



On the Correlation of a Helicopter Brake Assembly Model by means of 3D Scanning Laser Doppler Vibrometry

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Motivation of the Study

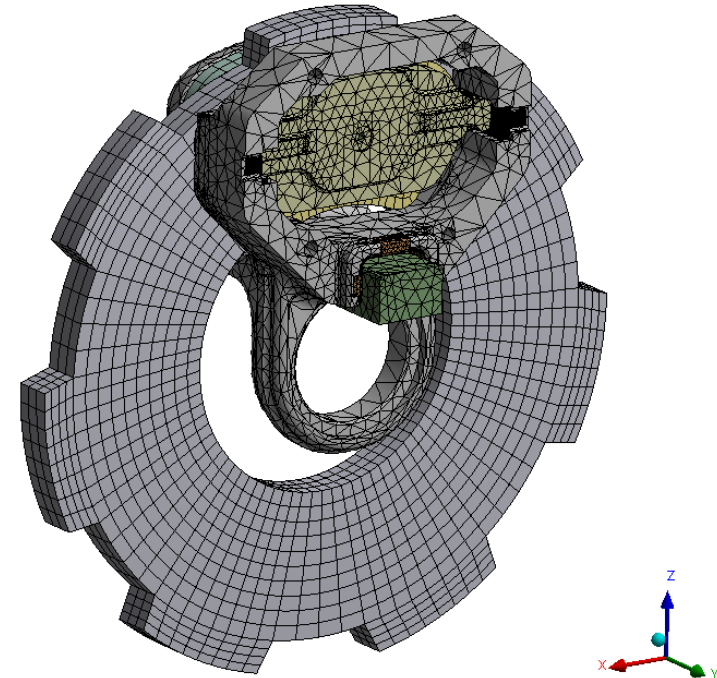


Photo source : www.journal-aviation.com

In the automotive industry, brake squeal is perceived since decades as a comfort and quality perception issue.

Brake squeal has gained relevance during the last years in the aviation industry, which strives to offer more comfortable aircraft, while keeping noise levels to a minimum.

Motivation of the Study

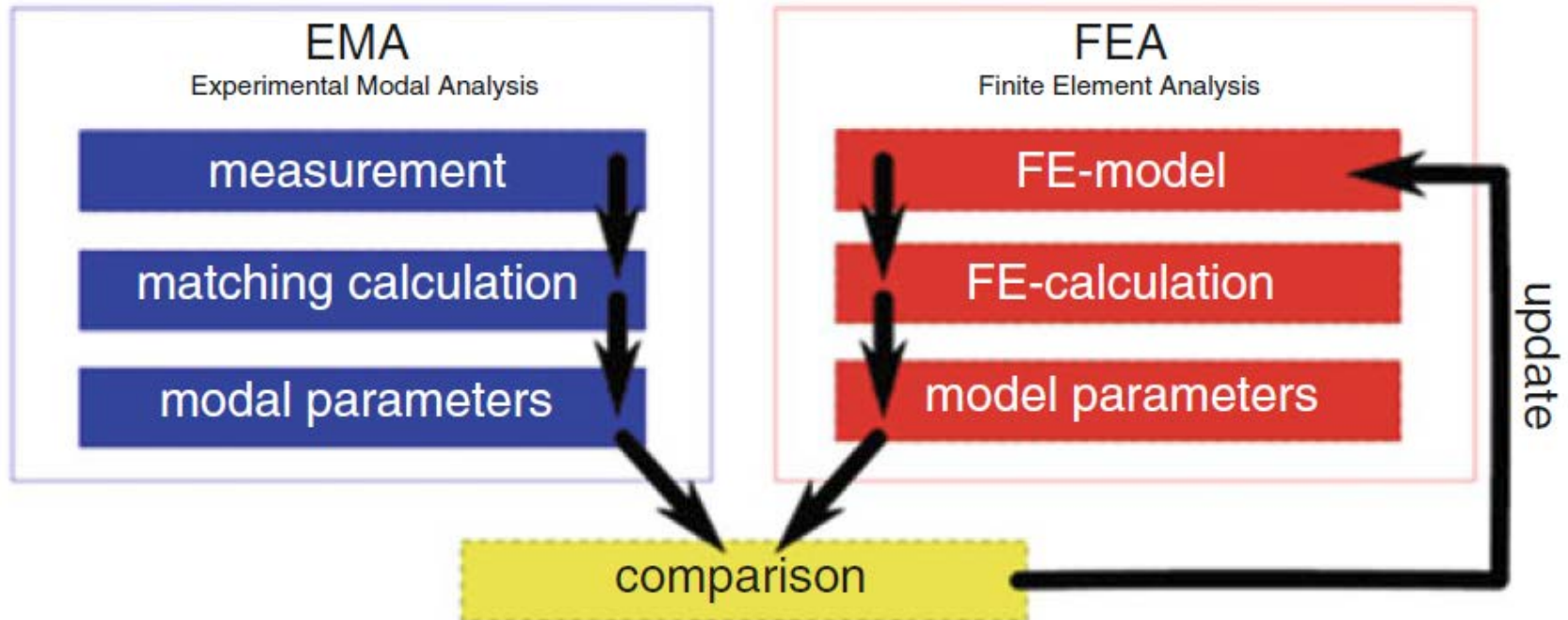


Brake rotor and pad are made of carbon-carbon composites.

- Lightweight composite material, anisotropic properties, non-linearly distributed damping components.
- Phenomena like contact non-linearities and interfacing need to be taken into account on the FE model, to simulate a braking event.

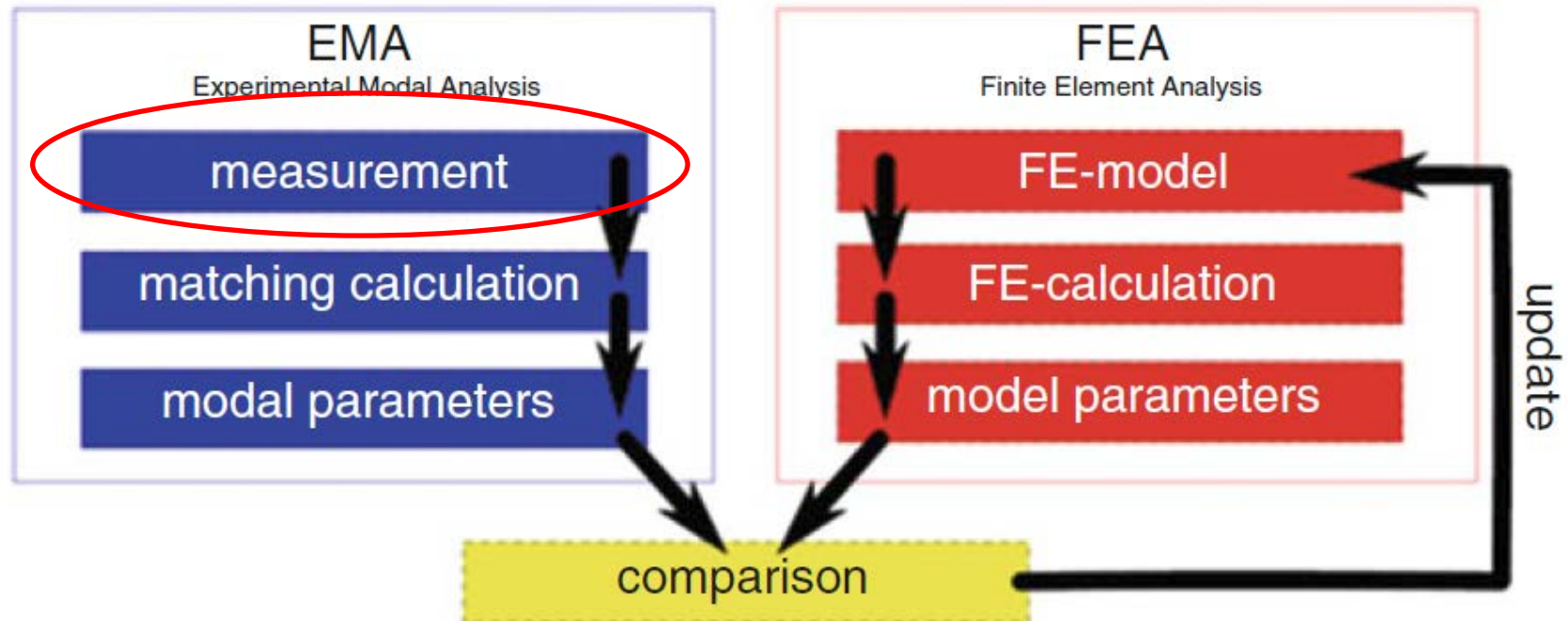
Not straightforward FE modeling!

Motivation of the Study



BLASCHKE, P., SCHNEIDER, T., Reactionless Test to Identify Dynamic Young's Modulus and Damping of Isotropic Plastic Materials, Topics in Modal Analysis, Vol. 7, Proceedings of the IMAC XXXI, Garden Grove, CA, USA, 2013.

Motivation of the Study



BLASCHKE, P., SCHNEIDER, T., Reactionless Test to Identify Dynamic Young's Modulus and Damping of Isotropic Plastic Materials, Topics in Modal Analysis, Vol. 7, Proceedings of the IMAC XXXI, Garden Grove, CA, USA, 2013.

- Modal test - 3D SLDV + Scalable Automatic Modal Hammer
 - Adjustable, repeatable excitation up to 20 kHz
 - NO mass loading → NO accelerometers
 - NO work piece modification → NO shakers
 - High number of DOFs for FE correlation → test automatization

Experimental Setup

Scalable Automatic
Modal Hammer (SAM)

3D SLDV computer & data
management module

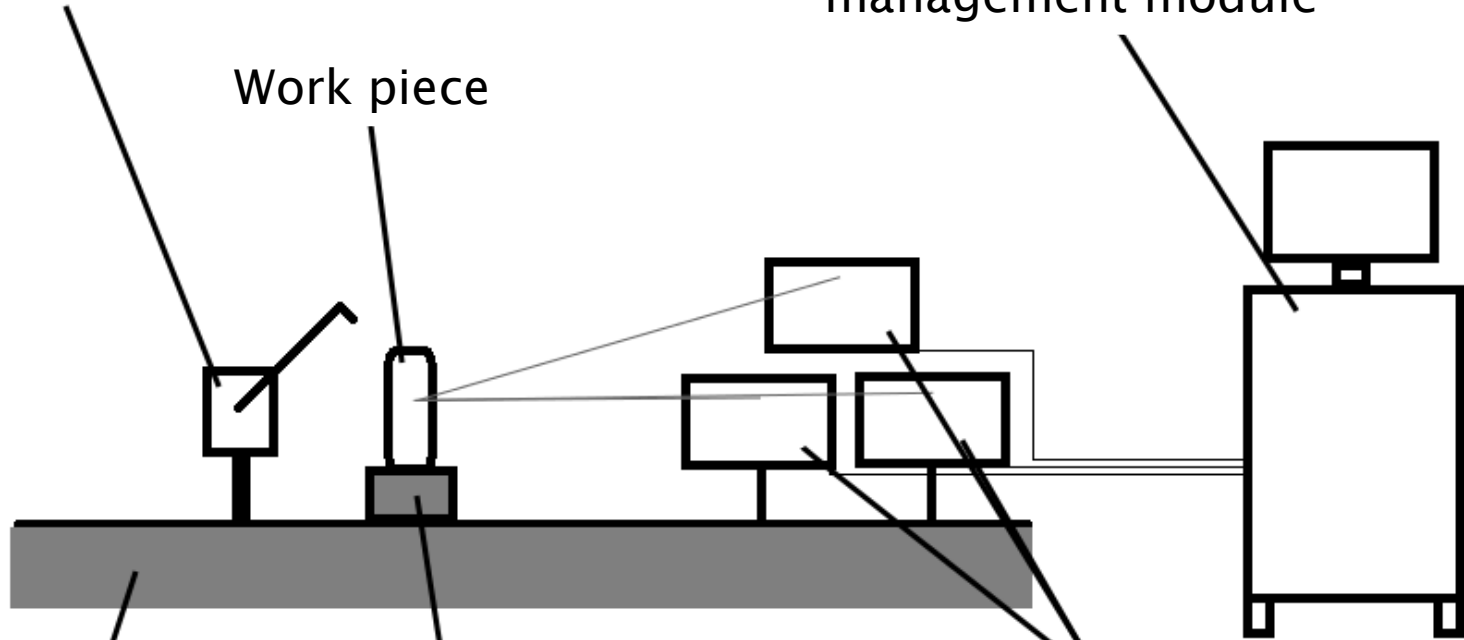
Work piece

Work piece

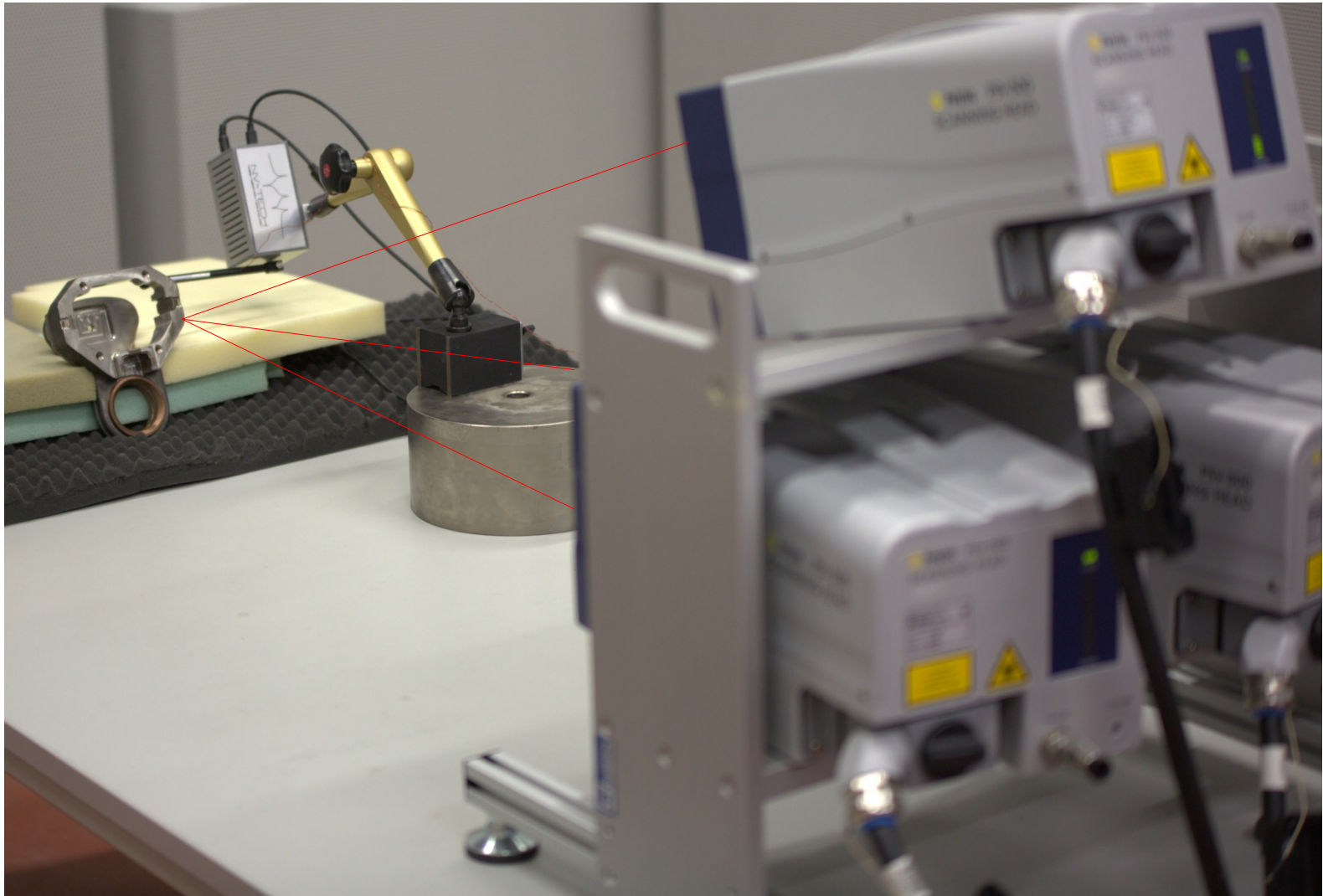
Foam mat

Test bench

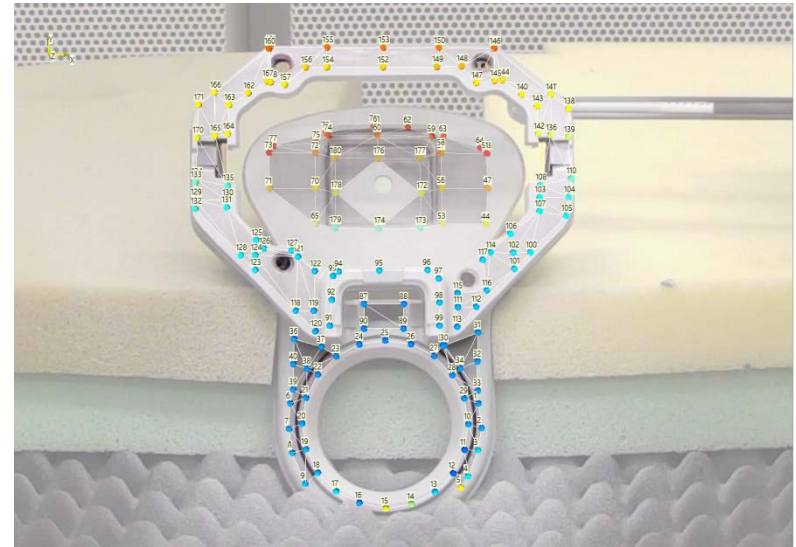
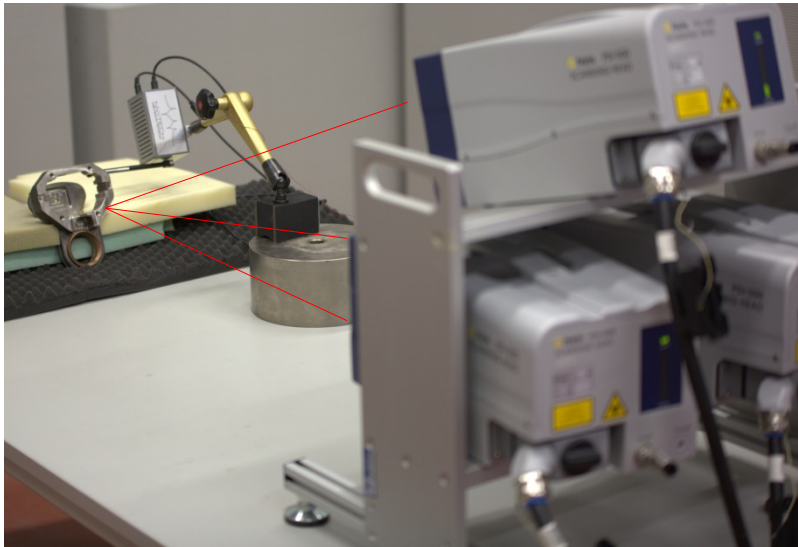
3D SLDV scanning
vibrometer heads



Testing Challenges: Brake Caliper



Testing Challenges: Brake Caliper

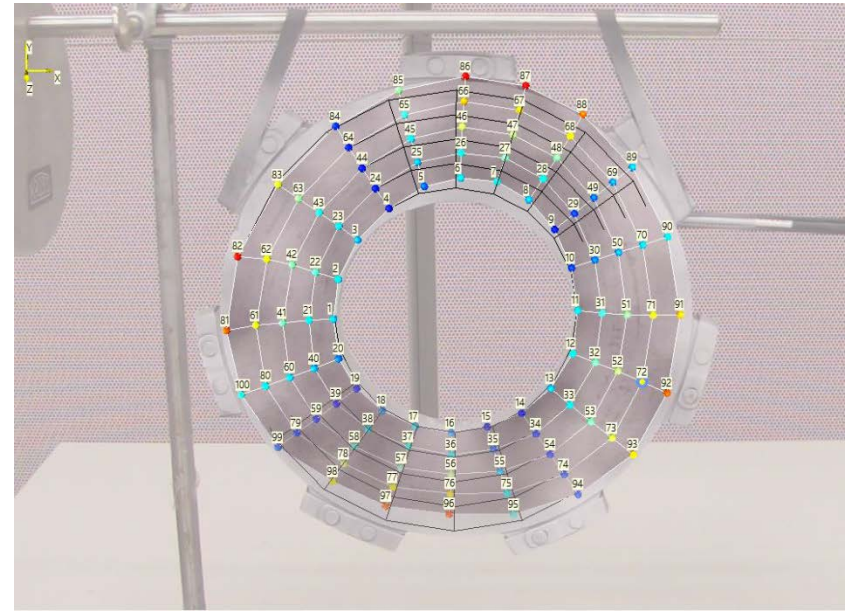
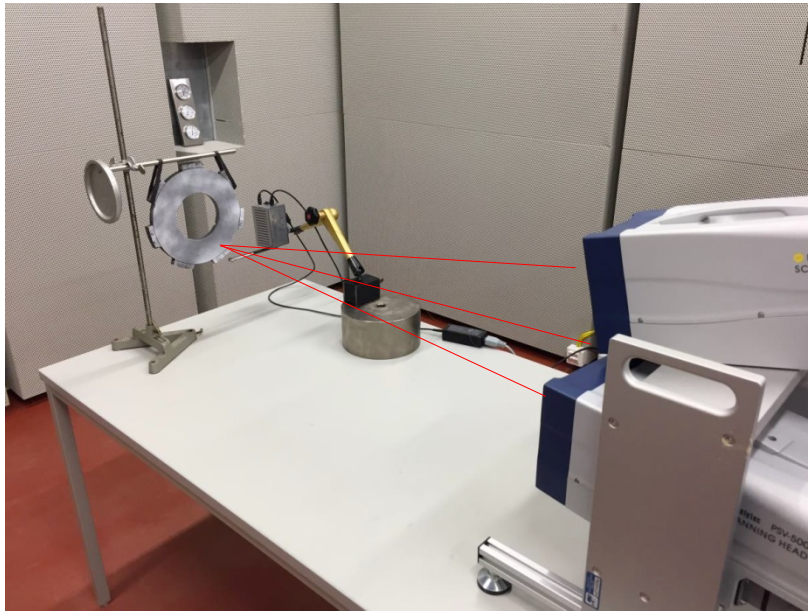


- Brake caliper placed leaning against soft foam mats.
- The chosen experimental setup allows the laser scanning of the entire structure in only one shot → reduction of testing time.
- 173 tested DOFs, 18 DOFs disabled due to poor line of sight.
- SAM set to impact at the rear side of the structure, to avoid interference in the laser scanning. The impact point is sensitive for all vibrational modes.

Testing Challenges: Brake Disc

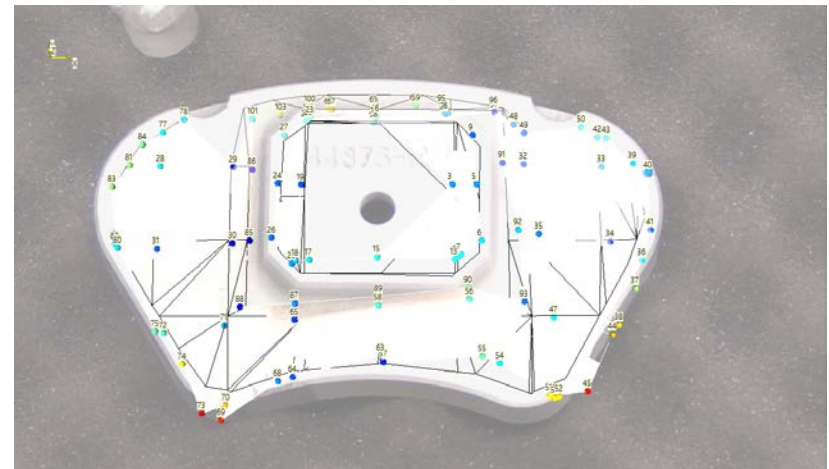
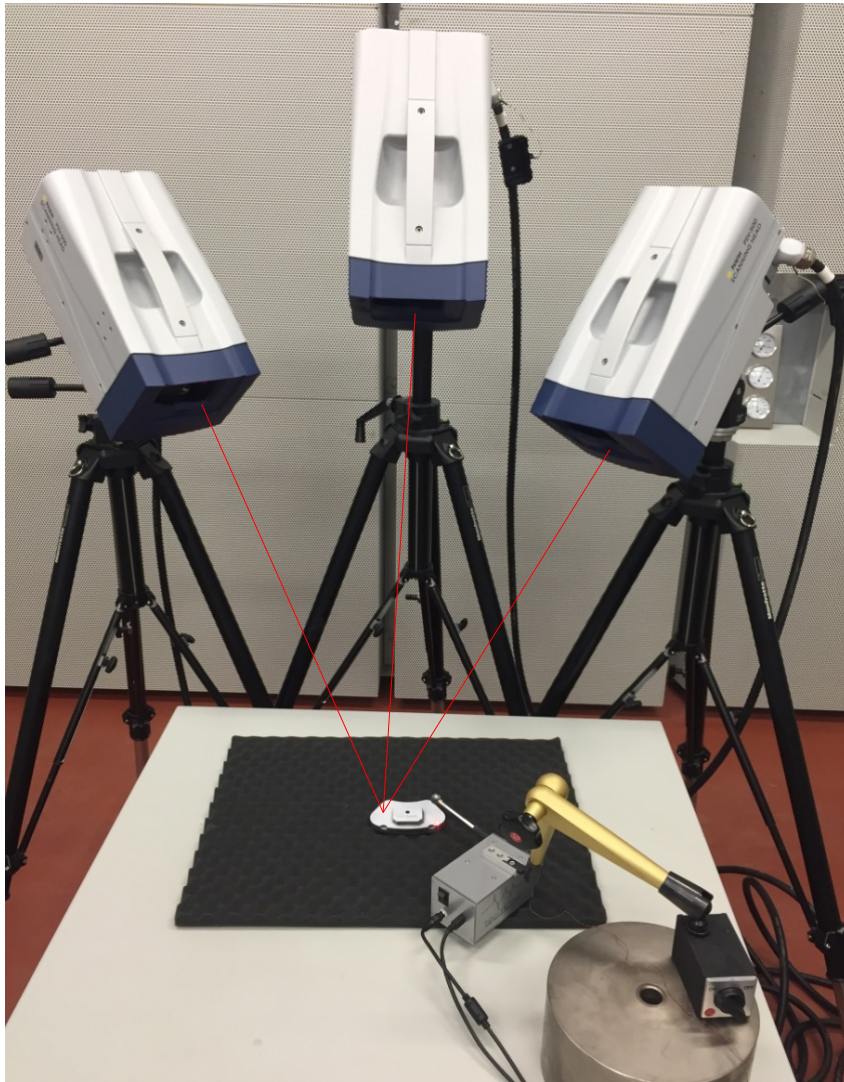


Testing Challenges: Brake Disc

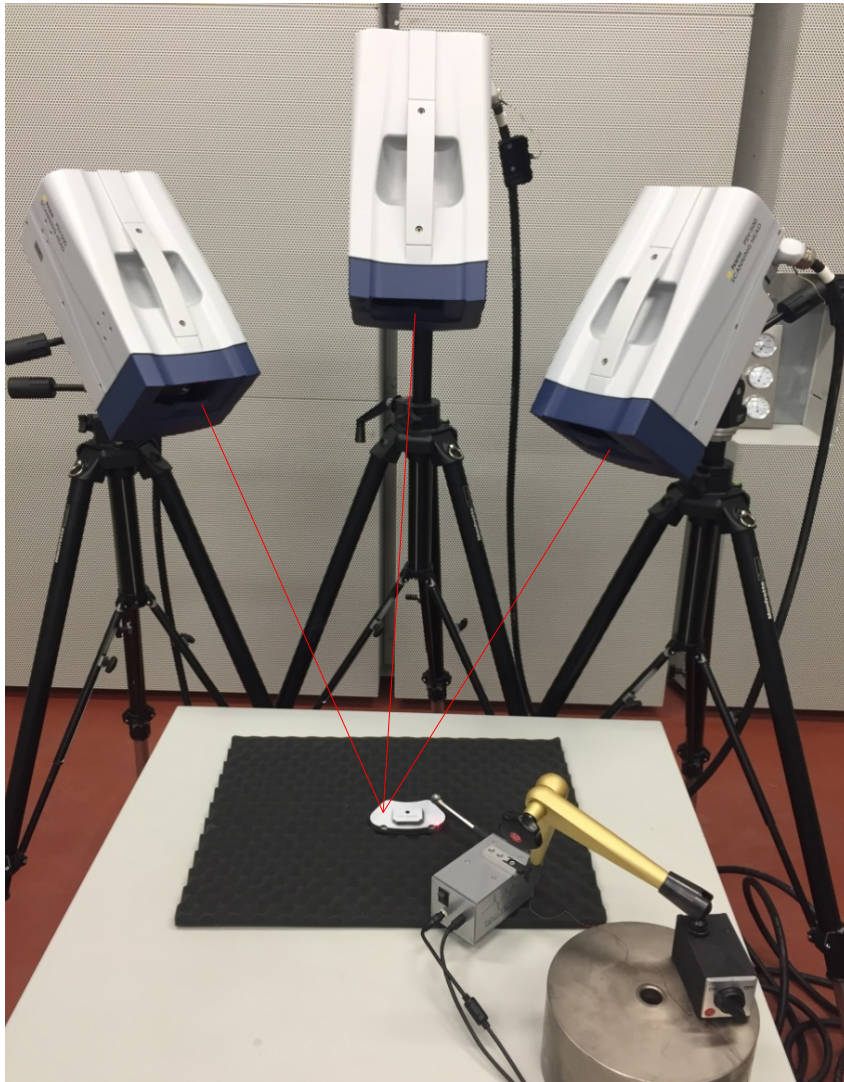


- Brake disc hanging on elastic rubber bands.
- Setup allows the laser scanning of the entire structure in only one experimental setup without a re-alignment of the 3D SLDV laser heads → reduction of testing time.
- 100 tested DOFs, 96 DOFs measured optimally.
- Brake disc needed to be sprayed with white developer in order to improve the laser reflectivity.

Testing Challenges: Brake Pad

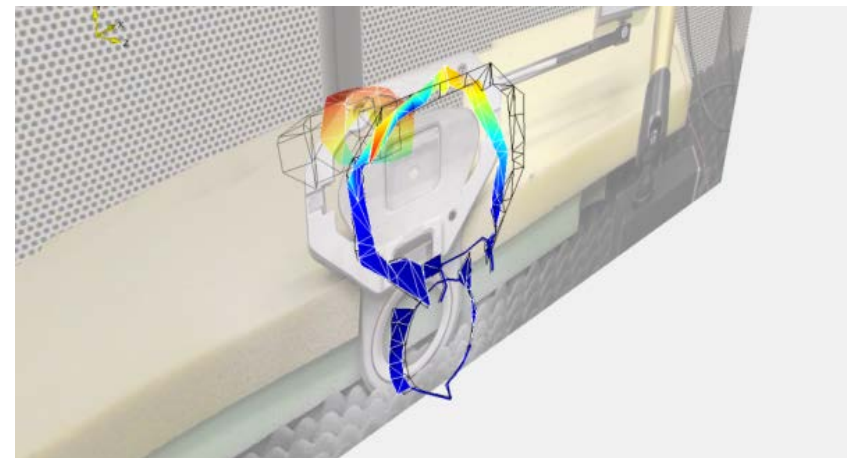
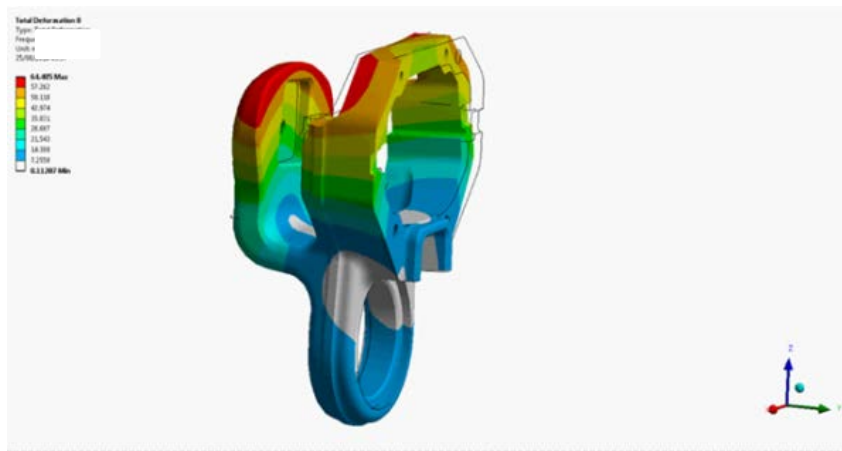
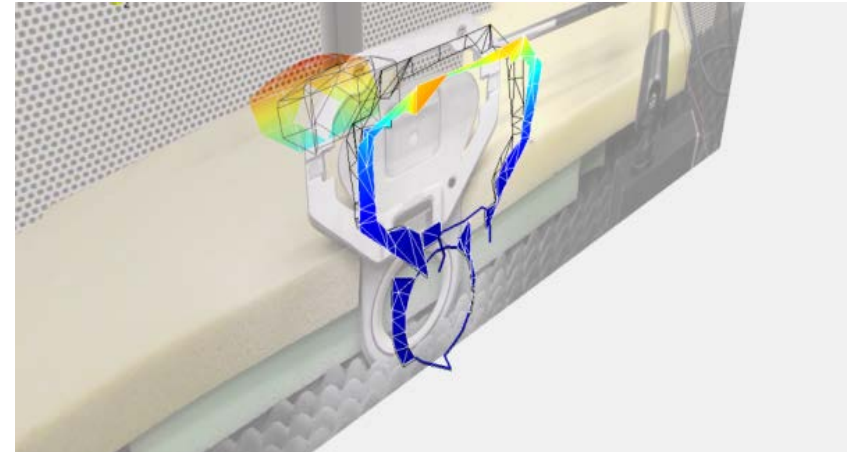
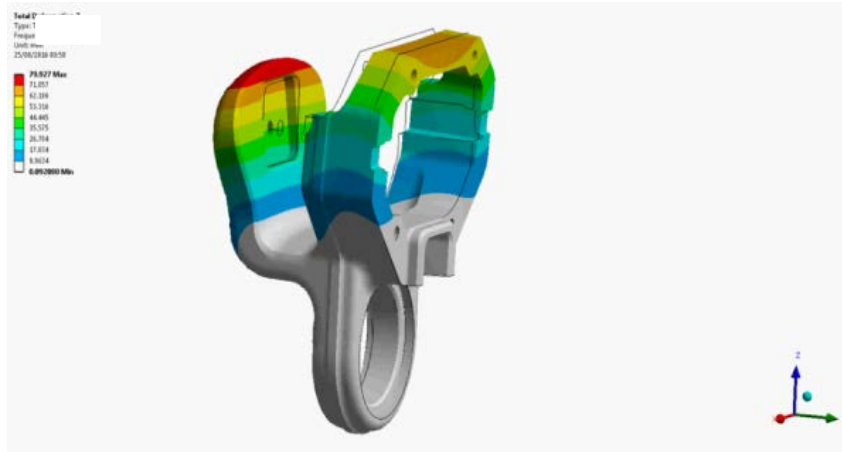


Testing Challenges: Brake Pad



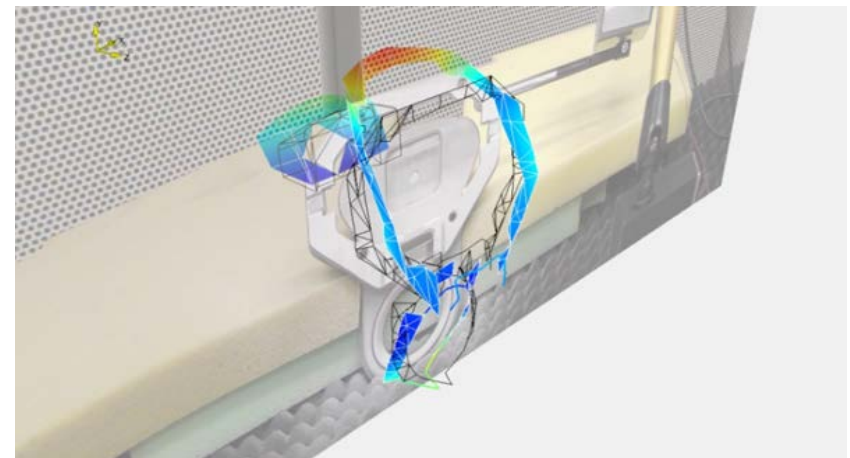
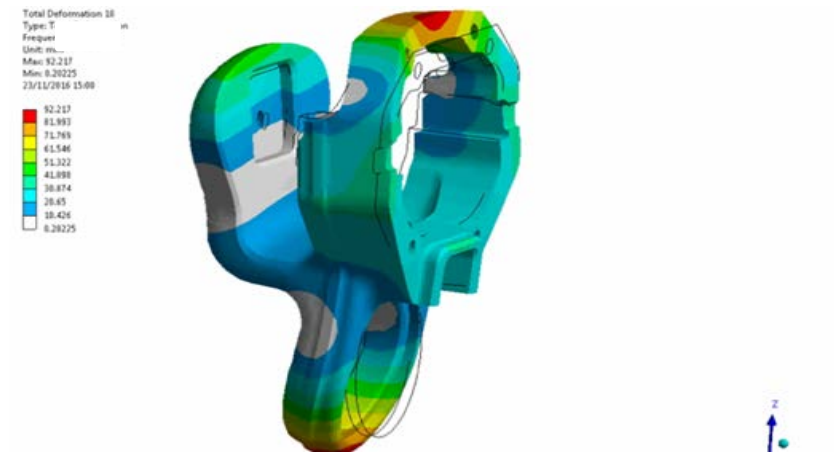
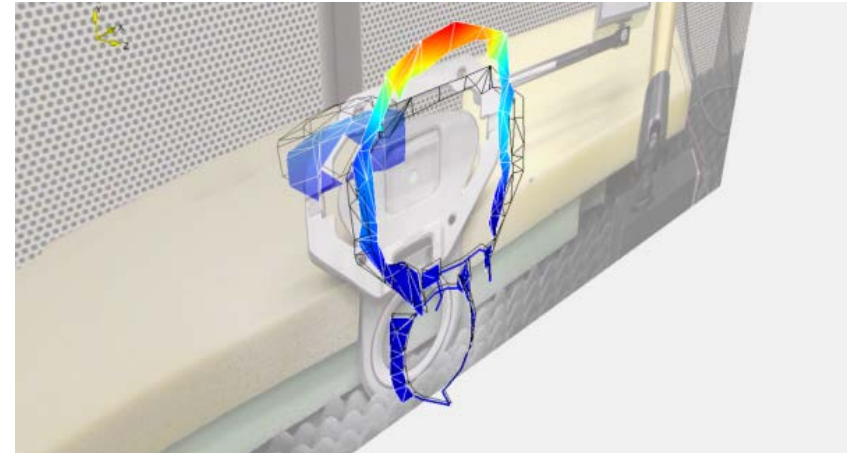
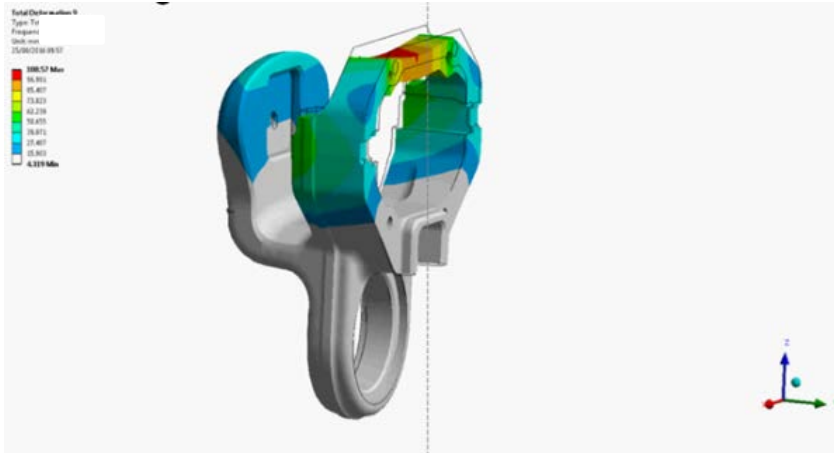
- Hanging the brake pad for the test was impractical.
- The 3D SLDV heads needed to be realigned to fit the new experimental setup.
- 106 DOFs tested, 5 DOFs disabled due to SAM interference on the scanning.
- Brake pad needed to be sprayed with white developer in order to improve the laser reflectivity.

Results and Discussion: Brake Caliper



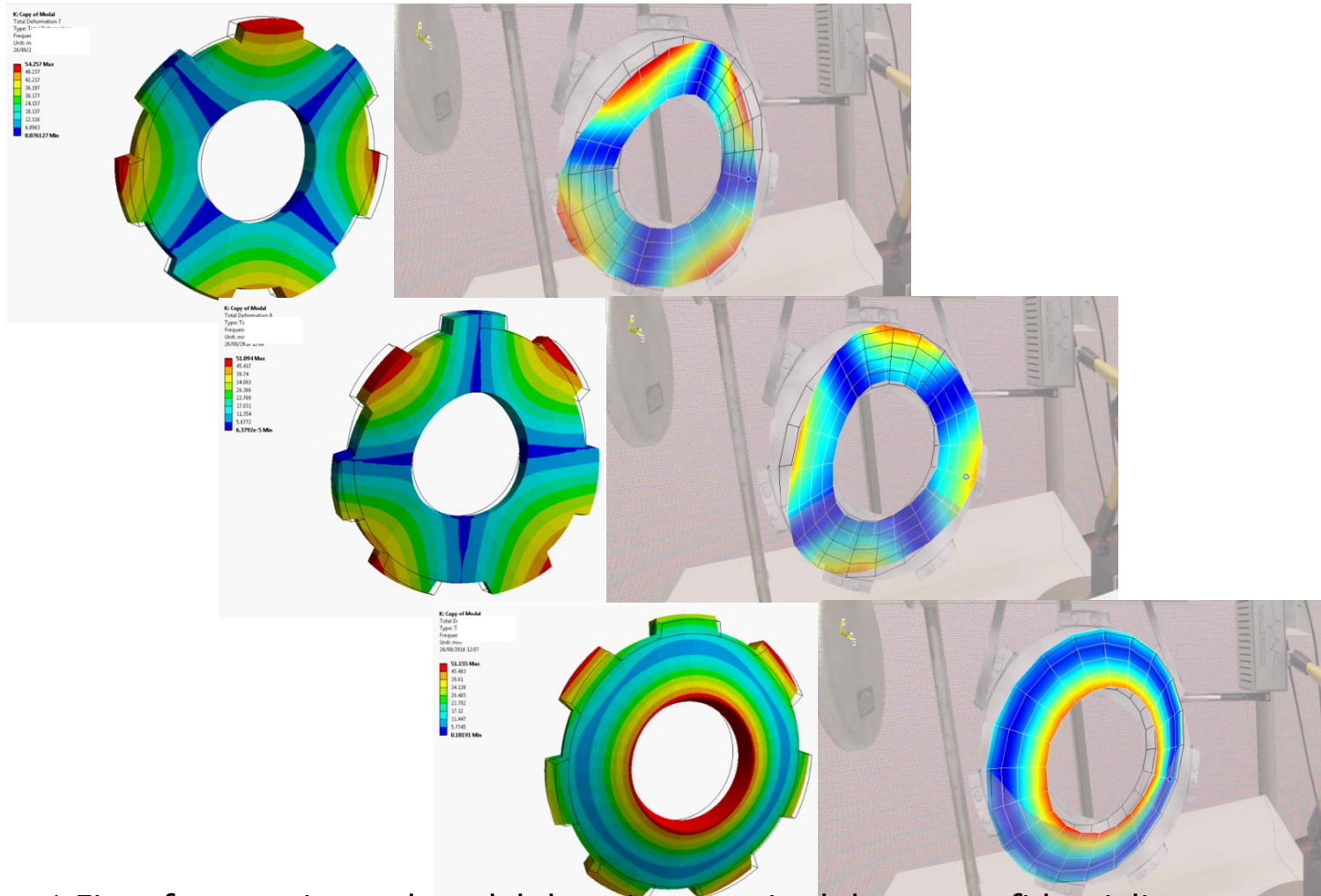
* Eigenfrequenzen und modal damping omitted due to confidentiality reasons.

Results and Discussion: Brake Caliper



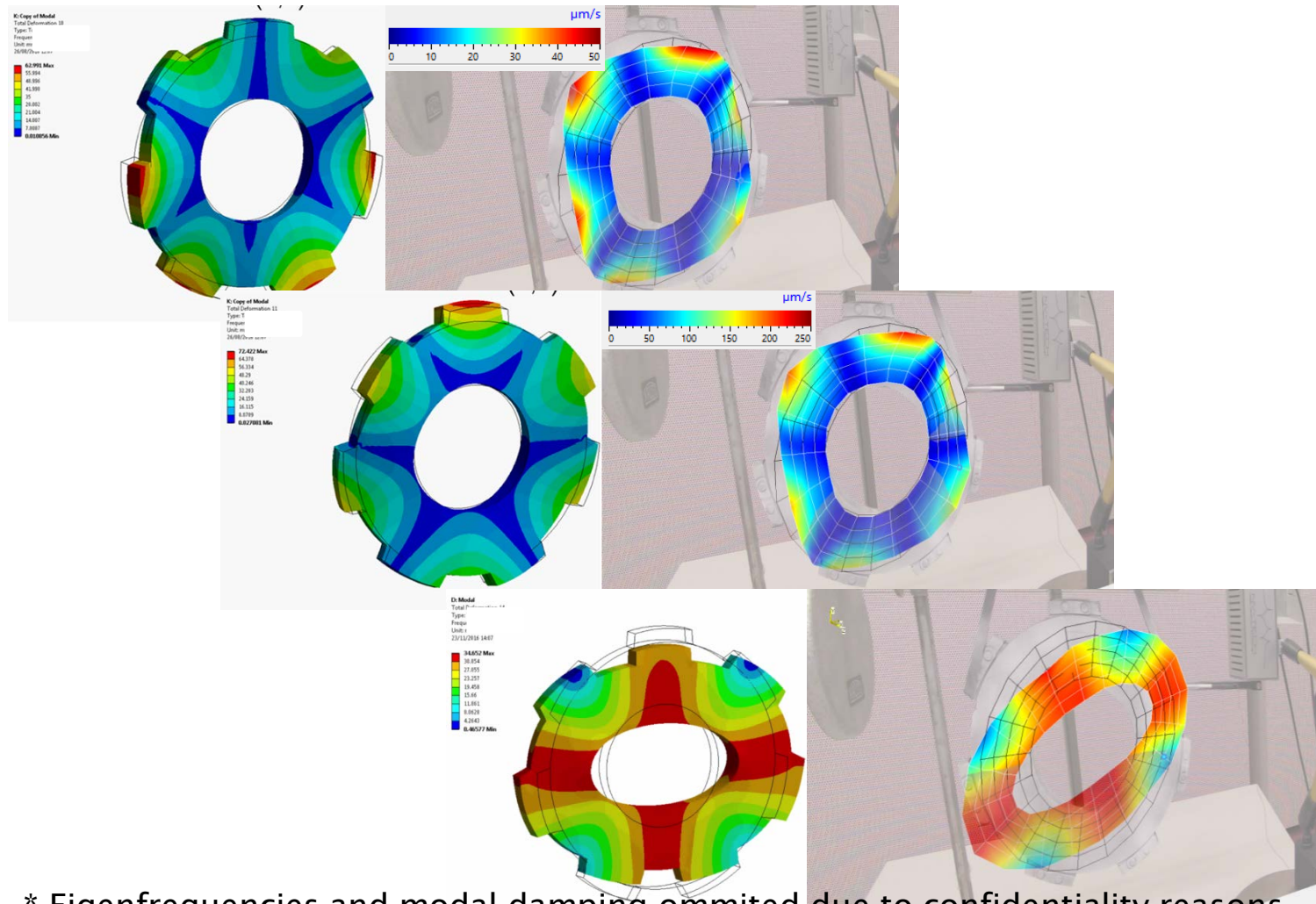
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Results and Discussion: Brake Disc



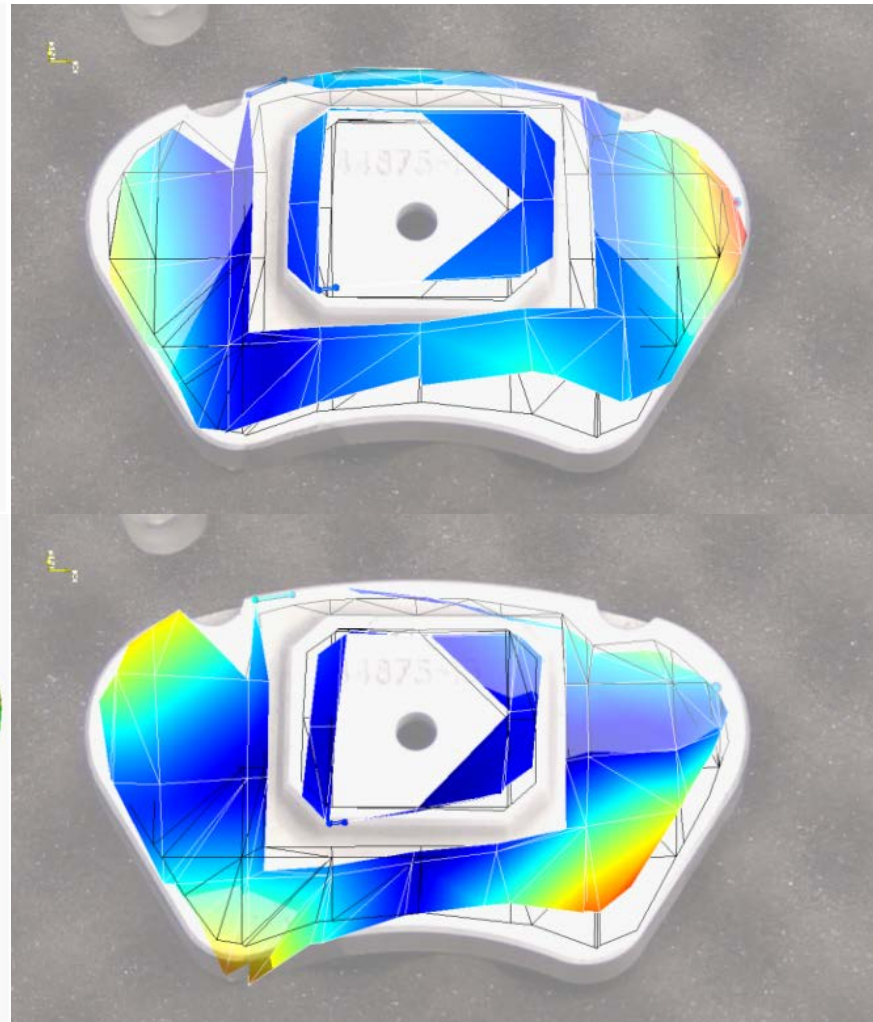
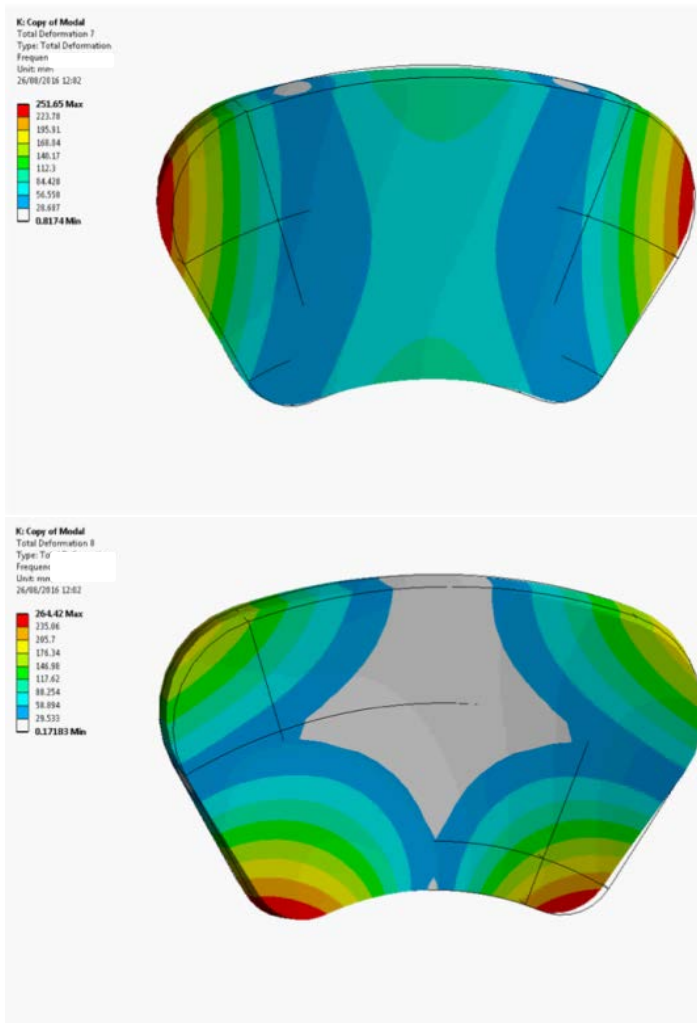
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Results and Discussion: Brake Disc



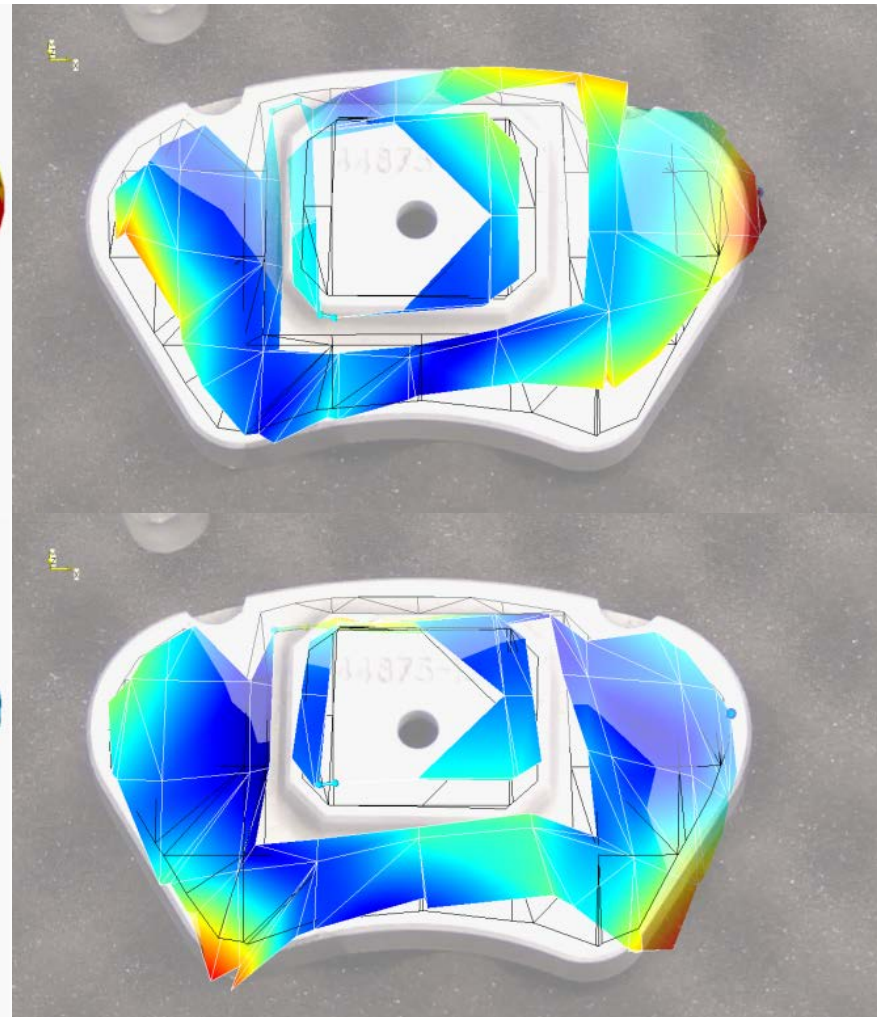
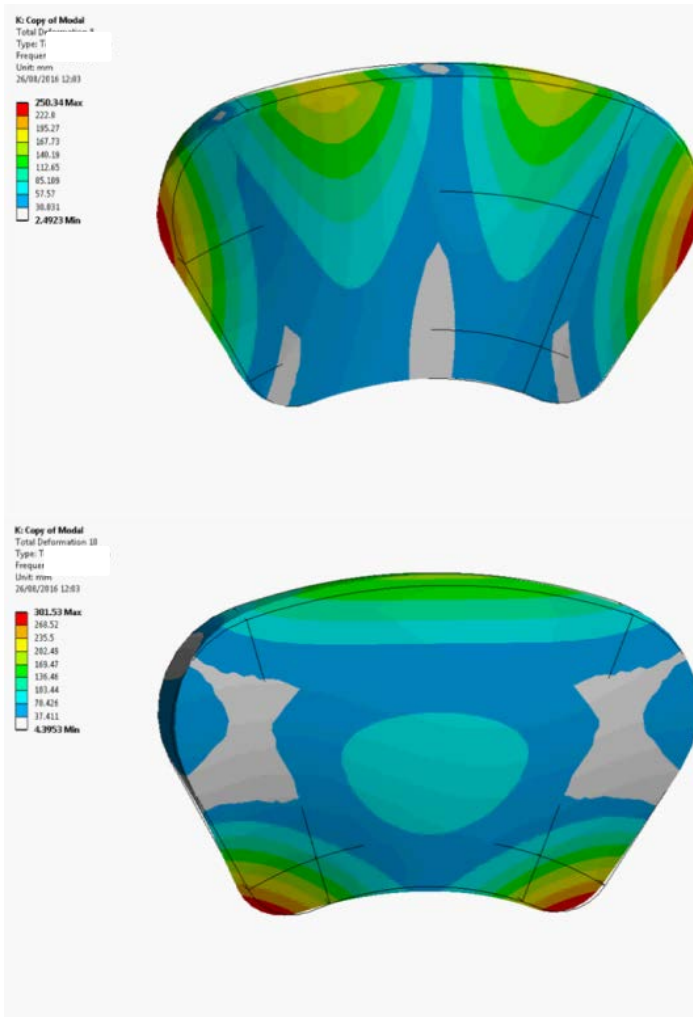
* Eigenfrequencies and modal damping omitted due to confidentiality reasons.

Results and Discussion: Brake Pad



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Results and Discussion: Brake Pad



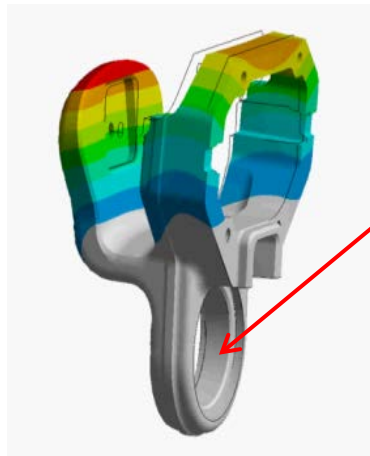
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- Established a comparison between FEA and EMA eigenfrequencies and mode shapes.
- Good agreement on mode shapes up to the highest modes on the bandwidth.
- Poor initial correlation between FEA and EMA eigenfrequencies.

Conclusions

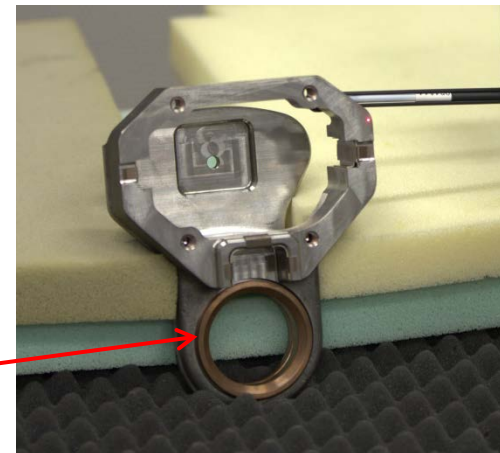
The misalignment between experimental and simulated eigenfrequencies has two main causes:

- 1) an inexact input of the material properties due to complex, non-proportional material parameters
- 2) the real tested geometry is different from the CAD version used on the FEA model.



No bronze ring attached

Bronze ring attached



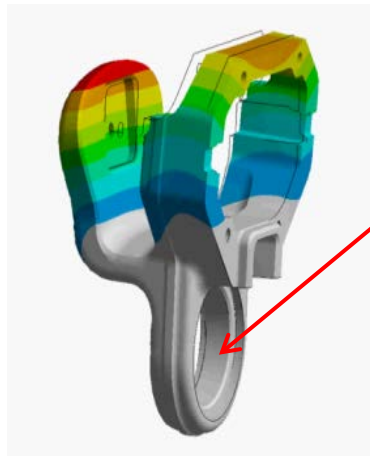
Conclusions

Many low-frequency experimental modes are lower than their experimental counterparts → observed mass loading effect.

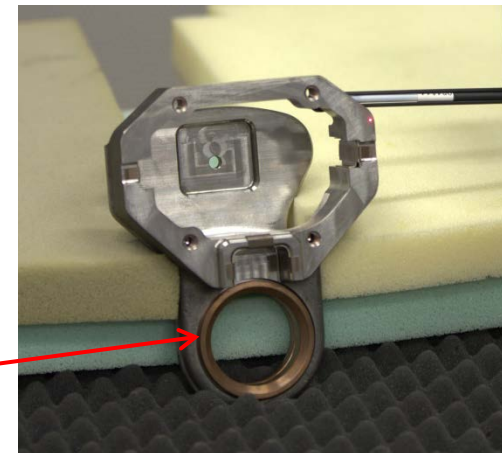
$$\omega_n = \sqrt{\frac{k}{m}}$$

Where k is the stiffness of the system and m is the mass of the system.

The natural frequency of the system decreases with an increasing mass, in this case, the mass loading due to the bronze ring.



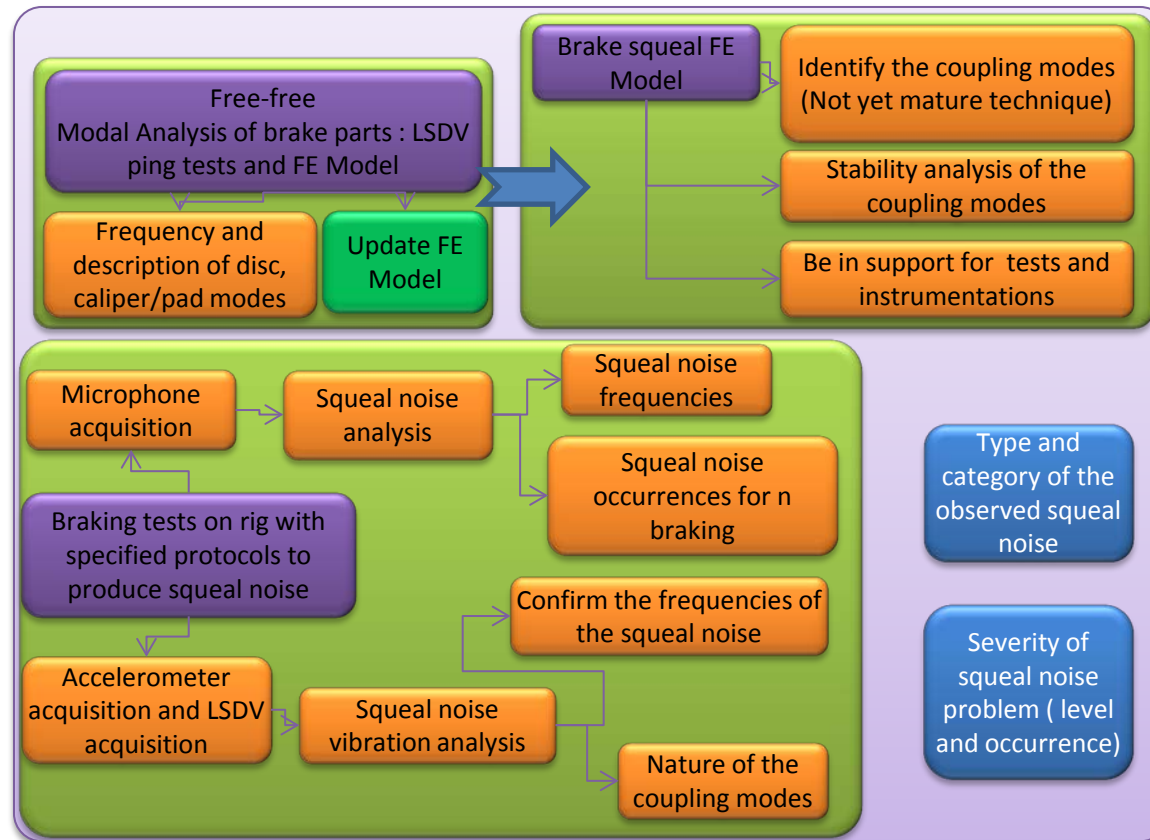
No bronze ring attached



Bronze ring attached

- Update of the material and geometry parameters.
- True modal correlation procedure by means of harmonic response analysis, of cross-MAC analysis and, if necessary, of iterative methods.
- Commercial softwares such as FEMtools are a useful tool for this correlation.

- Model updating is among one of the important milestones in squeal noise analysis methodology and problem solving



Lab Tour



To the TH Wildau lab tour visitors:

We meet at 14:00 at the TH Wildau stand here at the exhibition.

The lab is accessible by car with several available parking spots.

Thanks for your attention! Questions...?

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