



# Welcome

## The HAPT Project

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# Outline

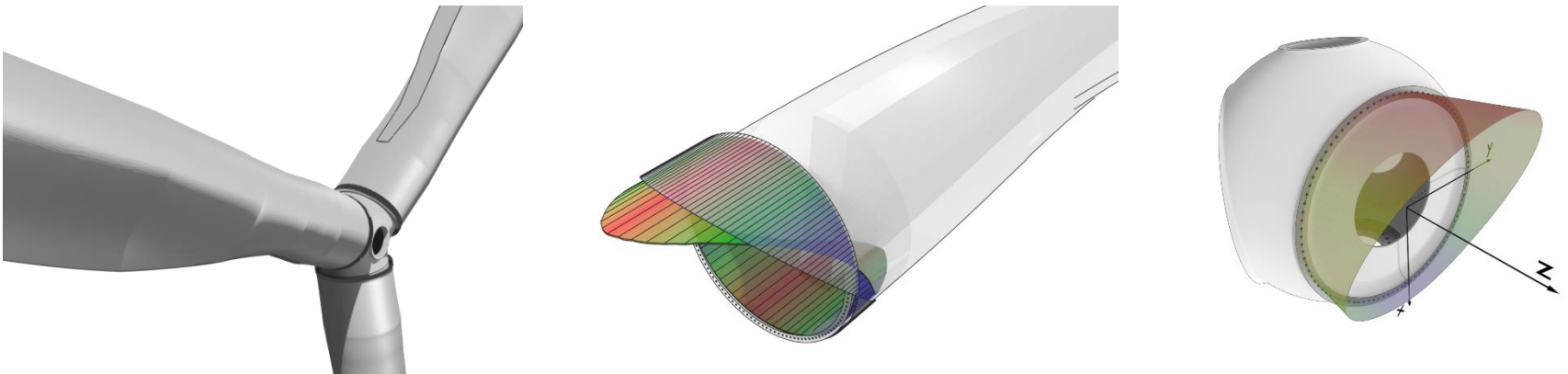
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- Wind turbine bearing test rigs & test procedures
- BEAT6.1 rig
- An endurance run program for blade bearings

# Blade bearings

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- ↪ Oscillating movements
- ↪ Dynamic (stochastic) loads
- ↪ Relatively soft interfaces (blade, hub) influence load distribution
- ↪ Common bearing type: Four-point contact ball bearings



# State of the art

Wind turbine bearing test rig & test procedures

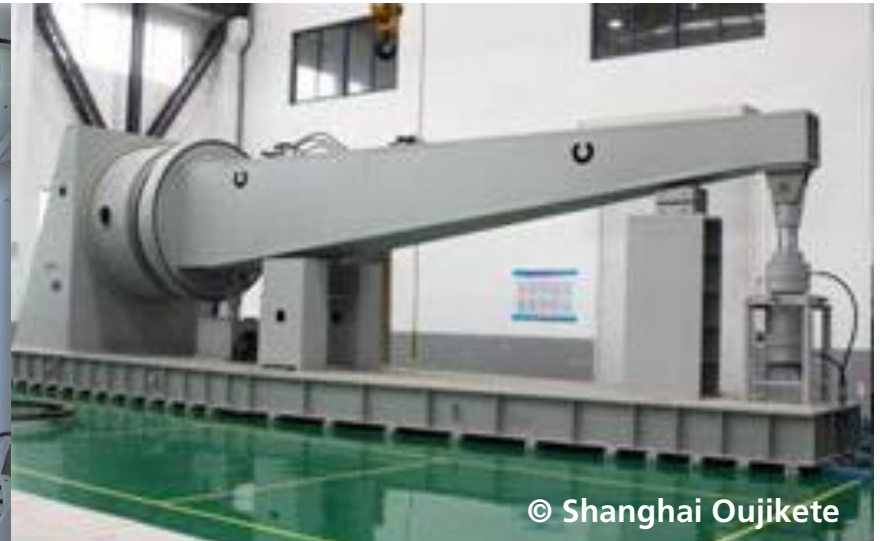
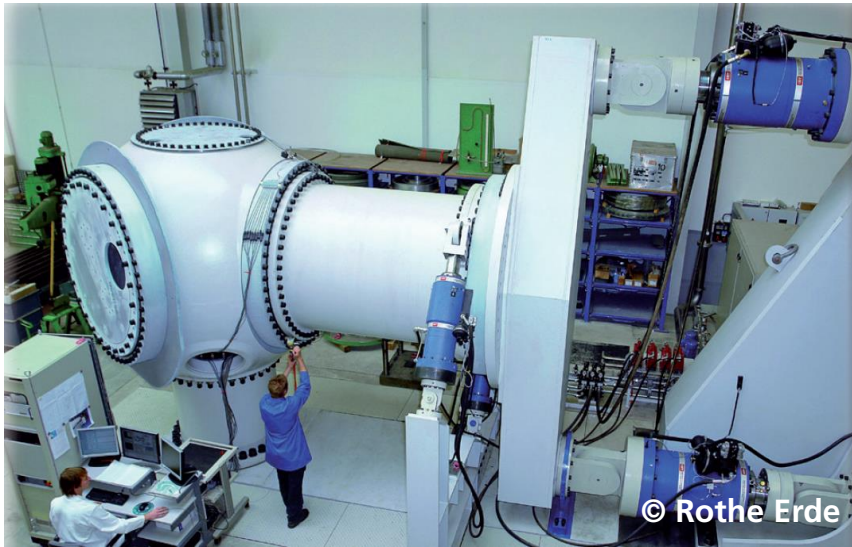
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- ↖ Origin: OEM, bearing manufacturer, research institution
- ↖ Interfaces: Hub & blade side
- ↖ Load application: DOF, static vs. dynamic
- ↖ Bearing size
- ↖ Pitch capability

# OEM test rigs



# Bearing manufacturer test rigs

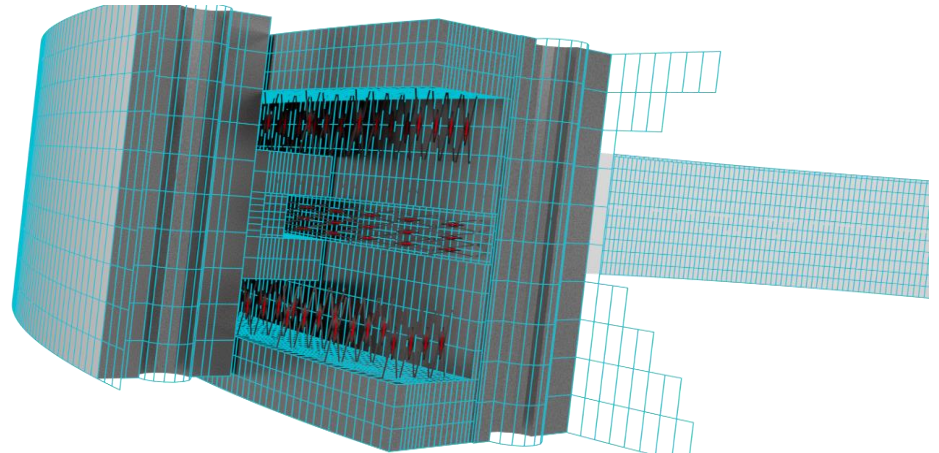




# Bearing test procedures

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- ↪ Functionality
- ↪ Extreme load
- ↪ Friction torque measurement
- ↪ Rolling contact fatigue endurance (oscillating / rotating)
- ↪ Structural fatigue endurance
- ↪ ‚Robustness‘ test



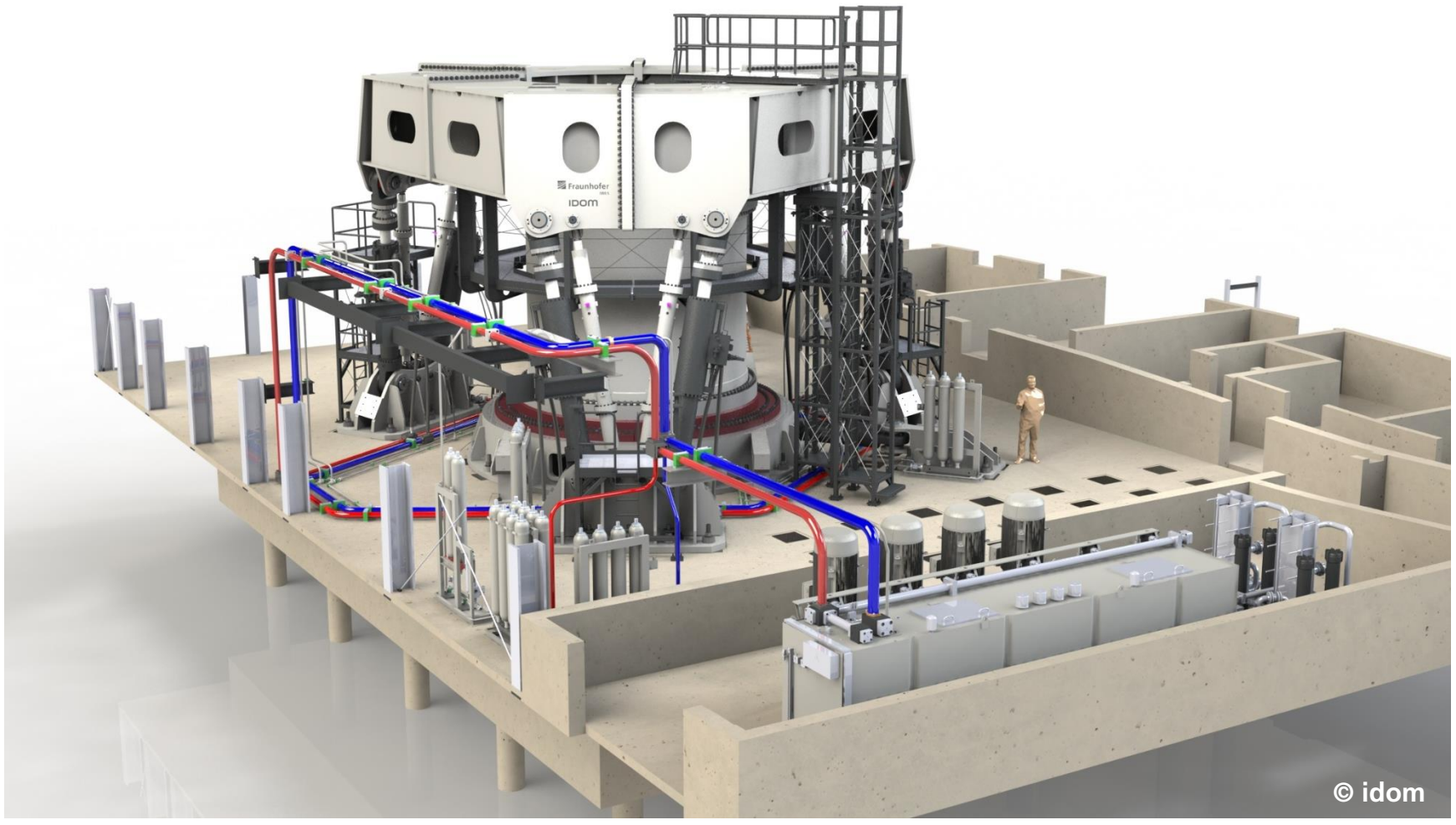
# BEAT6.1

Bearing Endurance & Acceptance Test rig

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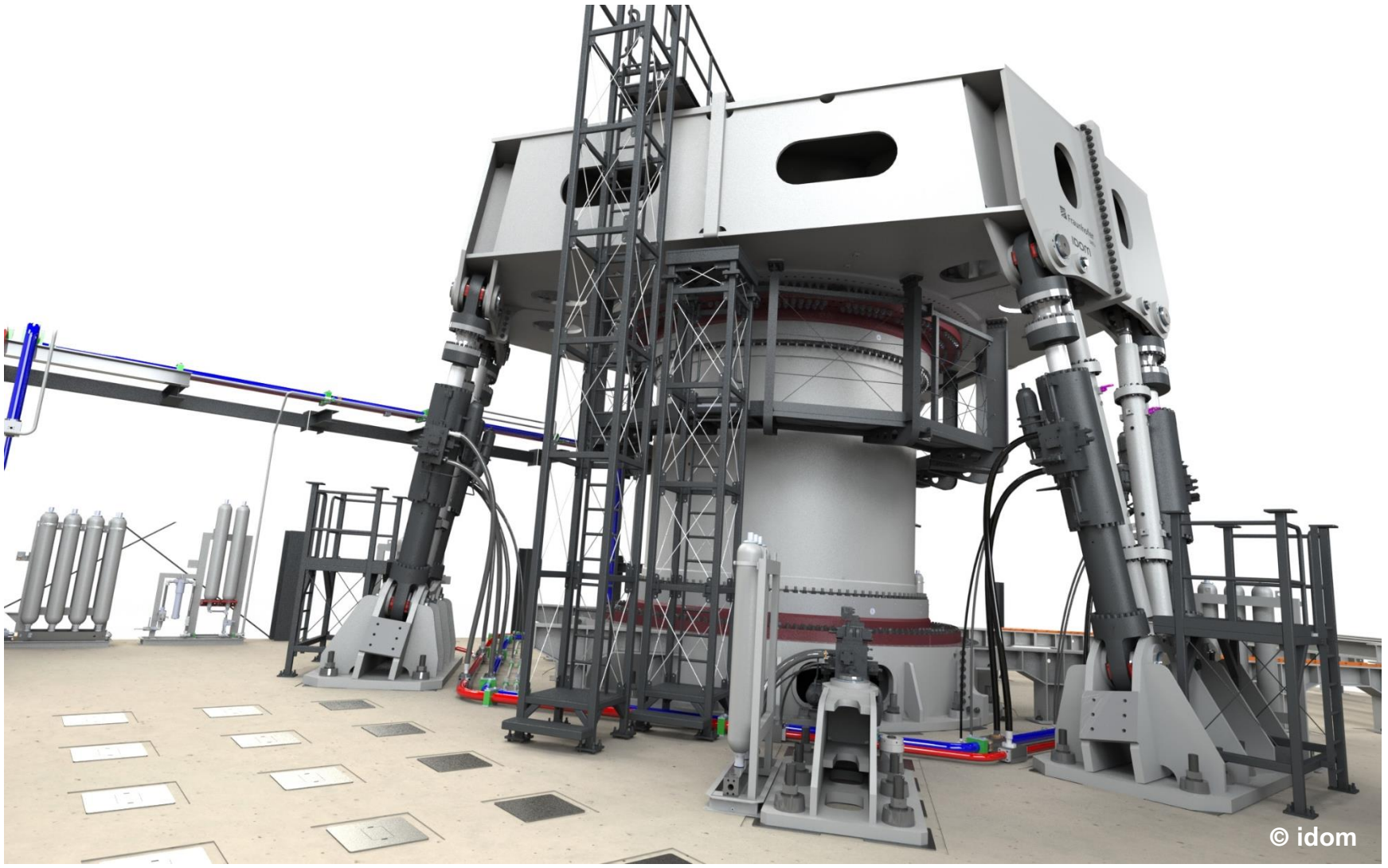
- ↖ Bearing diameter 3 – 6.5 m
  - ↖ 6 DOF dynamic load application (+/- 25 MNm @0.75 Hz)
  - ↖ 50 MNm extreme load
  - ↖ Hydraulic + electric pitch
  - ↖ Interface stiffness emulation
  - ↖ Fully integrated, automated TBMC (1 ms cycle time) with DAQ data base
  - ↖ Autonomous operation 24/7
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# BEAT6.1



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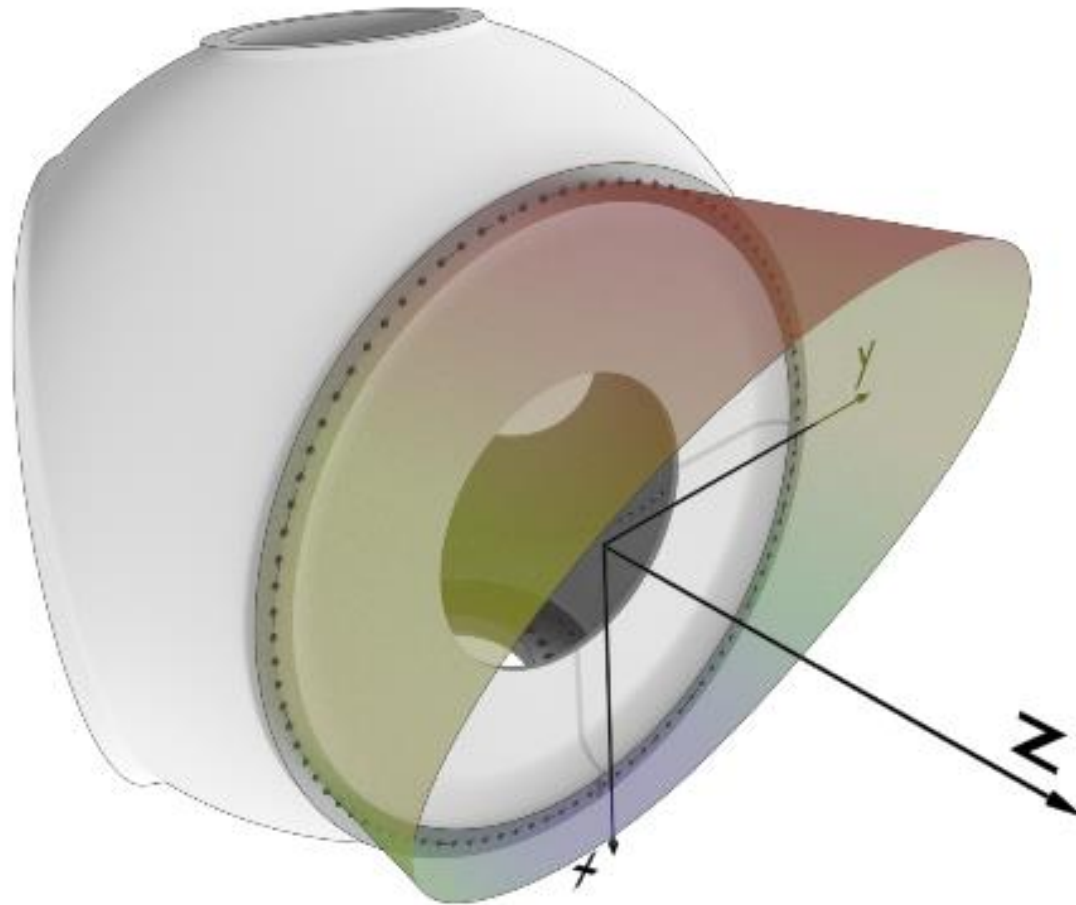
# BEAT6.1



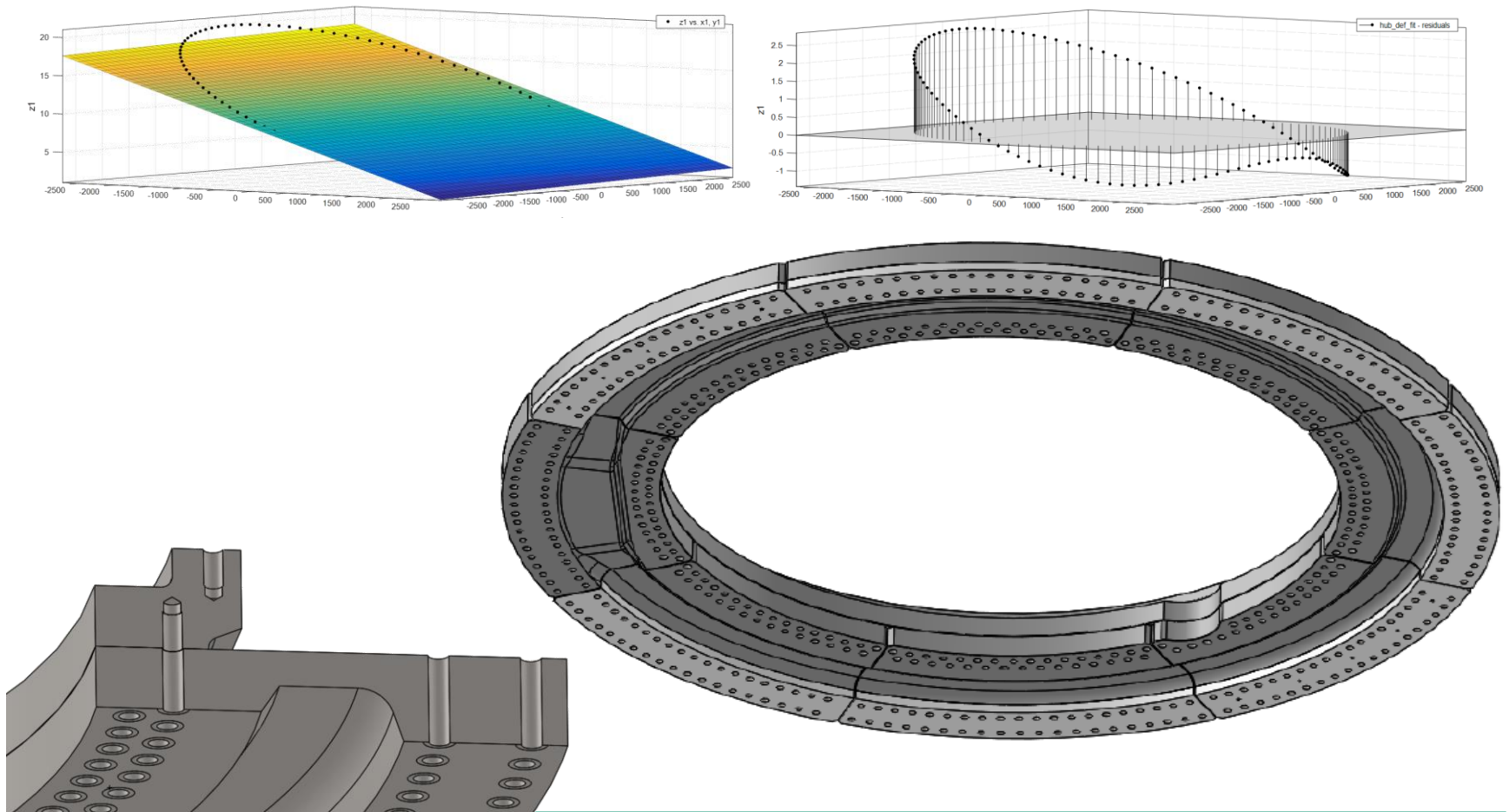
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# BEAT6.1 – Hub Interface

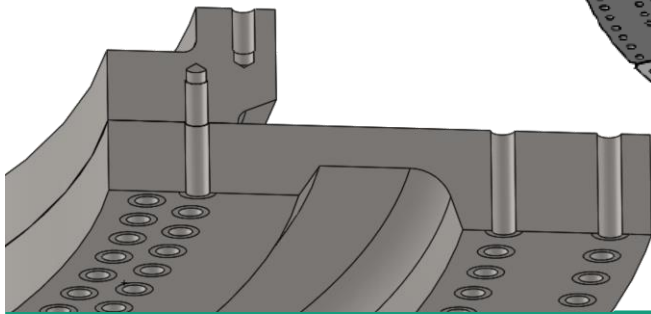
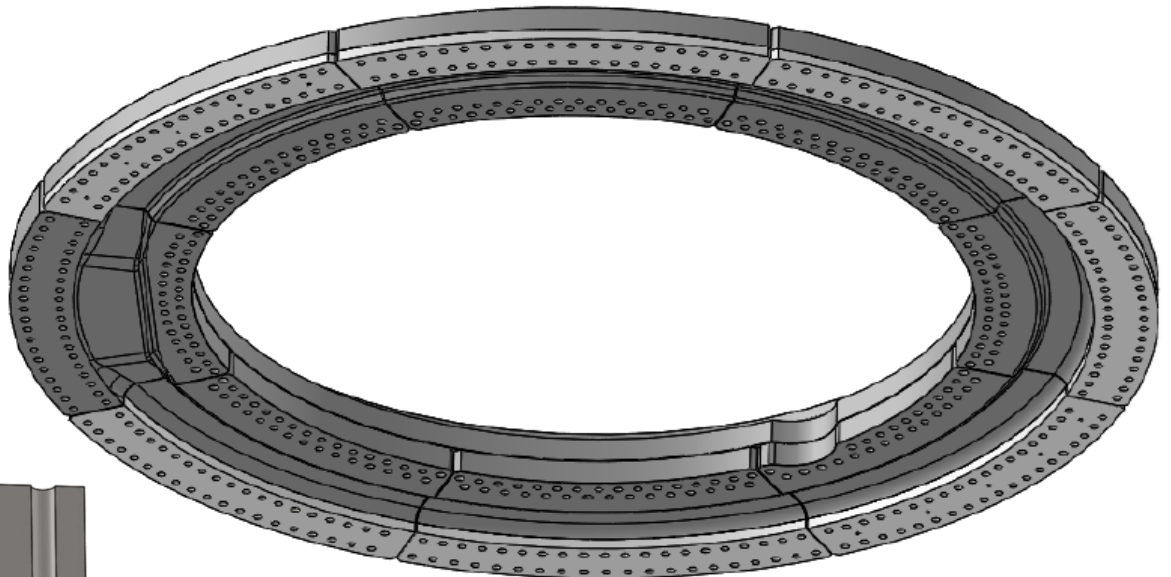
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# BEAT6.1 – Hub Interface

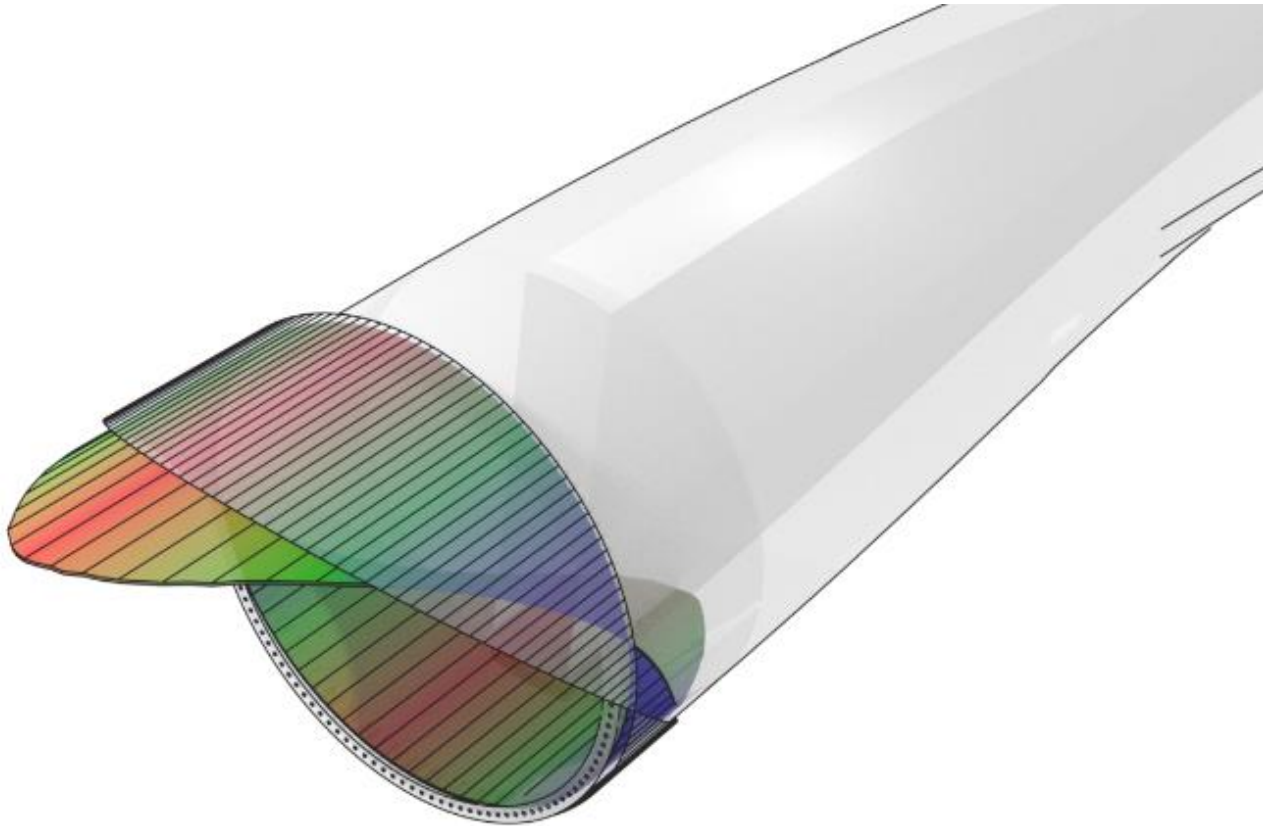


# BEAT6.1 – Hub Interface

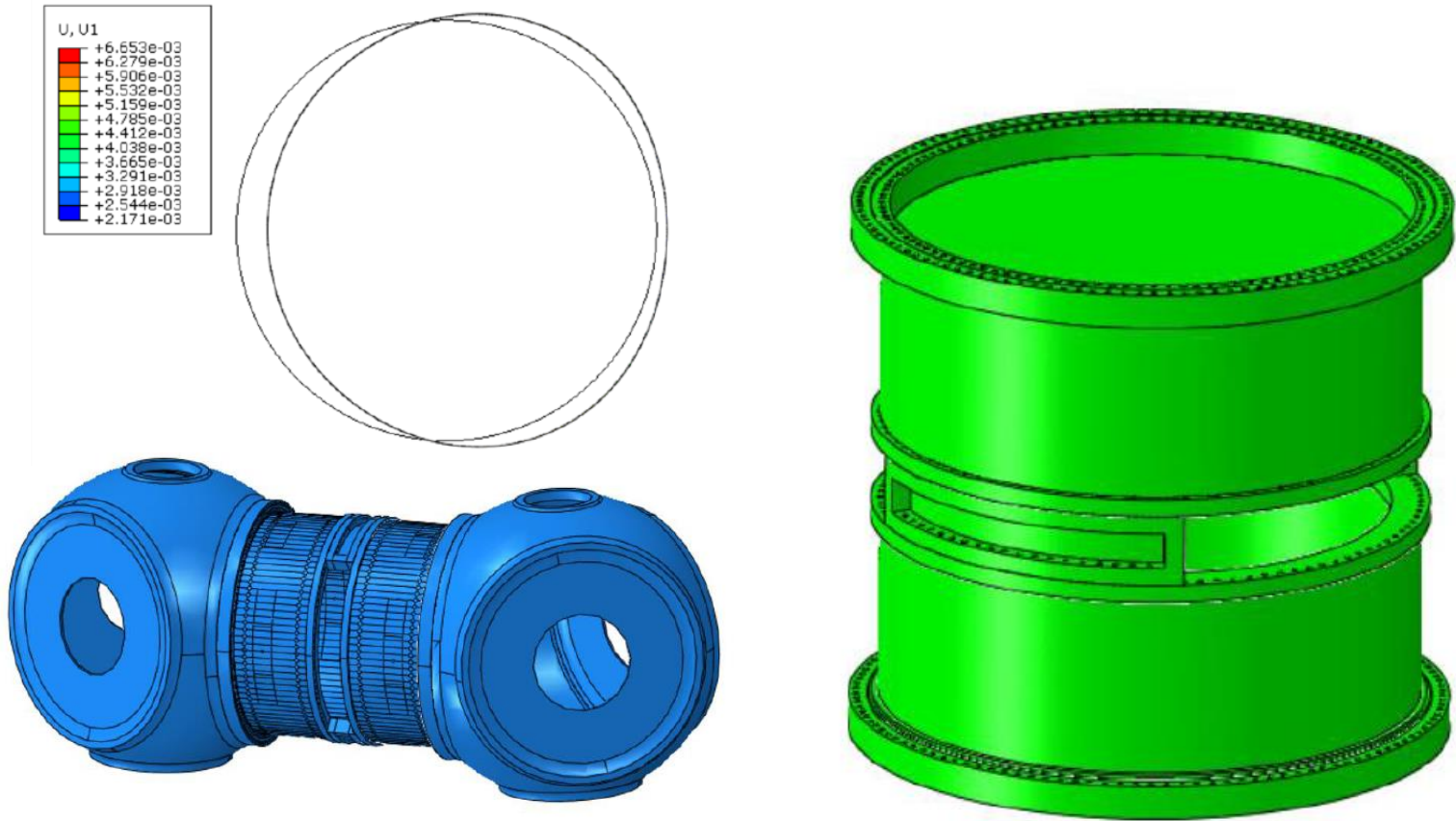


# BEAT6.1 – Blade interface

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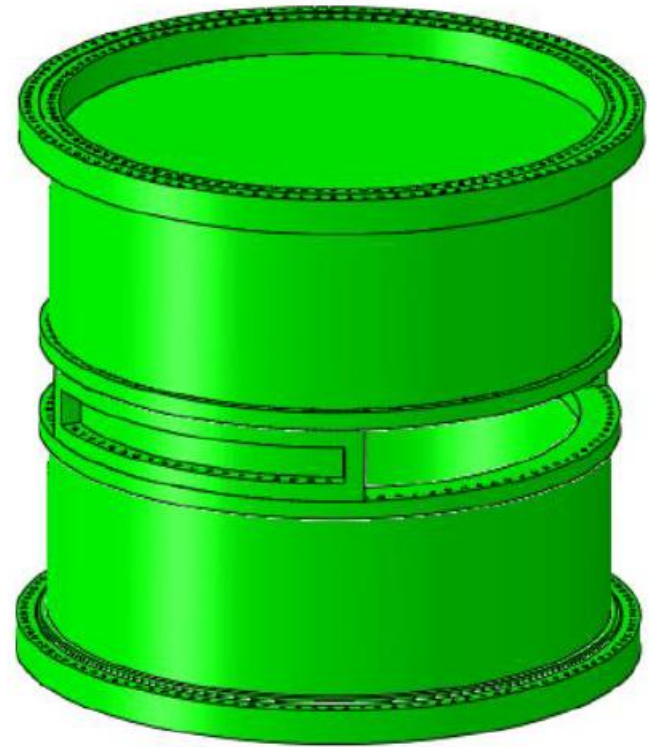
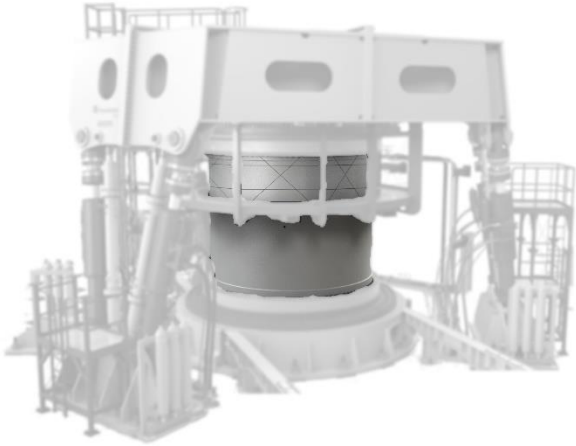


# BEAT6.1 – Blade interface



# BEAT6.1 – Blade interface

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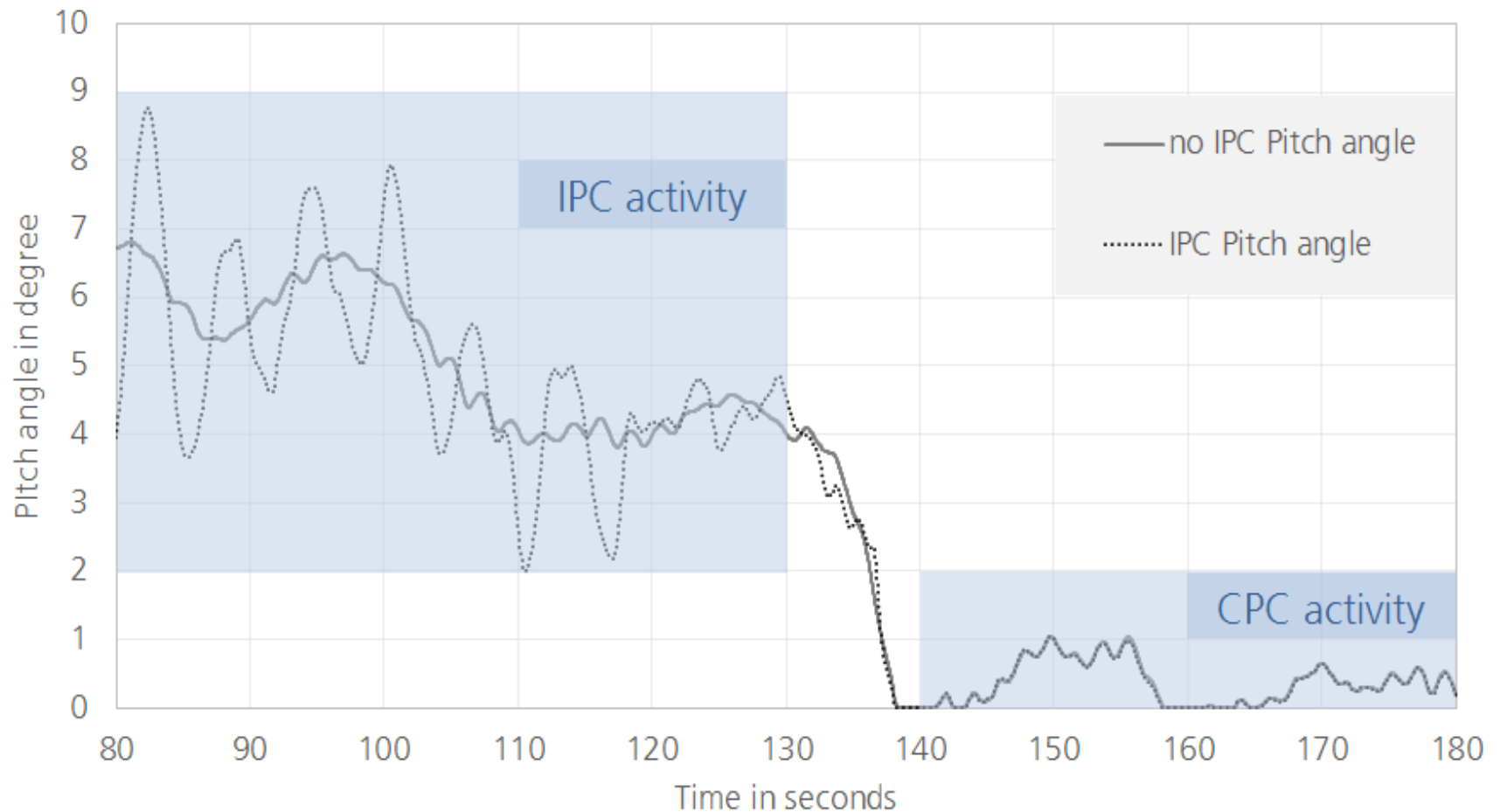
# HAPT

A highly accelerated endurance run program for pitch bearing

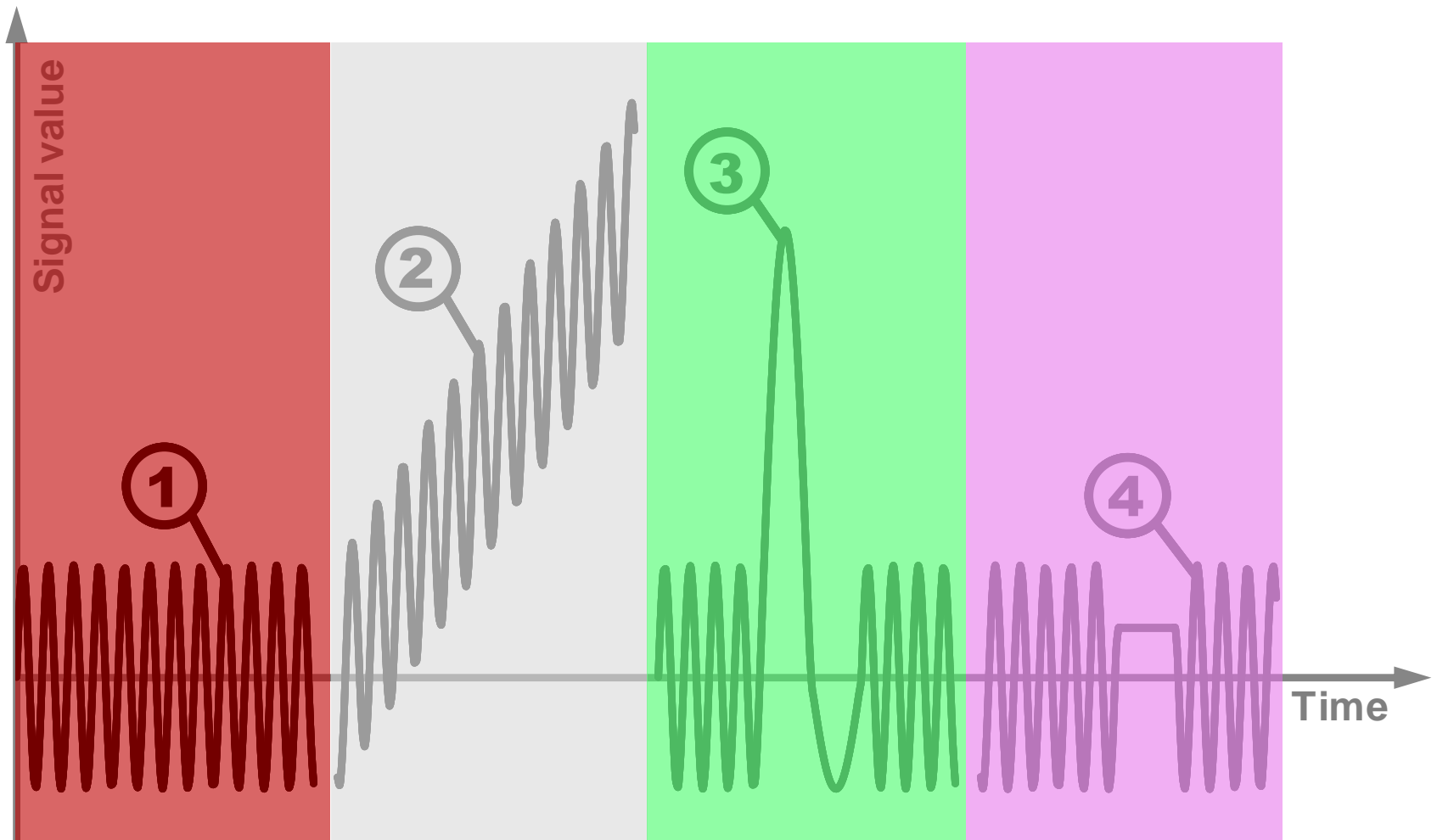
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- Main focus: Raceway wear
- Included: Functionality & Robustness (Raceway & Structure)
- Included: FE model validation, friction torque measurement
- Included: Transient situations (e.g. Start & Stop)
- Not included: RCF endurance

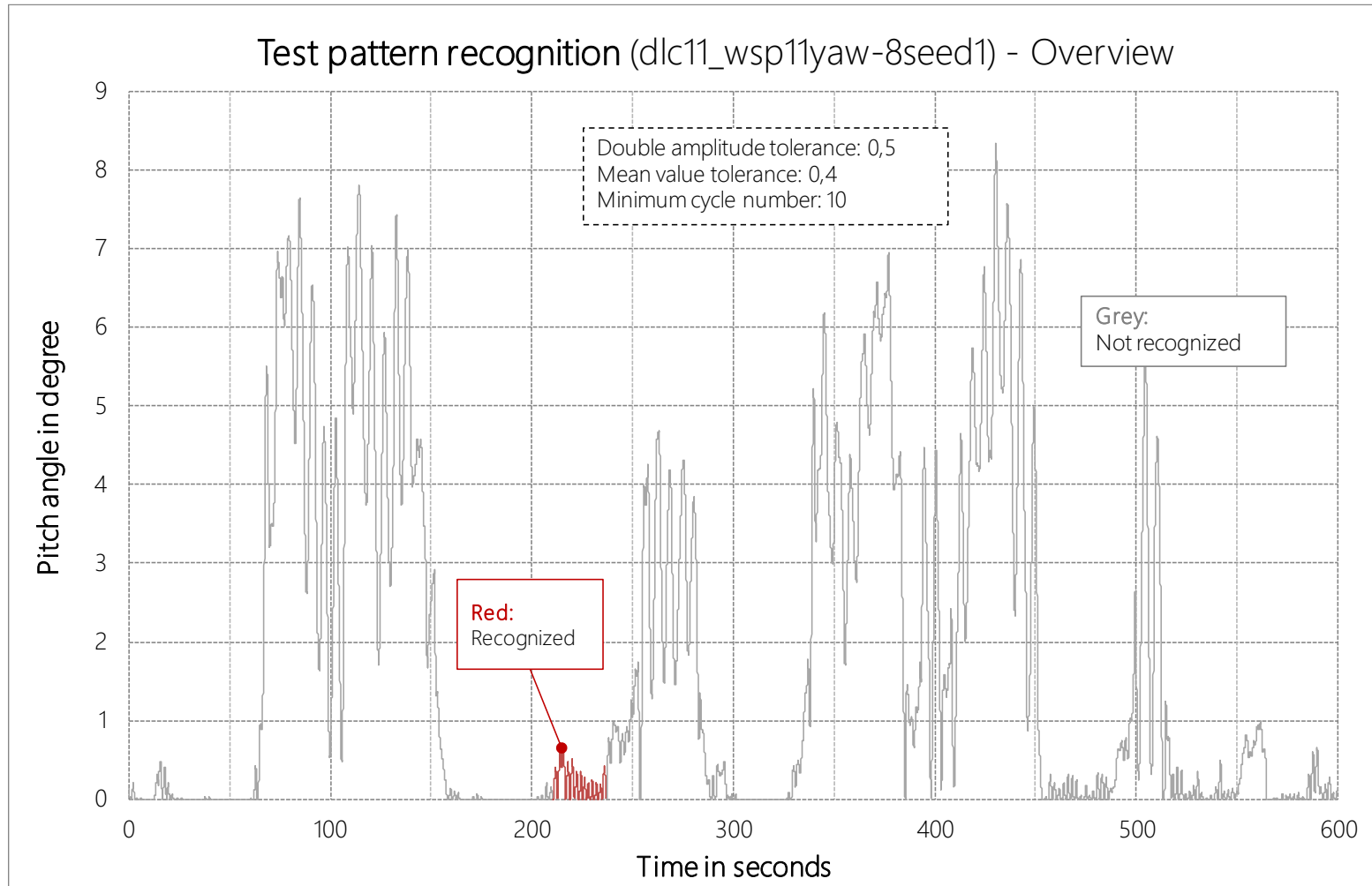
# Raceway wear



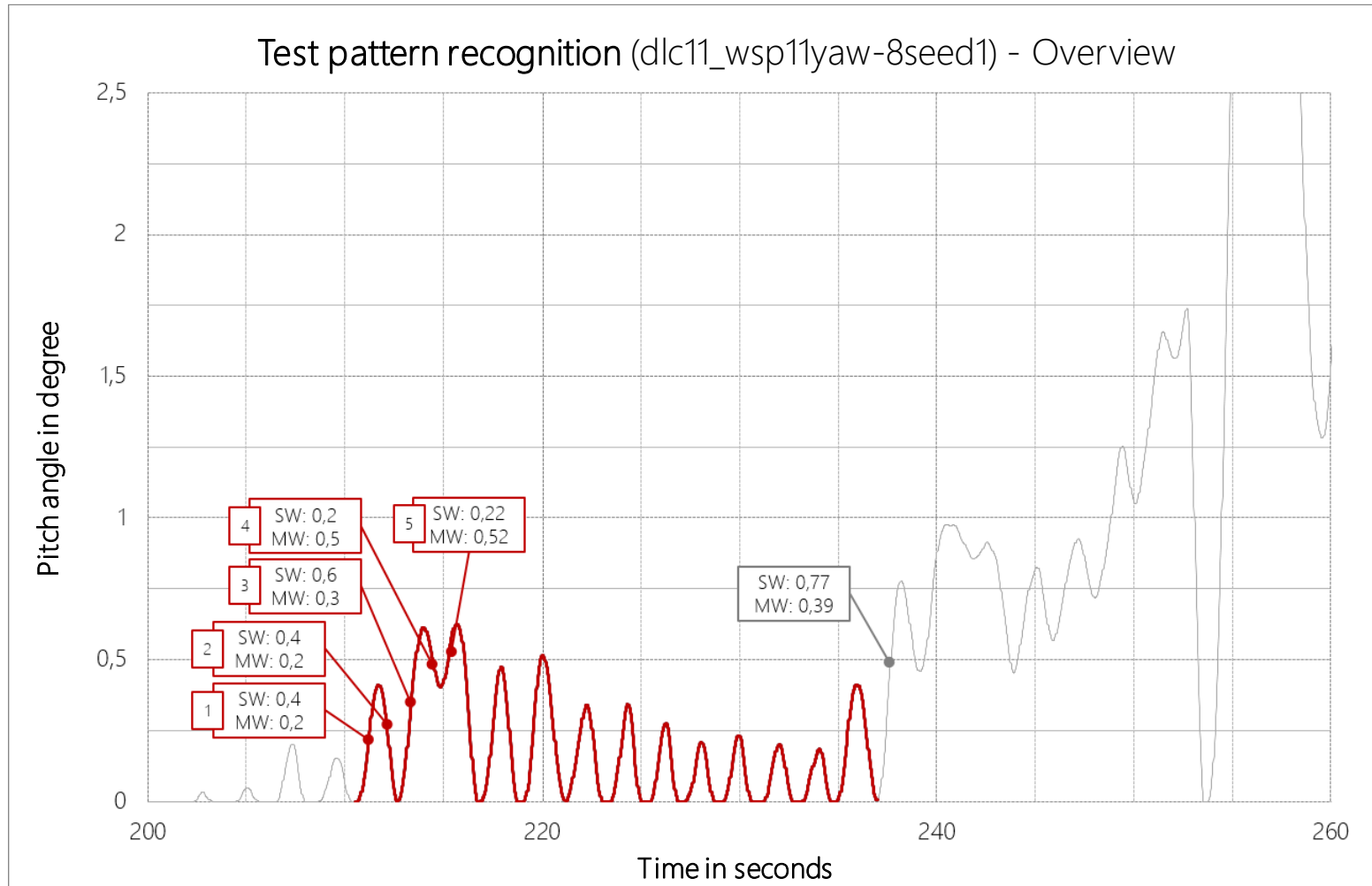
# Movement patterns



# Pattern recognition in time series



# Pattern recognition in time series



# The way to an endurance run program

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- Time series:
  - Evaluate movement patterns (critical to wear)
  - Evaluate load dynamics (FFT / Known functions)
  - Build transition library
  - Determine transient load cases (e.g. start / stop)
- Time series / Weibull:
  - Get multipliers
  - Put time series in realistic but random order (day / year)
  - Force transient DLC according to occurrence
- Stitching
  - Set phase angle to minimize gaps between pattern blocks
  - Transitions: Select from transition library (round robin)
- Evaluate test profile
  - Duration
  - Energy consumption / Dynamics



## Conclusion

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The BEAT6.1 is a versatile, dynamic 6 DOF 50 MNm test rig with realistic blade bearing interfaces.

BEAT6.1: We'd love to try it on large main bearings as well.

The HAPT program is a true endurance run for blade bearings, based on raceway wear.

HAPT program: We'd love to apply it to other blade bearings as well.

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# Methodological competence



Awarded with **“Norddeutscher Wissenschaftspreis”** for the successful cooperation within the “Research Alliance Wind Energy” for the joint project “Smart Blades”



**ISO9001-certified** in the areas of “product development up to the prototype stage, technology development and optimization, technology assessments and studies” as well as “trials in demonstration centers”.



**Accredited** according to **DIN EN ISO / IEC 17025:2005** for

- testing of mechanical loads on wind turbines
- determination of physical properties of fibre enhanced synthetic materials and fibre composite materials using mechanic-technological and thermal testing
- full-scale structural testing of rotor blades



## References





## HAPT project overview

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### Project target IWES

Design and test an accelerated endurance run for wind turbine pitch bearings.

### Project partners



### Budget

€ 11.0 million

~€ 0.5 million

~€ 1.1 million

### Duration

2016 / 1 / 1 to 2020 / 09 / 30

# Acknowledgements

## Fraunhofer IWES is funded by the:

**Federal Republic of Germany**

**Federal Ministry for Economic Affairs and Energy**

**Federal Ministry of Education and Research**



**European Regional Development Fund (ERDF):**

**Federal State of Bremen**

- Senator of Civil Engineering, Environment and Transportation
- Senator of Economy, Labor and Ports
- Senator of Science, Health and Consumer Protection
- Bremerhavener Gesellschaft für Investitions-Förderung und Stadtentwicklung GmbH



**Federal State of Lower Saxony**

**Free and Hanseatic City of Hamburg**





**Thank You For Your Attention**

Any questions?

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