

**Arbeiten des DLR Instituts für Aeroelastik  
für HALO im Rahmen des DLR EB  
HALO User Meeting am 24. 5. 2006 in  
Oberpfaffenhofen**



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

# Übersicht

- Wo stehen wir ?
- Was ist zu tun ?
  - HALO STC (DLR)
  - Bauvorschriften
  - Erfahrungen
  - Randbedingungen
- Wie gehen wir vor ?
- Was kostet das ?

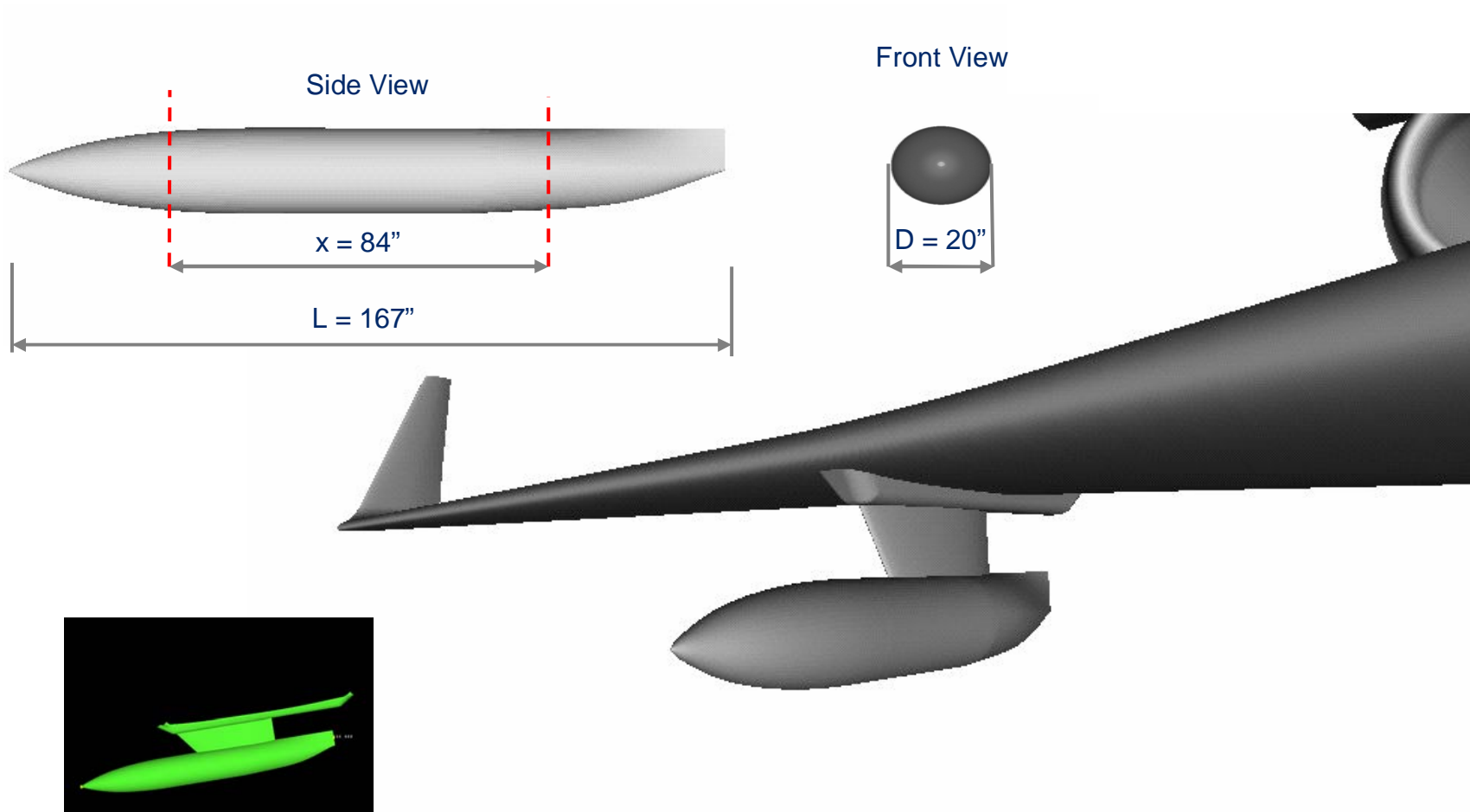
# Wo stehen wir ?

- 5.-7.5.04 OP
- 20.8.04 BS
- 28.9.04 BS
- 6.4.05 BS
- 20.5.05 BS Briefing LBA/DLR für HALO-Meeting
- 25./26.5.05 Specialists Meeting at GAC (Gläser, Kommallein, Horstmann, Altenkirch, Piening, Kießling)
- 28./29.9.05 PDR Interior Wing Modification Review with DLR and RUAG (Piening, Kießling)
- 5./6.11.05 Expert Meeting at GAC (Gläser, Piening, Schwochow, Kießling) => Review of Data, Travel Report
- 16.-20.1.06 Manufacturing Meeting at OP (DLR and RUAG)
- **5.4.06 Meeting in GÖ**
- 11.4.06 Meeting in BS
- 8.-12.5.06 PDR at GAC
- 24. 5. 06 User Meeting in OP
- ?.6.06 Meeting at GAC

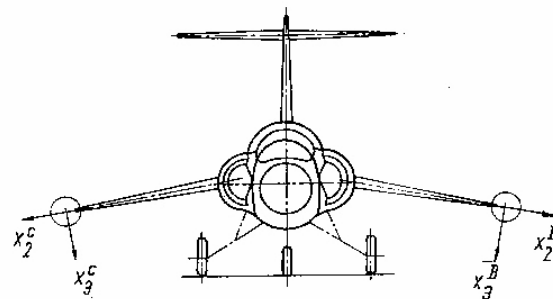
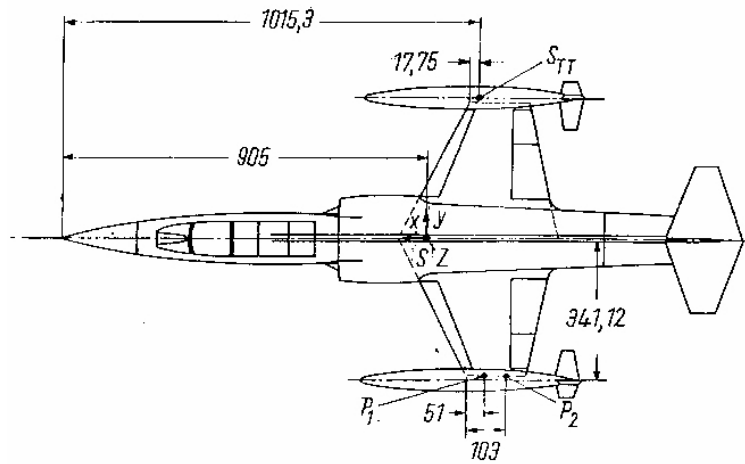
# HALO STC (DLR part)

- Supplemental Type Certificate (STC) for Customer Furnished Equipment (CFE)
  - Wing stores (preliminary specified)
    - 3 stations per side
    - provisions for stores covered by GAC STC (ASC 128)
  - Belly Pod + Ventral Fin
  - Equipment in winglets (winglet hard points)
  - ...
- Subcontracts for design and manufacturing
  - aeroelastic consulting for subcontractors / FB-OP

# High Altitude Long Range Research Aircraft GAC20-M1 Wing Pod

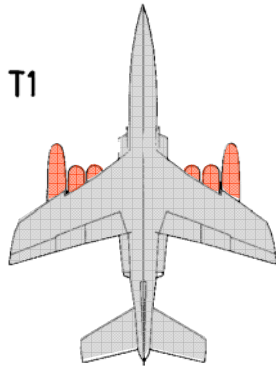


# AGARD “Programme of Flutter and Vibration Analysis of the F 104 G Aircraft” (1966-1969)

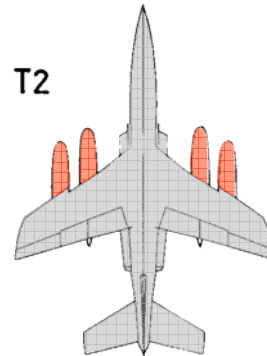


# GVT on Alpha-Jet in Multiple Store Configurations (1974 at Dornier, Oberpfaffenhofen)

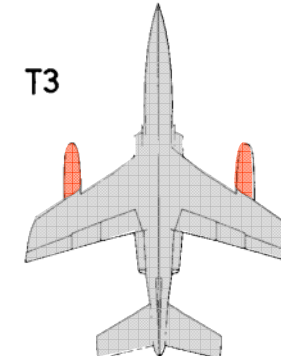
**Outboard:** fuel tank, empty  
**Inboard:** „twin“ store



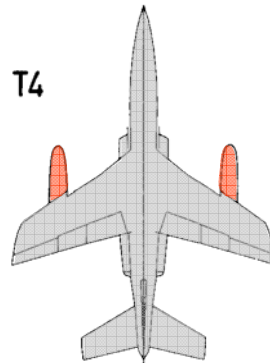
**Outboard:** fuel tank, empty  
**Inboard:** M116 A2 store



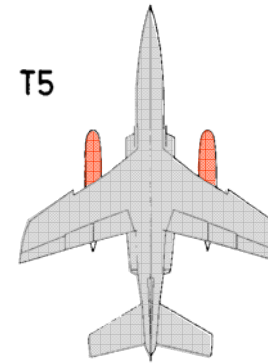
**Outboard:** fuel tank, 50% full  
**Inboard:** --



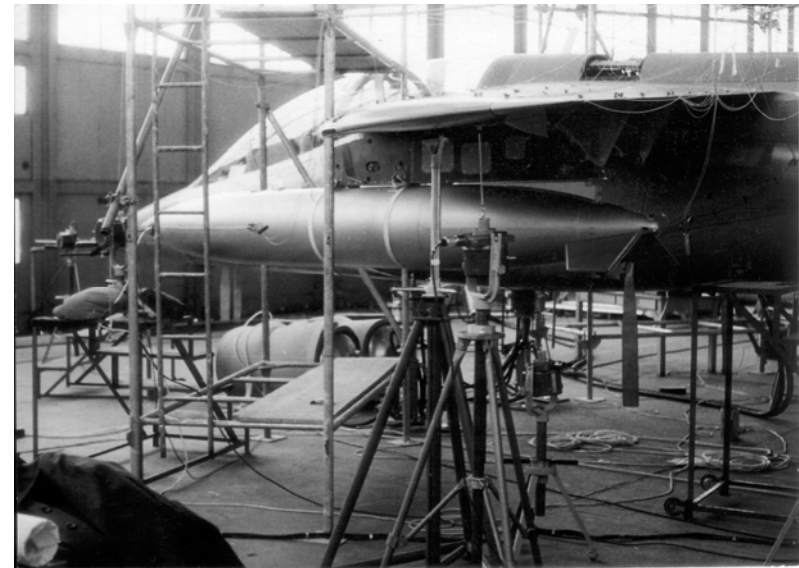
**Outboard:** fuel tank, 100% full  
**Inboard:** --



**Outboard:** --  
**Inboard:** M116 A2 store



# GVT on Alpha-Jet in Multiple Store Configurations



# Large Ground Vibration Test Activities of DLR AE



**DLR/ONERA cooperation**

**AIRBUS planes**

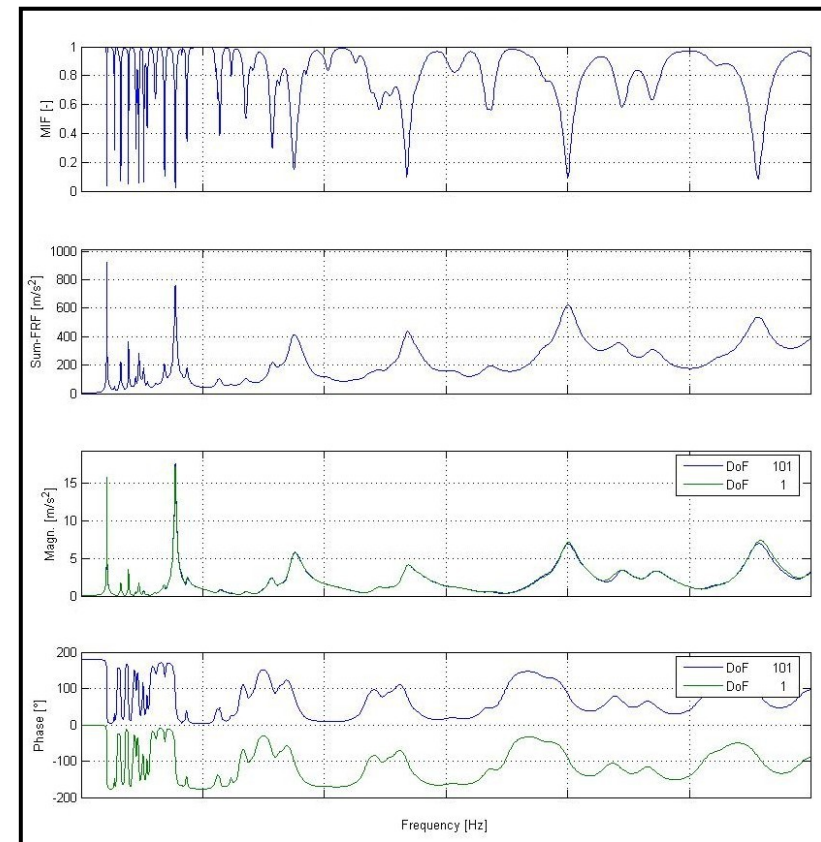
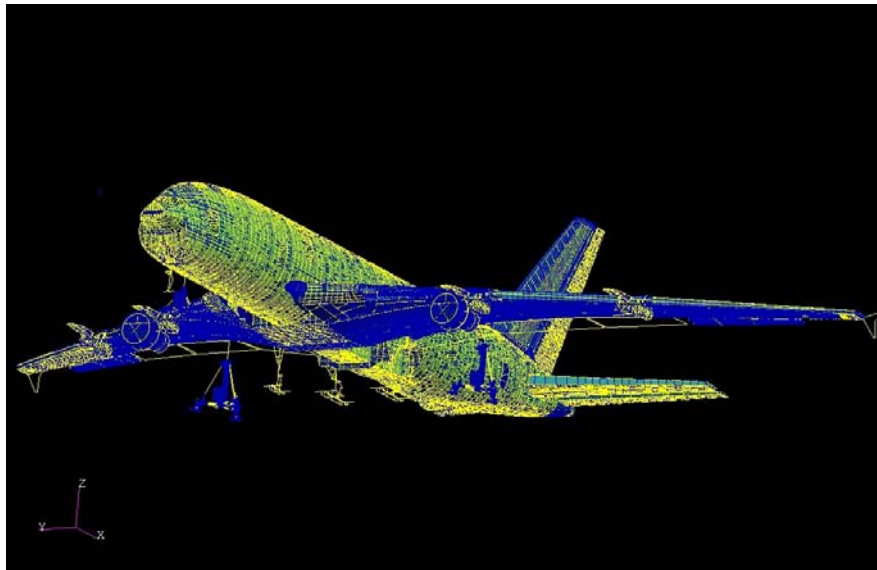
- **A318**
- **A340-300/500/600**
- **A310-MRTT**
- **A380-800/800F**



# A380 Test Preparation

Numerical analysis with FE-model

- High modal density: 5 modes/ Hz
- Calculation of MIF and FRF for typical exciter configurations
- Planning of exciter positions



MIF: Mode Indicator Function

FRF: Frequency Response Function

# Basic structure of AE work packages

- Data collection and support
- Certification requirements
- Ground Vibration Test
- Store Rig Test
- Structural Analysis
- Aerodynamic Analysis
- Aeroelastic Analysis
- Flight Vibration Test Support

# Basic alternative approaches

## 1. Certification of each new configuration for its own

- Ground Testing of each new configuration
- Flutter Analysis based on measured modes
- Flight Testing
- **Less effort for one configuration, but much more effort for many configurations**

## 2. Certification of specified “standard” configurations plus database for future analysis of special configurations

- Ground Testing of basic configurations
- Derivation of FE model, validation by tests
- Flutter analysis based on measured modes and FE model for use of “standard” equipment with specified tolerances
- Investigation of new configurations by validated FE model and/or modal correction methods
- **More initial effort, less effort for new configurations and requirements**

# Estimate of HALO GVT

- modes per configuration 55 + 10 up to 50 Hz
- + 8 +2 up to 60 Hz
- about 80 modes (symmetric and antisymmetric) including rigid body modes
  
- Measurement of 4 configurations \* 80 modes = 320 modes
- 4 days per configuration (10 hour shifts)
- typical AE team: 3 scientists, 2 engineers, 1 technician
- 21 days (3 weeks) for complete test

# Important Wing Store Data

- Pods and Probes
  - mass range (500, 1000, 1500 lbs including mount system)
  - C.G. range (0" to 42.5" aft of front spar = wing elastic axis)
  - radius of gyration range (?)
  - flexibility (?)
- Hanger Beam
  - mass
  - flexibility
- Rack (Standard Mount)
  - mass
  - flexibility
- Pylon & Fairing
  - mass
  - flexibility



# Proposal for test program and analysis

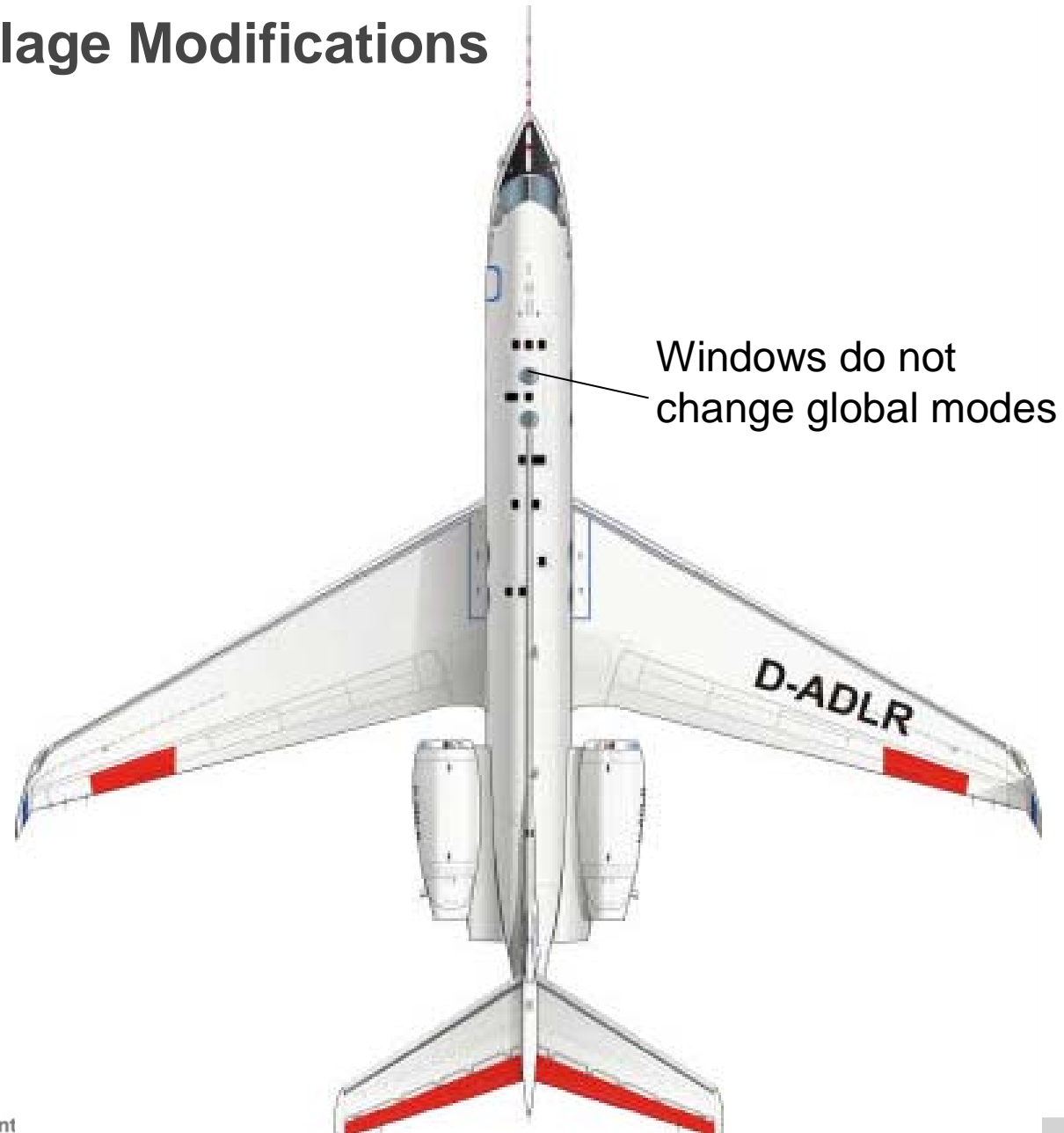
- GVT
  - only airframe modes, no emphasis on control system modes
  - no local modes except STC relevant (pods, etc.)
  - nose boom should be dealt with separately
  - frequency range up to 60 Hz (global up to 50 Hz) to cope with modal correction analysis requirements
  - suspension modes below 1 Hz (use of DO-728 suspension)
  
- no failure cases considered relevant for DLR STC (except pod attachment)

# Winglets

large winglets  
equipment installation



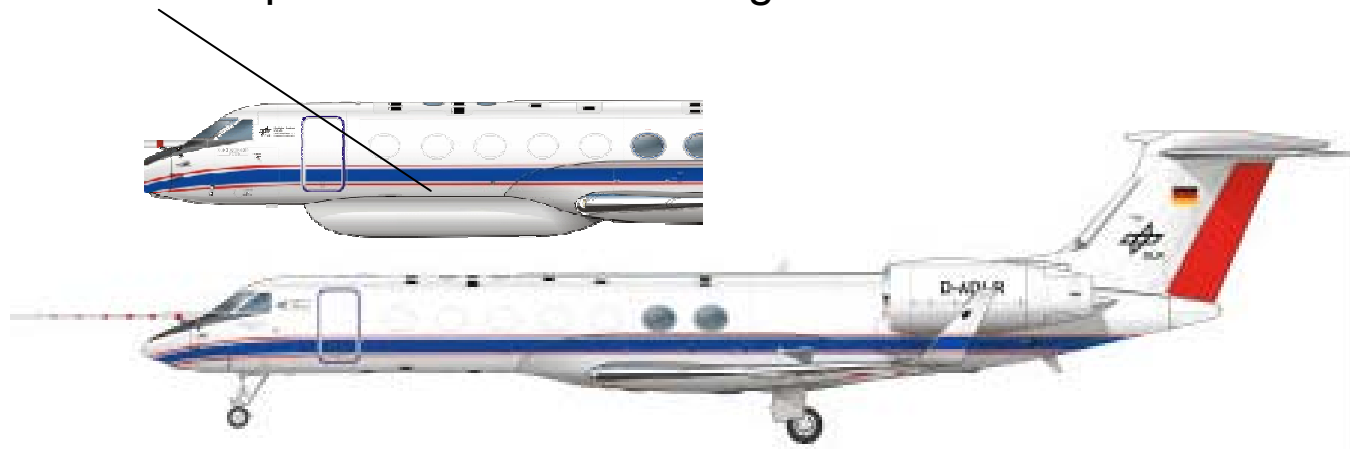
# Fuselage Modifications



# Belly Pod



12 attachment points at bottom fuselage



# Possible Approach for HALO Modifications

## ➤ **Ground Vibration Testing**

- Complete aircraft: clean wing and 3 pod configurations
- Store Rig Test for properties of hanger beam, pylon, pod
- Focus on wing and modifications
- Output: Eigenmodes with eigenfrequency, modal damping, and generalized mass

## ➤ **Computational Model Updating**

- Finite element model adjusted to GVT results
- Emphasis on wing/pylon/pod modeling (attachment)
- Output: Improved finite element model for flutter analysis of pod configurations

## ➤ **Aerodynamic Model**

- ZAERO aerodynamics, possibly TDLM AICs
- CFD calculations for correction
- State Space Model

## ➤ **Aeroelastic Analysis**

- ZAERO g-solution
- Gust loads?

## ➤ **Flight Test Support**

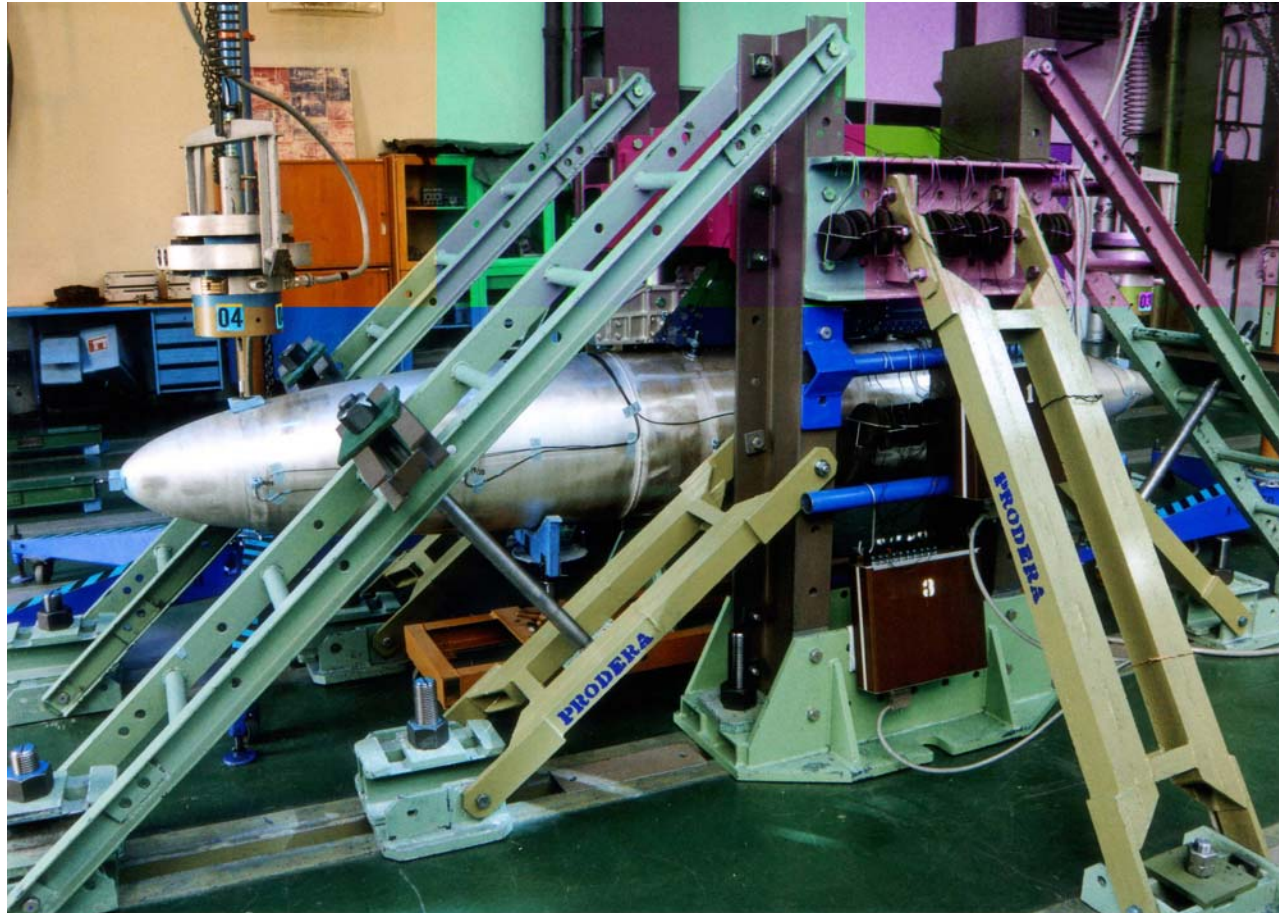
- Analysis Support
- Equipment (specification)
- Test support (quick look, test data analysis)

# GVT Pickups, Excitation, Evaluation

- 74 wings
  - 16 winglets
  - 36 attachment points
  - 36 stores
  - 9 landing gear
  - 16 engines
  - 40 HTP
  - 22 VTP
  - 43 fuselage
  - 4 noseboom
  
  - 296 in total
- multi-point excitation
  
  - evaluation of FRFs (LMS and inhouse software)
  
  - phase resonance method for tuning important modes
  
  - accuracy for model updating (Remark: no basic FE model available)



# Pod Rig Test



Courtesy: VZLU, Prag

# Conclusion

## Proposed:

- **Certification of specified “standard” configurations plus database for future analysis of special configurations**

## Efforts:

- **Initial activity**  
allowing use of specified “standard” equipment,
- **Activity on demand**  
for analysis of additional “special” configurations

## Next steps after acceptance by HALO project management:

- **Preparation phase including**
  - **concept presentation to certification authorities**
  - **specification of “standard” equipment**