DLR - Deutsches Zentrum für Luft- und Raumfahrt
Institut für
Aerodynamik und Strömungstechnik

DLR - German Aerospace Center
Institute of
Aerodynamics and Flow Technology

DLR Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

Methods for determination of dynamic derivatives and for simulation of maneuvering aircraft

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Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

Institute of Aerodynamics and Flow Technology

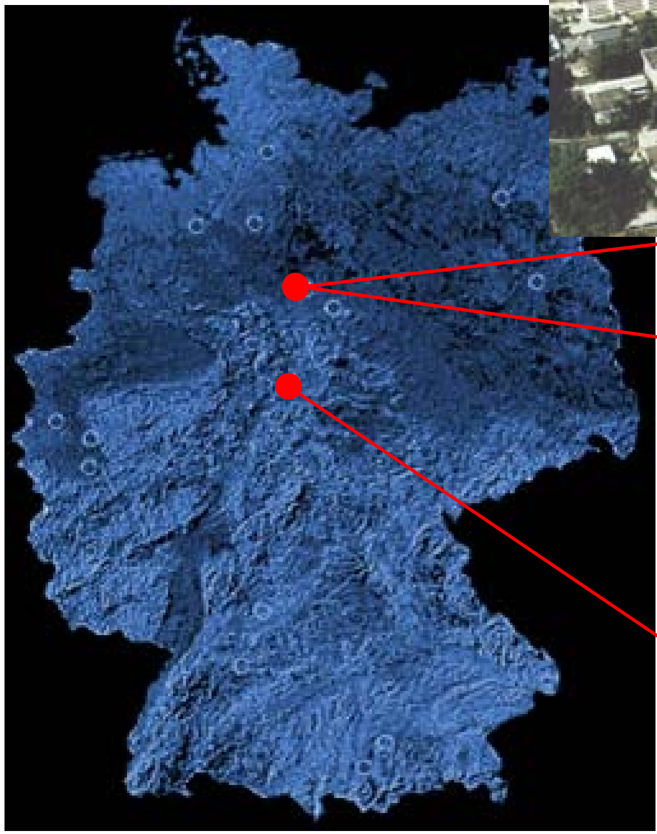
Mission:

Exploration, application, and assessment of advanced aerodynamics and flow technologies for efficient air and space transportation

Strategy:

Provision of research based aerodynamic and aeroacoustic knowledge, software, and services to aerospace industry

Locations

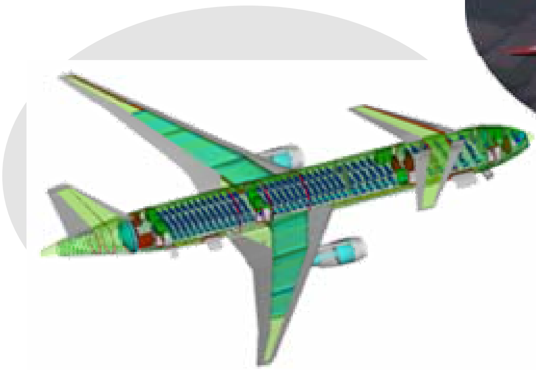


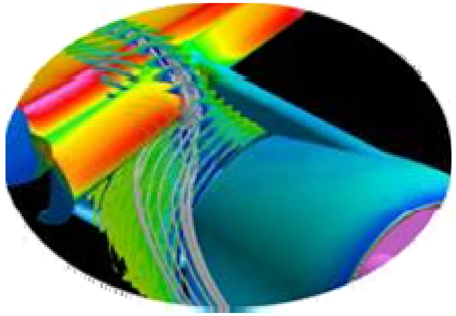
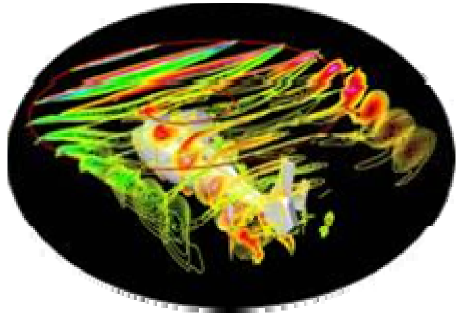
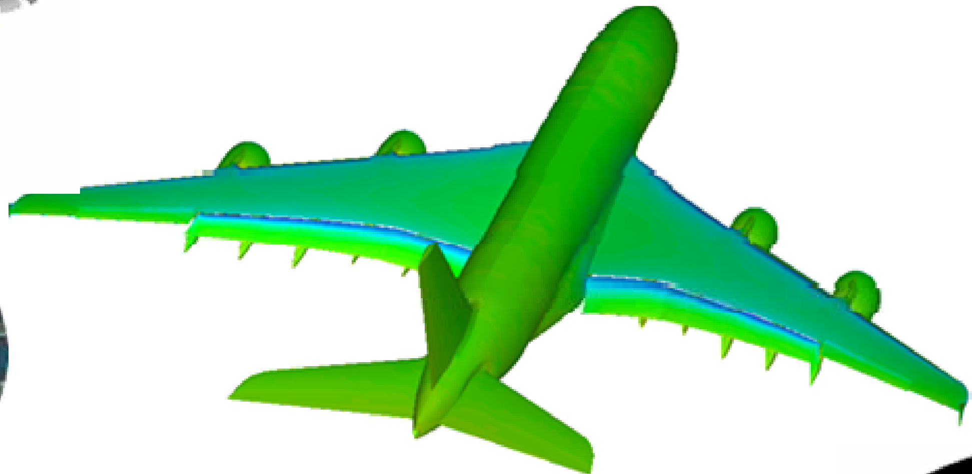
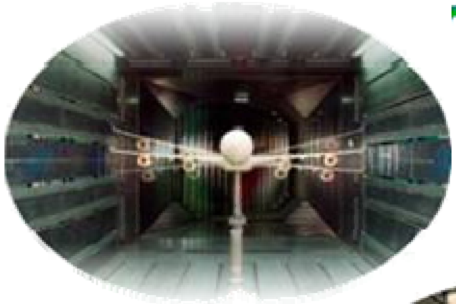
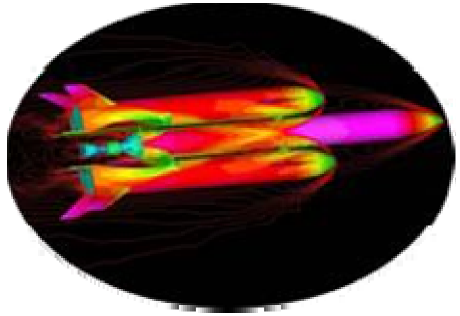
DLR - Braunschweig

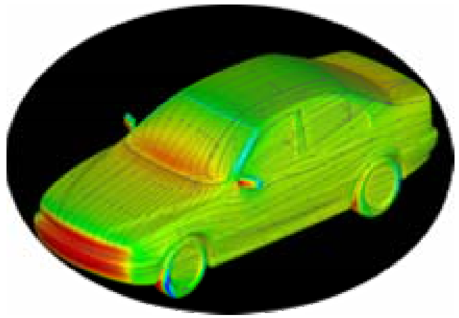
DNW-NWB

DLR - Göttingen u. DNW-TWG

Our Research Areas



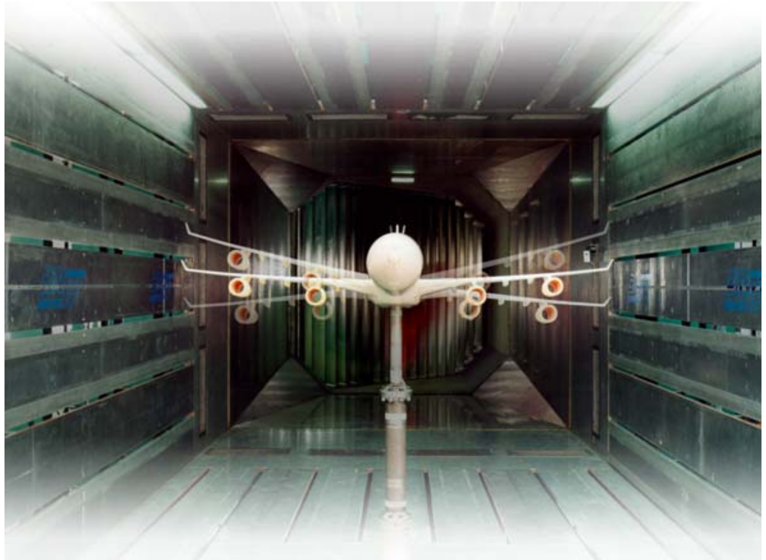
Prediction of Dynamic Derivatives

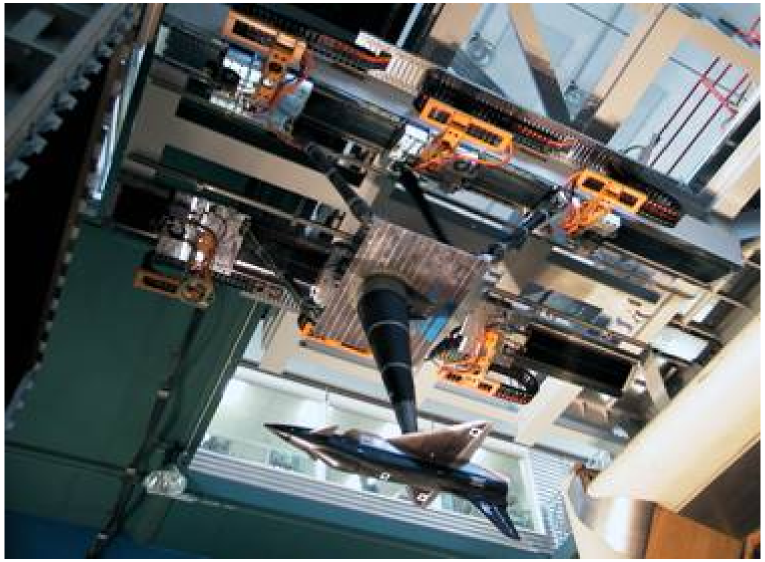
- Dynamic derivatives are required for flight mechanic simulation
- Structural loads are calculated by means of the dynamic derivatives
- Dynamic measurements are needed for validation and verification of computational dynamic codes.

DLR-Project SikMa

Simulation of complex Maneuvers

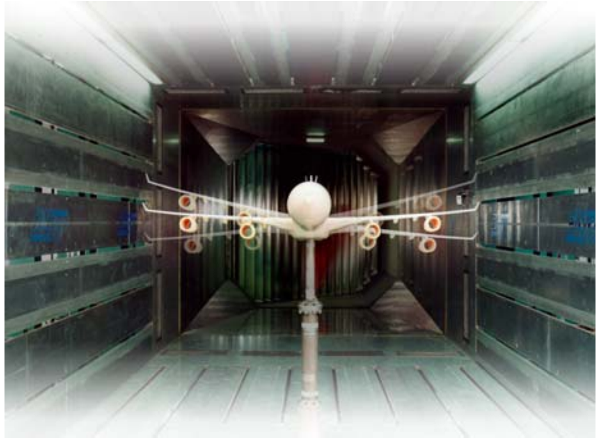
- Unsteady wind tunnel data for computer code validation





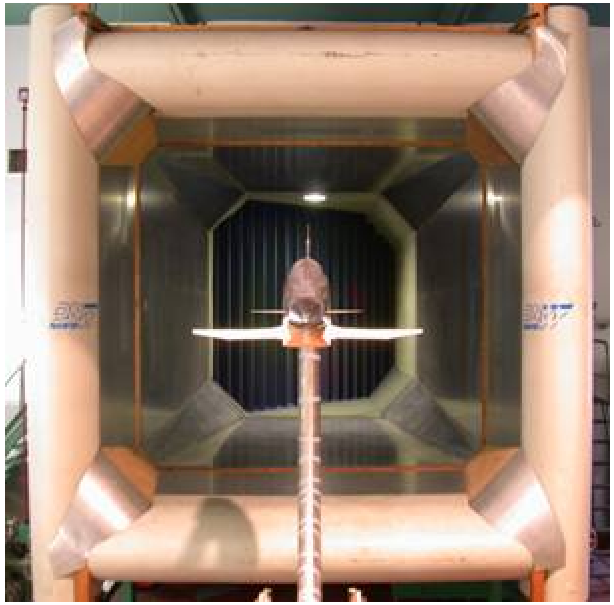
Type of unsteady maneuver simulations wind tunnel experiments

- Unsteady measurements of forces, moments, and surface pressure distribution
- Motion of wind tunnel models
    - Periodic movement
    - complete maneuver simulation
    - time accurate, time synchronized movement of the model and control devices
- Unsteady determination of the spatial model position



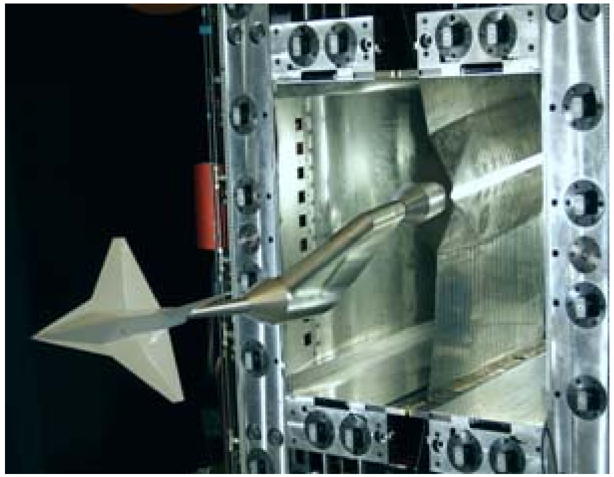
Wind tunnel facilities

Low speed wind tunnel Braunschweig (DNW-NWB)



- Test section 3.25×2.8m
- Ma number range: 0 ÷ 0.26 (for open test section)
- Re-number 1.8 x 10^6 (based on 0.1√s)

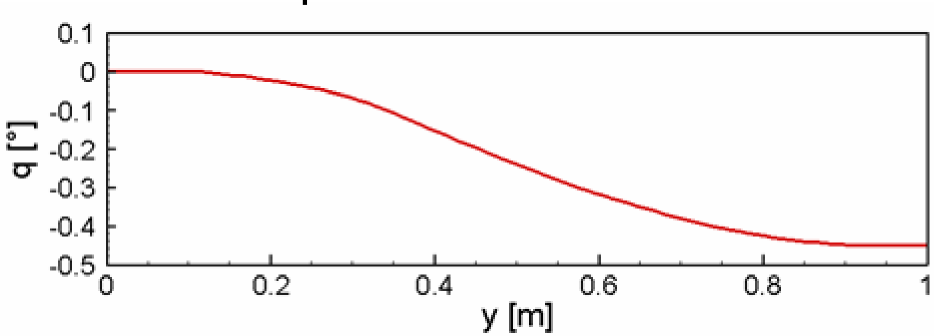
Transonic wind tunnel Göttingen (DNW-TWG)



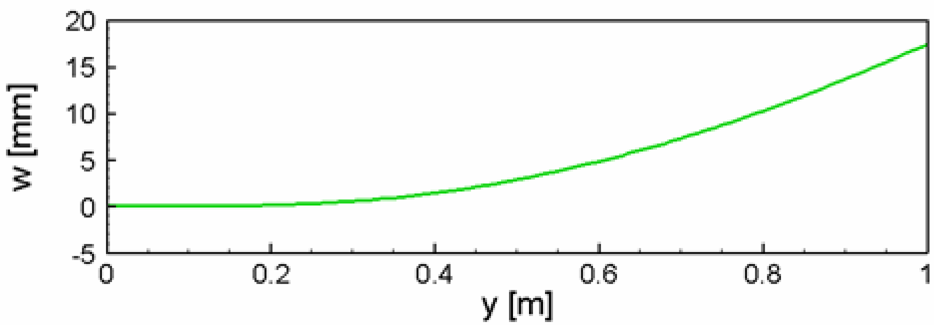
- Test section 1×1m
- Ma number range: 0.3 ÷ 1.2 (with perf. walls)
- Re-number 1.8×10^6 (based on 0.1√s)

Requirements of the wind tunnel models (1)

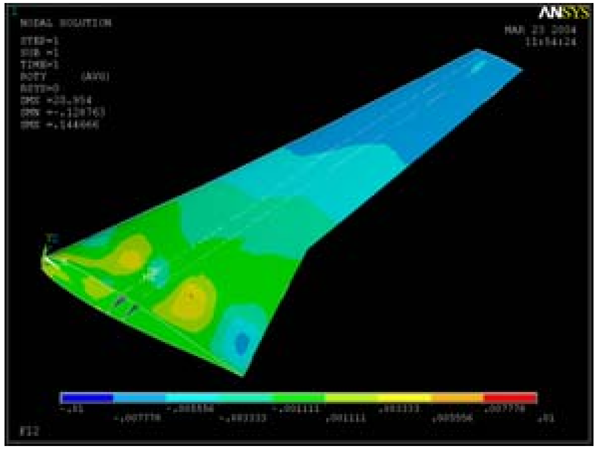
- The mass forces of the model must be as small as possible, in order to receive a favorable relationship from aerodynamic forces and moments to the mass and inertial forces.
- The elastic deformation should be as small as possible.



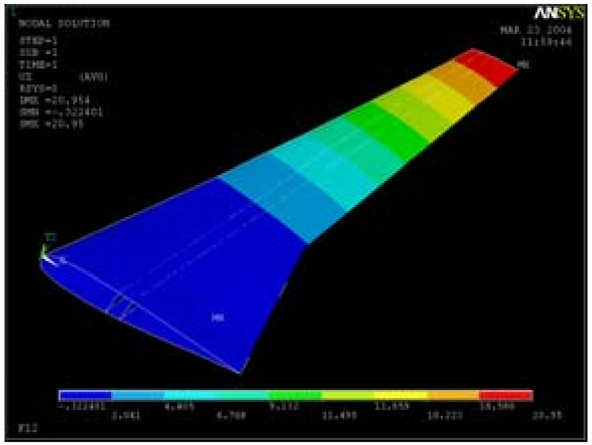
Deformation of the wing (angle of twist)



Deformation of the wing (bending)



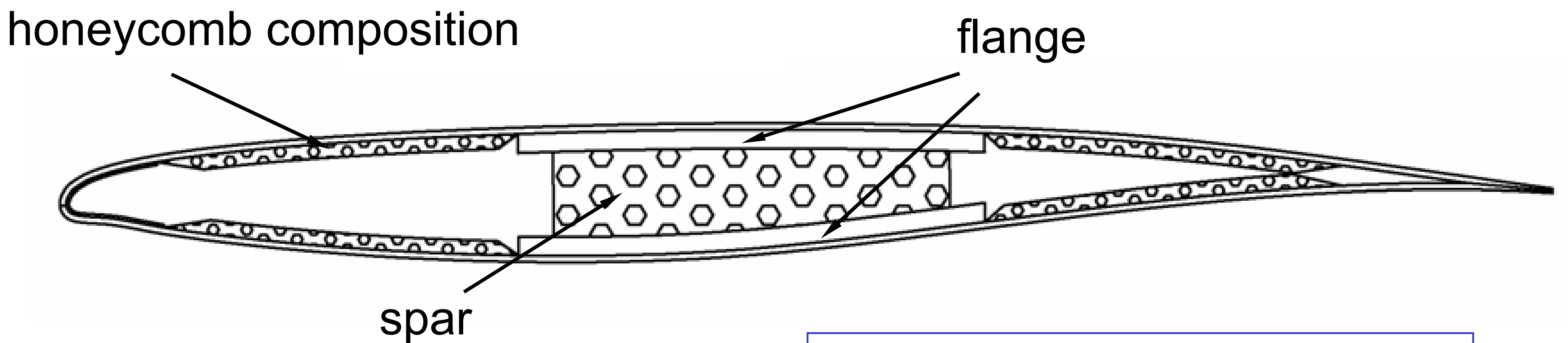
1.asymmetric Eigenmode



1.symmetric Eigenmode

Requirements of the wind tunnel model (2)

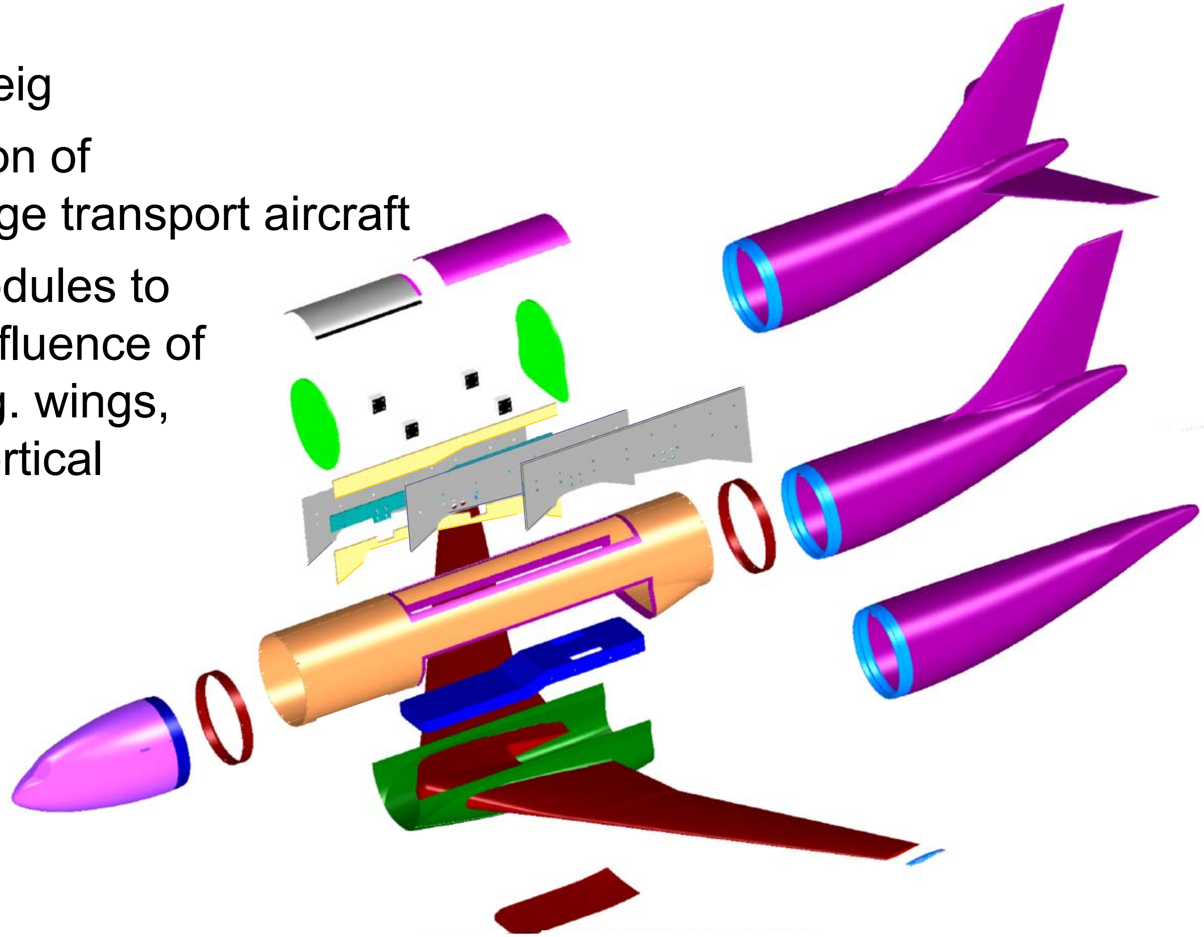
- The natural frequencies of critical modes of motion should clearly above 15 Hz.
- These constraints are met by a specifically developed, extremely light weight CFRP-Sandwich construction of the model. The weight of the model with a wingspan of 2 m can be held under 8 kg.



typical profile cross section

Wind tunnel models (1)

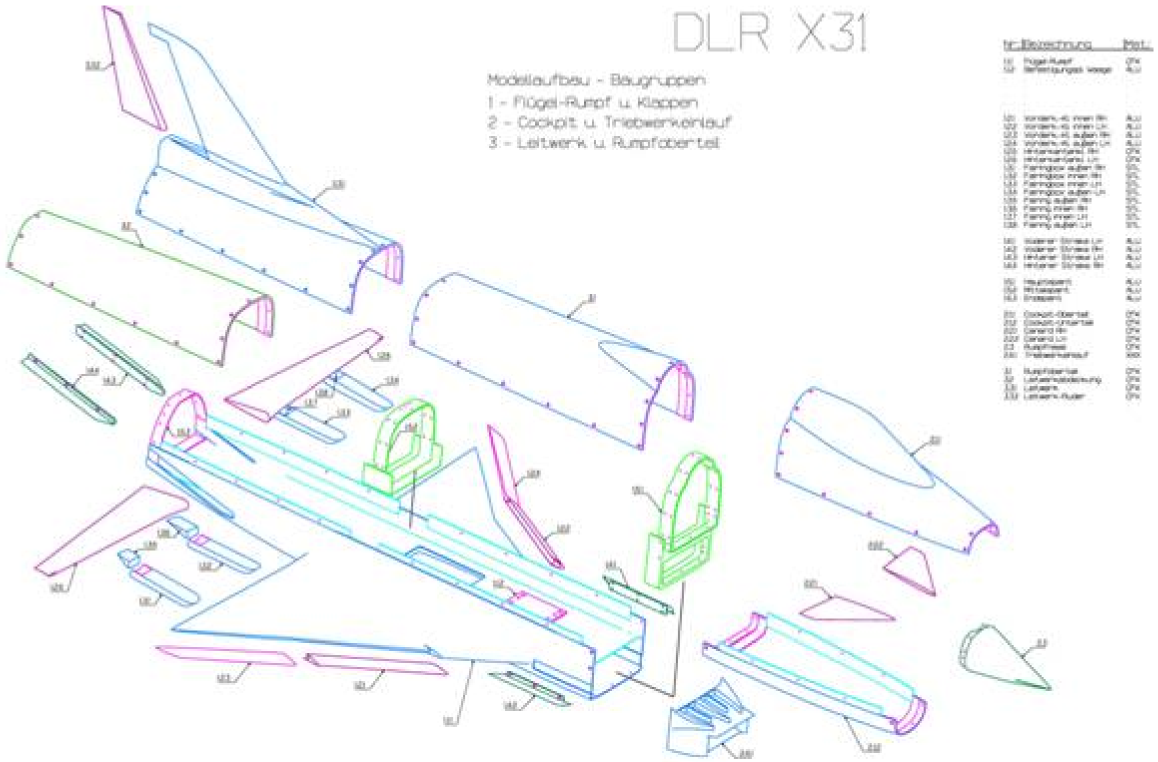
- Model design is done by the DLR work shops in Göttingen and Braunschweig
- F12 model for determination of dynamic derivatives for large transport aircraft
- The models are built in modules to allow the analysis of the influence of individual components (e.g. wings, winglets, horizontal and vertical stabilizers, etc.).
- CFRP model with a total weight of 12kg
- Internal 6-component strain gauge
- Steady and unsteady pressure sensors at the wing and tails



AIRBUS type wind tunnel model DLR F12

Wind tunnel models (2)

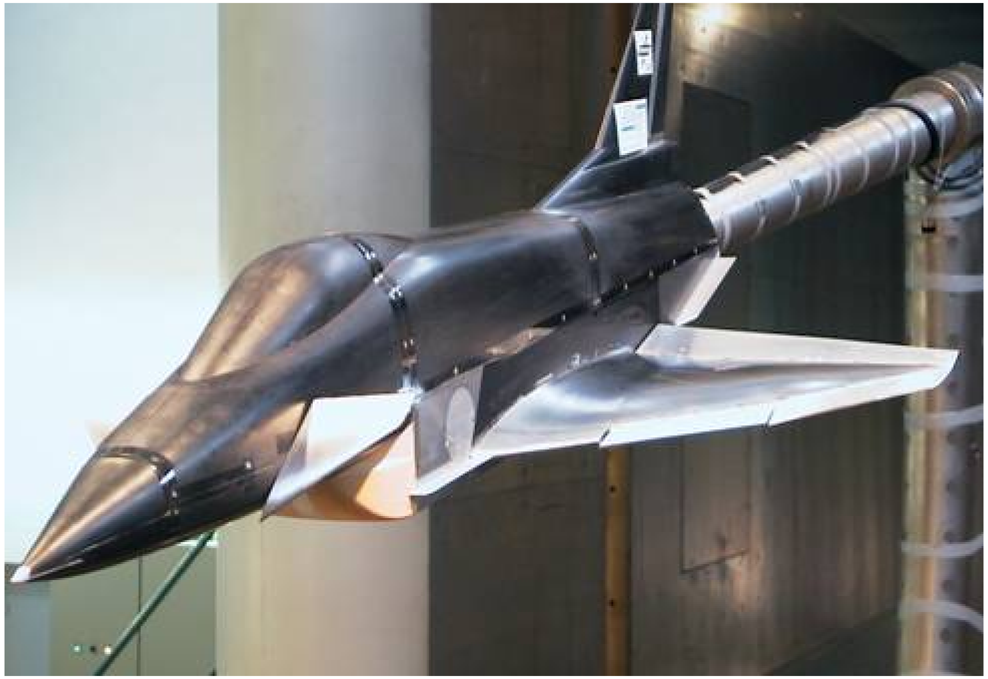
- X-31 CFRP model with a total weight of 10kg
- Manually movable control devices
- Internal 6-component strain gauge
- Piezo-resistive pressure sensors for measuring the unsteady pressure distribution at 60% and 70% chord length
- Internal 64 channel 16 bit telemetric system for data transfer
- Maneuver simulations via MPM-System in DNW-NWB



X-31 1:7 scaled CFRP-model with control devices

Wind tunnel models (3)

- X-31 model with remote controlled canard, leading- and trailing-edge flaps and ruder
- CFRP fuselage, steel wing and aluminum made control devices
- 8 internal servo engines for control device movement
- Internal 6-component strain gauge
- Piezo-resistive pressure sensors for measuring the unsteady pressure distribution at 60% and 70% chord length
- Internal 64 channel 16 bit telemetric system for data transfer
- Control device velocity up to 200°/s
- Maneuver simulation via MPM-System in DNW-NWB



X-31 1:7 scaled Remote-Control-Model

Wind tunnel models (4)

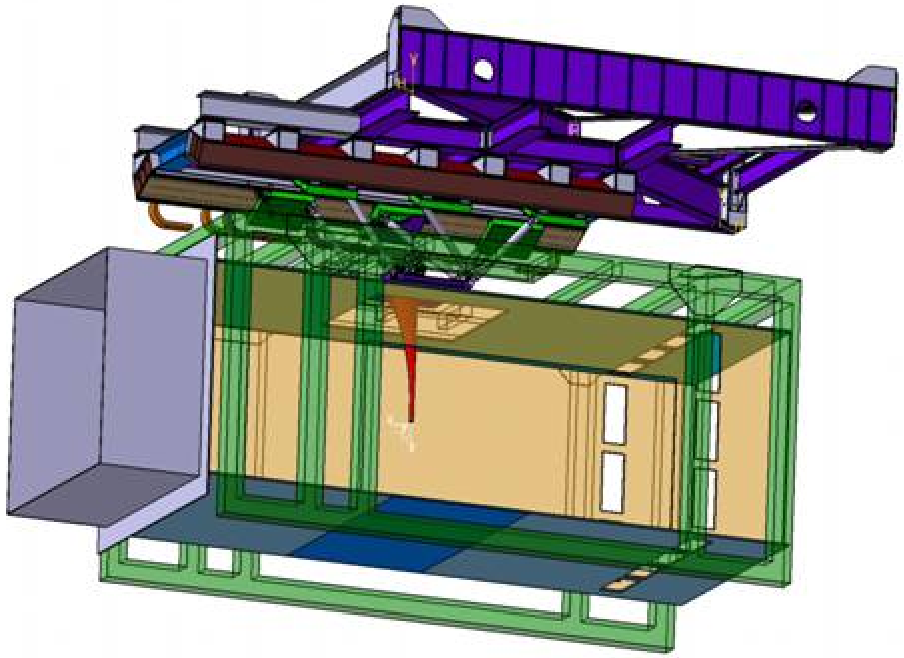
- 65°-swept cropped delta wing configuration with remote controlled movable trailing-edge flaps
- Internal 6-component piezo-balance
- Piezo-resistive pressure sensors at 60% and 80% chord length
- Control device velocity up to 300°/s
- Guided and control device forced free-to-roll maneuver around longitudinal axis via roll rig in TWG

Delta-wing model with trailing-edge flaps

Maneuver simulation in the wind tunnel (1)

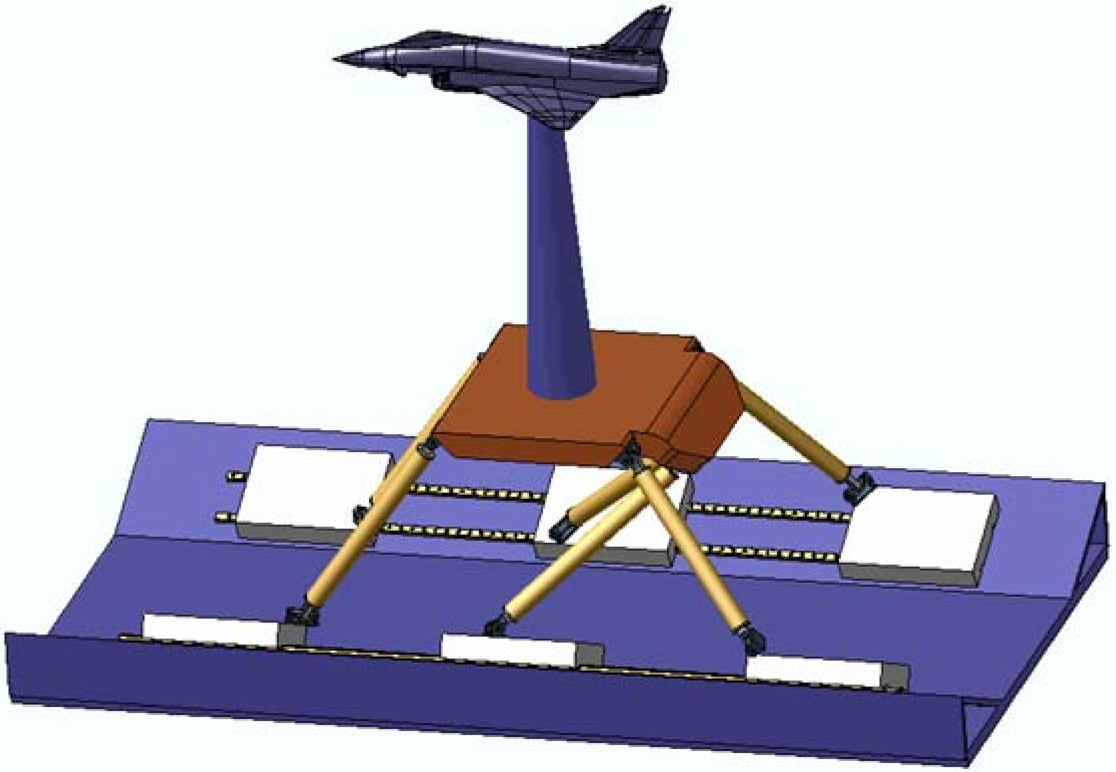
- Synchronized, dynamic similar movement of the model and the control devices via **Model Positioning Mechanism (MPM)** of NWB
- 6 DoF parallel kinematics
- Use of six constant length rods made from CRP (small masses, high stiffness 1400N/µm)
- Use of linear electromagnetic motors (highest accuracy and highest dynamic)
- Operational since December 2004 DLR has applied for a patent on this device

Maneuver simulation in the wind tunnel (2)

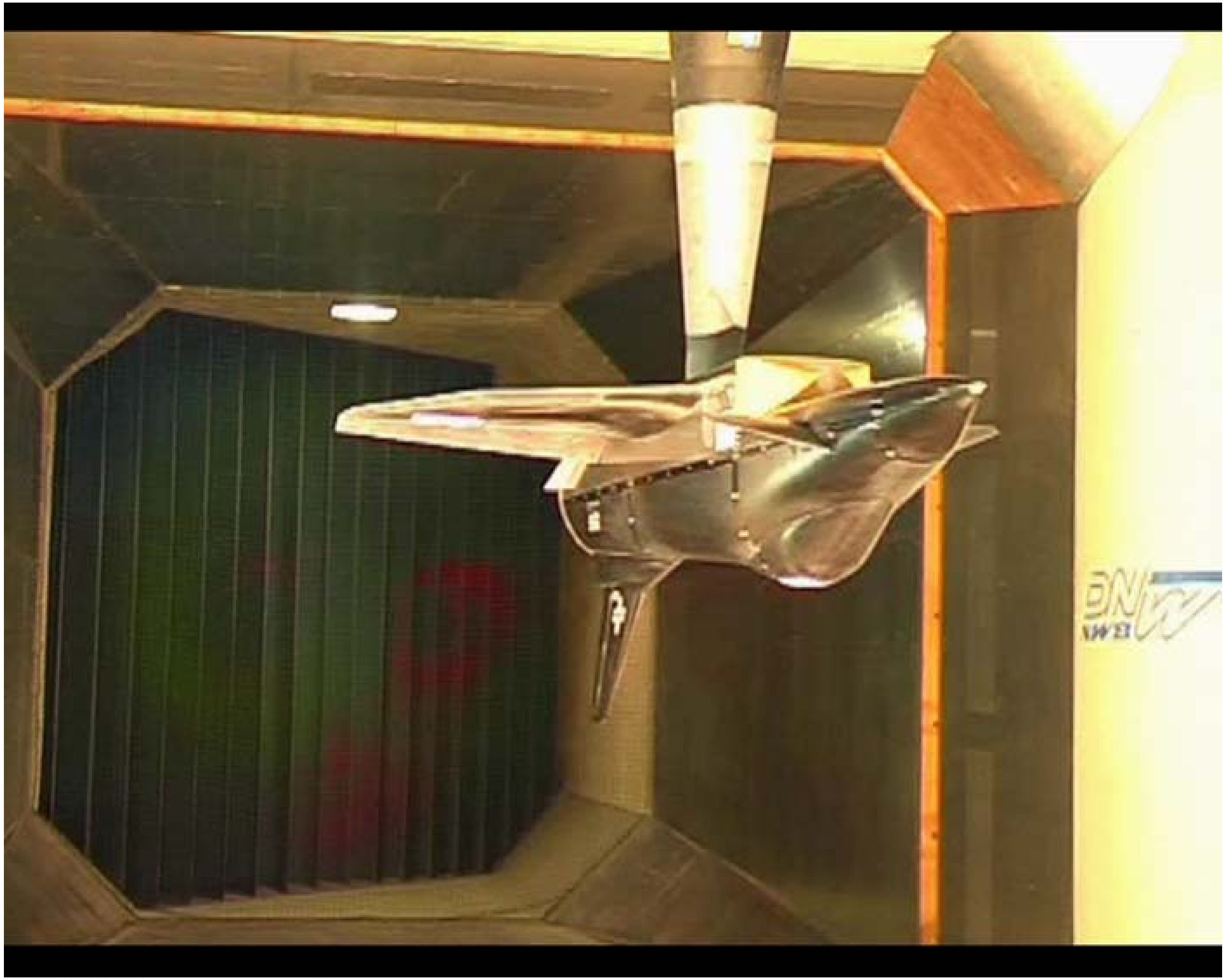


Model Positioning Mechanism (MPM)

Maneuver simulation in the wind tunnel (3)



Maneuver simulation in the wind tunnel (4)



Thank You for Your Attention

For further information you will find the DLR and DNW at

Hall 2
Stand 2U/D19

Hall 1
Stand 1U/A14