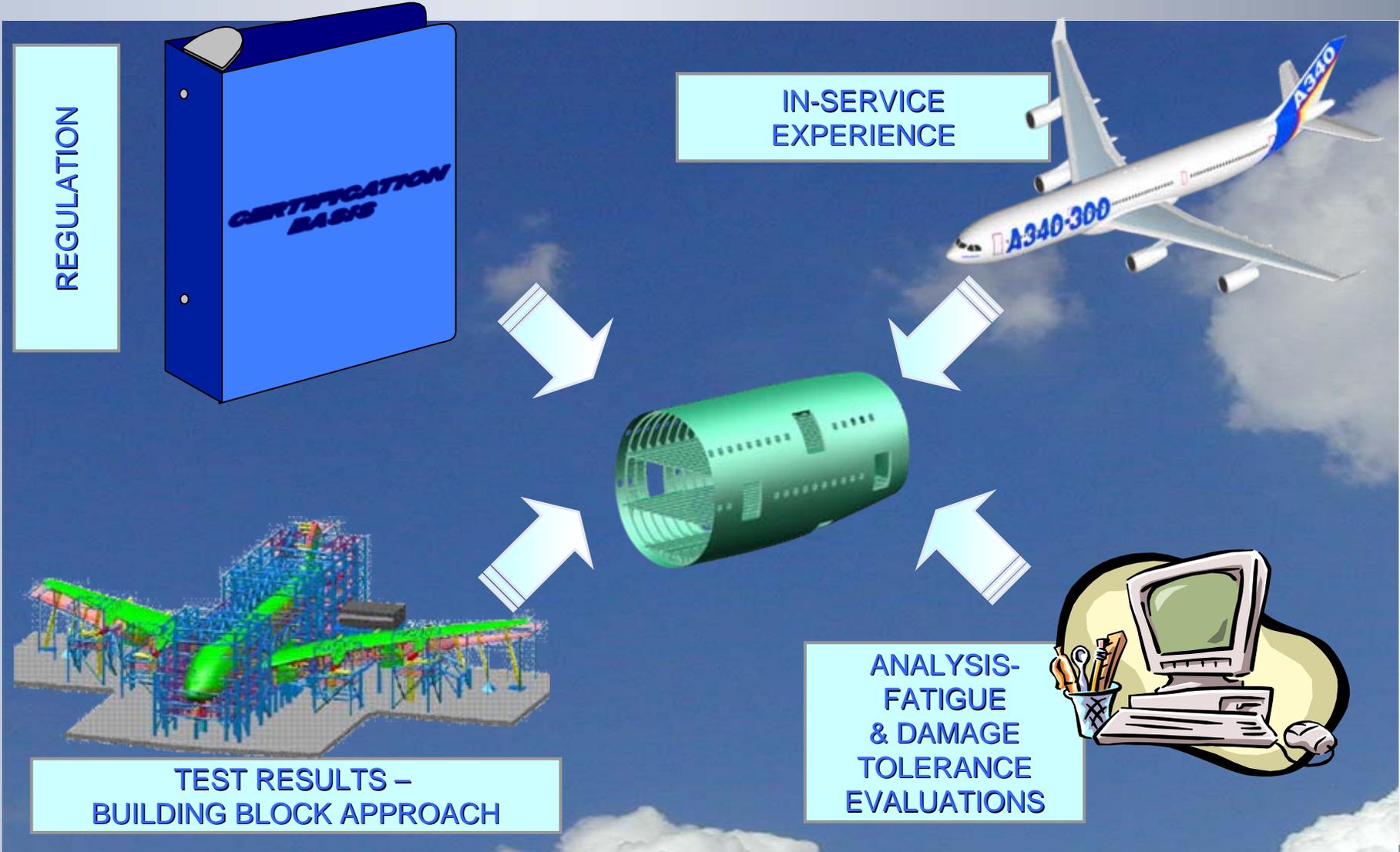
Airbus Fuselage Design



Classical metal design

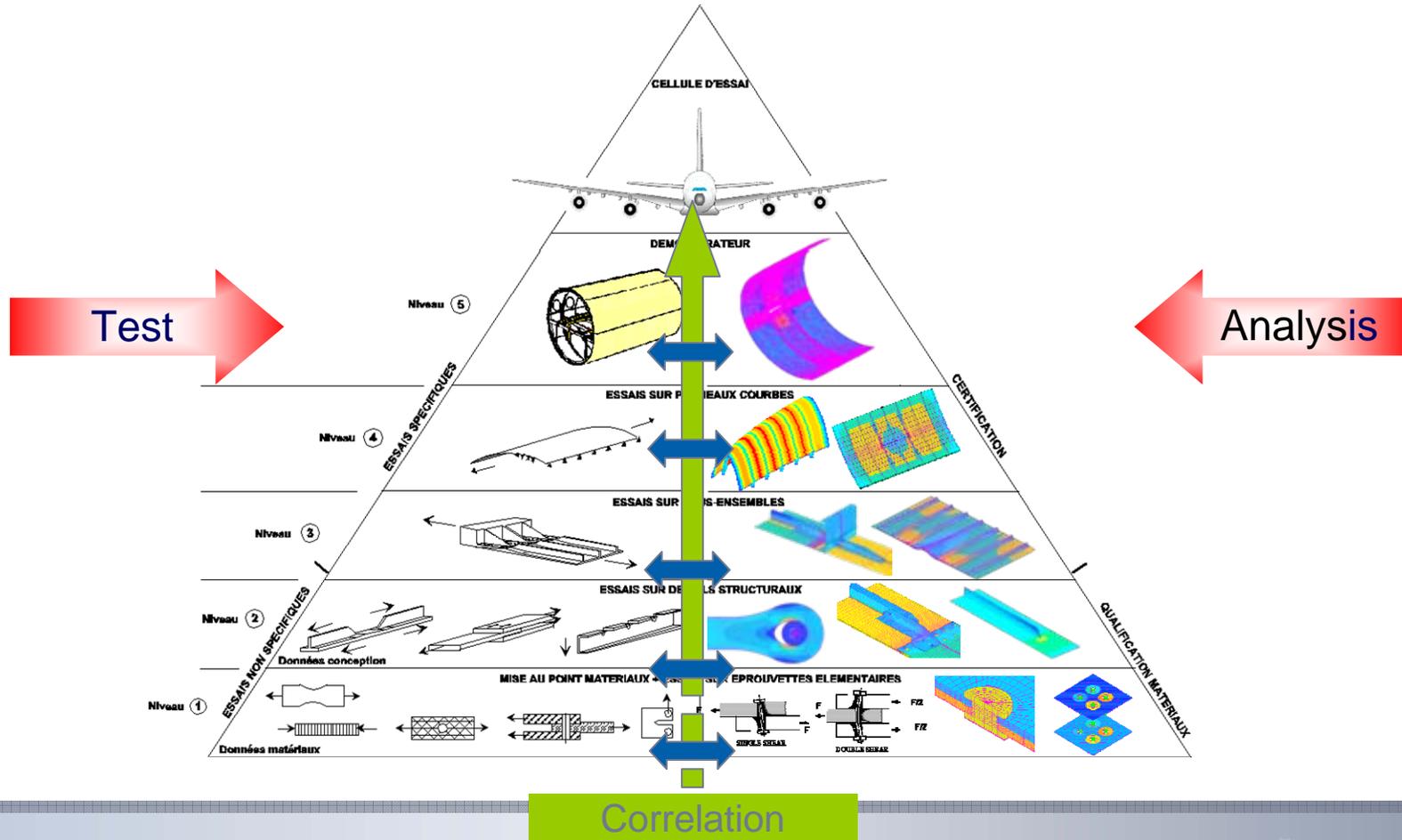
- Skins: 2XXX, 7XXX, 6XXX or GLARE for A380
- Chemically /mechanically milled, upper shells bonded
- Frames: sheet metal or machined extrusions
- Stringers: Sheet metal or extrusions
- Riveted, bonded or welded stringers

Methodology



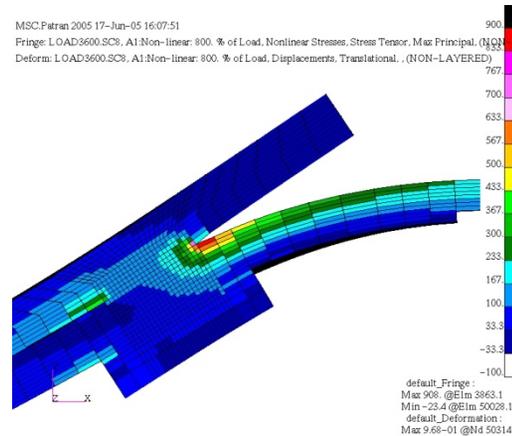
Building block approach

Analysis supported by tests



Coupon tests for fatigue

- Tests to support and to calibrate the analytical approach
- Goals:
 - Fatigue performance of the material on simple notched and joint specimen
 - Check mean stress dependence
 - Check of spectrum sensitivity
 - Proof of technology factors such as surface treatment, manufacturing tolerances, bolt fit, cold expansion etc....



Coupon tests for Damage Tolerance (DT)

- **Tests to support and to calibrate the analytical approach**
- **Goal: Characterization of DT properties**
 - **Crack growth resistance for constant amplitude**
 - **Check of spectrum sensitivity**
 - **Determination of residual strength properties (toughness, R-curve or K_{Ic} , K_{Ic})**
 - **Check sensitivity to other environmental influence, ageing, low temperature, fluids etc.**

Goals of component and full scale fatigue tests (including tear down)

- **Validation of crack initiation life** to meet the design goals
- **Validation of the predicted fatigue and crack growth behavior** to confirm the damage tolerance goals
- Establishment of in-service structural inspection program for fatigue purposes (to be ready prior to first D-check)
- **Detection of areas of early local cracking** to change series production at an early stage to minimize retrofit activities
- **Demonstration that the structure is free from significant MSD/MED up to the DSG/DSO** to meet required safety standards (addressed by new certification rules)
- **Validation of the structural damage capability**
- **Validation of the global and local stresses** determined by FEM analysis
- **Validation of NDI procedures** for hidden structure subject of maintenance program
- **Validation of fatigue lives of typical major repair solutions, reworks and dents** to confirm repair concepts and allowable damages (SRM)

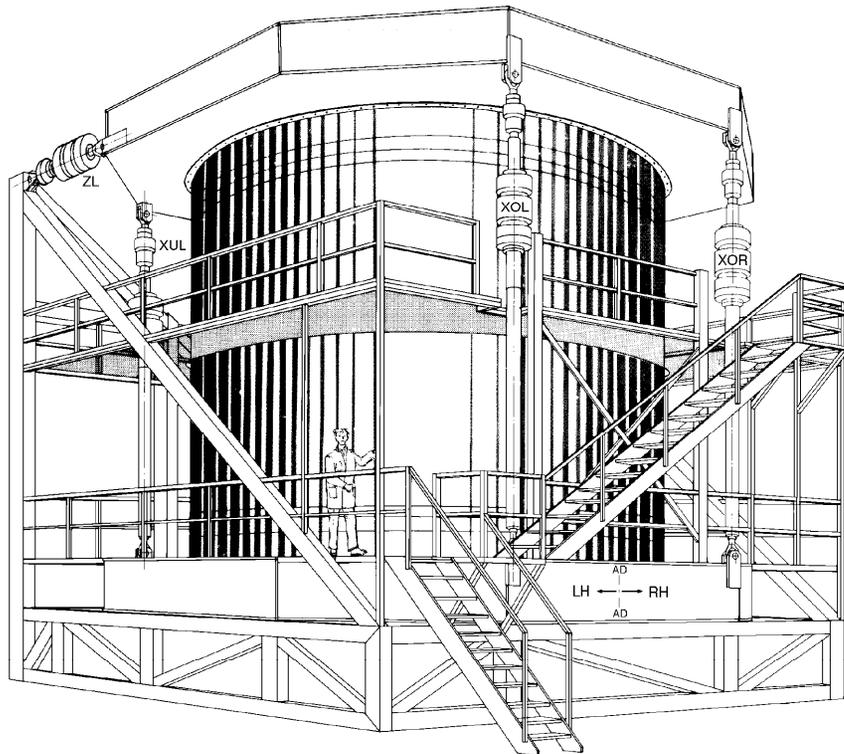
Component test: Panels



Fuselage panel with internal pressure and longitudinal loads (flight by flight)

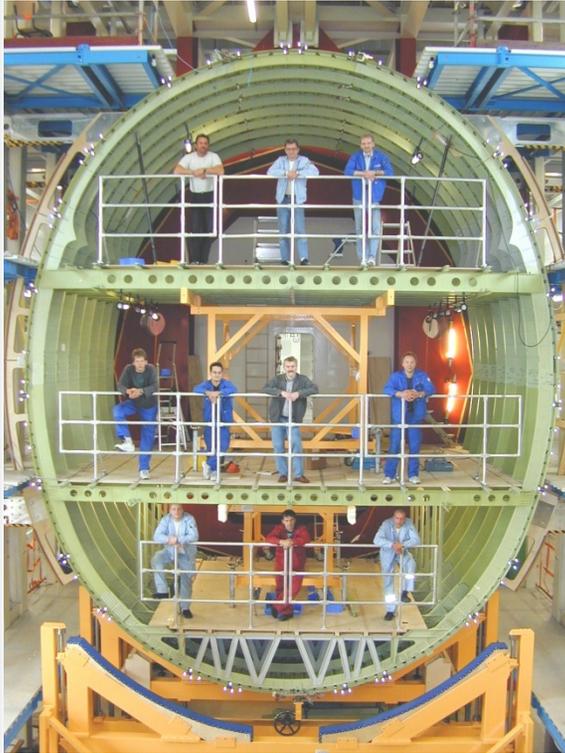
- Used in frame of development, research and certification
- Fatigue tests of complex panels including circumferential and longitudinal joints, repairs
- Fatigue, crack growth and residual strength testing

Barrel tests



- Structure identical to A/C
- Loading:
 - Internal pressure only
 - Or superposition of internal pressure with mechanical loading (flight by flight program)
- Fatigue, crack growth and residual strength
- Repairs, dents etc included

Airbus Barrel tests

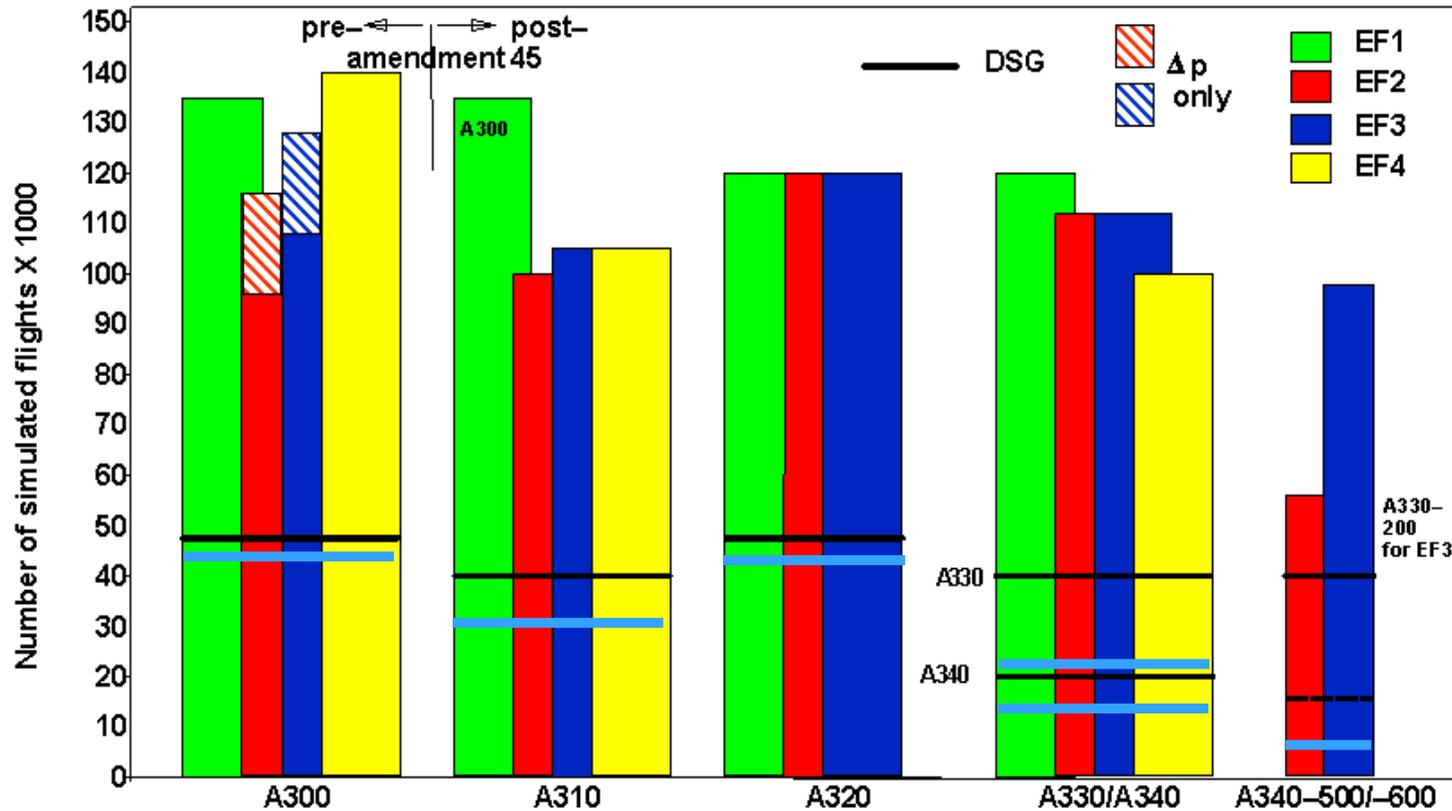
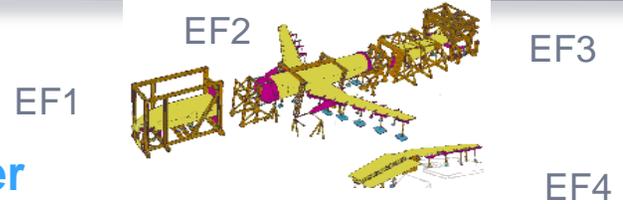


- **A300/A310:** Due to MSD on first A300 lap joints
- **A340 two different specimens:** Check of new rivet systems, new materials and new assembly technologies
- **A320 before start of development:** Investigation of design concepts
- **Megaliner (similar to A380) before start of development:** Investigation of design concepts, validation of allowable

Airbus Full Scale Multi Section Fatigue Tests

- Flight by flight loading
- Test for type certification

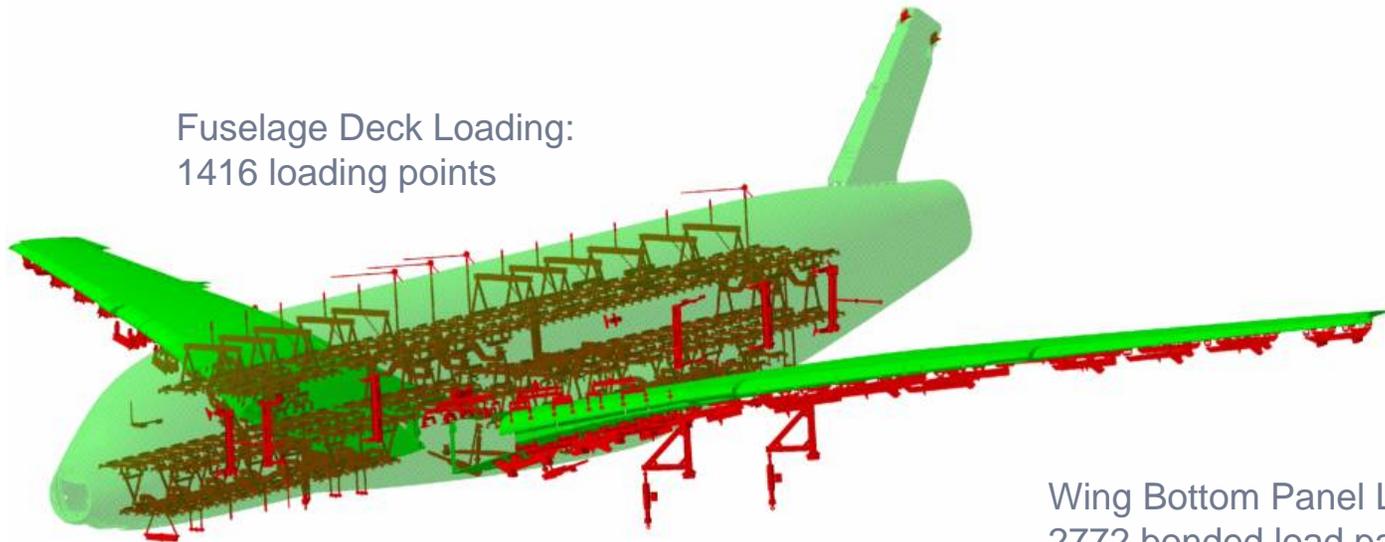
— Fleet leader



A380 Full Scale Fatigue Test (full aircraft)

- **Test Goal (N = 3.2 * D.S.G.)** **60800** simulated flights
- **Fatigue Load Application (flight-by-flight, typical mission mix)**
- **Load Enhancement (all loads inc. dp)** **10%**

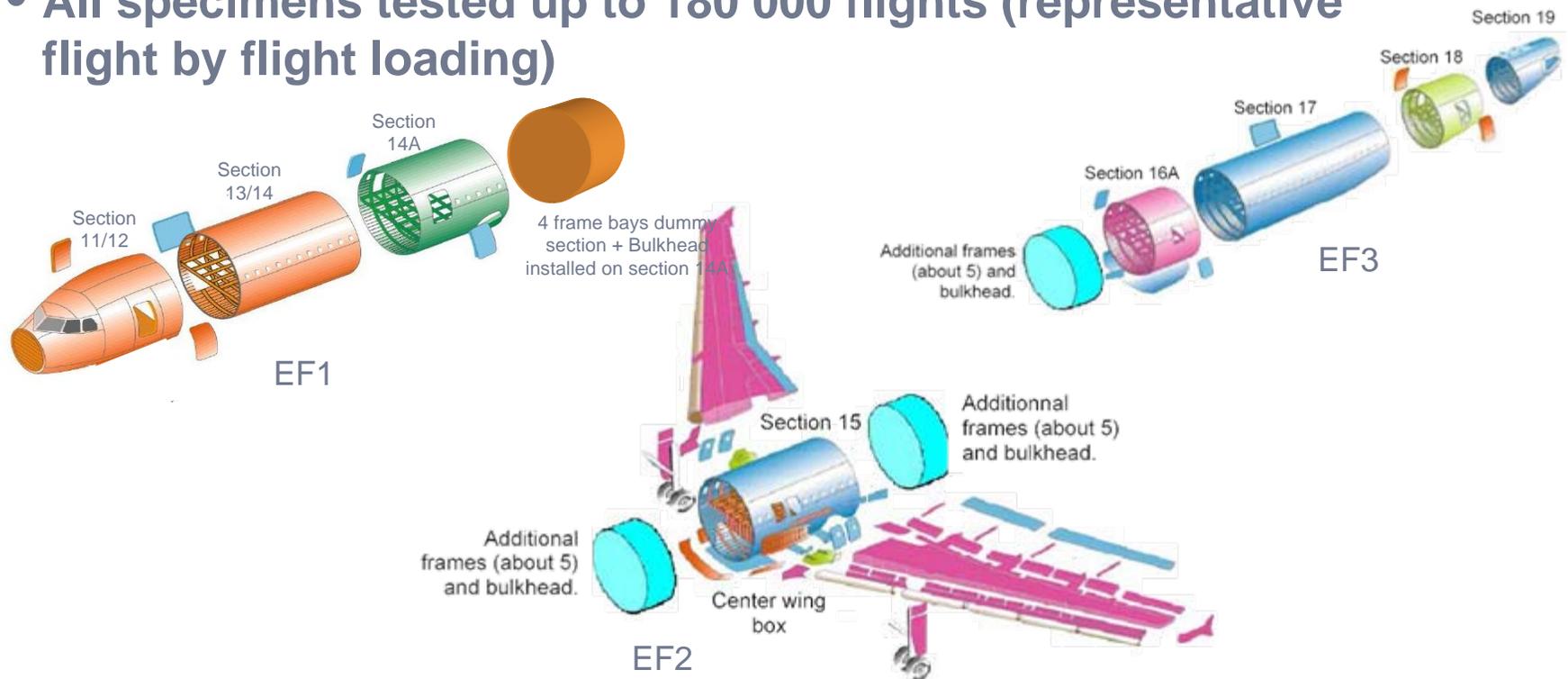
Fuselage Deck Loading:
1416 loading points



Wing Bottom Panel Loading:
2772 bonded load pads

A320 Extended Service Life Goal Multi Section Tests

- Forward fuselage (incl. Section 14A of A321) = NEF01
- Center fuselage + wing = NEF02
- Rear fuselage (incl. Section 16A of A321) = NEF03
- All specimens tested up to 180 000 flights (representative flight by flight loading)



Conclusions

- ▶ **Efficiency of predictions relies on the good balance and correlation between analysis and test.**
- ▶ **Tests used as support for all analysis and definition of maintenance program.**
- ▶ **Material data for F&DT calculation based on extensive testing.**
- ▶ **Full pyramid of tests available to support development, research and certification.**
- ▶ **Huge experience in structural testing of fuselage structures.**
- ▶ **All Airbus variants have been tested for at least 2 DSG.**
- ▶ **New full scale fatigue tests for life extension with excellent structural performance covering different local modifications, repair.....**

Thank you!





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