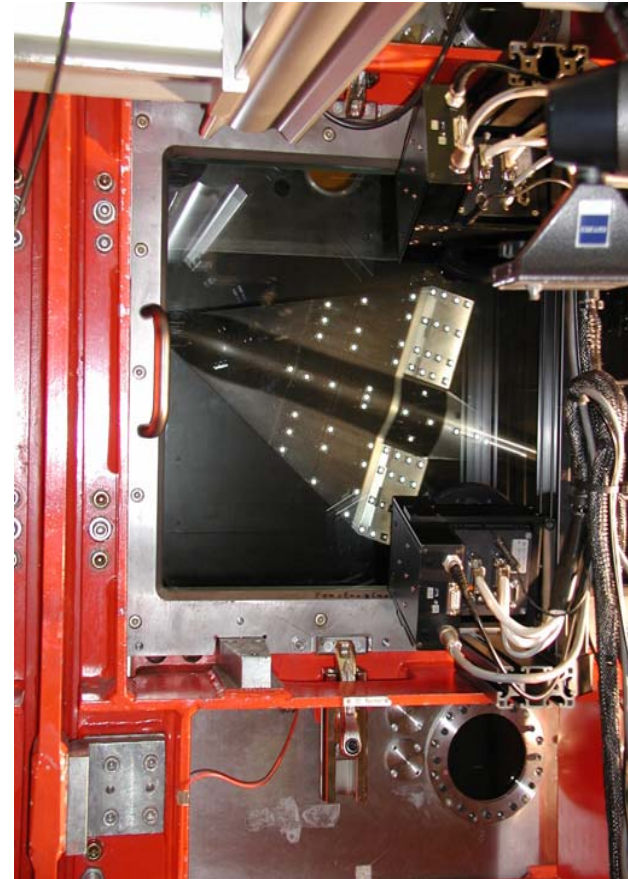


High Speed Wind Tunnel Testing:  
3D Non-Contact Position and Deformation  
Measurement of a Delta Wing Model at  
Transonic Mach Numbers

Aerospace Testing Expo 05

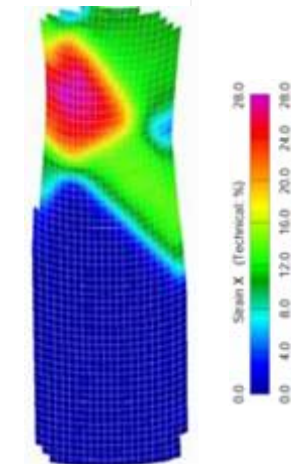
Dipl.-Ing., M.Sc. (PSU) Oliver Erne, GOM  
Dr. Burkhard Gölling, DLR (Airbus)

04/2005



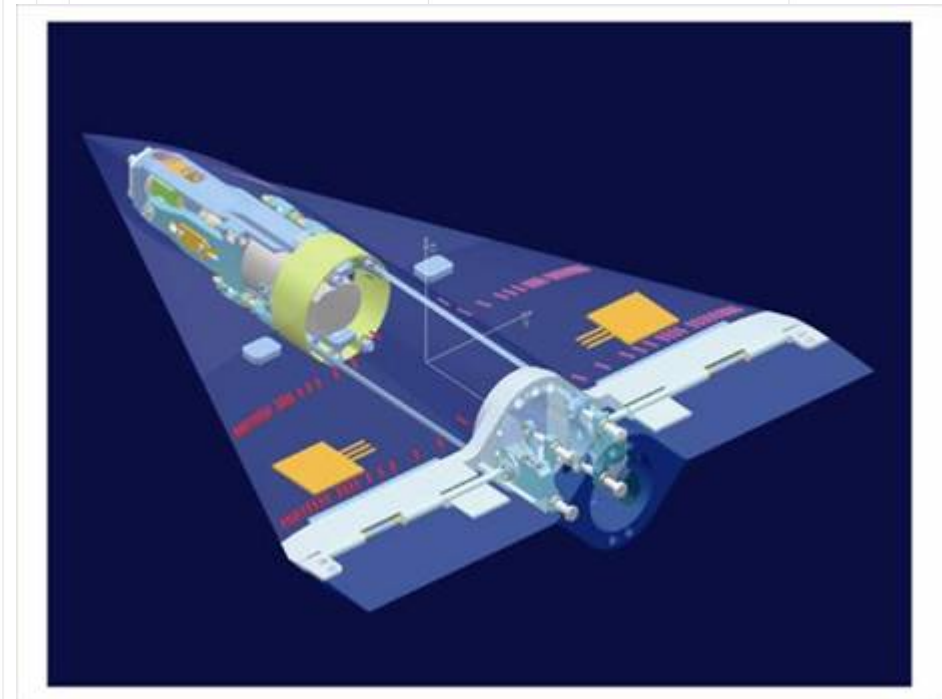
## About GOM:

- Development, Production and Distribution of Optical 3D Measuring Techniques
- Headquarter: Braunschweig, Germany
  - 5 Offices in Europe
  - 30 sales technical partners worldwide
- Fields of Expertise:
  - Digitizing, Scanning, Quality Control (ATOS)
  - Coordinate Measurement, Photogrammetry (TRITOP)
  - Deformation measurement
    - Full Field (ARAMIS, ESPI)
    - Points (TRITOP Def., ARGUS, PONTOS)



## About the project:

- Aerosum model (DLR, SikMa)
- Aerodynamic simulation
- Investigations of rolling instabilities
- Interest:
  - Mechanical behavior of the model in a transonic wind tunnel
  - Elastic deformation of model and roll rig
  - Dynamic measurements



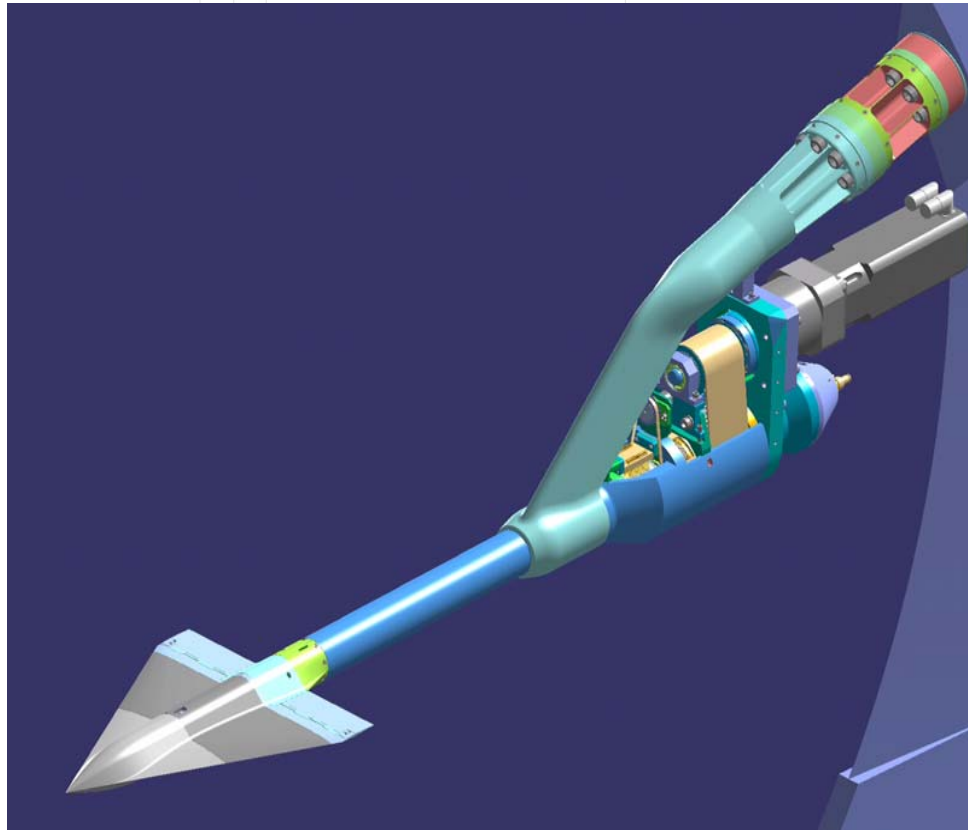
## Goal:

- Position measurement
  - With/without wind load
- Deformation measurement
  - Dynamic movements
- Requirements for measurement system
  - 3D
  - Non-contact
  - Glass window
  - Precise
  - Fast
  - >40 Measurement positions



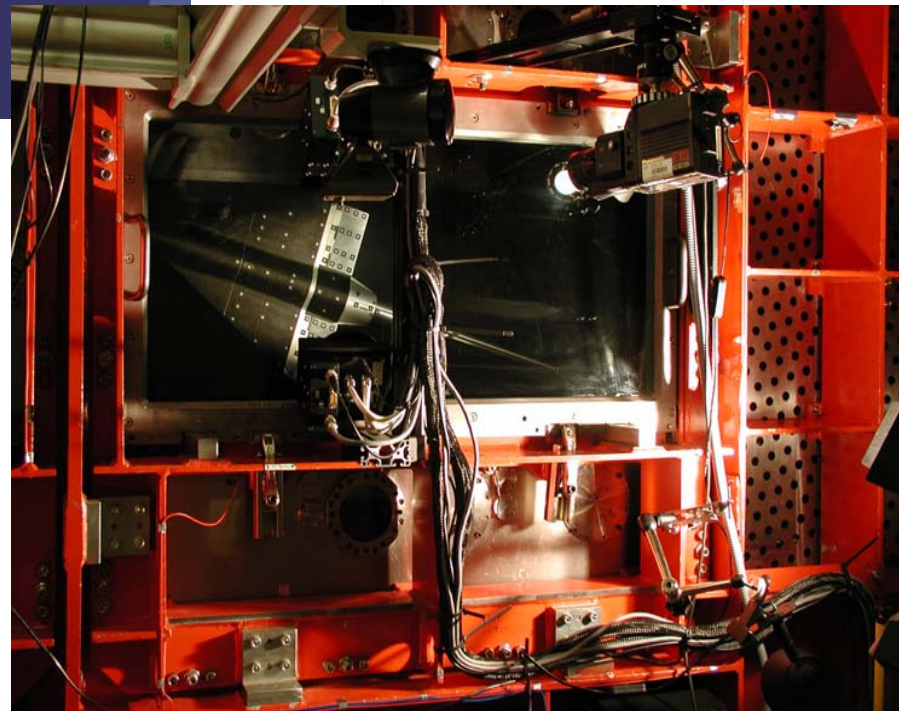
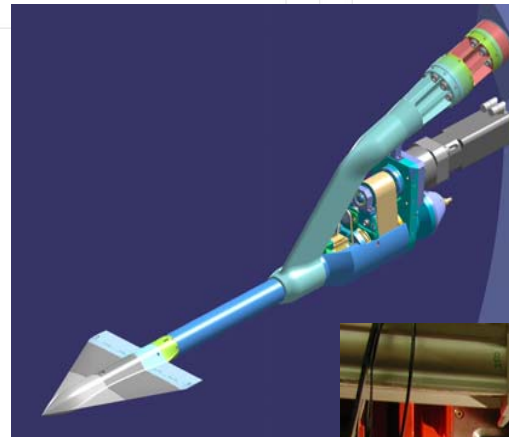
## Setup

- Aerosum model
- Roll-rig



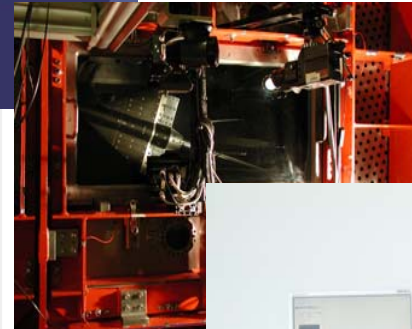
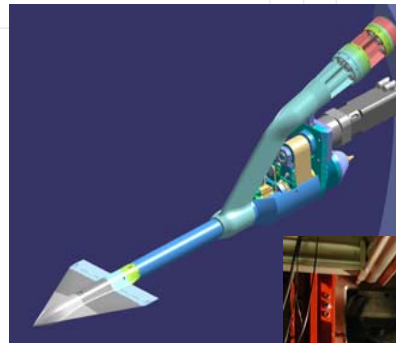
## Setup

- Aerosum model
- Roll-rig
- Transonic wind tunnel
  - DNW-TWG Göttingen



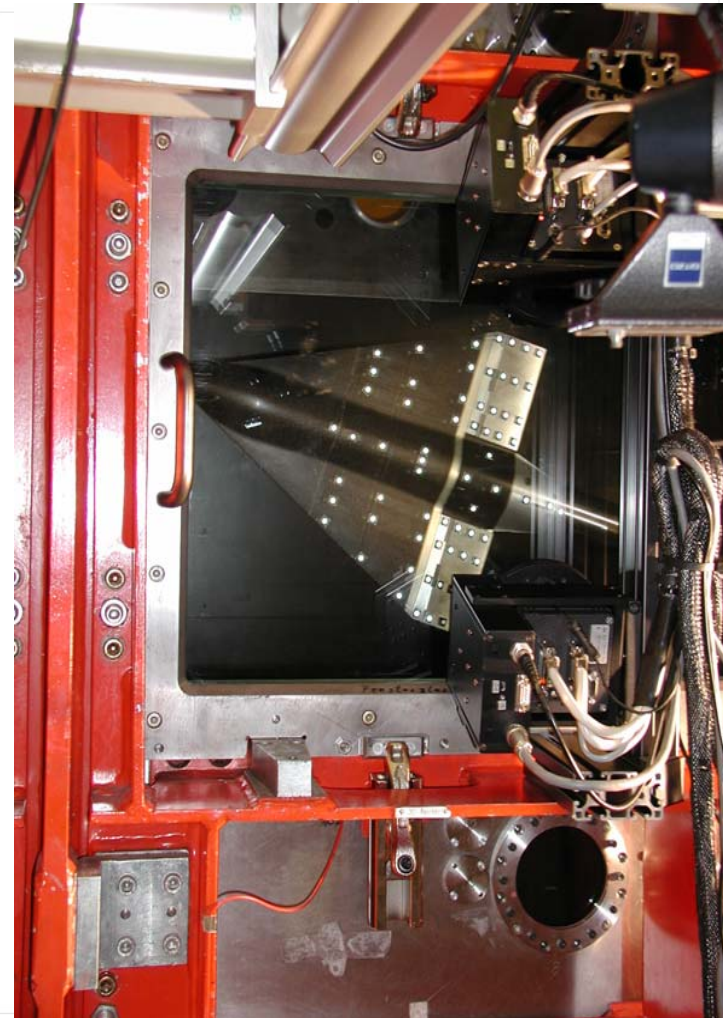
## Setup

- Aerosum model
- Roll-rig
- Transonic wind tunnel
  - DNW-TWG
- PONTOS
  - Optical 3D position and displacement measurement system



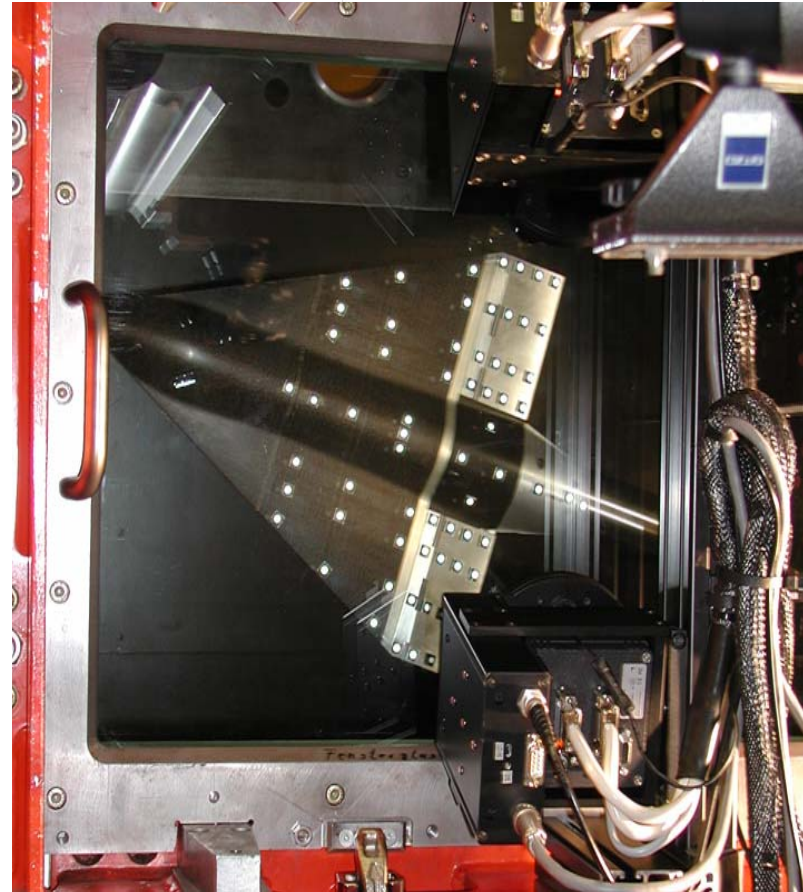
## System: Components

- PONTOS Sensor  
Two Digital Video Cameras, Illumination
- Calibrated Stereo Camera setup
- Control and Evaluation Electronics
- PONTOS - Software



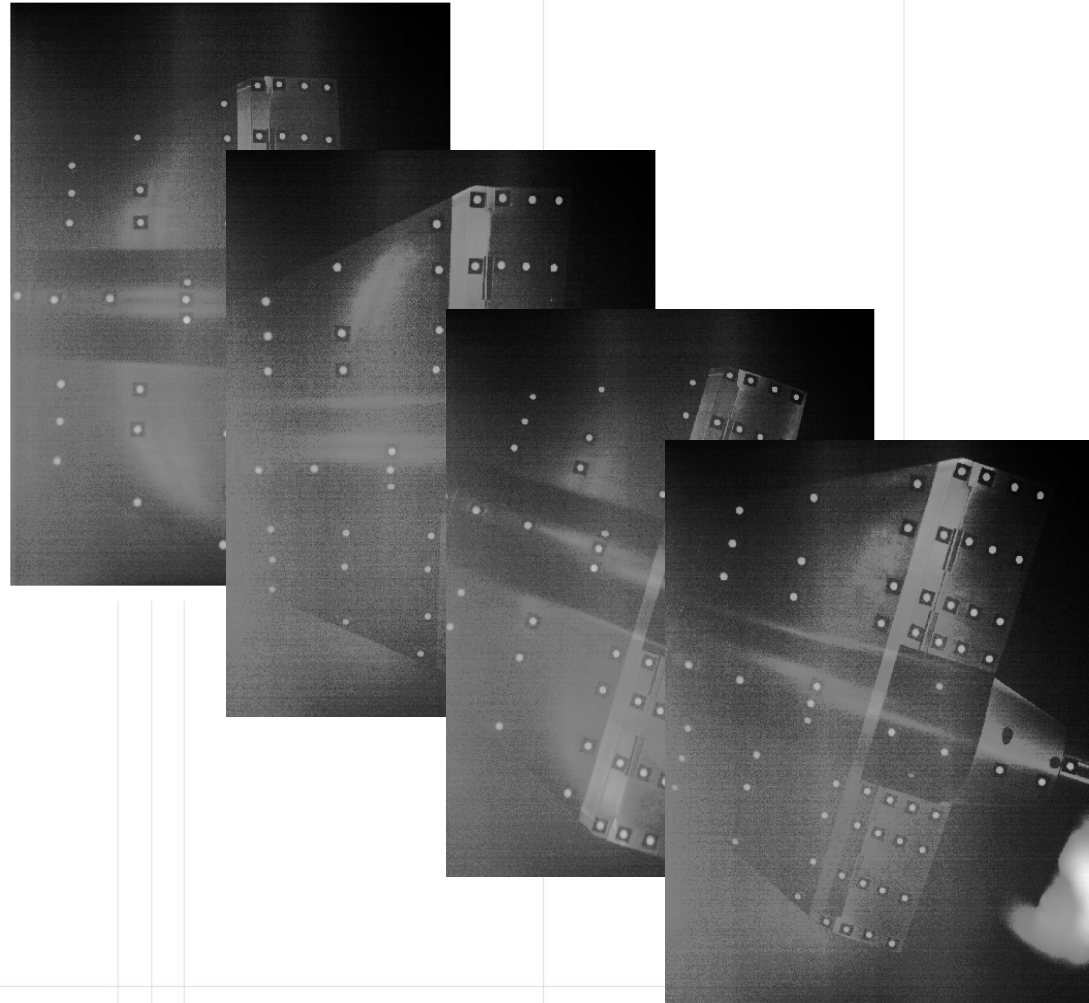
## Definition of Relevant Measurement Points: Adhesive Markers

- Measurement points
- Use of adhesive targets: 0.1 mm
- Precision of point determination: 0.01 Pixel
- Automatic computation of 3D-coordinates and displacements



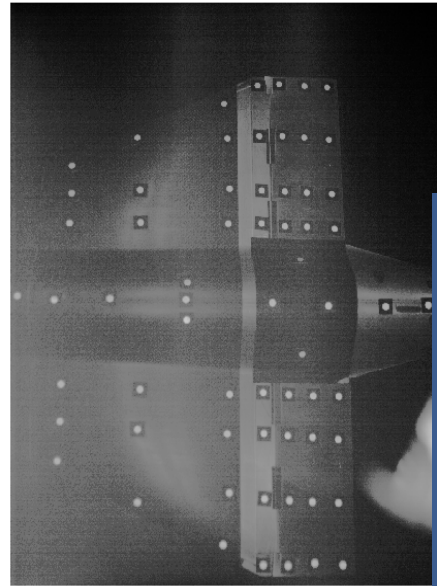
## Test: Position Measurement 1

- Test conditions
  - No wind
- Variables:
  - $90^\circ$  roll,  $0^\circ$  angle of attack
  - $90 + 30^\circ$  roll
  - $17^\circ$  angle of attack
  - $17^\circ$  angle of attack,  $90 + 30^\circ$  roll



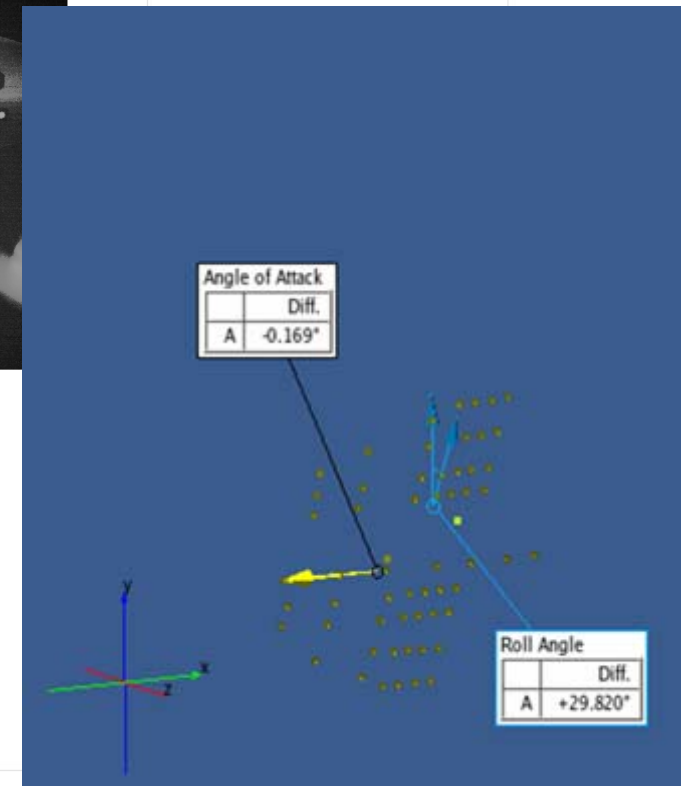
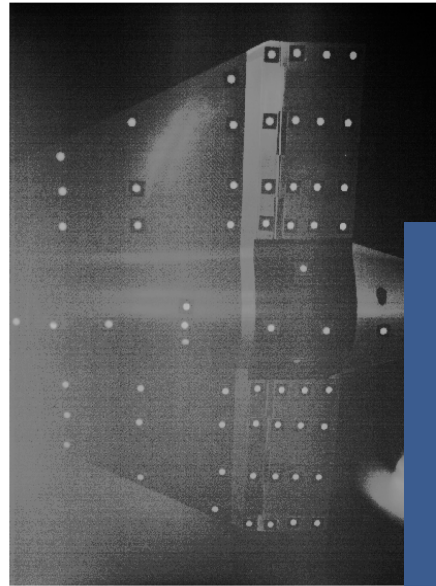
## Results: Position Measurement 1

- Test conditions
  - No wind
- Variables:
  - **90° roll, 0° angle of attack**
  - 90 +30° roll
  - 17° angle of attack
  - 17° angle of attack, 90 +30° roll



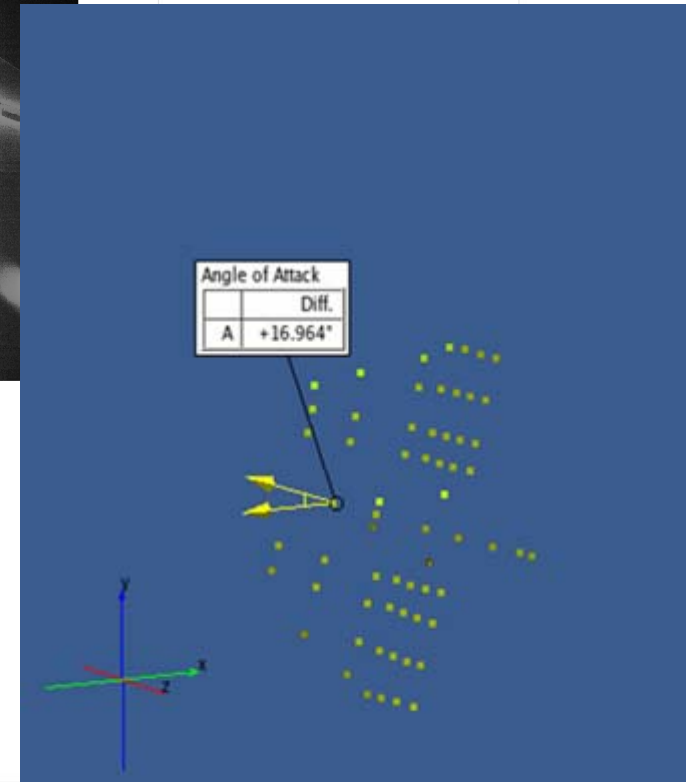
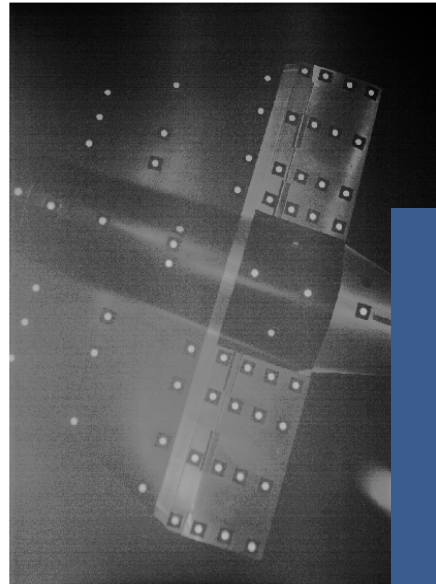
## Results: Position Measurement 1

- Test conditions
  - No wind
- Variables:
  - 90° roll, 0° angle of attack
  - **90 +30° roll**
  - 17° angle of attack
  - 17° angle of attack, 90 +30° roll



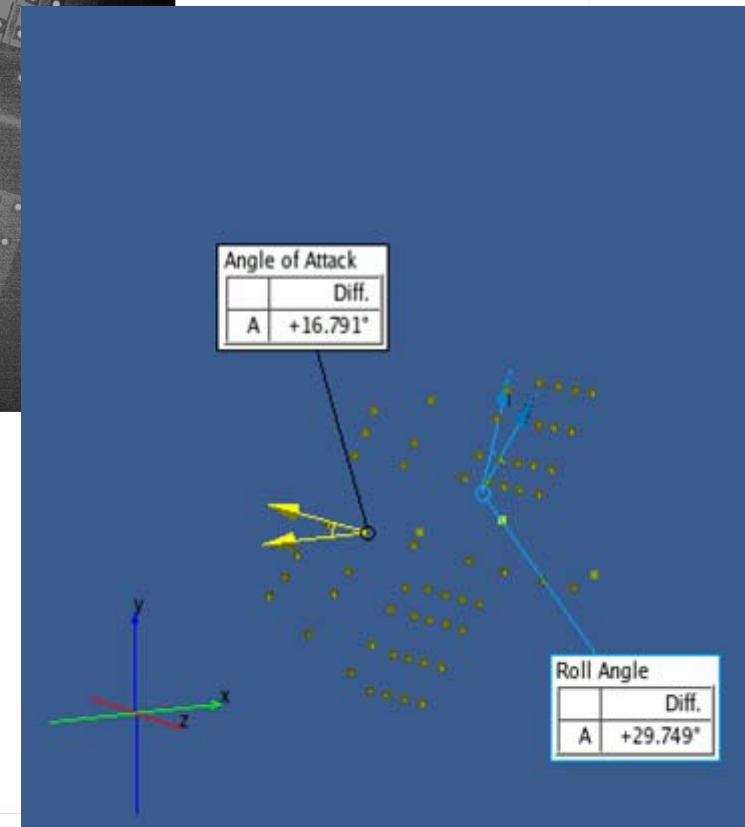
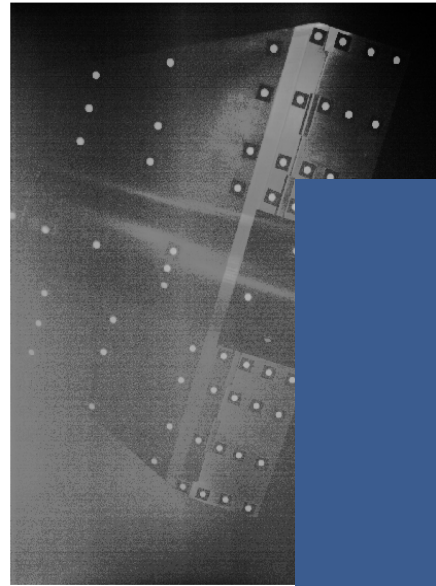
## Results: Position Measurement 1

- Test conditions
  - No wind
- Variables:
  - 90° roll, 0° angle of attack
  - 90 +30° roll
  - **17° angle of attack**
  - 17° angle of attack, 90 +30° roll



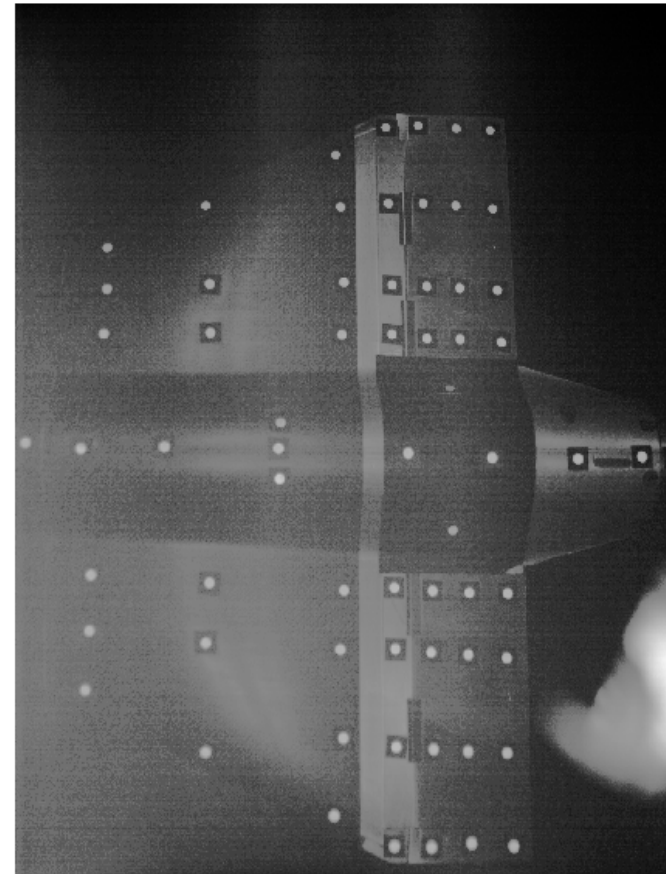
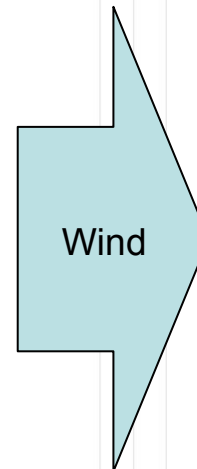
## Results: Position Measurement 1

- Test conditions
  - No wind
- Variables:
  - 90° roll, 0° angle of attack
  - 90 +30° roll
  - 17° angle of attack
  - **17° angle of attack, 90 +30° roll**



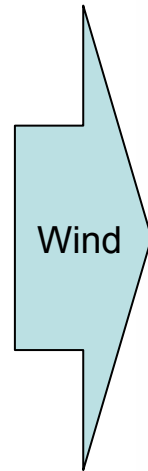
## Test: Position Measurement 2

- Test conditions
  - 90° roll
  - 0° angle of attack
- Variables:
  - No Wind
  - 0.5 Mach
  - 0.8 Mach

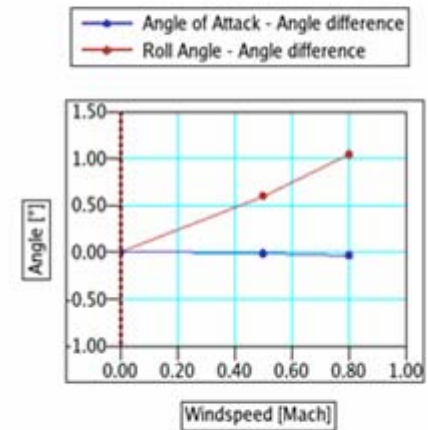
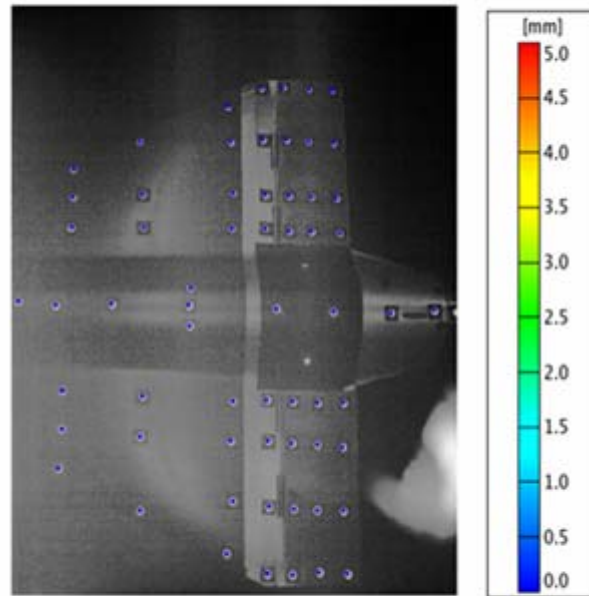


## Results: Position Measurement 2

- Test conditions
  - 90° roll
  - 0° angle of attack
- Variables:
  - No Wind
  - 0.5 Mach
  - 0.8 Mach



XYZ-Change of Position

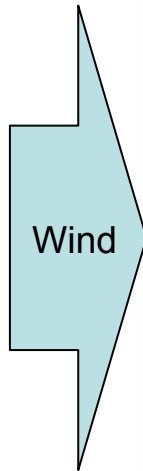


PONTOS

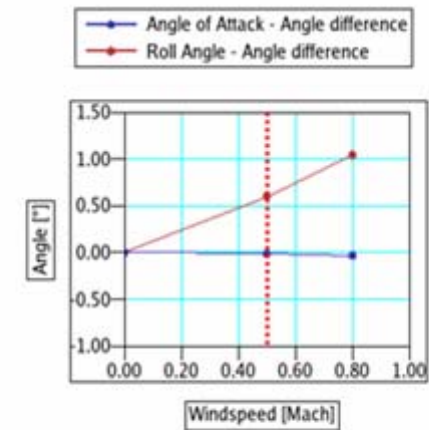
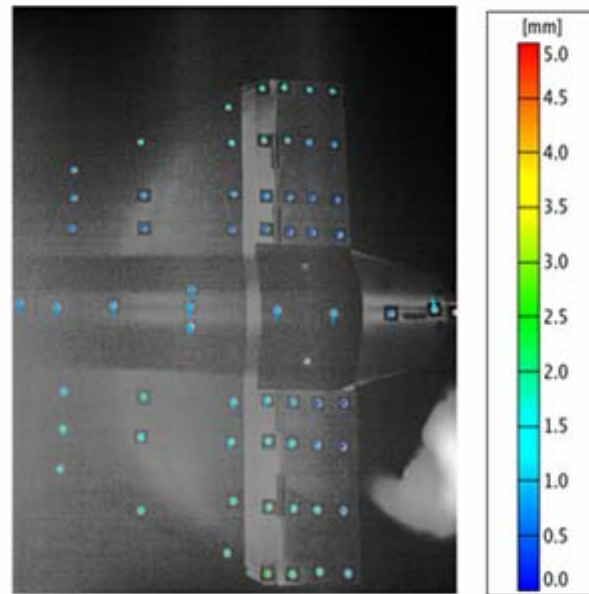
gom  
www.gom.cor

## Results: Position Measurement 2

- Test conditions
  - 90° roll
  - 0° angle of attack
- Variables:
  - No Wind
  - **0.5 Mach**
  - 0.8 Mach



XYZ-Change of Position

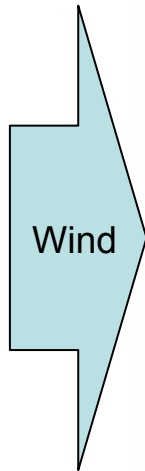


PONTOS

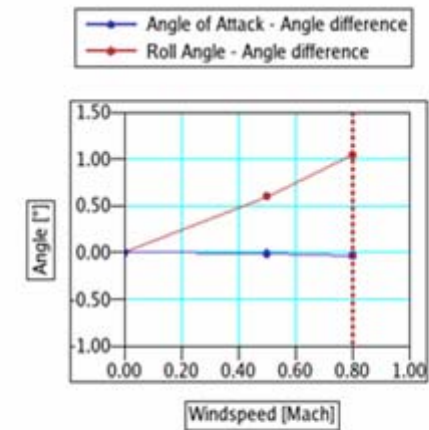
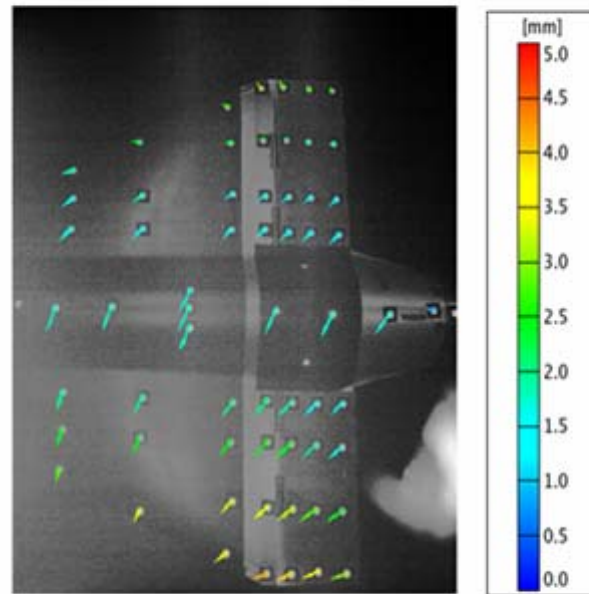
gom  
www.gom.cor

## Results: Position Measurement 2

- Test conditions
  - 90° roll
  - 0° angle of attack
- Variables:
  - No Wind
  - 0.5 Mach
  - **0.8 Mach**



XYZ-Change of Position



**PONTOS**

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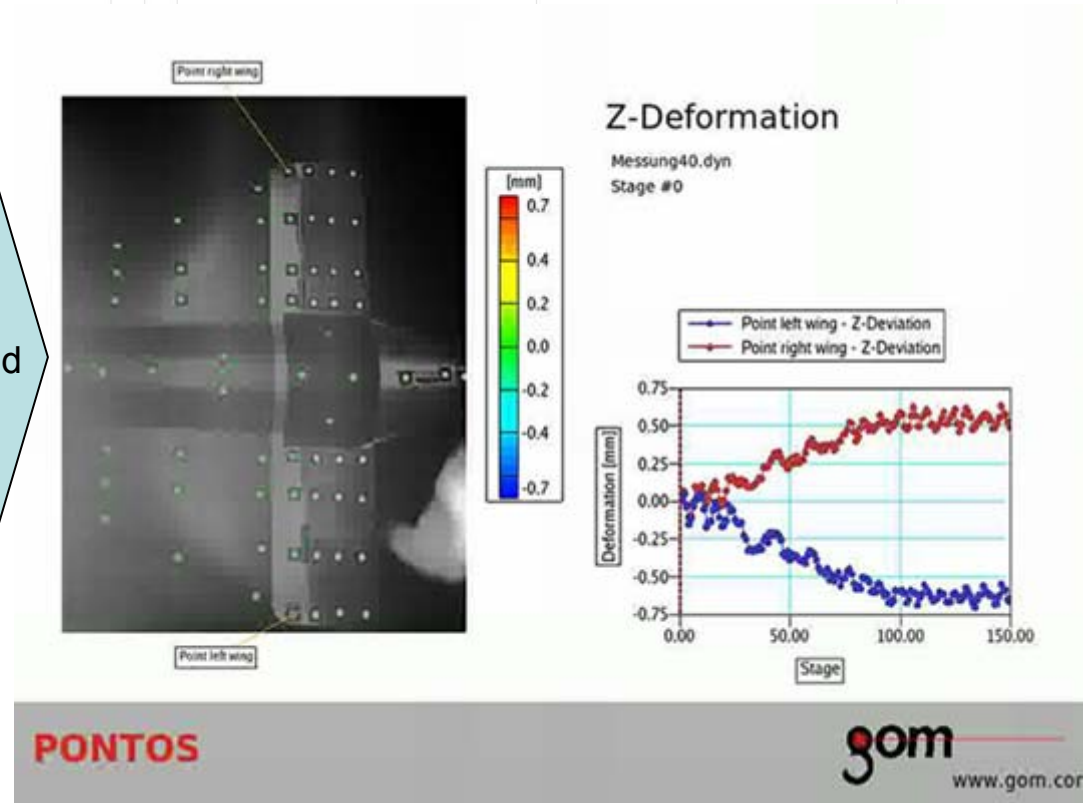
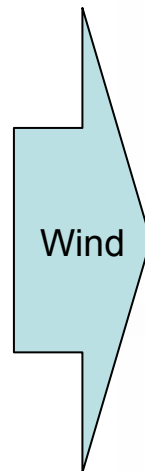
## Test: Deformation Measurement 1

- Deformation measurement of delta wing body
- Change of flap angle  $0^{\circ}$ - $15^{\circ}$  (asymmetrical)
- Wind speed Mach 0.8
- Acquisition frequency 10 fps



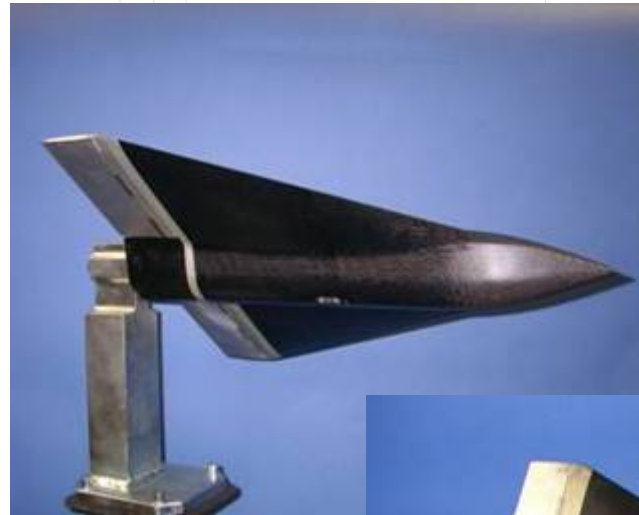
## Results: Deformation Measurement 1

- Deformation measurement of delta wing body
- Change of flap angle  $0^{\circ}$ - $15^{\circ}$  (asymmetrical)
- Wind speed Mach 0.8
- Acquisition frequency 10 fps



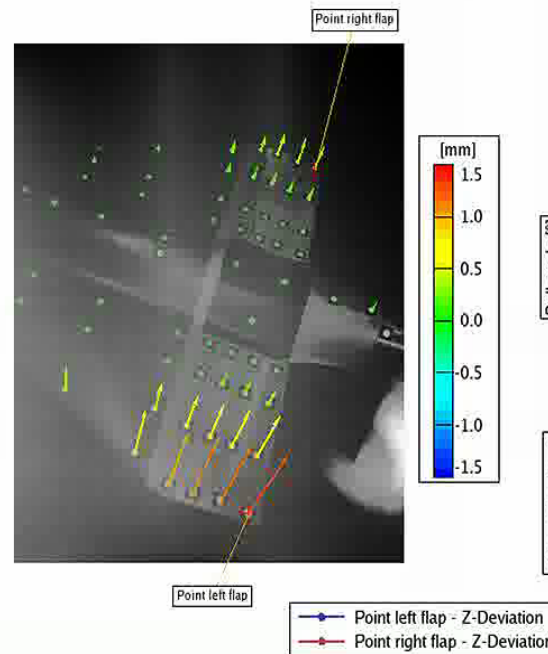
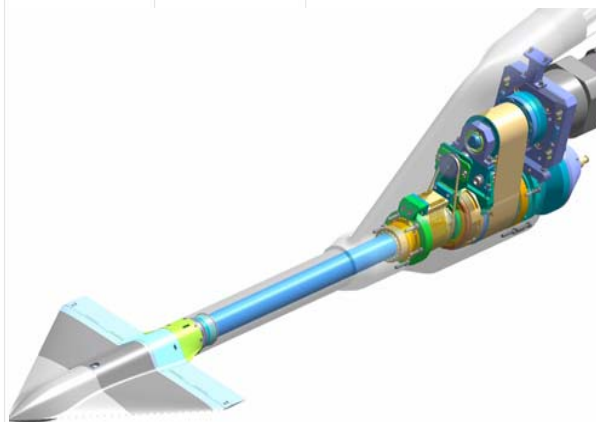
## Test: Deformation Measurement 2

- Deformation measurement of delta wing body
- Deformation measurement of flap
- Roll angle  $90^\circ \pm 30^\circ$ , 4.77Hz
- Wind speed Mach 0.8
- Acquisition frequency 460 fps



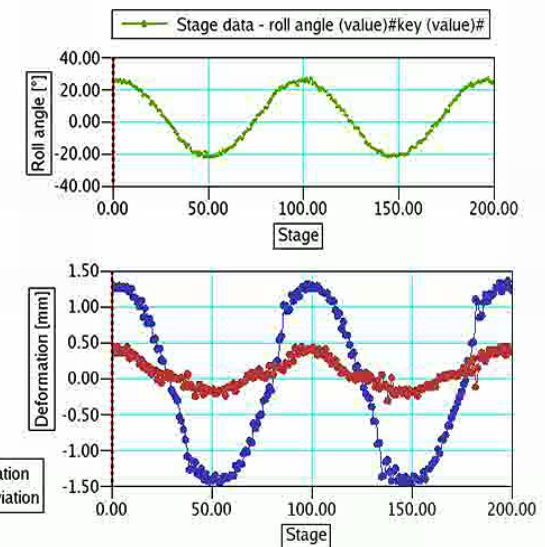
## Results: Deformation Measurement 2

- Deformation measurement of delta wing body and flaps
- **Roll angle  $90^\circ \pm 30^\circ$ , 4.77Hz**
- Wind speed Mach 0.8
- Acquisition frequency 460 fps



### XYZ-Deformation

Messung25.dyn  
Stage #0



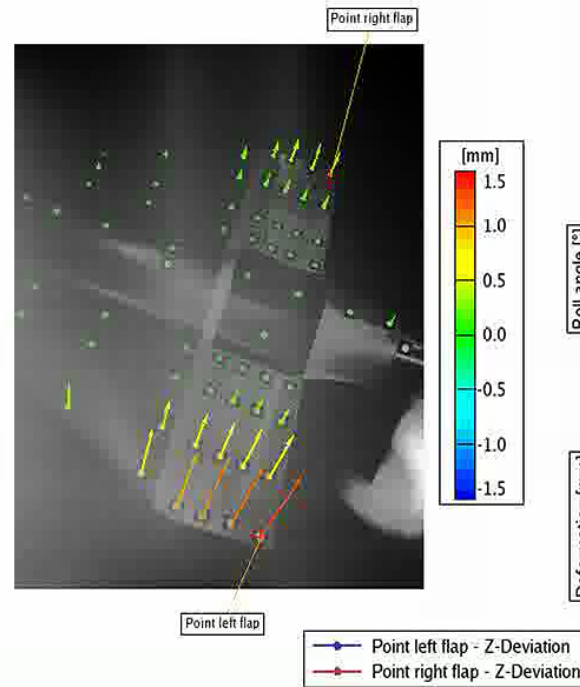
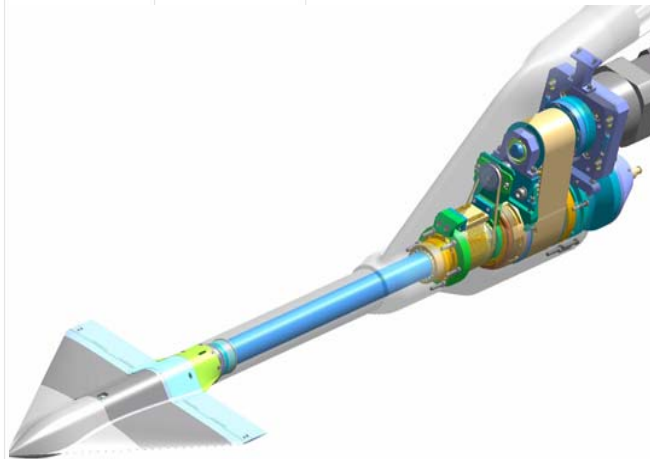
PONTOS



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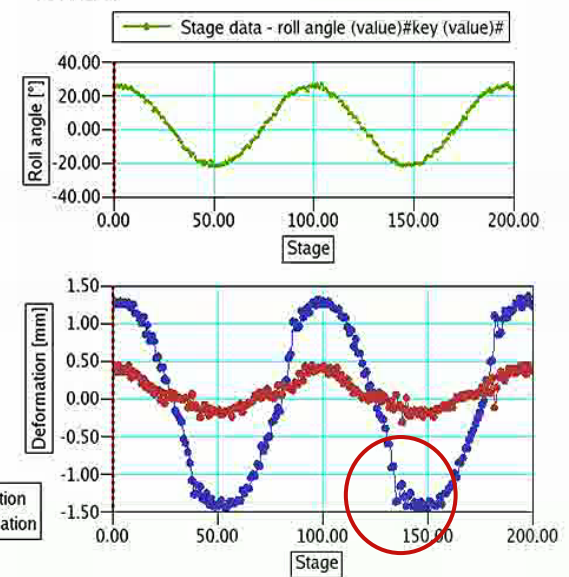
## Results: Deformation Measurement 2

- Deformation measurement of delta wing body and flaps
- **Roll angle  $90^\circ \pm 30^\circ$ , 4.77Hz**
- Wind speed Mach 0.8
- Acquisition frequency 460 fps



### XYZ-Deformation

Messung25.dyn  
Stage #0



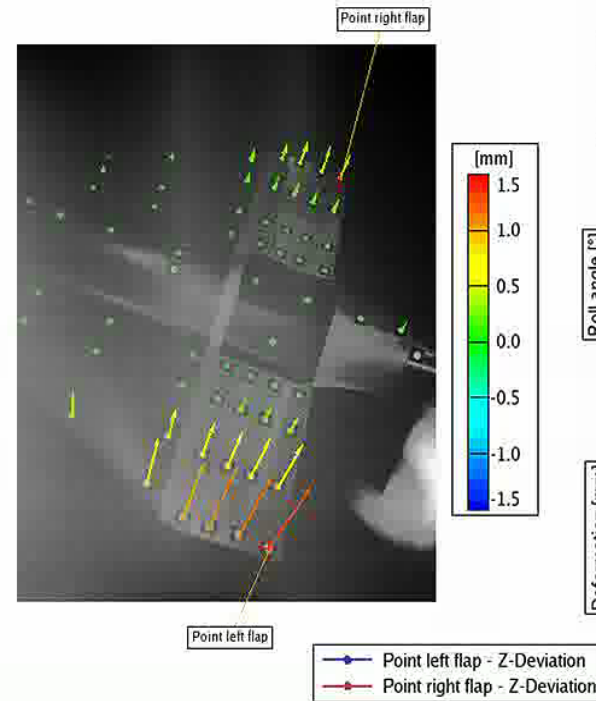
PONTOS



www.gom.com

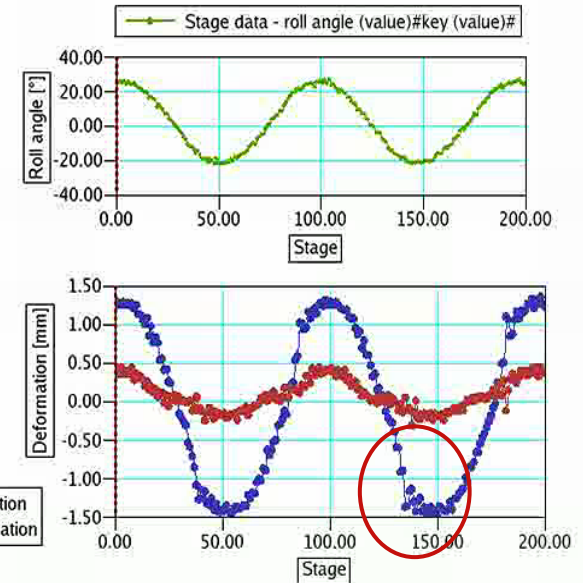
## Discussion: Deformation Measurement 2

- Discontinuities (0.25mm) due to?
  - Frictional issues
  - Measurement errors
  - Aeroelastic coupling



### XYZ-Deformation

Messung25.dyn  
Stage #0



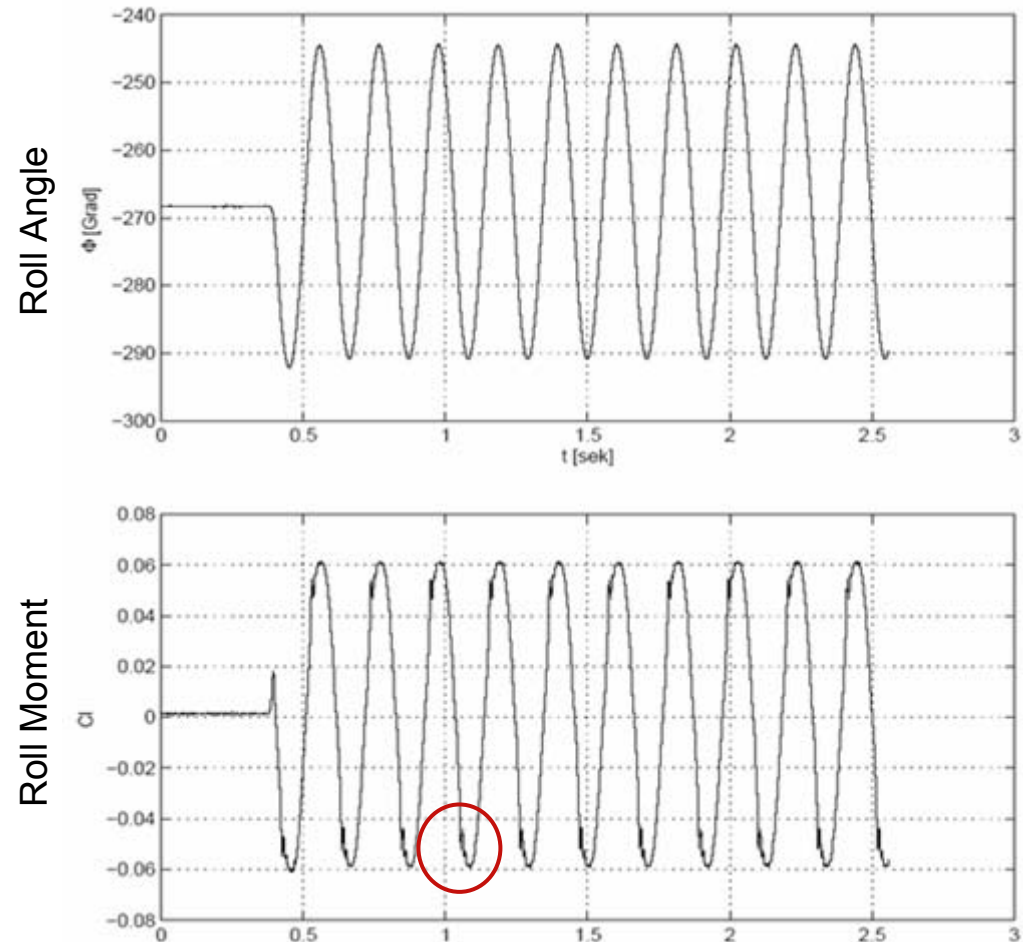
PONTOS



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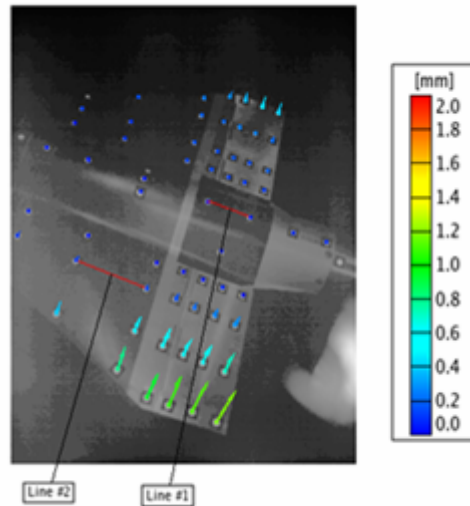
## Discussion: Deformation Measurement 2

- Comparison to roll moment measurements
- Similar effects in measurements of roll moment



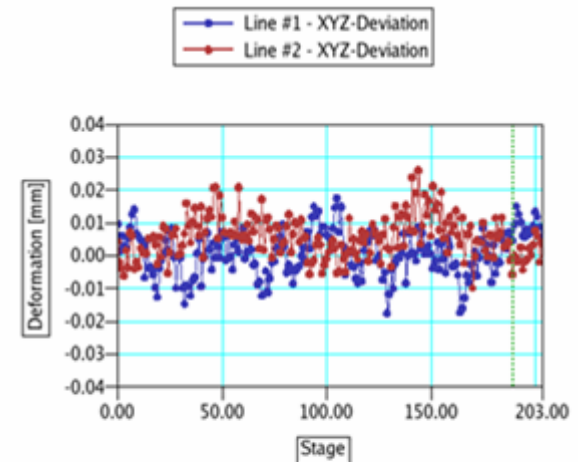
## Discussion: Deformation Measurement 2

- Precision?
- Noise level determination:
  - Distance measurement under conditions of
    - Aerodynamic load
    - Large displacements
- $<0.04\text{mm}$



### XYZ-Deformation

Messung25.dyn  
Stage #189



**PONTOS**

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## Conclusion/Summary

- Wind Tunnel Testing at Transonic Mach Numbers
- Measurement of Aerodynamically and Mechanically Loaded Structures
- Non-Contact 3D Position Measurement, Easy Determination of Major Parameters (Coordinates, Angle, Change of Position, etc.)
- Non-Contact 3D Deformation Measurement
- High Speed Data Acquisition
- Precise
- Possibility to measure aeroelastic coupling effects

## Summary

- PONTOS
- Complete Measurement of 3D Displacements / Deformations
- Typ. 500 fps at 1.3 MegaPixel or up to 10.000 fps
- Non Contact Measurement
- Simple Preparation
- Mobile and Easy Handling

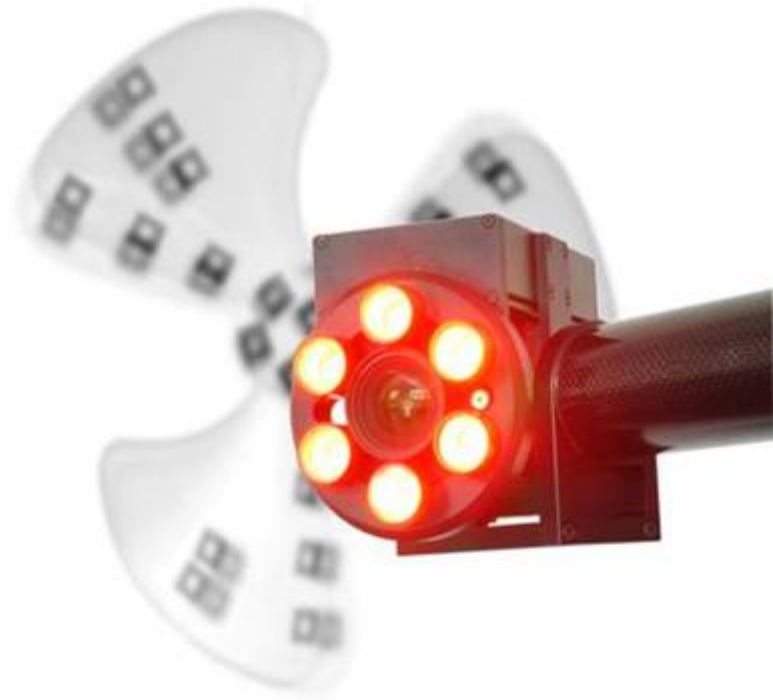


Thanks!

Oliver Erne  
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www.gom.com  
Mittelweg 7-8

38106 Braunschweig

We'd like to welcome you in  
Hall 2, D15



**gom**  
Optical Measuring Techniques