



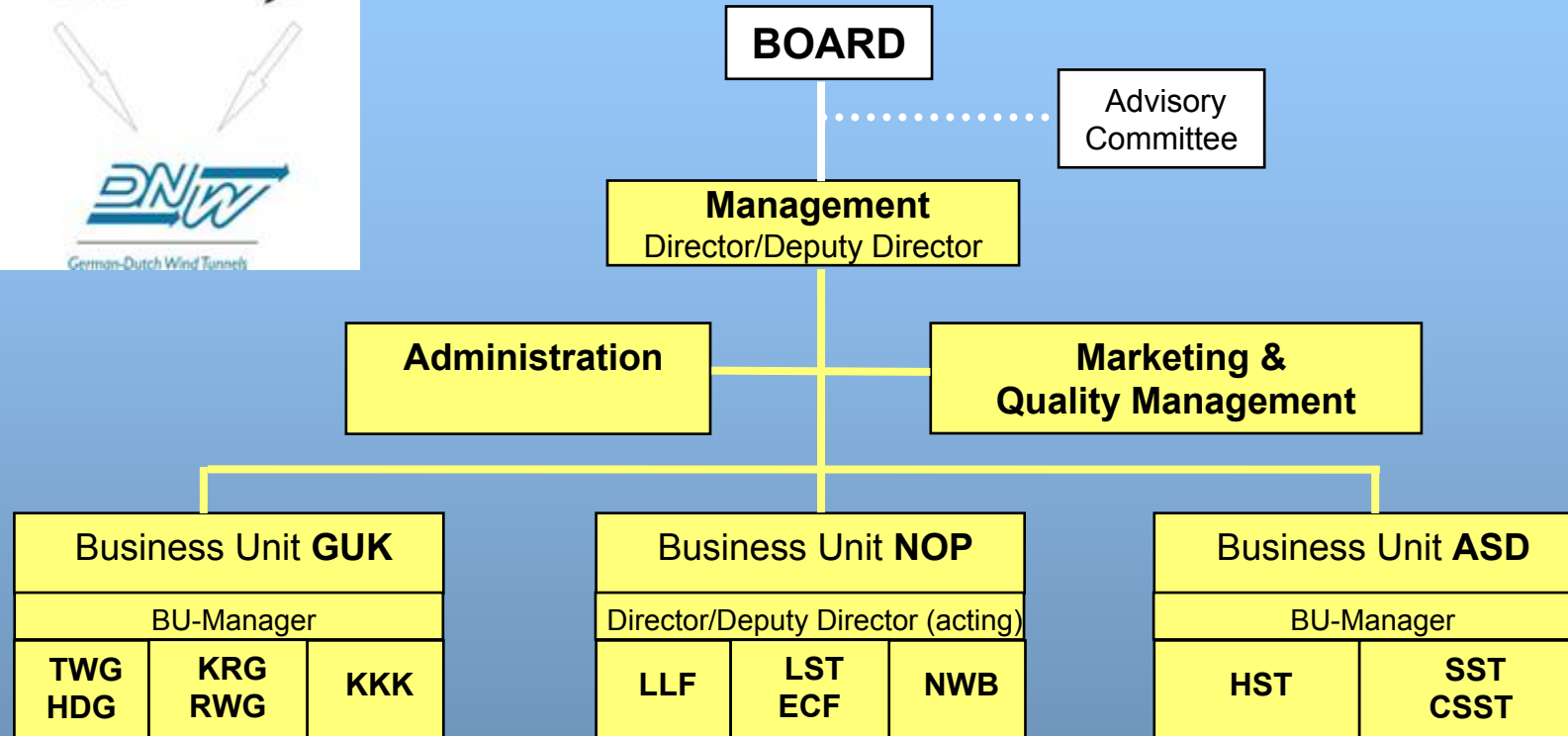
German-Dutch Wind Tunnels

The Model Positioning Mechanism of DNW-NWB Based on a New Parallel Kinematic

Dr. A. Bergmann



Organization of German-Dutch Wind Tunnels (DNW)



GUK Göttingen und Köln
TWG Transsonischer Windkanal Gö.
HDG Hochdruckwindkanal Gö.
KRG Kryo-Rohrwindkanal Gö.
RWG Rohrwindkanal Gö.
KKK Kryo-Kanal Köln

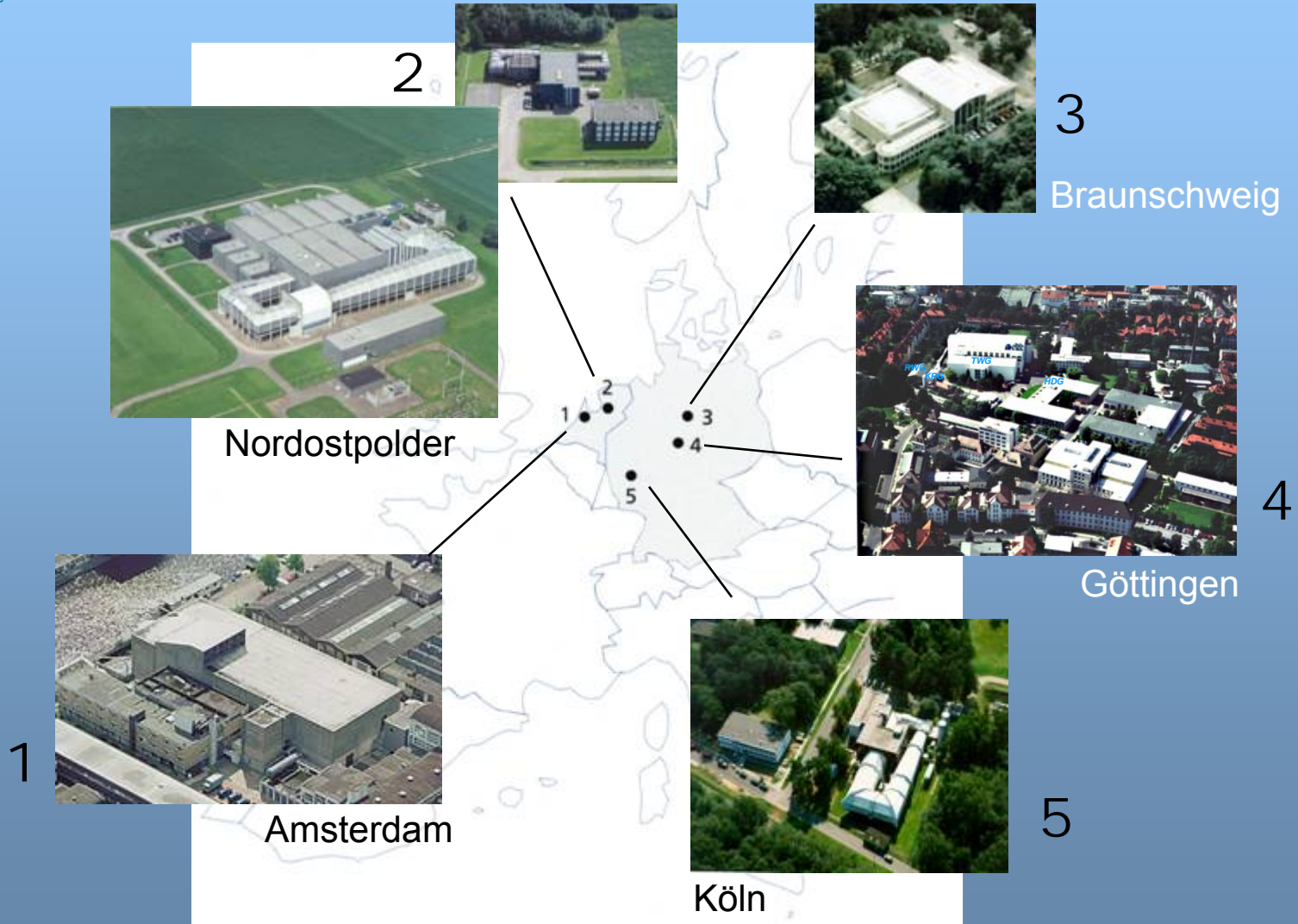
NOP Nordostpolder
LLF Large Low-Speed Facility
LST Low Speed Tunnel
ECF Engine Calibration Facility
NWB Niedergeschwindigkeits-Windkanal Braunschweig

ASD Amsterdam
HST High Speed Tunnel
SST Super Sonic Tunnel
CSST Continuous Super Sonic Tunnel



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Sites of DNW Foundation

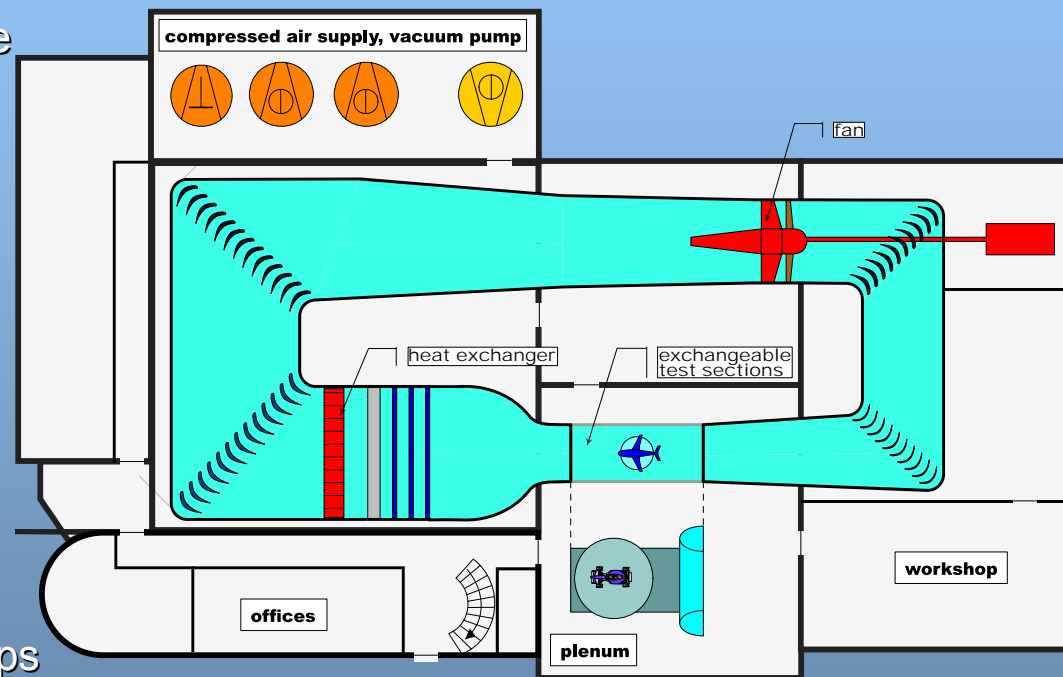




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Low-Speed Wind Tunnel NWB

- Operated by the foundation DNW, located in Braunschweig
- Atmospheric, closed circuit type
- Nozzle exit 3.25m x 2.8m (10.6' x 9.2')
- 1.6MW electric motor
- Max free stream velocity >80 m/s (260ft/s)
- Open, closed or slotted test sections
- Heat exchanger 1MW
- Secondary air installations for continuous operation with reciprocating and screw compressors and vacuum pumps





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Single organisation provides the benefit of resource sharing and technology transfer

Measurement & Simulation Techniques

Aero-acoustics Techniques for Source Localisation

Engine Simulation Techniques for Take-off and Landing

LLF, LST, NWB, HST

Engine Simulation Techniques for Cruise Conditions

LLF, LST, NWB

Stereo Pattern Recognition Technique for Deflection Determination

HST

LLF, NWB

Particle Image Velocimetry Technique for Flow Field Investigation

LLF, LST, NWB, HST, TWG

Oscillating Motion Technique for Dynamic Derivative Determination

NWB

NWB

Maneuver Simulation

KRG

Transonic Profile Development Technique

KKK

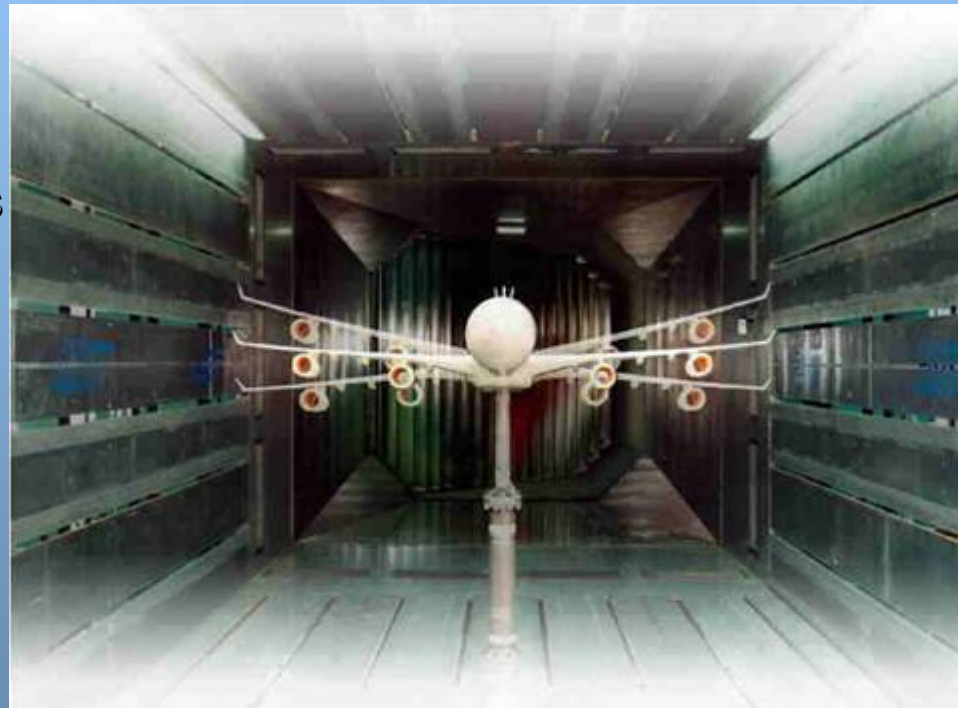
Cryogenic Development Technique

HST, TWG, NWB

Pressure Sensitive Paint Technique

Why do we need dynamic test capabilities?

- Prediction of dynamic derivatives required
 - for flight mechanics simulation
 - for calculation of structural loads
 - for validation and verification of computational dynamic codes
- Simulation of complex and realistic aircraft maneuvers required
 - for computer code validation
- Need of a multi axis test rig





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Advancing the state of the art at DNW – NWB (1)

Mobile Oscillatory Derivative Balance (MOD) since 1970



Serial kinematic structure:

Number of DoF is achieved by serial arrangement of the corresponding number of linear and rotative axes

The bottom-most axis of movement has to carry the weight of all those lying above it.

→ NOT well suited for the requirements

- > high stiffness

- > low mass

The errors (thermal, geometric, caused by loads) of movement of all axes are added

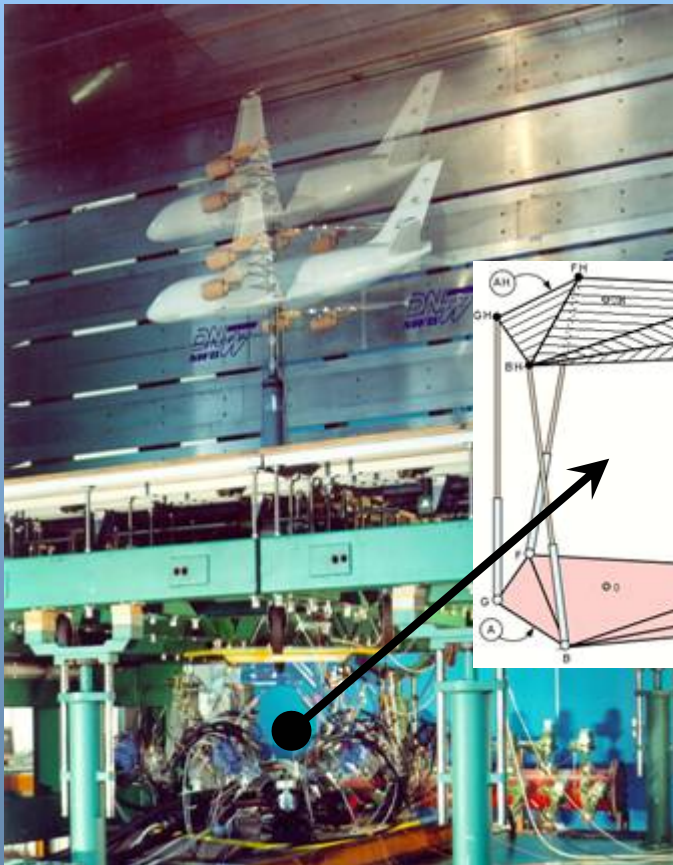
Electrically driven



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Advancing the state of the art at DNW – NWB (2)

Oscillatory Motion System (OMS) since 2000



Parallel kinematic structure based on Stewart Platform

6 telescope like, driven legs \rightarrow 6DoF

Masses to be moved are smaller

Errors not added

Only forces in axial direction of the legs (largest stiffness)

Available working space smaller compared to machine - size

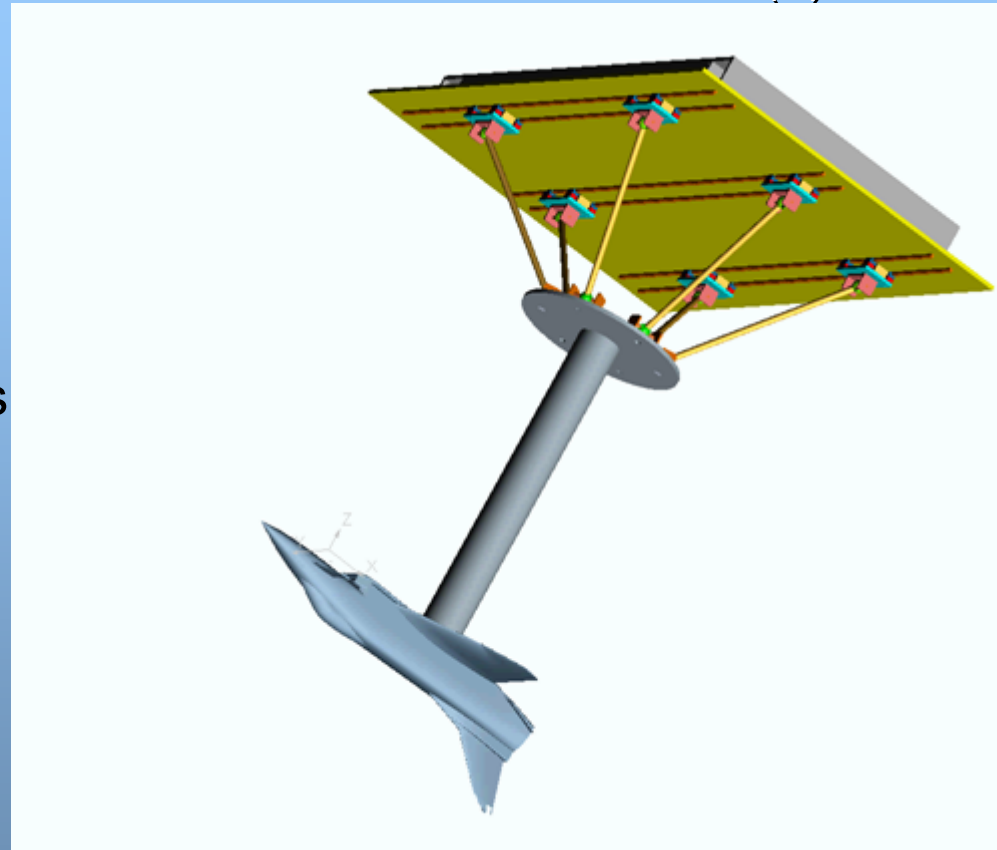
Hydraulically driven

Advancing the state of the art at DNW – NWB (3)

Approach since 2003:

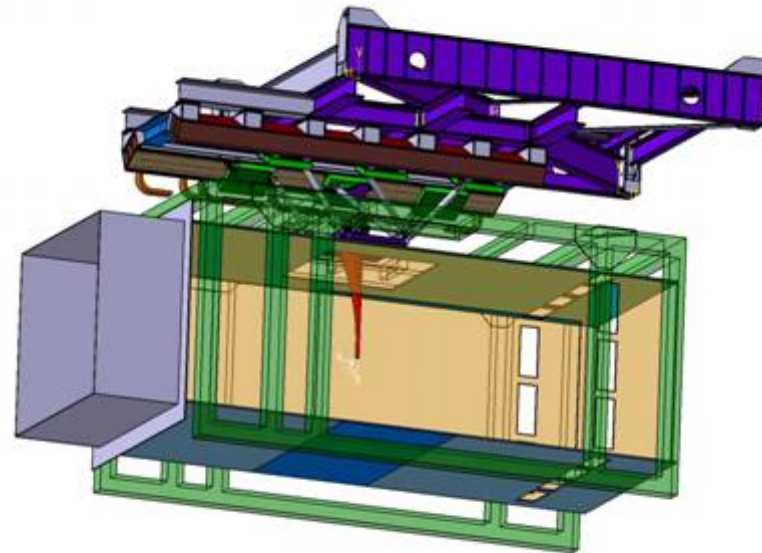
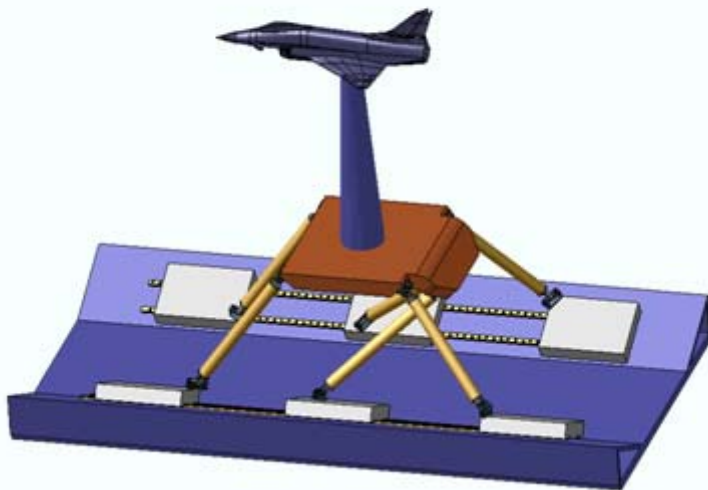
Investigation of an existing prototype of milling machine based on parallel kinematics

aim: develop an optimized system to meet the requirements of WT model support



Principle of Rod kinematic
6 rods with constant length
rail guides, electrical linear motors

Advancing the state of the art at DNW – NWB (4) Revolutionary new Support Model Positioning Mechanism (MPM) of NWB



Operational since December 2004
DLR has applied for a patent on this device



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Model Positioning Mechanism (MPM), Requirements

6 DoF

Workspace (long., lateral, heave): 1100mm, 300mm, 500mm

Pivoting angles of	- 5° to + 5° for rolling, accuracy	< 0.005°
	-15° to + 7° for pitching	< 0.01°
	-10° to +10° for yawing	< 0.005°

Near constant and high stiffness all over the workspace

First eigenfrequency > 20 Hz

Max acceleration 2.5 g

Oscillatory Motion of the model in the modes

Yawing, Pitching, Rolling, (Heave) up to 3 Hz with 5° (60mm) Amplitude

Max payloads	Fx / Fy / Fz	1500 / 1000 / 5000 N
	Mx / My / Mz	500 / 1000 / 600 Nm

All requirements are fulfilled

Model Positioning Mechanism (MPM), Details (1)



- Use of conventional standard components → cheaper
- Use of six constant length rods made from CRP → small masses, high stiffness ($1400\text{N}/\mu\text{m}$)
- Reduction to two parallel tracks → unique design of a parallel kinematic, cheaper, simpler
- Use of linear electromagnetic motors → highest accuracy and highest dynamism

Model Positioning Mechanism (MPM), Details (2)

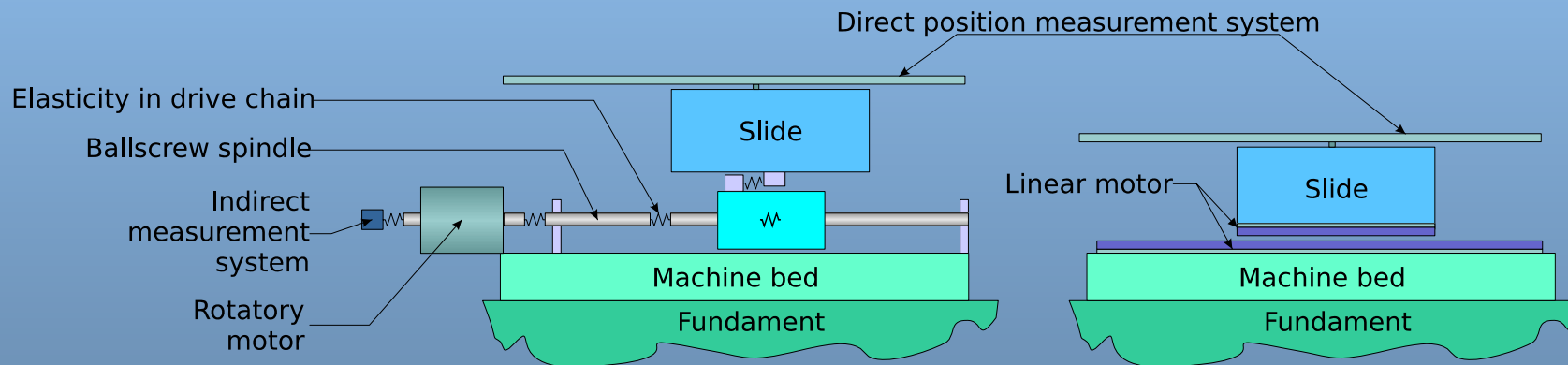
Comparison:

Conventional ballscrew drive

Indirect force build-up
⇒ reduced dynamics

Linear direct drive

Force build-up directly at the slide
⇒ **highest dynamics**

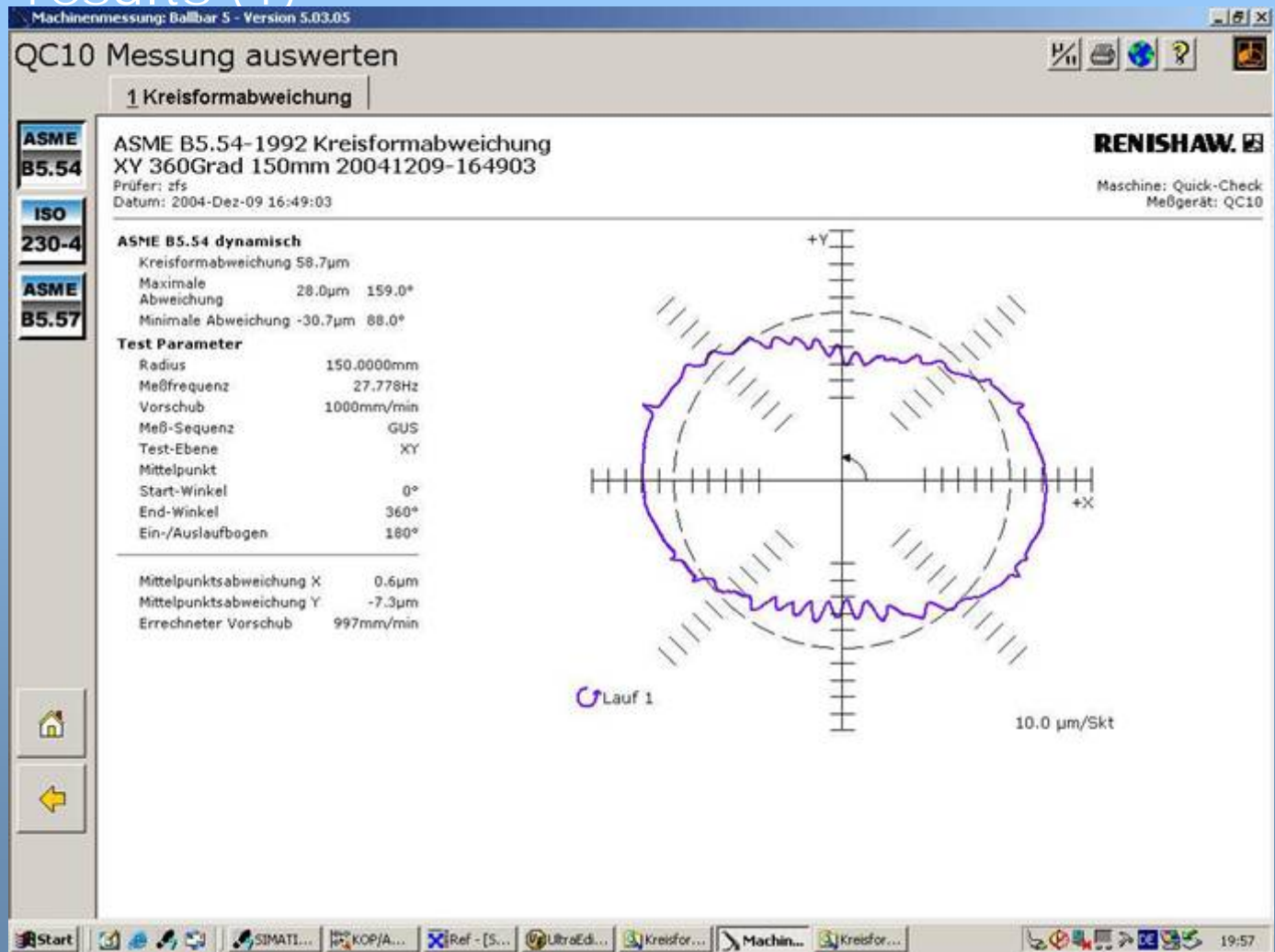


Rated Force: 8,100 N
Max Force: 20,700 N
Velocity at F_{max} up to 6 m/sec



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Model Positioning Mechanism (MPM), first results (1)



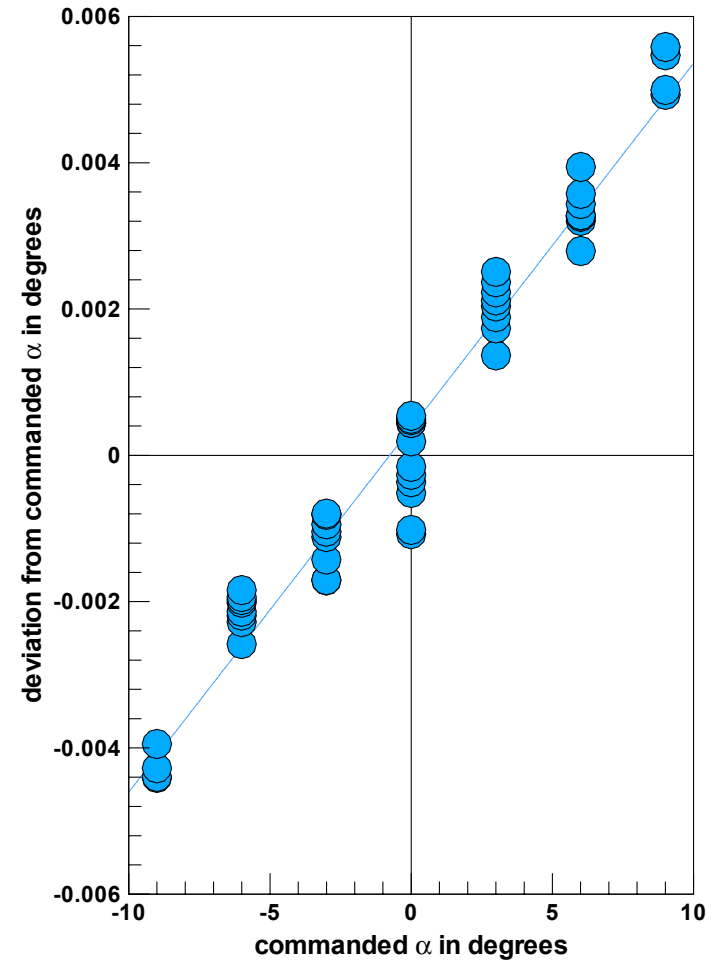
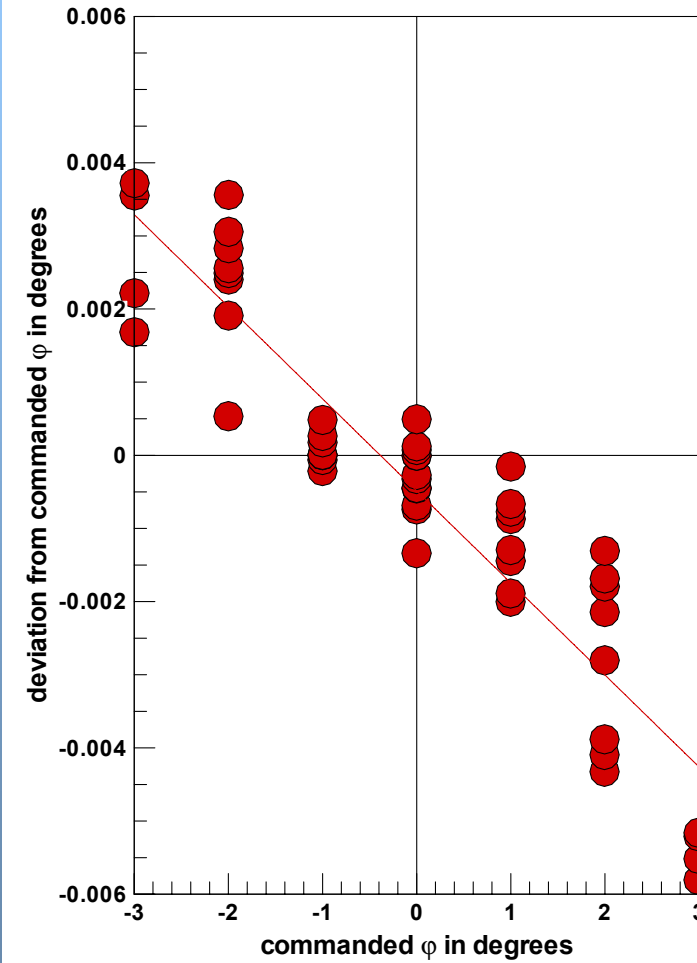
Result from
Ball Bar Test



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Model Positioning Mechanism (MPM), first results (2)

Static accuracy





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The unique Model Positioning Mechanism (MPM), installed in NWB for dynamic testing





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Thank You for Your Attention

For further information please visit

→ DLR at Hall 2, Stand 2U/D19



→ DNW at Hall 1, Stand 1U/A14

