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GROUND VIBRATION TESTS ON AIRBUS A380-800

Ulrich Fuellekrug, Gerrit Gloth¹ and Manfred Degener¹

Pascal Lubrina²

¹ Institute of Aeroelasticity, German Aerospace Center (DLR)

² Office National d'Études et de Recherches Aérospace (ONERA), DDSS





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Ground Vibration Tests on Airbus A380-800

- ▶ Why Ground Vibration Testing?
- ▶ Basics of a Ground Vibration Test
- ▶ Airbus A380-800
- ▶ Test Preparation and Test Setup
- ▶ Test Performance
- ▶ Test Results
- ▶ Summary and Conclusions



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Why Ground Vibration Testing?

- ▶ Investigation of the dynamic behaviour
- ▶ Experimental identification of modal parameters
 - ✧ measurement of resonance frequencies, normal modes, modal damping, generalized masses
- ▶ Validation of the dynamic Finite Element Model
 - ✧ adjustment of FE model parameters (Model Updating)
- ▶ Flutter analysis according to regulations of FAA and JAA for aircraft type certification
 - ✧ flutter computations with updated FE model
 - ✧ flight clearance
 - ✧ flight flutter testing

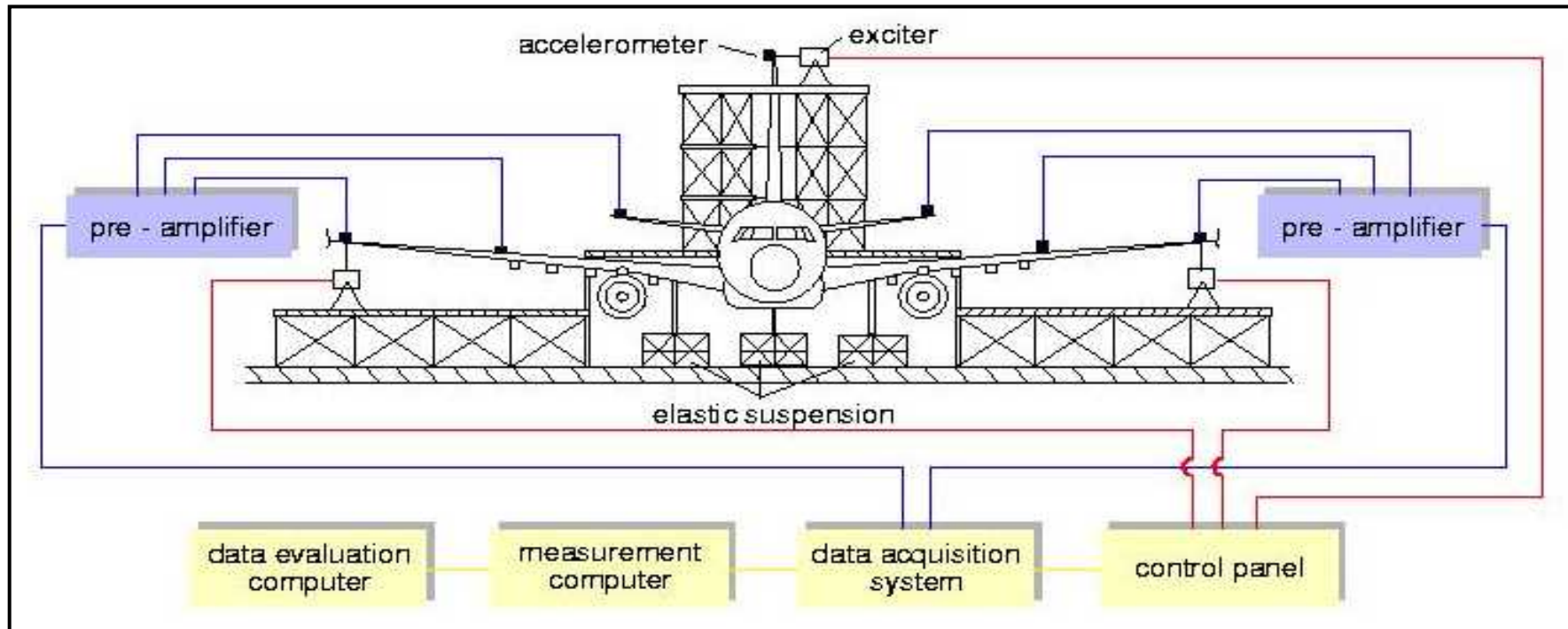


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Basics of a Ground Vibration Test (1)

Test Setup





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Basics of a Ground Vibration Test (2)

Test Methods

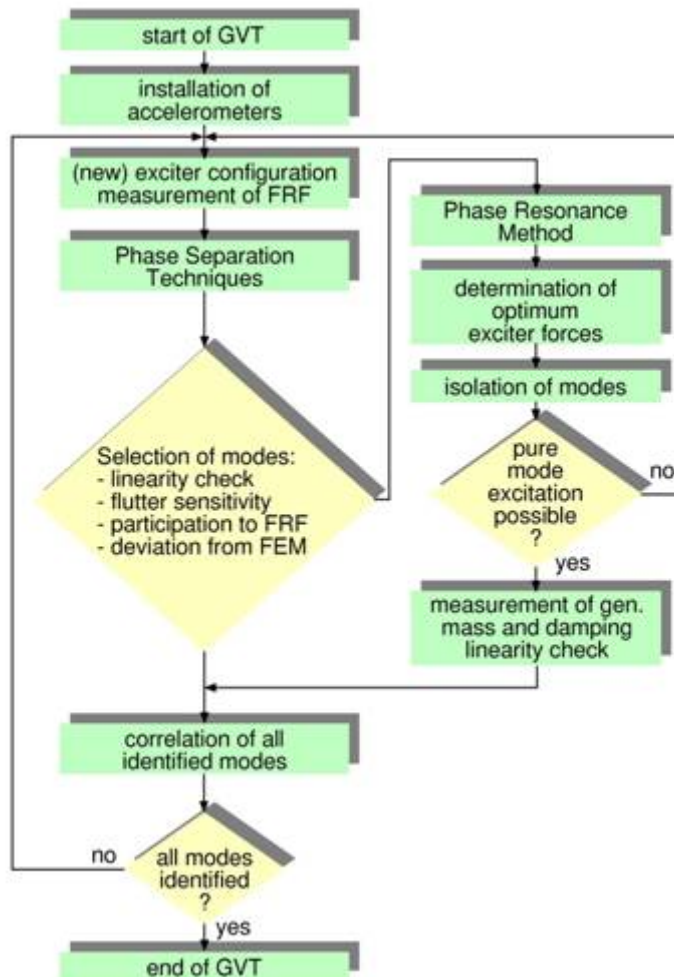
- ▶ Phase Resonance Method (PhRM)
 - ✧ force appropriation for each mode (time consuming)
 - ✧ direct measurement of the real normal modes
 - ✧ reliable, high accuracy possible
 - ✧ investigation of structural nonlinearities
- ▶ Phase Separation Techniques (PhST)
 - ✧ analysis of measured FRF
 - ✧ reduced test duration possible
 - ✧ suitable exciter configurations required
 - ✧ careful and time consuming data evaluation



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Basics of a Ground Vibration Test (3)



Improved Test Strategy:

- ✧ combination of PhRM and PhST
- ✧ reduction of test duration by 1/3
- ✧ enhancement of data quality
- ✧ fast analysis with PhST
- ✧ detailed analysis and non-linear analysis with PhRM



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Airbus A380-800

Super Jumbo A380 - „Flagship“ of the 21st century
Largest passenger aircraft of the world

- ✧ span: 80 m
- ✧ length: 73 m
- ✧ height: 24 m
- ✧ two decks: main and upper deck
- ✧ maximum take off weight: 560 tons
- ✧ cabin layout for 555 to 806 passengers



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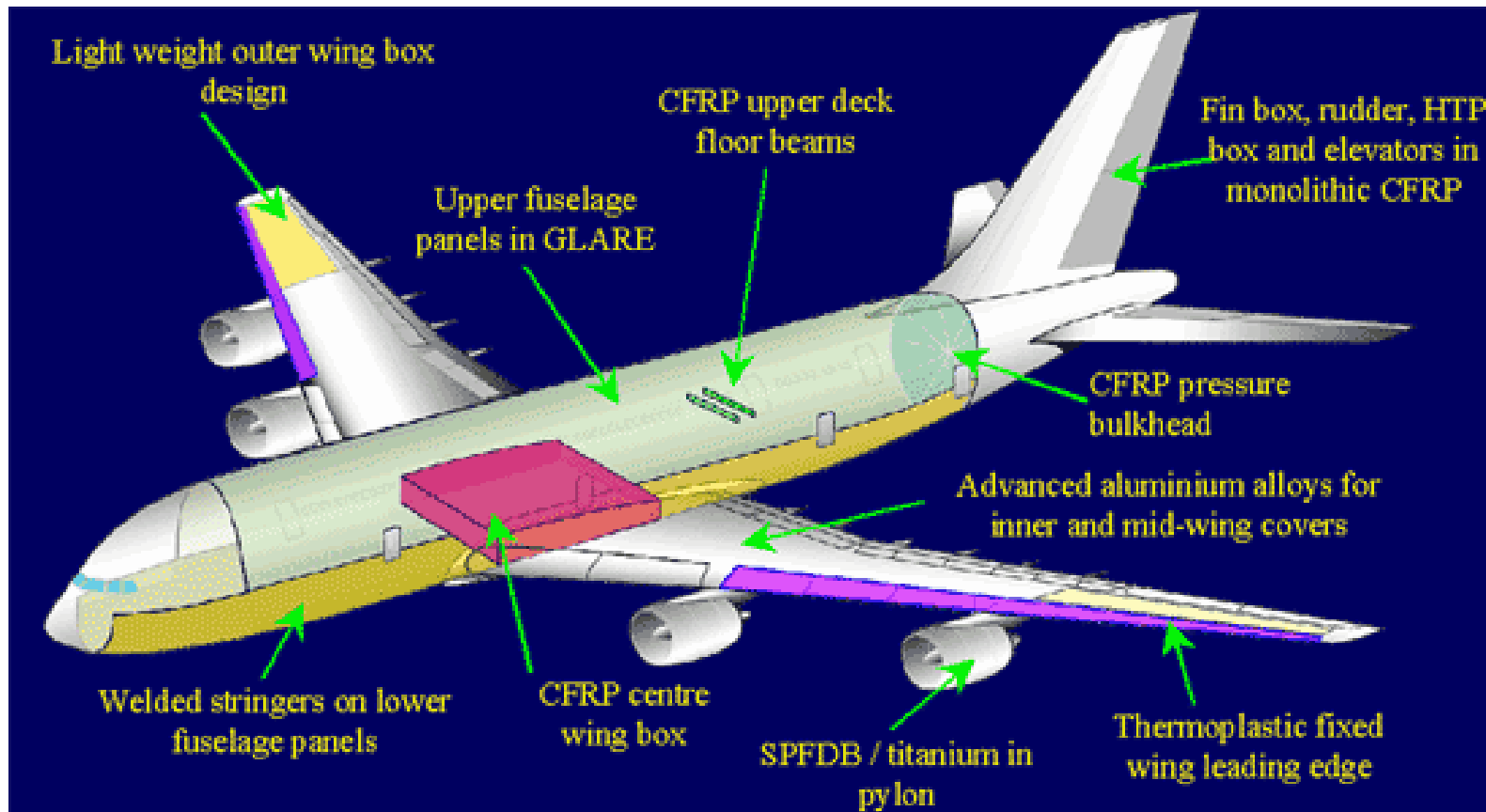


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Airbus A380-800

Utilization of new materials





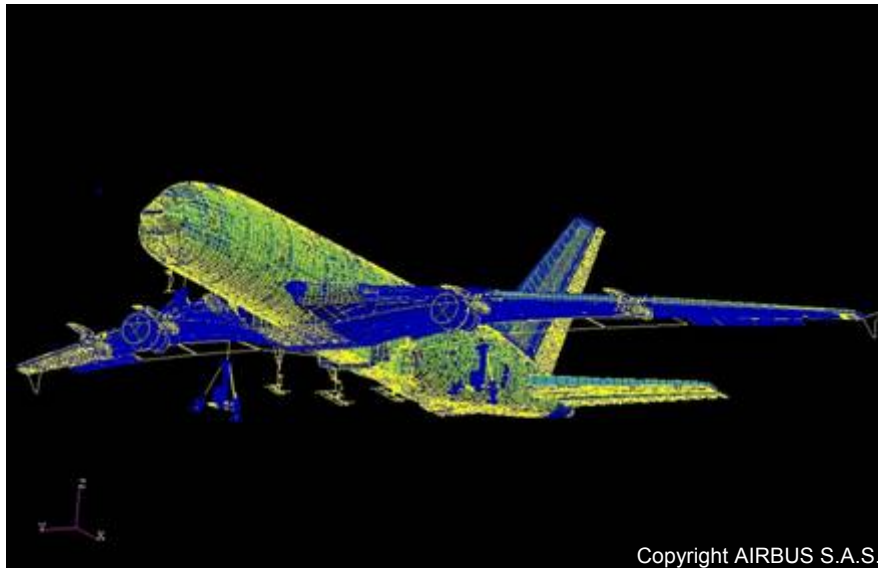
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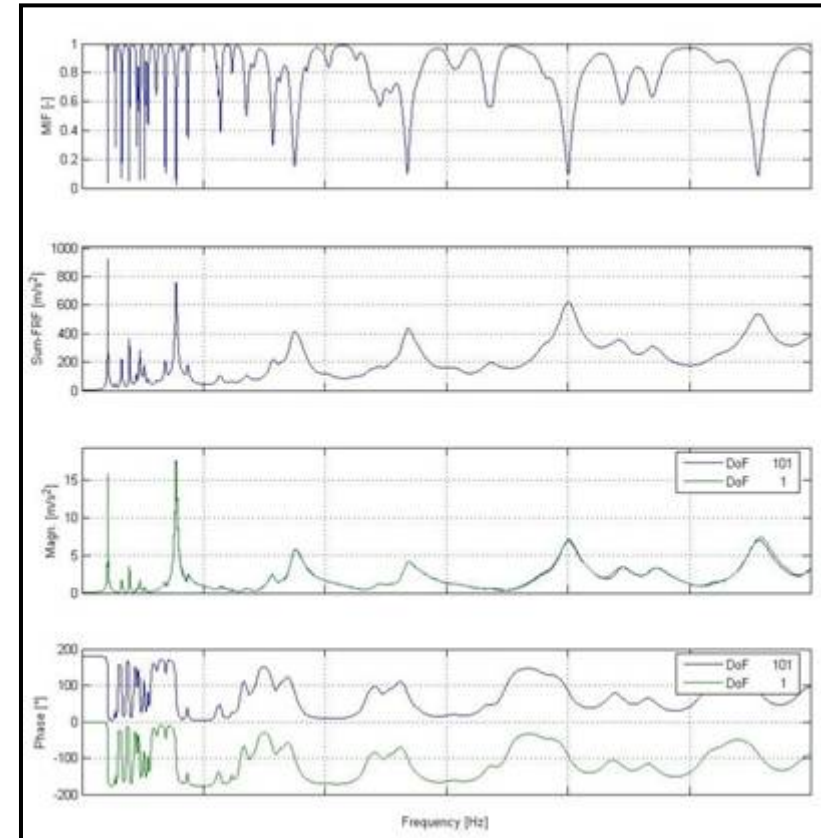
Test Preparation

Numerical computations with the Finite Element model

- ✧ high modal density: 5 modes / Hz
- ✧ computation of MIF and FRF for typical exciter configurations
- ✧ planning of exciter placement



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Test Setup

- ▶ Working platforms for sensor and exciter installation
- ▶ Total number of acceleration sensors: 850
 - ✧ sensors on aircraft: 450
 - ✧ sensors on systems: 260
 - ✧ sensors on decks: 80
 - ✧ additional sensors: 60
- ▶ Total number of exciters: 20
 - ✧ forces from 300 N up to 2200 N
- ▶ Total length of cables: ~25.000 m
- ▶ VXI system with 896 data acquisition channels
- ▶ Mobile container for test control and data analysis



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Test Setup



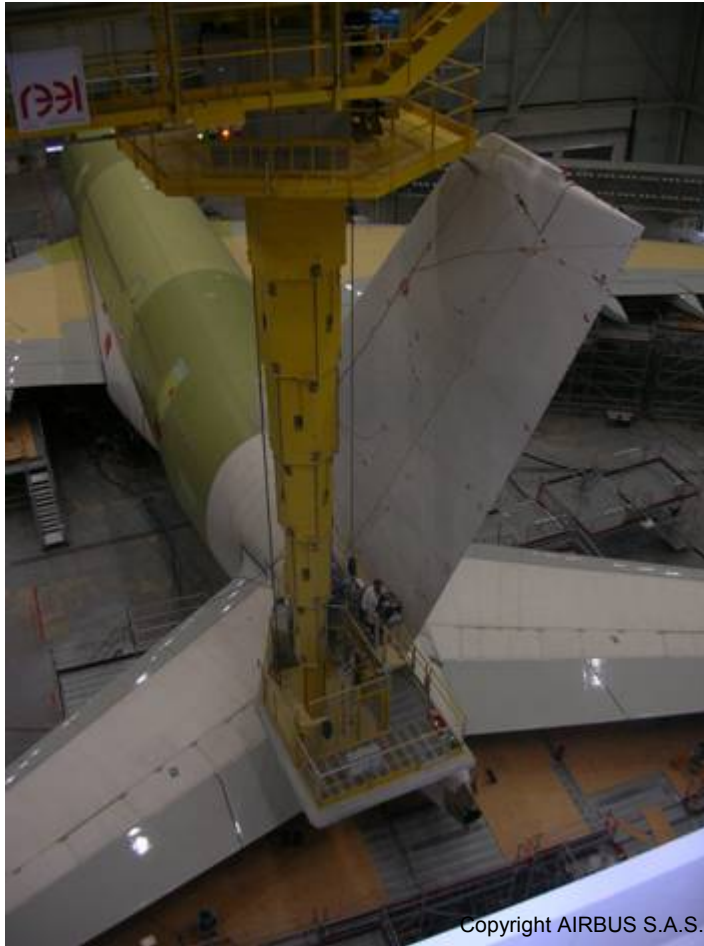
A380 during the Ground Vibration Test



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Test Setup - Accelerometers



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installation of accelerometers



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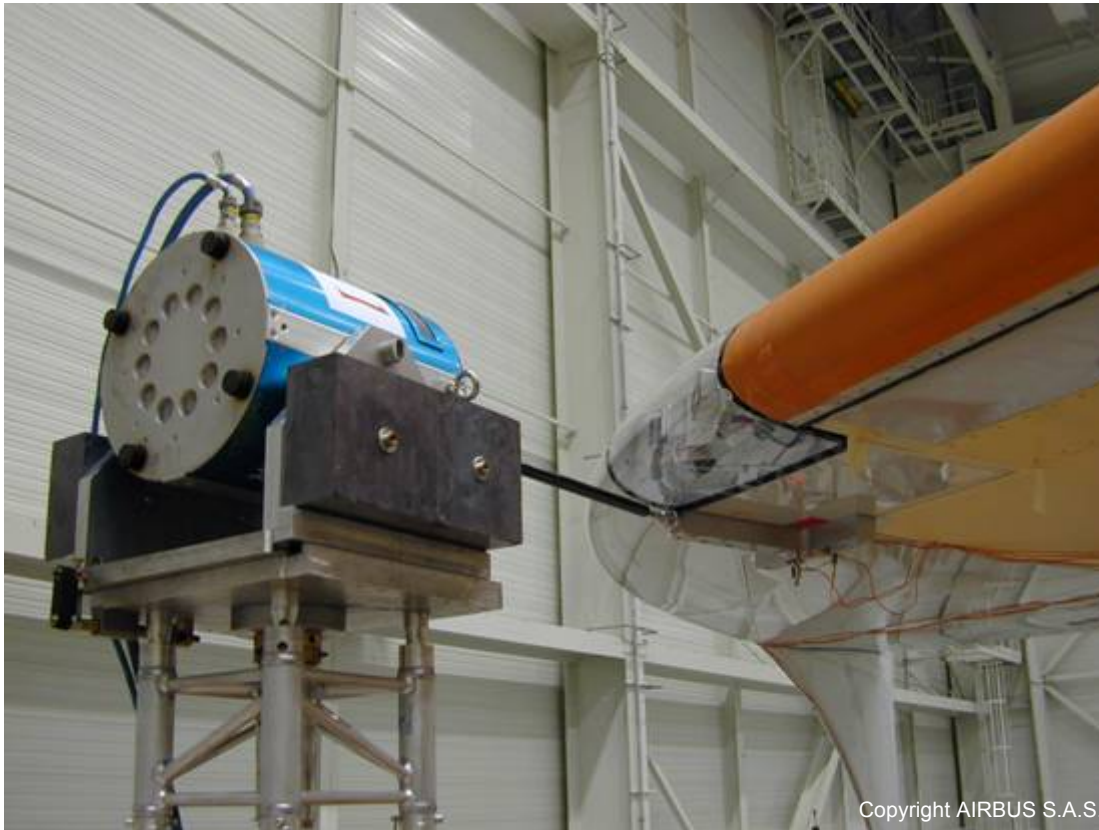
different accelerometer types



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Test Setup - Exciters



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exciter on a slip table at the wing tip



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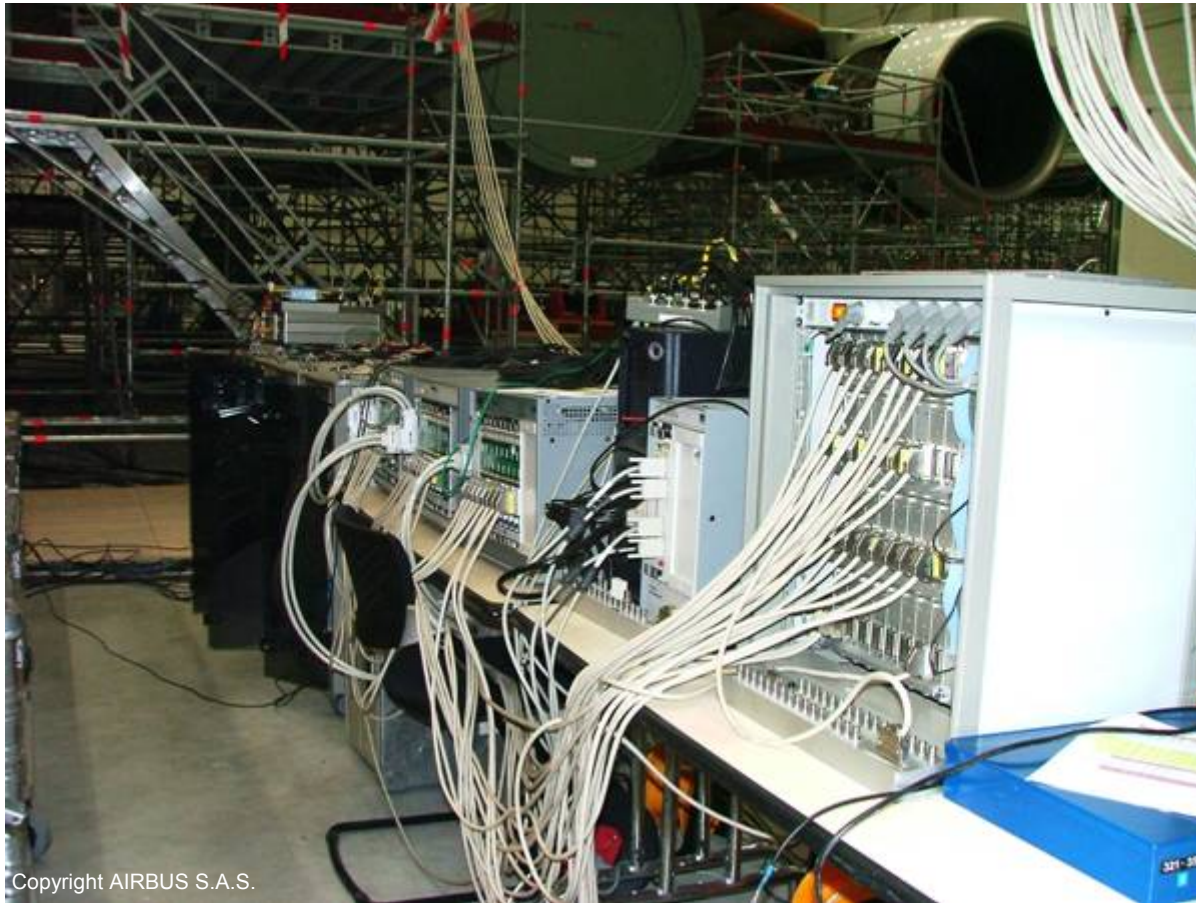
2000 N exciter



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Test Setup – VXI System



896 simultaneous data acquisition channels



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Test Setup – Measurement Container



A380 and mobile container



online analysis of measured data



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Test Performance

- ▶ Joint test performance of ONERA and DLR
- ▶ Test team:
 - ✧ 25 persons for test setup
 - ✧ 7 test engineers
 - ✧ 6 technicians
- ▶ Test period: 7 January to 8 February 2005
- ▶ Daily working hours from 7:00 to 22:00 in 2 shifts
- ▶ Test duration:
 - ✧ 5 days for test setup
 - ✧ 23 days for test performance
 - ✧ 1 days for dismantling



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Test Performance – Test Programme

- ▶ Aircraft vibration test
 - ✧ configuration 1: empty fuel tanks
 - ✧ configuration 2: filled fuel tanks
 - ✧ tests on control surfaces and flaps
 - ✧ identification of modal parameters
- ▶ Windmilling tests
 - ✧ excitation at the engines with high force levels
 - ✧ measurement of dynamic responses (FRF)
- ▶ Deck tests
 - ✧ excitation at the decks with inertia forces
 - ✧ measurement of dynamic responses (FRF)
 - ✧ identification of modal parameters



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Test Performance – New Developments

- ▶ Different boundary conditions:
 - ✧ aircraft on jacks (instead of low frequency suspension by air springs)
- ▶ Development and utilization of a jack safety device
 - ✧ surveillance of jack motions
- ▶ Notching of excitation forces
 - ✧ limiting aircraft accelerations
 - ✧ accounting for maximum exciter strokes
- ▶ Computation of FRF from virtual driving points for
 - ✧ symmetric excitation
 - ✧ antisymmetric excitation



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Test Performance – Excitation at the engine



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Test Performance – Vibrations of the wing



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Test Results

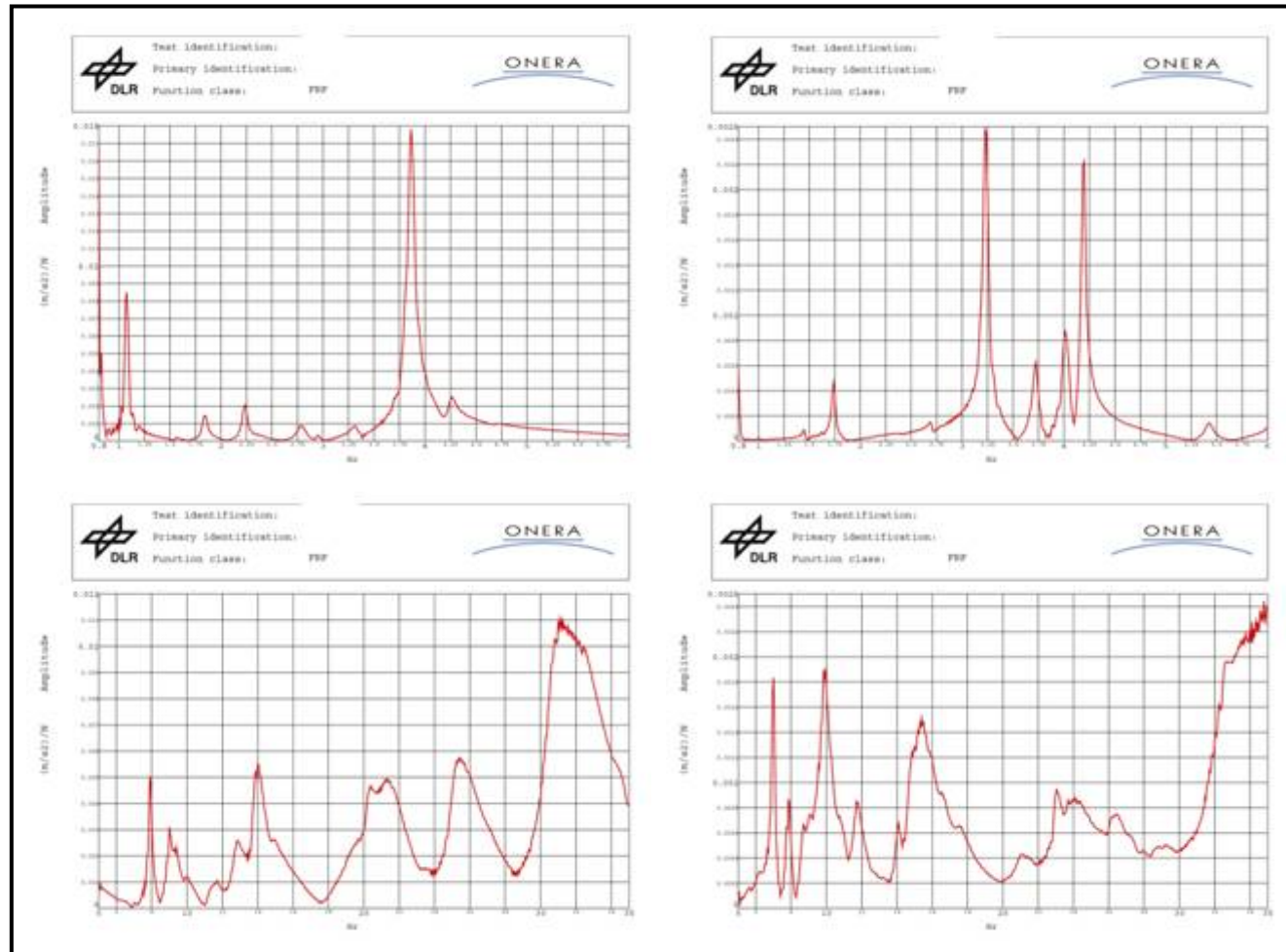
- ▶ Aircraft vibration test
 - ✧ 111 modes for configuration 1
 - ✧ 89 modes for configuration 2
- ▶ Windmilling tests
 - ✧ 38 sine sweep runs
 - ✧ 30020 measured FRF
- ▶ Deck tests
 - ✧ 19 sine sweep runs
 - ✧ 1520 measured FRF
 - ✧ 37 identified modes



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Test Results – Example for measured FRF

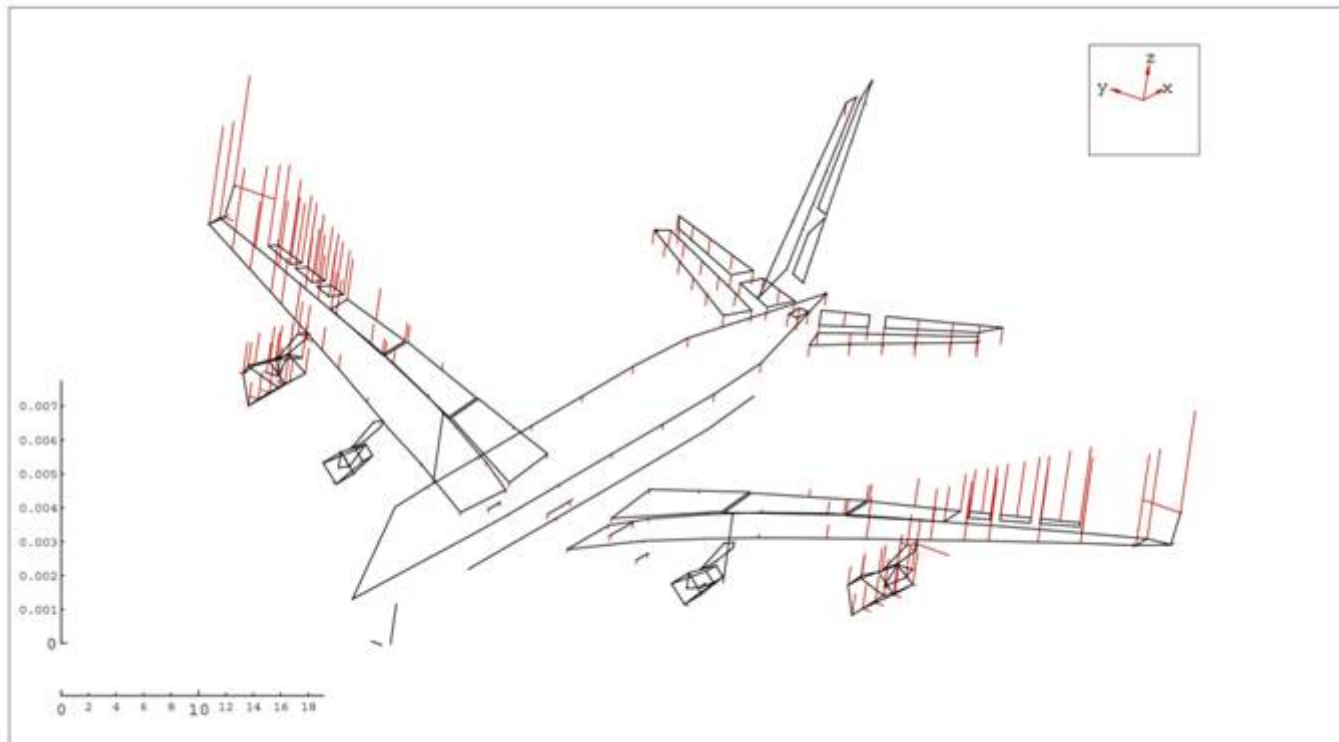




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Test Results – Example for measured modes (1)

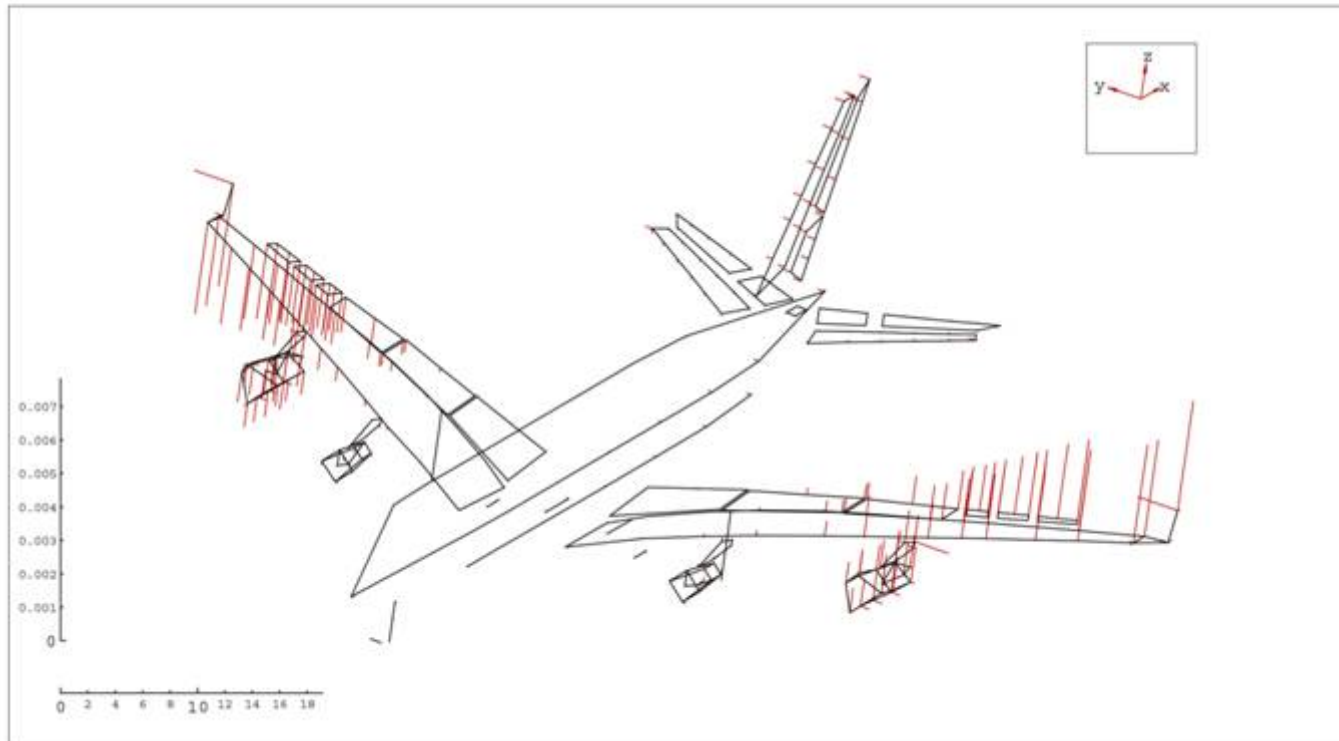




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Test Results – Example for measured modes (2)

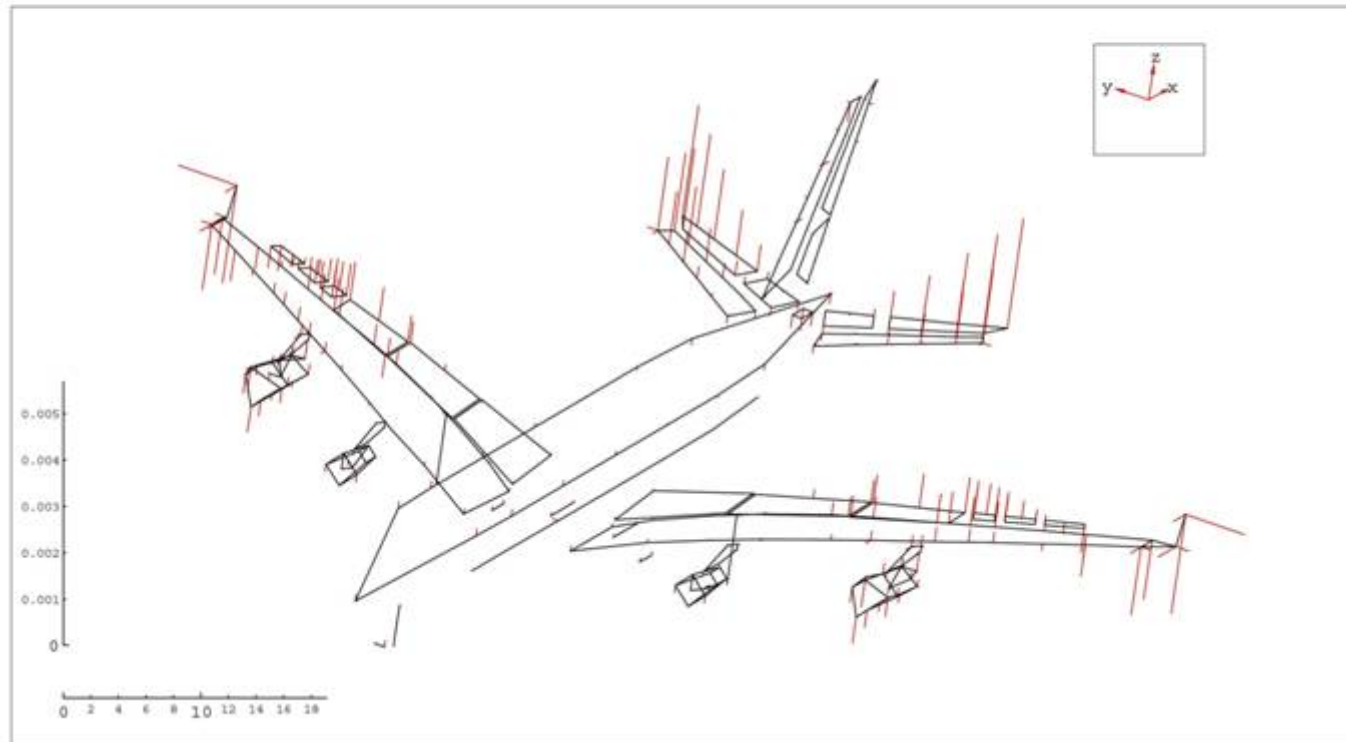




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Test Results – Example for measured modes (3)





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Summary and Conclusions

- ▶ Basics of Ground Vibration Testing
- ▶ Insight into Ground Vibration Tests on A380
- ▶ Next planned tests of ONERA and DLR:
 - ✧ A380-800 with EA GP7200 engines
 - ✧ Freighter version A380-800F
 - ✧ Stretched versions of A380 with longer fuselage (?)
 - ✧ Military Transport Aircraft A400M (?)
 - ✧ A350 (?)
- ▶ Application of GVT technology in astronautics
 - ✧ Satellites
 - ✧ Launcher / launcher components