



# Fuselage Structural Integrity Forum

## Panel 3

Washington, DC

September, 21<sup>th</sup>, 2011

- Fuselage Design Overview
- Static, Fatigue and DT Evaluation
  - Methodology and Criteria
  - Fatigue Loads
  - Tests

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## EMB 120 – Brasilia (maiden flight - 1983)

- 30 seat turboprop
- Pressurized fuselage with circular cross section
- Part 25 damage tolerant structure – DSG = 60,000 flight cycles
- Full scale fatigue test
  - two lifetimes or 120,000 flights
  - additional 15,000 FC (residual strength, crack propagation & tear down)



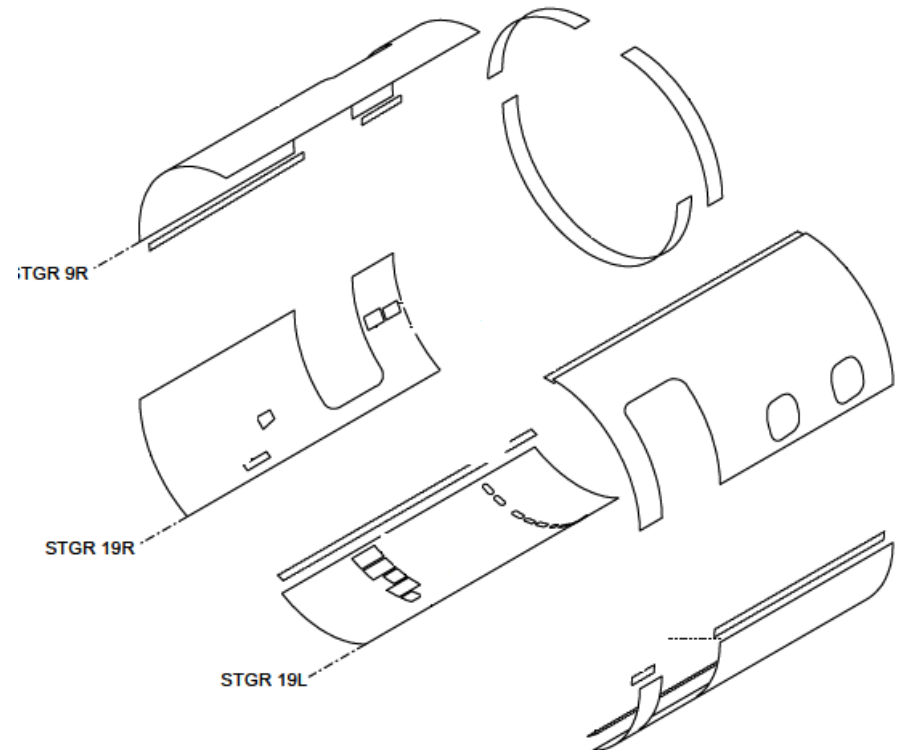
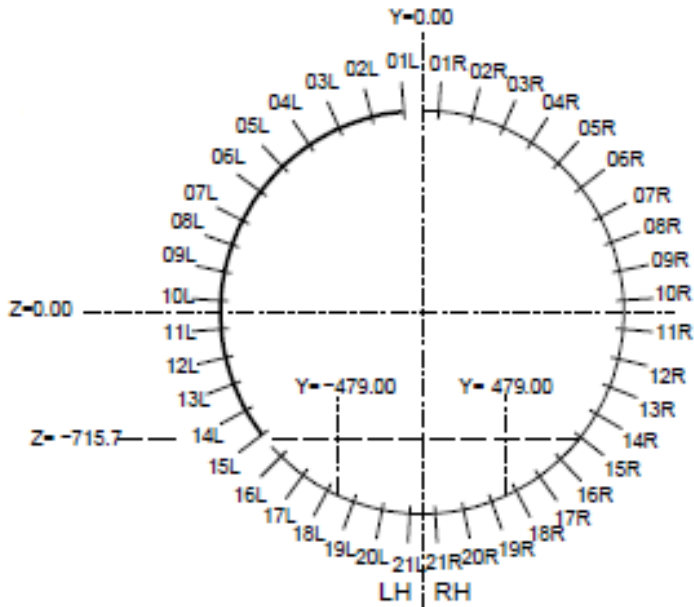
## ERJ 145 Family (maiden flight 1995)

- 37 to 50 seat twin-jet
- Part 25 damage tolerant structure – DSG = 60,000 flight cycles
- Multi load path - fail safe structure / crack arrest structure
- Over 1,000 aircraft delivered
- ~15,900,000 flights cycles accumulated
- Fleet Leader ~ 30,560 FC



## ERJ 145 Family

- All aluminum, conventional stiffened shell
- Circular cross section  $\Rightarrow$  same design concept of EMB 120
- Circumferential and longitudinal butt-joint splices
- All aluminum



## EMBRAER 170/190 - *E-Jets* (maiden flight February, 2002)

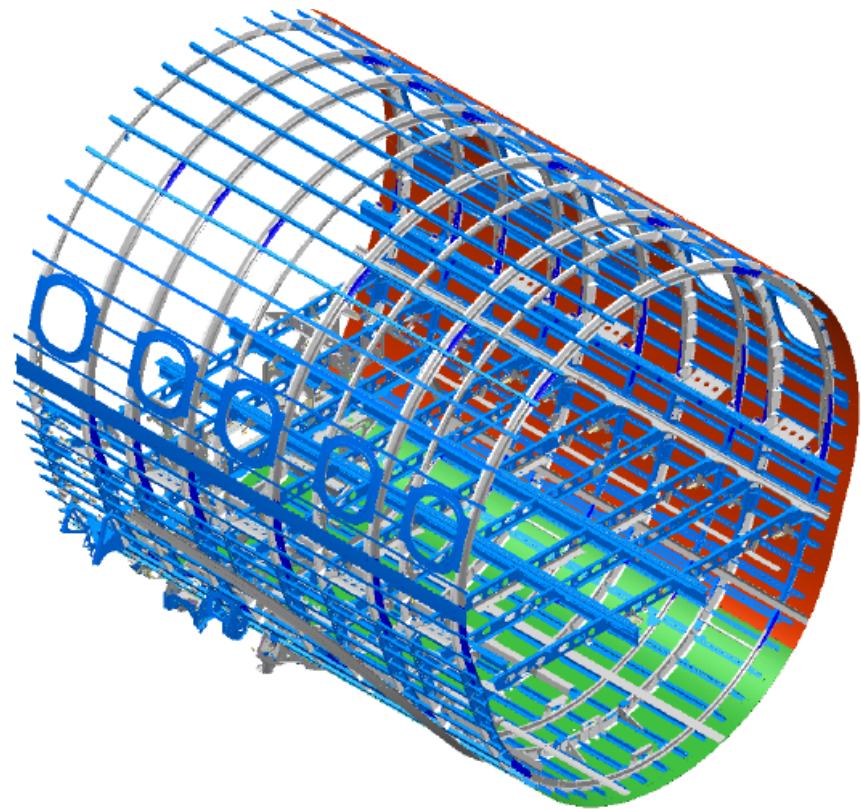
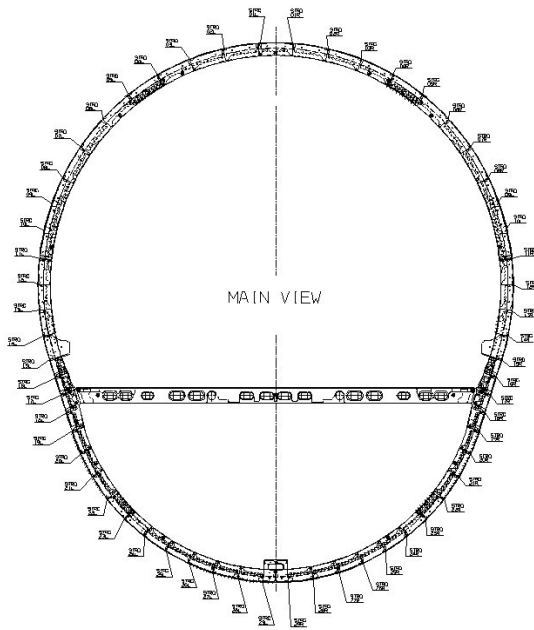
- 70 to 122 seats, wing-mounted turbofan engines
- Part 25 damage tolerant structure – DSG = 80,000 flight cycles
- Multi load path - fail safe structure / crack arrest structure
- Over 744 aircraft delivered
- ~4,473,322 flights cycles accumulated
- Fleet Leaders
  - ~ 14,397 FC (E 170/175)
  - ~ 12,829 FC (E190/195)





## Embraer 170/190 - *E-Jets*

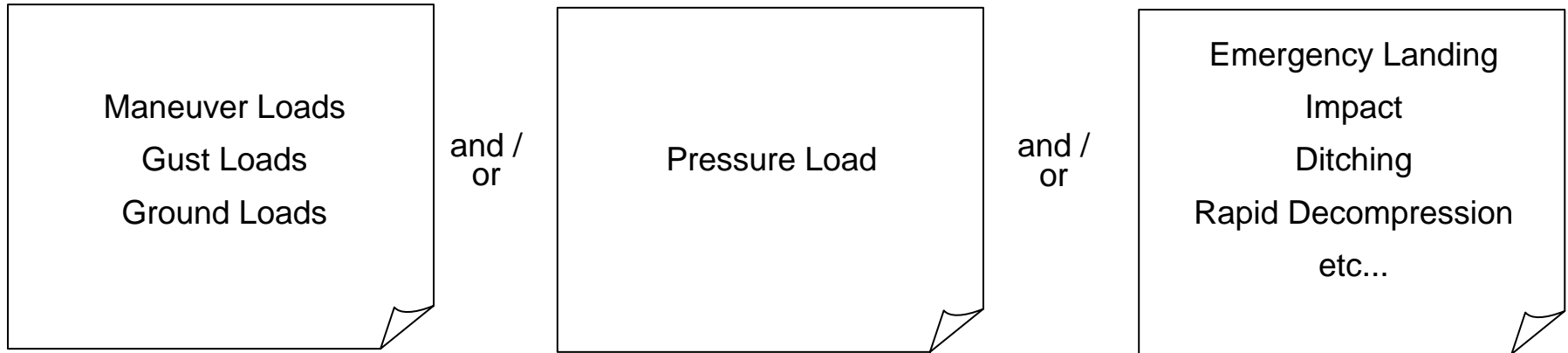
- Double-bubble section
- Conventional stiffened shell
- Circumferential butt-joint splices and longitudinal lap and butt-joint splices
- All aluminum





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## Static Strength



Static strength checked for:

- Limit loads
  - maximum loads expected in service
  - pressure corresponding to maximum relief valve setting x 1.33
- Ultimate loads - Limit loads x 1.5
- Damaged structures (residual strength)

## Fatigue and Damage Tolerance Design Criteria

- Guidelines for Embraer and partner engineers

The contents include

- design service goal
- flight mission profiles
- multiple load path damage tolerant structure
- initial flaw criteria
- detectable flaw size criteria
- critical crack length criteria
- inspection threshold and interval criteria
- criteria for selection of SSI's and PSE's
- considerations about WFD
- full-scale fatigue test



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Page: 1 of 54

ISSUED BY:

EMBRAER: VAE/OEE/GEW/GWA/

**REPORT No.:** 135-FA-1401

**PROGRAM:** EMB-135BJ

**TITLE:** FATIGUE AND DAMAGE TOLERANCE  
STRUCTURAL DESIGN CRITERIA

**ATA 2200 No.:** N/A

**CLASSIFICATION:** PRIVATE

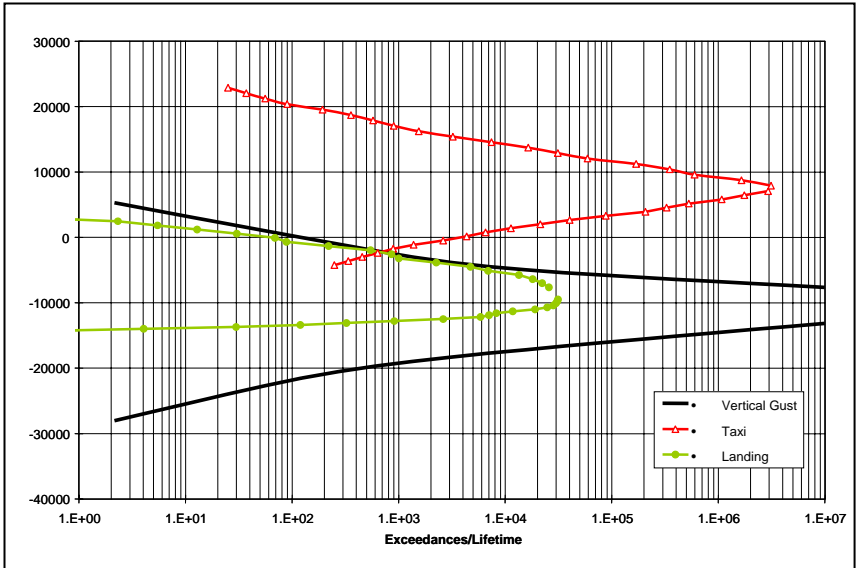
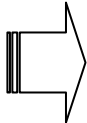
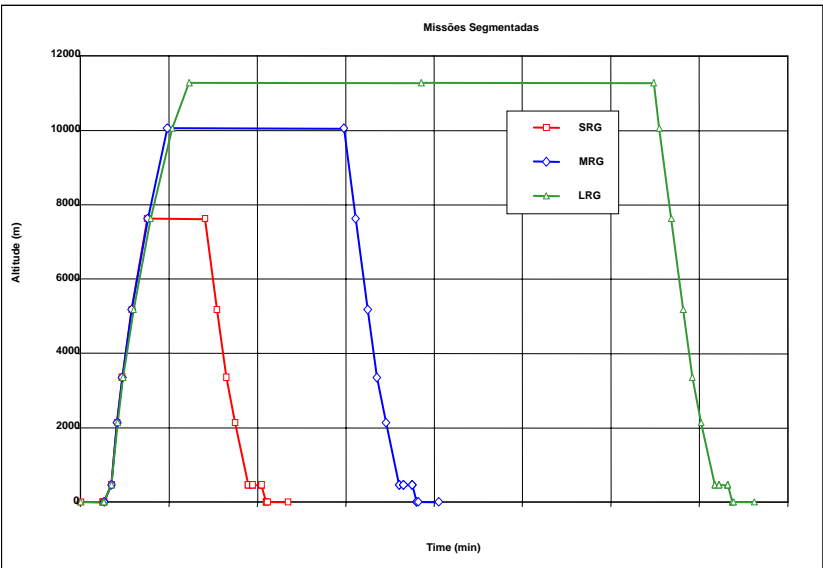
In order to validate this Report, the "Approval List" and the Technical Report front page (showing the applicability) shall be attached as an integral part of the Report, which presents the date, electronic signatures and the approval status for each revision.

## Fatigue and Damage Tolerance Design Criteria

- Multi load path - fail safe structure / crack arrest structure
- Inspectability of all structural parts
- Fatigue analysis
  - Scatter factor  $\Rightarrow$  4 to 8
- Inspection Threshold Safety Factor
  - Single Load Path Structure  $\Rightarrow$  3
  - Multiple Load Path Structure  $\Rightarrow$  2
- Inspection Period Safety Factor
  - Single Load Path Structure  $\Rightarrow$  3
  - Multiple Load Path Structure  $\Rightarrow$  2

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# Static, Fatigue and DT Evaluation – Fatigue Loads



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**FSFT**



**HS**



**Wing Panel**



**Barrel**



**Fuselage Panel**



**Joints**



**K<sub>IC</sub>**



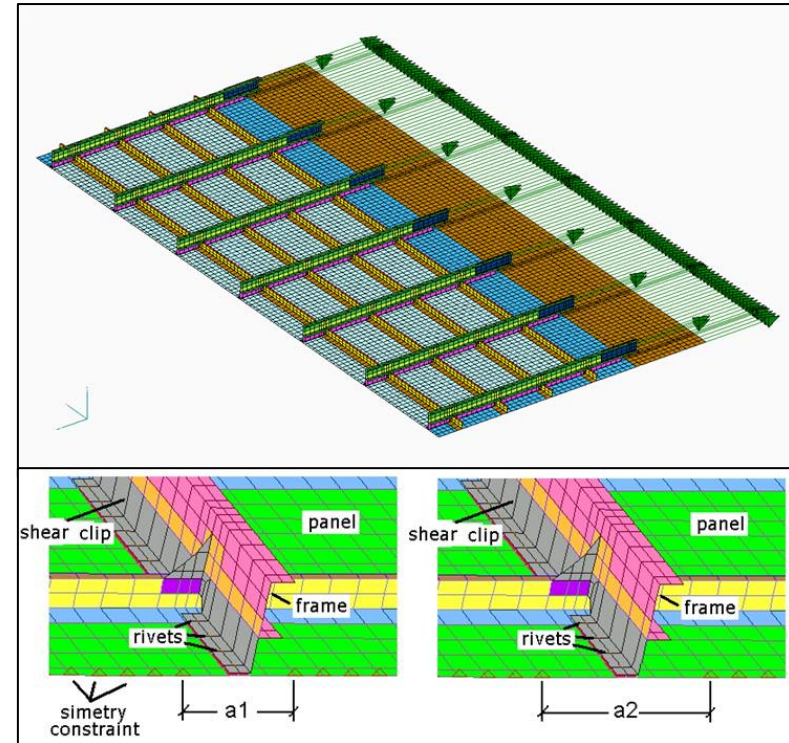
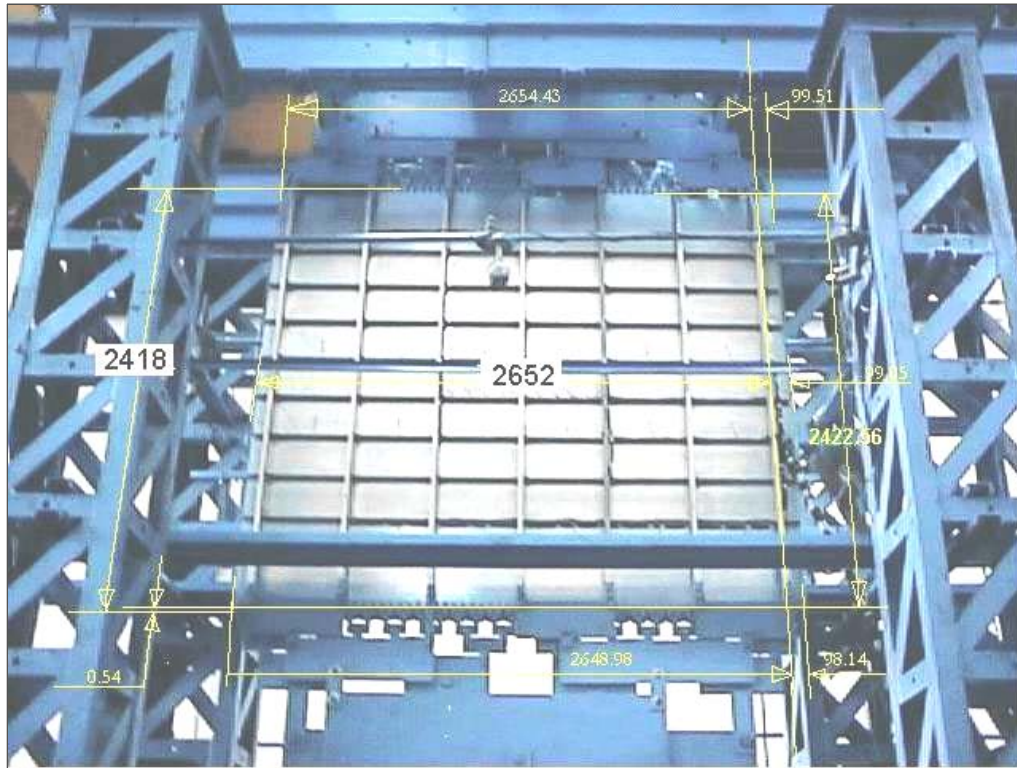
**Floor Beam**





## Fuselage Flat Panel Test

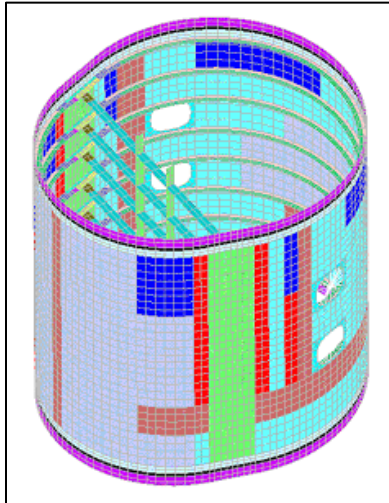
- Verification of residual strength
- Verification of crack propagation
- Validation of analysis methodology





## Fuselage Barrel Fatigue Test

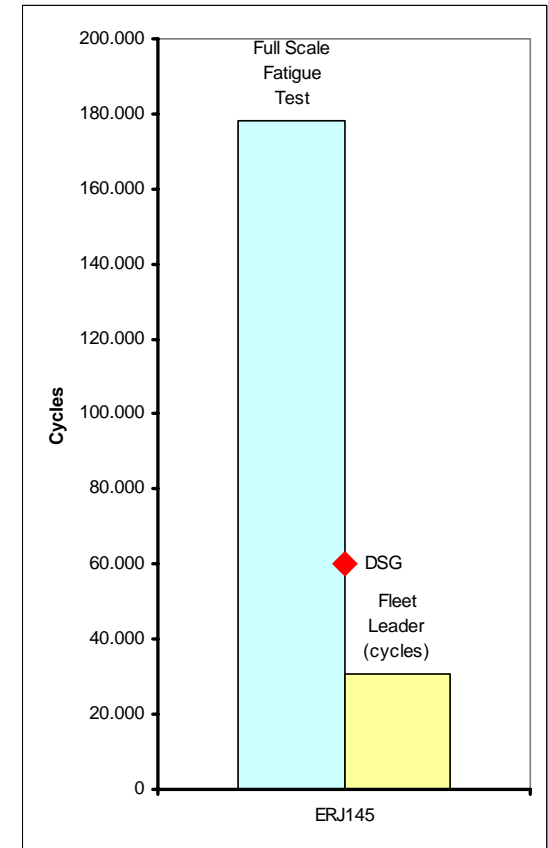
- Double-bubble section behavior
- Verification of different structural configurations
- Pressurization loads only
- Four Aircraft Design Lives (320,000 cycles)
- Residual strength test after fatigue test
- Crack growth test after fatigue test (80,000 cycles)
- Validation of analysis methodology



## Full Scale Fatigue Test (FSFT)

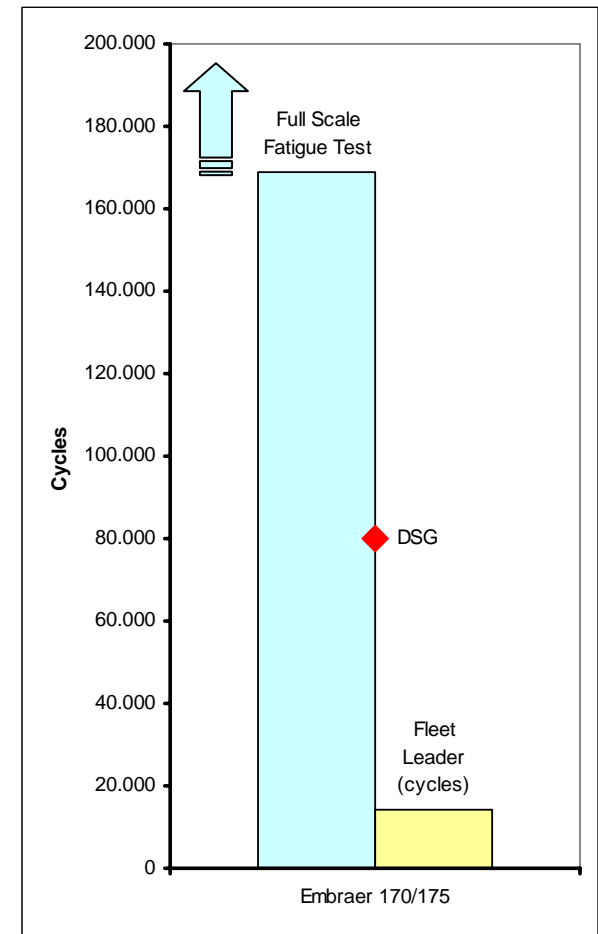
- Show there will be no Widespread Fatigue Damage (WFD) within two design lives
- Identify possible fatigue critical locations
- Validate crack propagation and residual strength characteristics
- Exercise suitable inspection methods
- Validation of analysis models and methodologies

## EMB-145 Family - Full Scale Fatigue Test - Finished





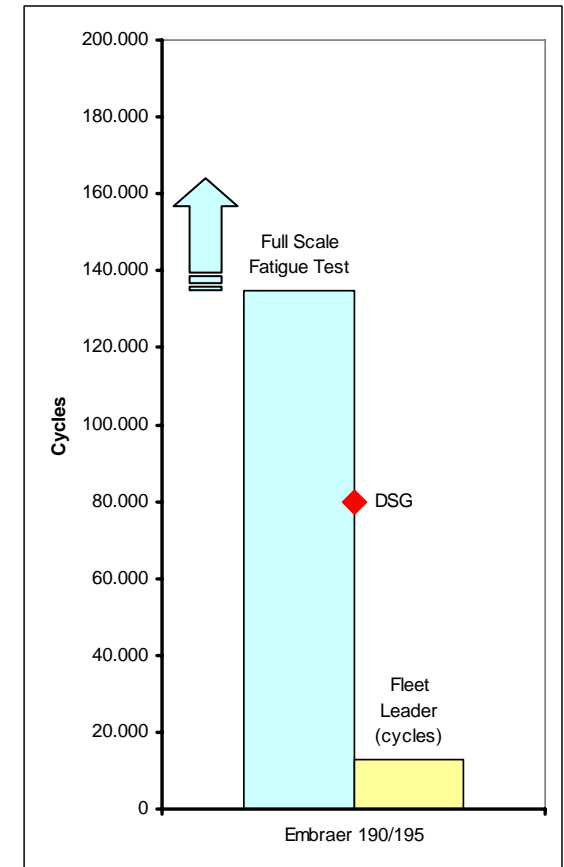
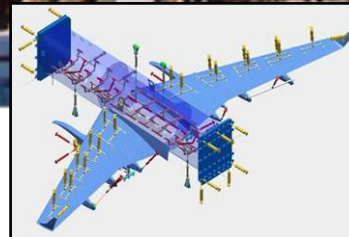
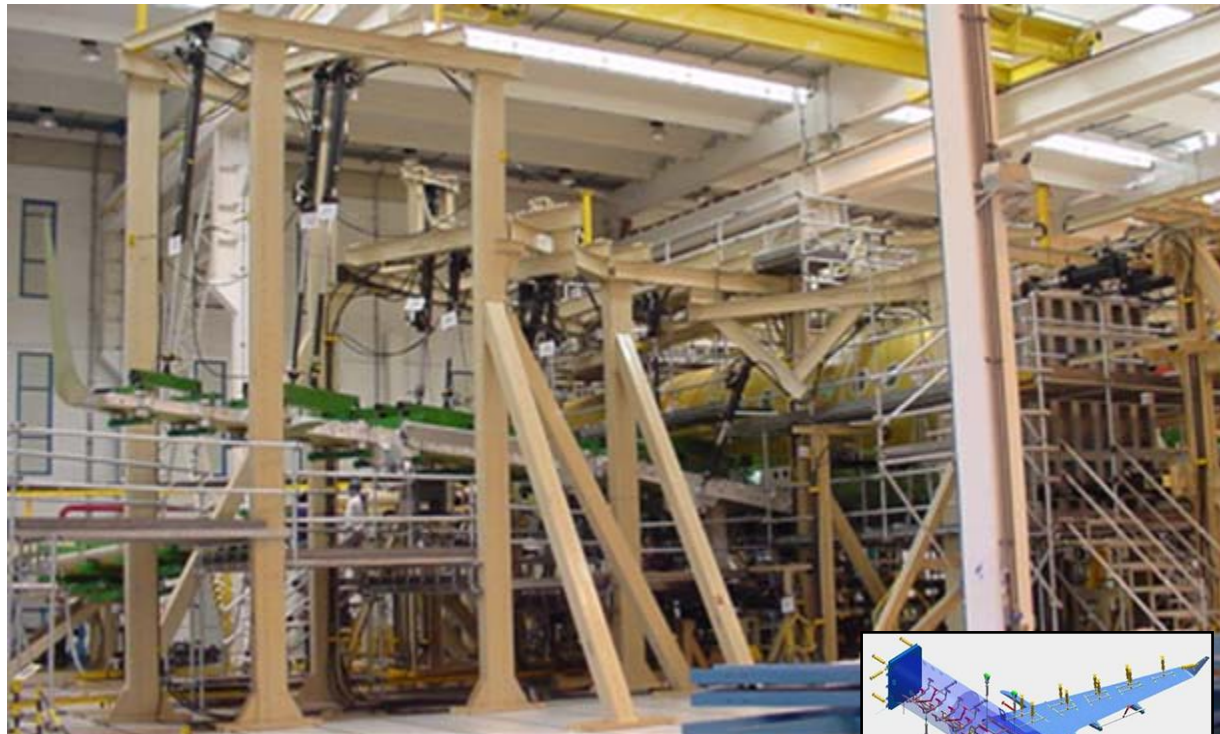
## ERJ 170/175 Full Scale Fatigue Test – on going





## ERJ 190/195 Full Scale Fatigue Test – on going

- Forward and rear fuselage not included (common with Embraer 170)



Thank you!

