Measurement of Seat Transfer Function to Enable Seat Vibration Calculation

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Volkswagen

Agenda

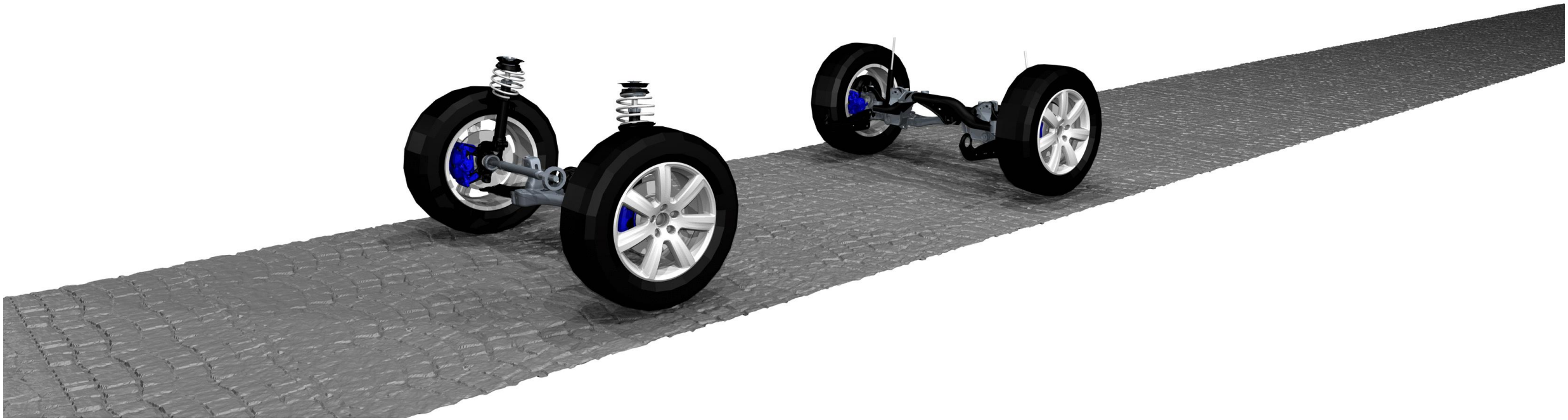
Model description: What is used in the whole vehicle calculation department (road noise)

NVH-Calculation and **Simulator-Measurements** with respect to the seat

ACC-TF-Method: procedure/identification/validation

Next Steps

Short Model Description



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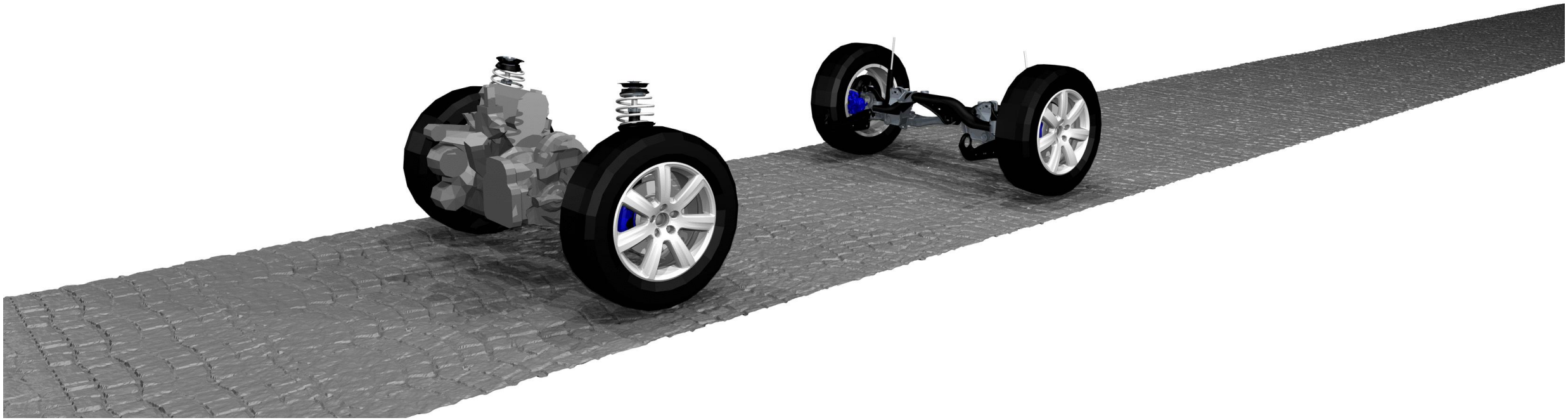
Short Model Description



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Short Model Description

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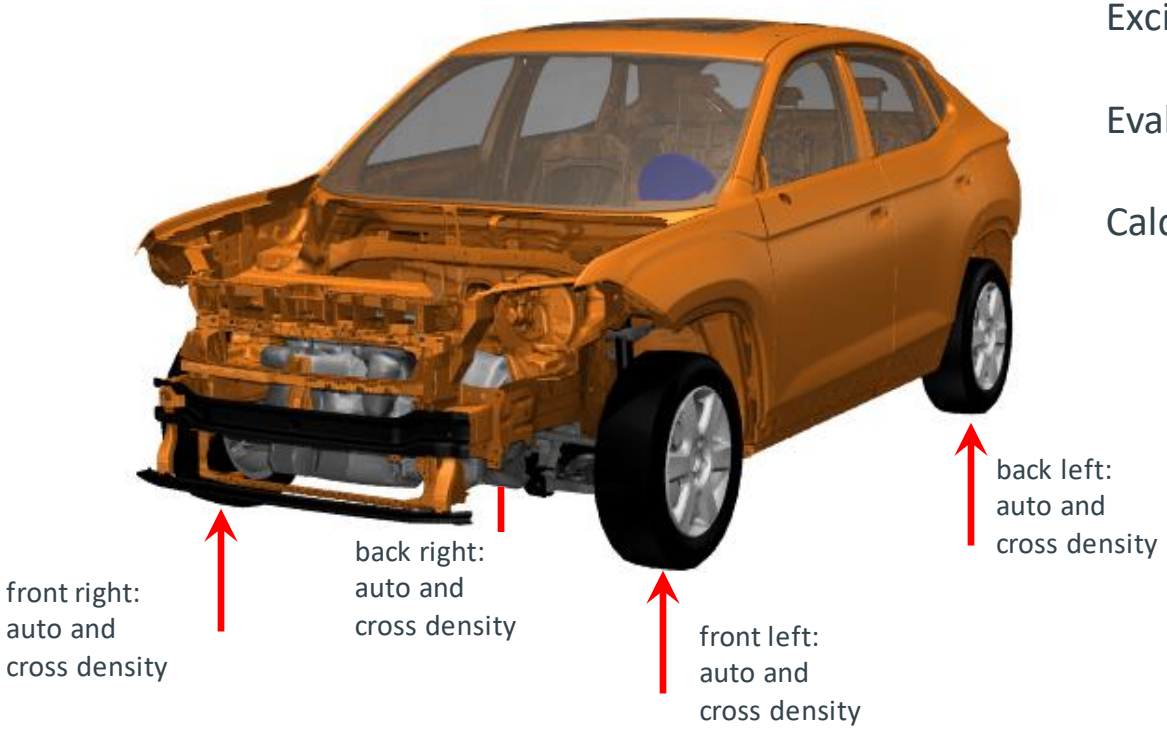
Straight Forward Road Noise Calculation



Excitation using **auto- and cross spectral** density at all tires

Evaluation of auto spectral density at specific points

Calculation in **frequency domain**

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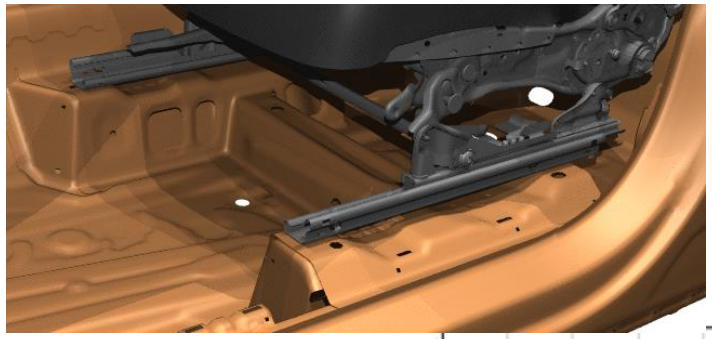
NVH-Calculation and Simulator Measurements

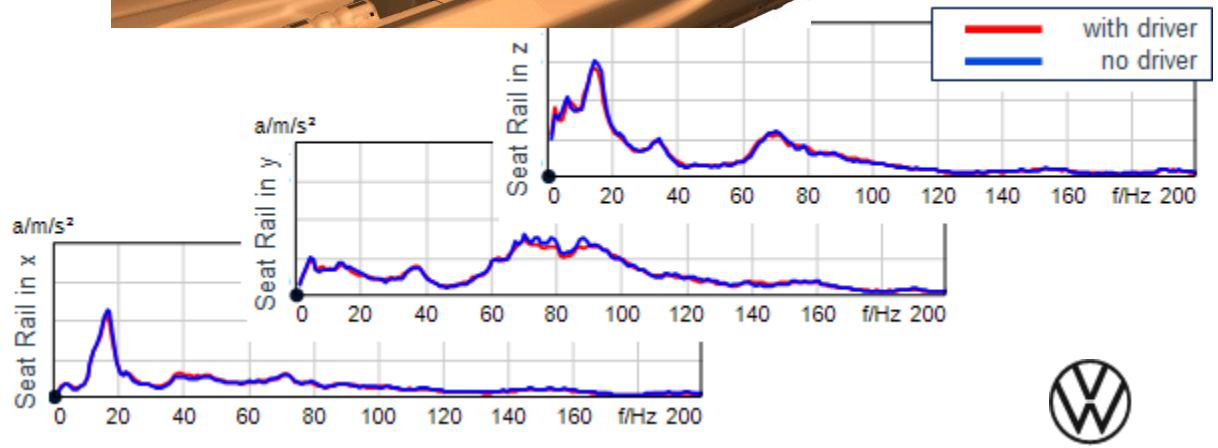
Discrepancy between required and available data for the NVH-Simulator (example seat)

NVH-Simulator specific seat **measurements,**
seat pads required

NVH-Calculation procedure

- Simulation in **frequency domain**
- In most cases no detailed seat model
- **No driver-model**
- Evaluation of **seat rail accelerations**
  (seat rain acceleration independent of driver, see measurement)





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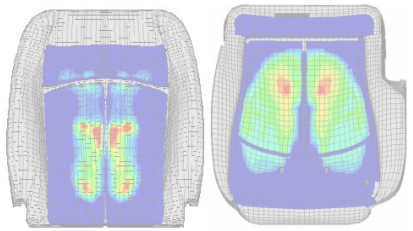
NVH-Calculation and Simulator Measurements

Possibilities to receive Seat Pad Accelerations

1. Model extension using a **driver model**
   - Driver model required
   - **Complex** contact modelling
   - Lot of parameters required
   - Detailed seat modelling
   - **Inefficient** for the simulation process

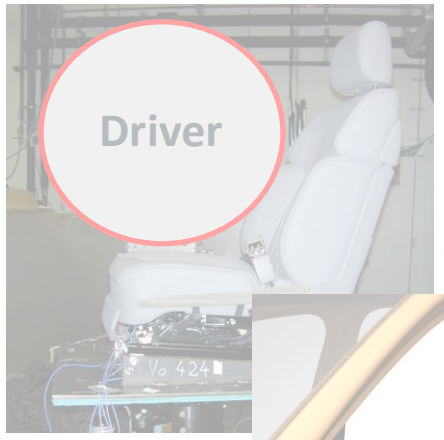


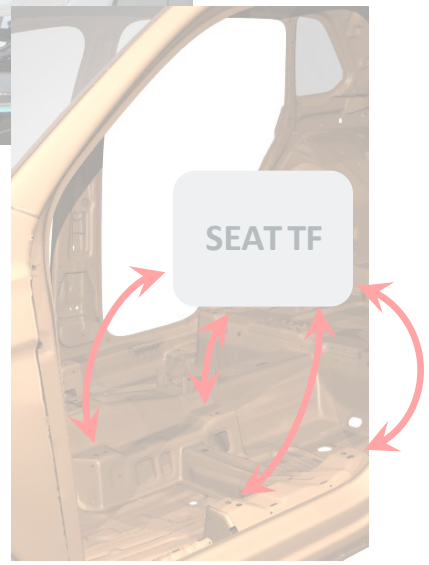
2007-01-2459

Virtual Simulation of Static and Dynamic Seating Comfort in the Development Process of Automobiles and Automotive Seats: Application of Finite-Element-Occupant-Model CASIMIR

Steffen Pankoke, Alexander Siefert

2. Include seat as a classical **TF into model**
   - Detailed TF measurement of the seat (with driver)
   - **Increased** modelling **effort**





3. Include an **acc**eleration **TF into model**
   - Seat measurement with driver in car
   - Important: No impact of TF on model
   - Easy way to apply in the calculation process

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ACC-TF of the Seat

Situation: **No influence** of driver **on seat rail** vibrations

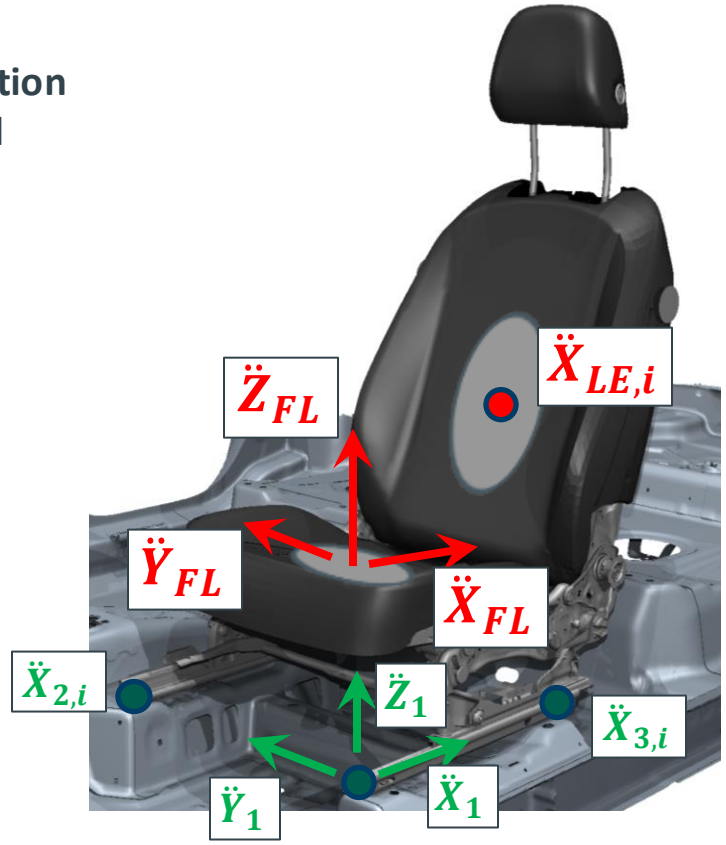
Calculation **process**: Seat structure model **sufficient** for correct **seat rail calculations**

Extend Calculation: **Include** the **acc**eleration **TF** into model (the ACC-TF may not influence the whole vehicle model)

Task: **Measurement** and **validation** of the **ACC-Transfer-Function**

Instrumentation: Triax-accelerometers at the 4 seat rails, 2 seat pads and impact hammer for excitation

$$\begin{bmatrix} \ddot{X}_{FL,i} \\ \ddot{X}_{LE,i} \end{bmatrix} = \begin{bmatrix} A(\Omega) & B(\Omega) & C(\Omega) & D(\Omega) \\ E(\Omega) & F(\Omega) & G(\Omega) & H(\Omega) \end{bmatrix} \begin{bmatrix} \ddot{X}_{1,i} \\ \ddot{X}_{2,i} \\ \ddot{X}_{3,i} \\ \ddot{X}_{4,i} \end{bmatrix}$$



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ACC-TF of the Seat

$$\begin{bmatrix} \ddot{X}_{FL,i} \\ \ddot{X}_{LE,i} \end{bmatrix} = \begin{bmatrix} A(\Omega) & B(\Omega) & C(\Omega) & D(\Omega) \\ E(\Omega) & F(\Omega) & G(\Omega) & H(\Omega) \end{bmatrix} \begin{bmatrix} \ddot{X}_{1,i} \\ \ddot{X}_{2,i} \\ \ddot{X}_{3,i} \\ \ddot{X}_{4,i} \end{bmatrix}$$

$$\begin{bmatrix} \ddot{X}_{FL} \\ \ddot{Y}_{FL} \\ \ddot{Z}_{FL} \\ \ddot{X}_{LE} \\ \ddot{Y}_{LE} \\ \ddot{Z}_{LE} \end{bmatrix} = \begin{bmatrix} A_{1,1} & A_{1,2} & A_{1,3} & B_{1,1} & B_{1,2} & B_{1,3} & C_{1,1} & C_{1,2} & C_{1,3} & D_{1,1} & D_{1,2} & D_{1,3} \\ A_{2,1} & A_{2,2} & A_{2,3} & B_{2,1} & B_{2,2} & B_{2,3} & C_{2,1} & C_{2,2} & C_{2,3} & D_{2,1} & D_{2,2} & D_{2,3} \\ A_{3,1} & A_{3,2} & A_{3,3} & B_{3,1} & B_{3,2} & B_{3,3} & C_{3,1} & C_{3,2} & C_{3,3} & D_{3,1} & D_{3,2} & D_{3,3} \\ E_{1,1} & E_{1,2} & E_{1,3} & F_{1,1} & F_{1,2} & F_{1,3} & G_{1,1} & G_{1,2} & G_{1,3} & H_{1,1} & H_{1,2} & H_{1,3} \\ E_{2,1} & E_{2,2} & E_{2,3} & F_{2,1} & F_{2,2} & F_{2,3} & G_{2,1} & G_{2,2} & G_{2,3} & H_{2,1} & H_{2,2} & H_{2,3} \\ E_{3,1} & E_{3,2} & E_{3,3} & F_{3,1} & F_{3,2} & F_{3,3} & G_{3,1} & G_{3,2} & G_{3,3} & H_{3,1} & H_{3,2} & H_{3,3} \end{bmatrix} \begin{bmatrix} \ddot{X}_1 \\ \ddot{Y}_1 \\ \ddot{Z}_1 \\ \ddot{X}_2 \\ \ddot{Y}_2 \\ \ddot{Z}_2 \\ \ddot{X}_3 \\ \ddot{Y}_3 \\ \ddot{Z}_3 \\ \ddot{X}_4 \\ \ddot{Y}_4 \\ \ddot{Z}_4 \end{bmatrix}$$

It is necessary to identify **72 frequency-dependent** acceleration **transfer-functions**

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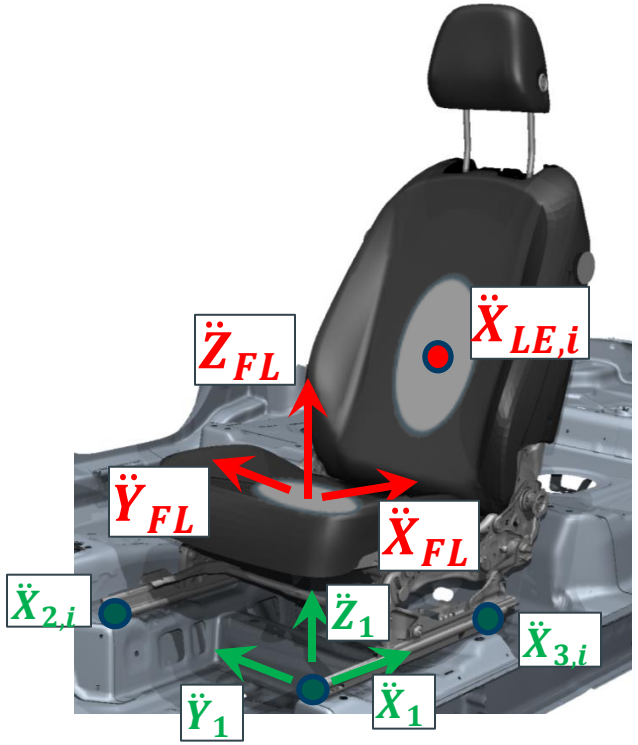
ACC-TF of the Seat



Impact excitation of seat with driver in car at the 4 **seat rails** in 3 directions leads to 12x6 Equations

→ Definite system of equations to identify the 72 frequency dependent acceleration TF's

Example of the first excitation set (1 of 12) in ***X*$_1$ direction**

$$\begin{bmatrix} \ddot{X}_{FL,1} \\ \ddot{Y}_{FL,1} \\ \ddot{Z}_{FL,1} \\ \ddot{X}_{LE,1} \\ \ddot{Y}_{LE,1} \\ \ddot{Z}_{LE,1} \end{bmatrix} = \begin{bmatrix} A_{1,1} & A_{1,2} & A_{1,3} & B_{1,1} & B_{1,2} & B_{1,3} & C_{1,1} & C_{1,2} & C_{1,3} & D_{1,1} & D_{1,2} & D_{1,3} \\ A_{2,1} & A_{2,2} & A_{2,3} & B_{2,1} & B_{2,2} & B_{2,3} & C_{2,1} & C_{2,2} & C_{2,3} & D_{2,1} & D_{2,2} & D_{2,3} \\ A_{3,1} & A_{3,2} & A_{3,3} & B_{3,1} & B_{3,2} & B_{3,3} & C_{3,1} & C_{3,2} & C_{3,3} & D_{3,1} & D_{3,2} & D_{3,3} \\ E_{1,1} & E_{1,2} & E_{1,3} & F_{1,1} & F_{1,2} & F_{1,3} & G_{1,1} & G_{1,2} & G_{1,3} & H_{1,1} & H_{1,2} & H_{1,3} \\ E_{2,1} & E_{2,2} & E_{2,3} & F_{2,1} & F_{2,2} & F_{2,3} & G_{2,1} & G_{2,2} & G_{2,3} & H_{2,1} & H_{2,2} & H_{2,3} \\ E_{3,1} & E_{3,2} & E_{3,3} & F_{3,1} & F_{3,2} & F_{3,3} & G_{3,1} & G_{3,2} & G_{3,3} & H_{3,1} & H_{3,2} & H_{3,3} \end{bmatrix} \begin{bmatrix} \ddot{X}_{1,1} \\ \ddot{Y}_{1,1} \\ \ddot{Z}_{1,1} \\ \ddot{X}_{2,1} \\ \ddot{Y}_{2,1} \\ \ddot{Z}_{2,1} \\ \ddot{X}_{3,1} \\ \ddot{Y}_{3,1} \\ \ddot{Z}_{3,1} \\ \ddot{X}_{4,1} \\ \ddot{Y}_{4,1} \\ \ddot{Z}_{4,1} \end{bmatrix}$$

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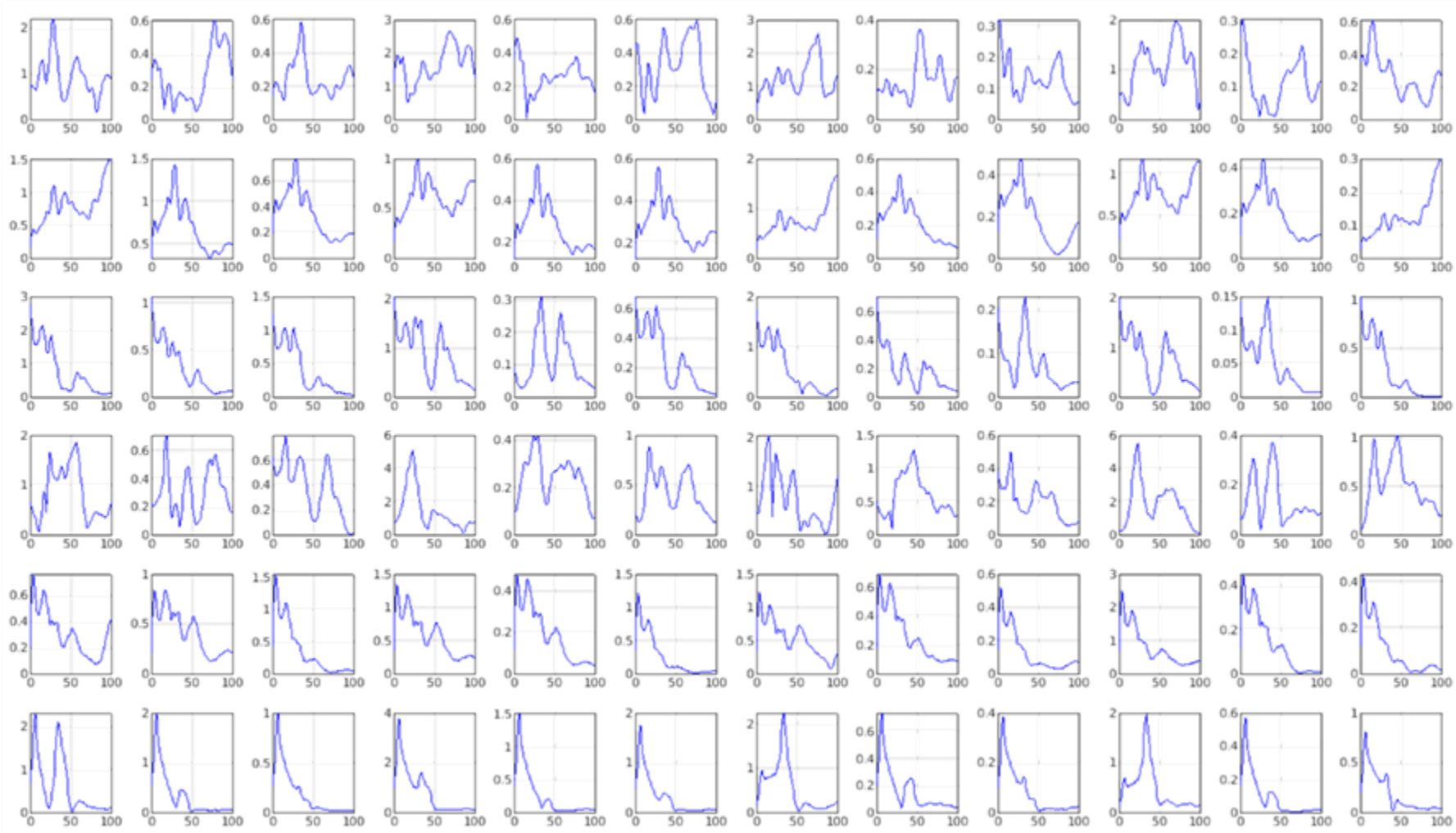
Identification of the ACC-TF

Amplitude of the **acceleration transfer function**

$$\begin{bmatrix} \ddot{X}_{FL} \\ \ddot{Y}_{FL} \\ \ddot{Z}_{FL} \\ \ddot{X}_{LE} \\ \ddot{Y}_{LE} \\ \ddot{Z}_{LE} \end{bmatrix} =$$



$$\begin{bmatrix} \ddot{X}_1 \\ \ddot{Y}_1 \\ \ddot{Z}_1 \\ \ddot{X}_2 \\ \ddot{Y}_2 \\ \ddot{Z}_2 \\ \ddot{X}_3 \\ \ddot{Y}_3 \\ \ddot{Z}_3 \\ \ddot{X}_4 \\ \ddot{Y}_4 \\ \ddot{Z}_4 \end{bmatrix}$$

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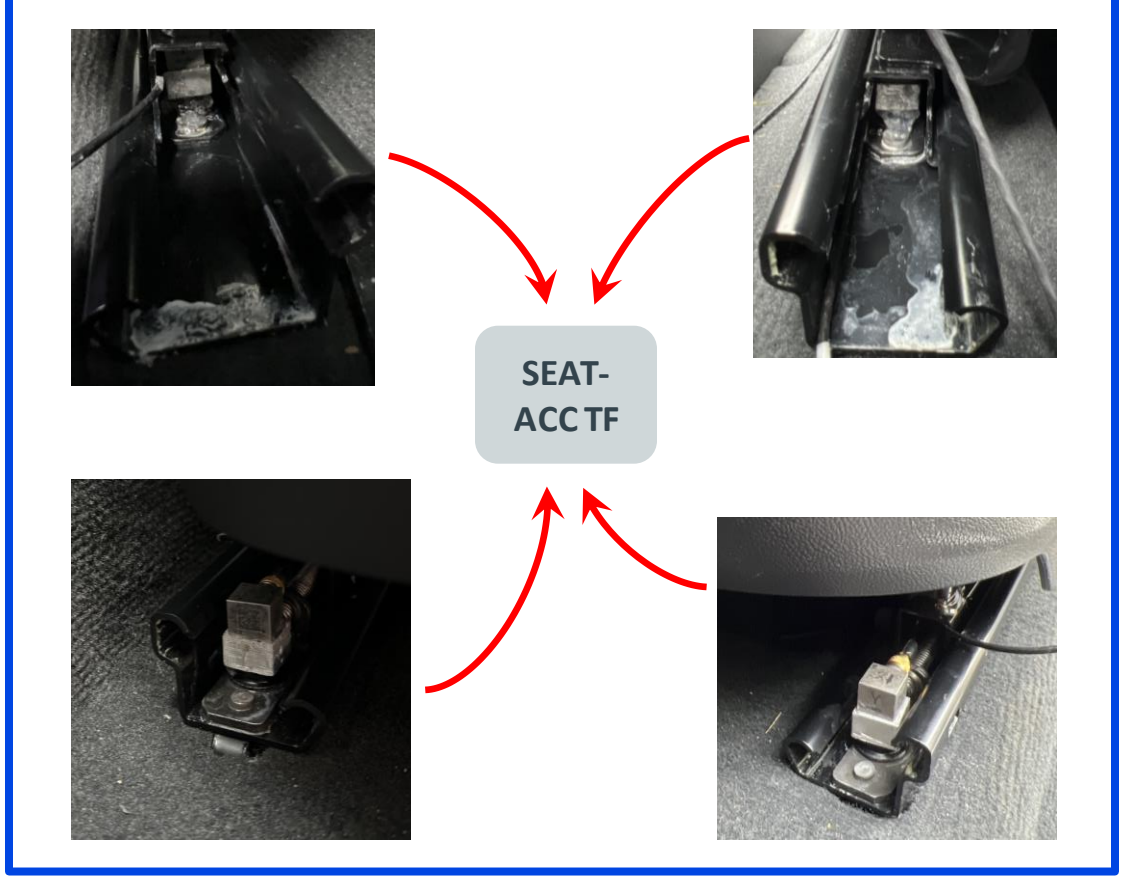
Validation of the ACC-TF

Comparison of **measured** seat pad accelerations with **calculated seat pad** accelerations on the basis of the measured seat rail accelerations and the acceleration transfer function



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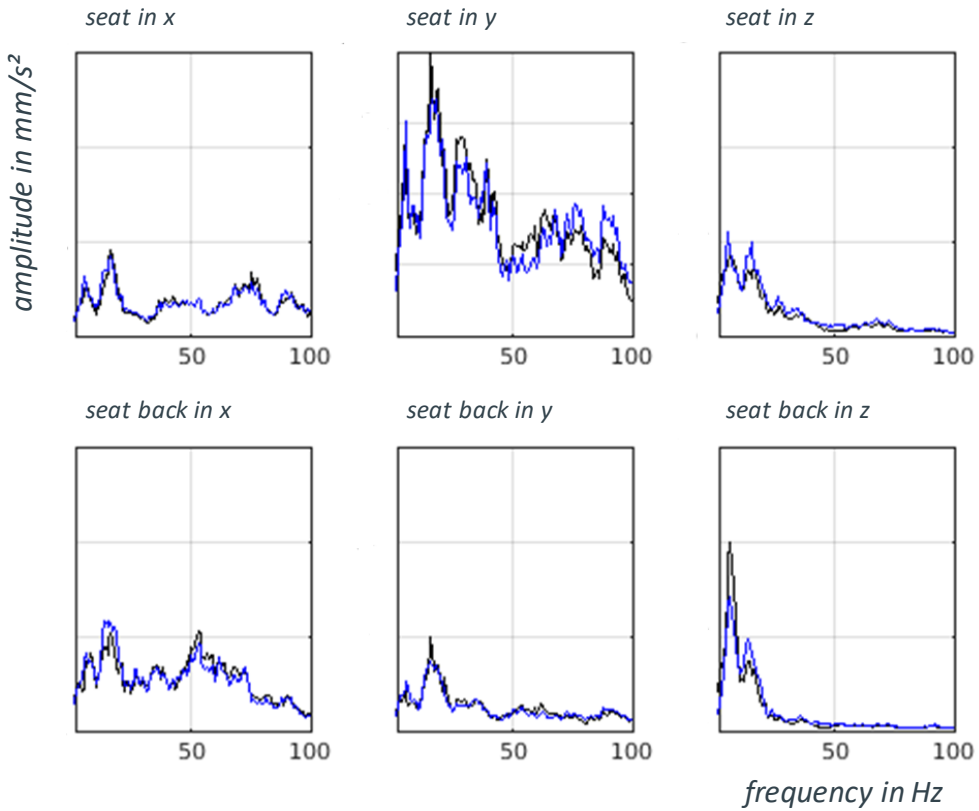
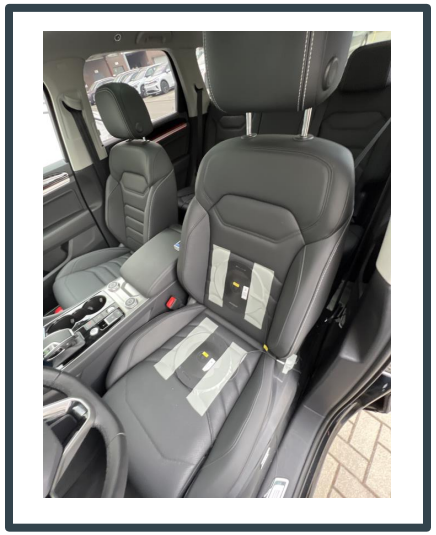
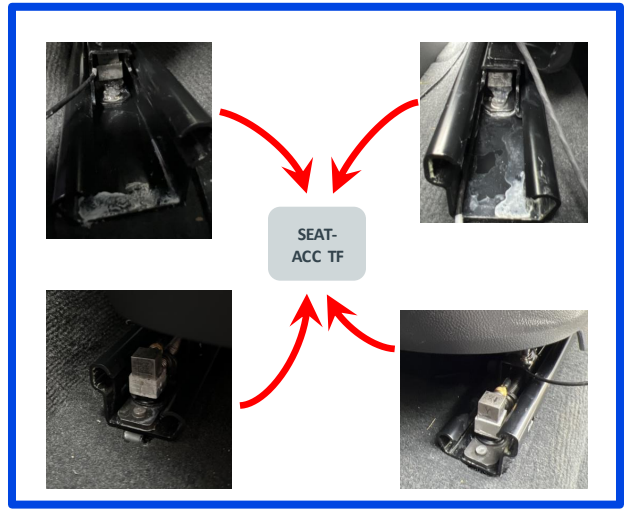
Validation of the ACC-TF

Comparison of **measured** seat pad accelerations with **calculated seat pad** accelerations on the basis of the measured seat rail accelerations and the acceleration transfer function (cobbled surface)







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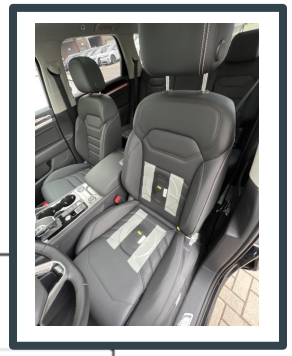
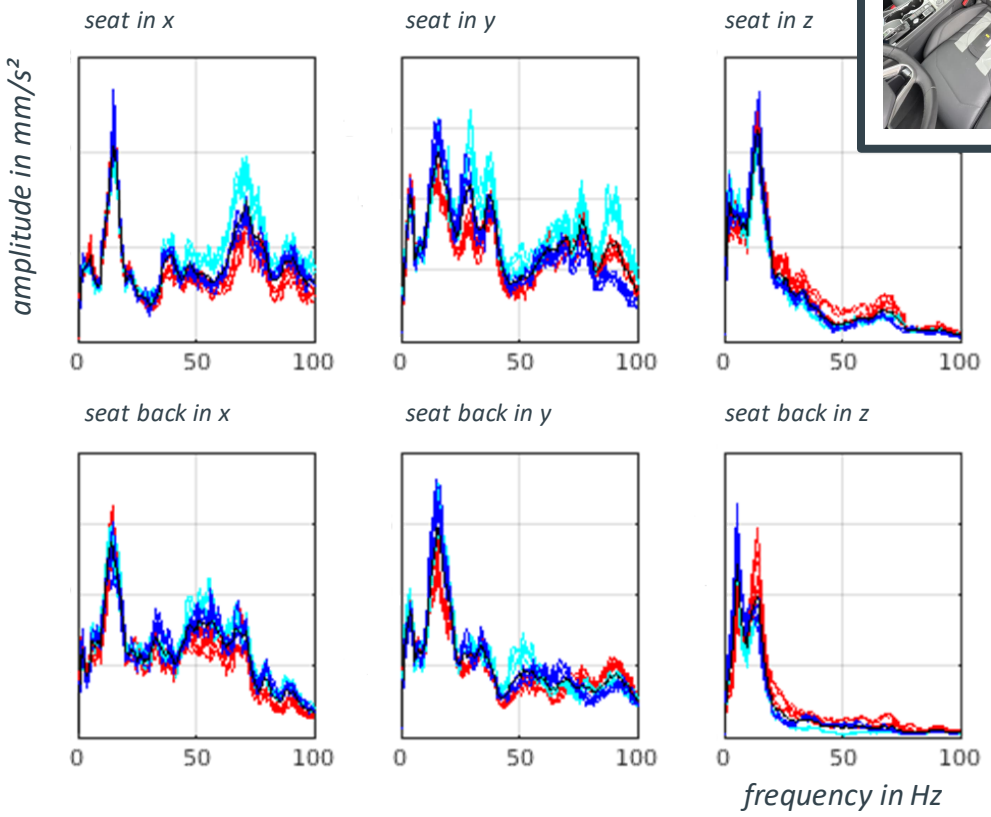
Validation of the ACC-TF

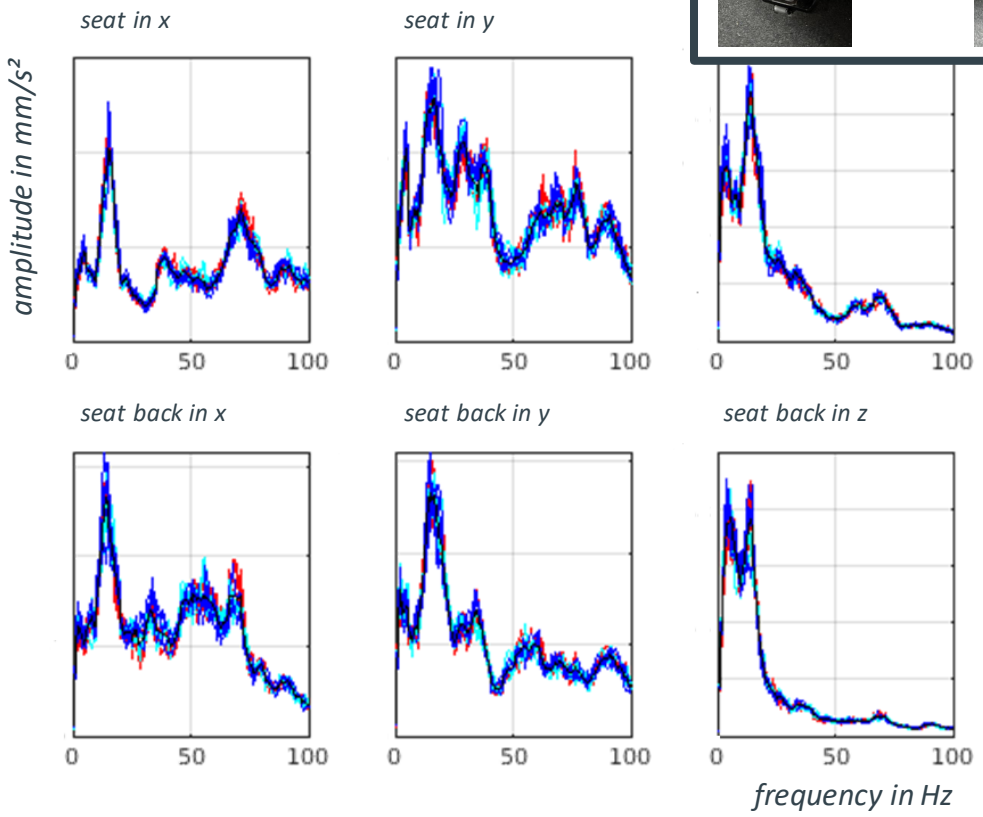
Comparison of scattering (measurement and calculation)

Measurement





Calculation



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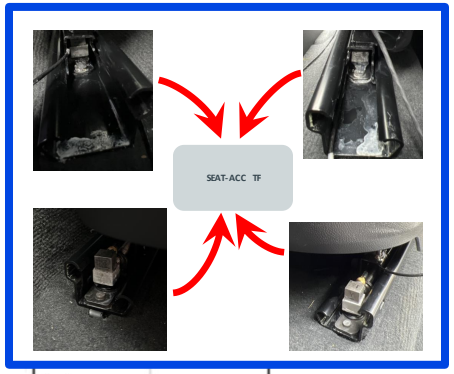
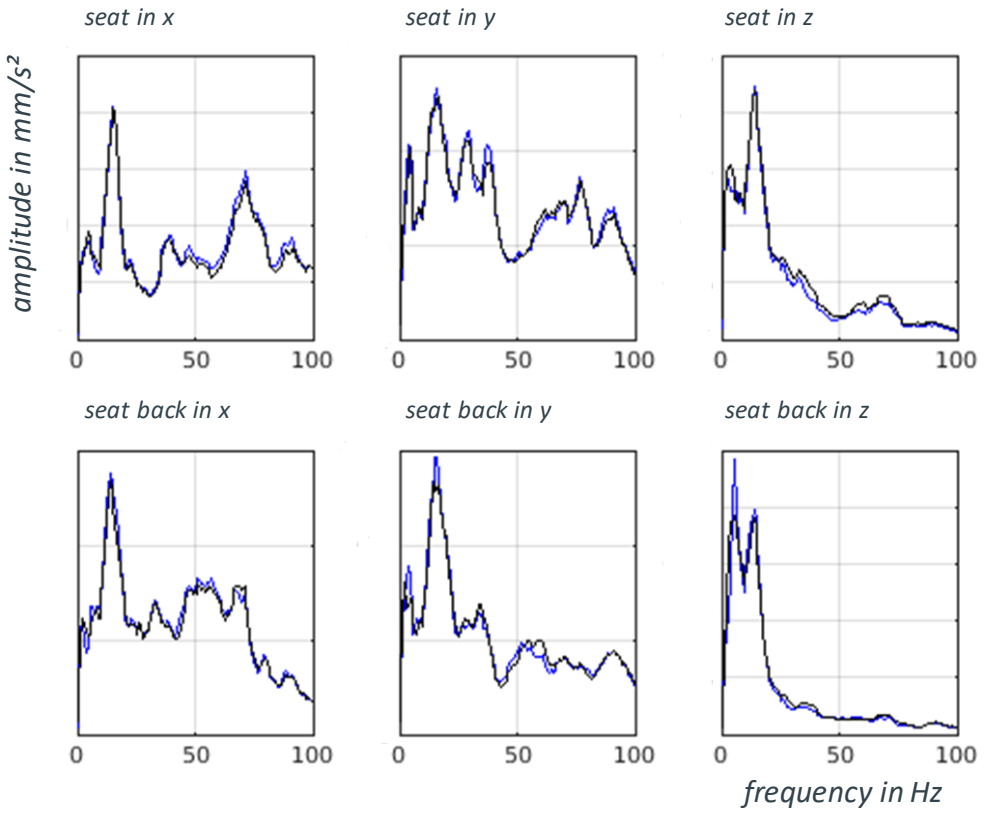
Validation of the ACC-TF

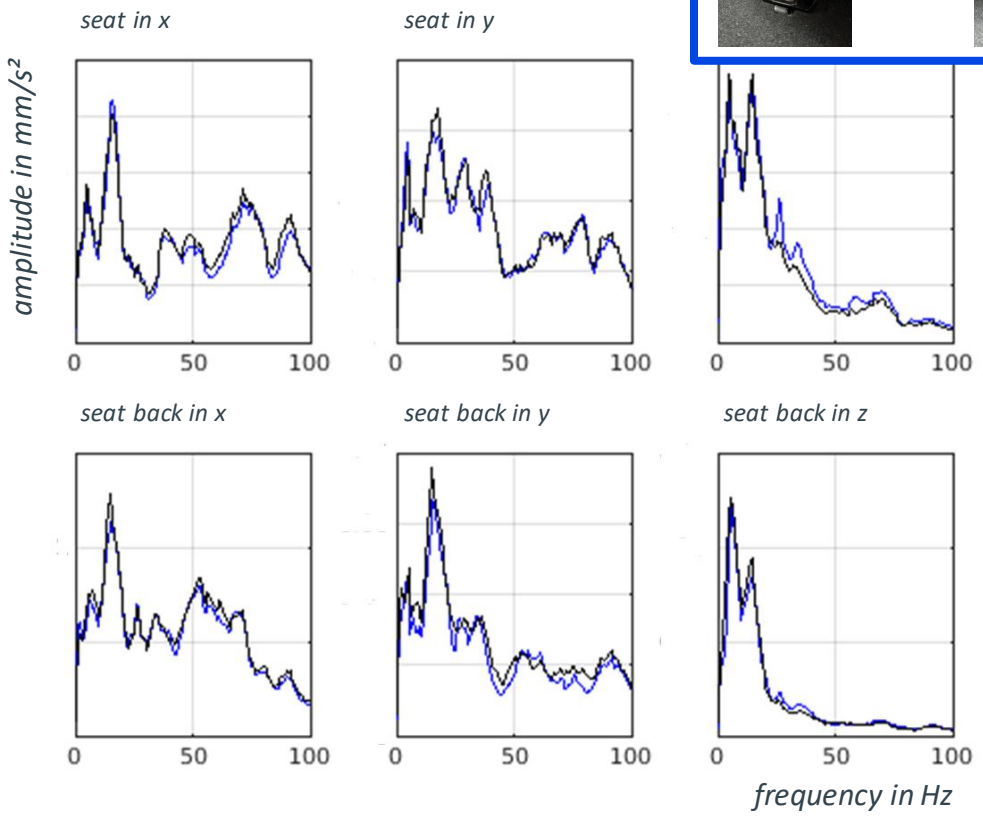
Influence of different surfaces on the results



Cobbled surface



Rough surface



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Next Steps

Measurement of **different seats** and comparison in different cars (identify a seat database)

Application of an **acceleration TF in Nastran** which does not affect the whole vehicle model, respectively the mechanical structure

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