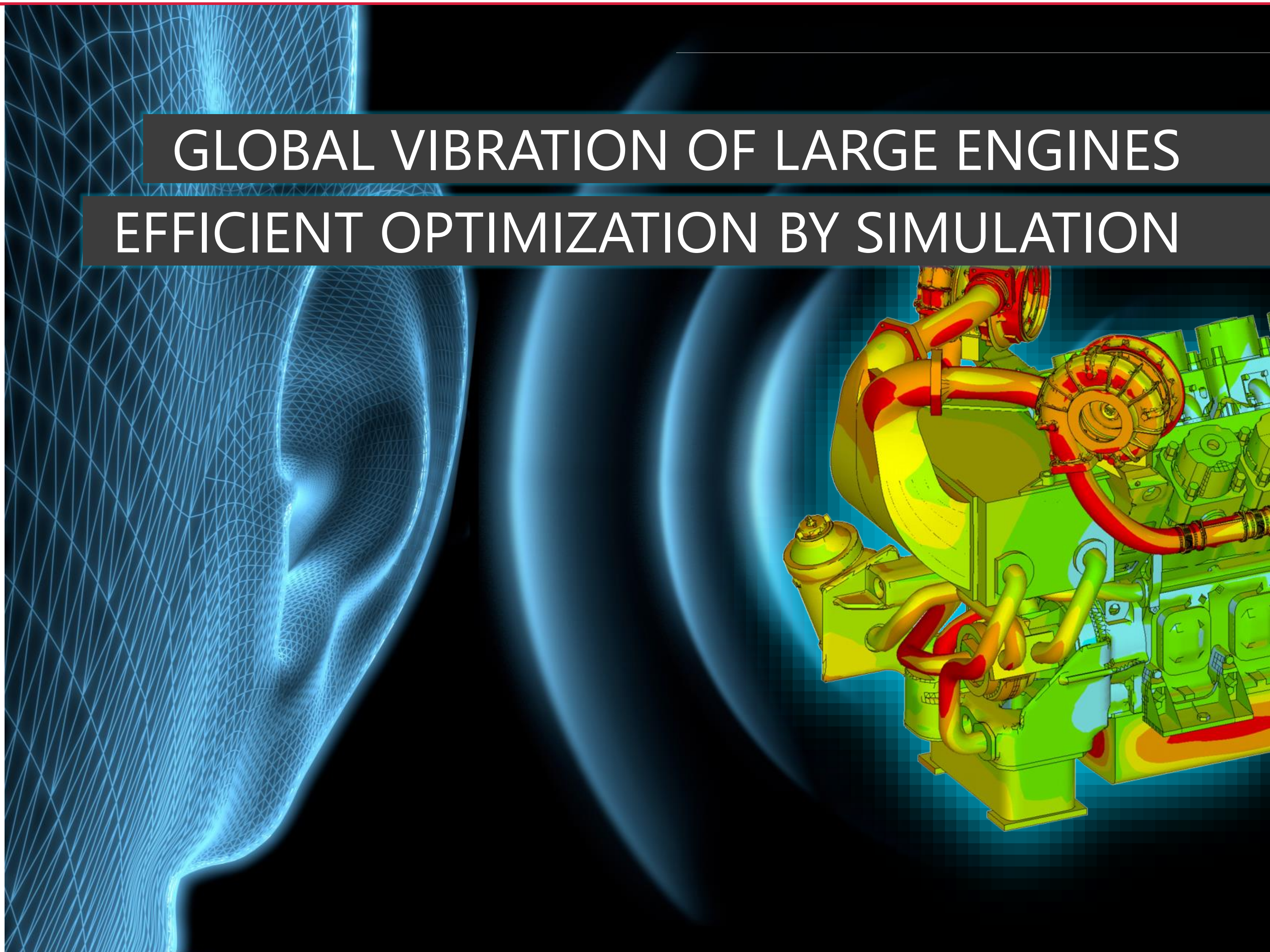
GLOBAL VIBRATION OF LARGE ENGINES
EFFICIENT OPTIMIZATION BY SIMULATION

JINAN CITY, NOVEMBER 1ST, 2020

M. BLEIJLEVENS
DR. S. LAUER

PREPARED FOR

9TH INTERNATIONAL SYMPOSIUM ON ENGINE RELIABILITY TECHNOLOGY

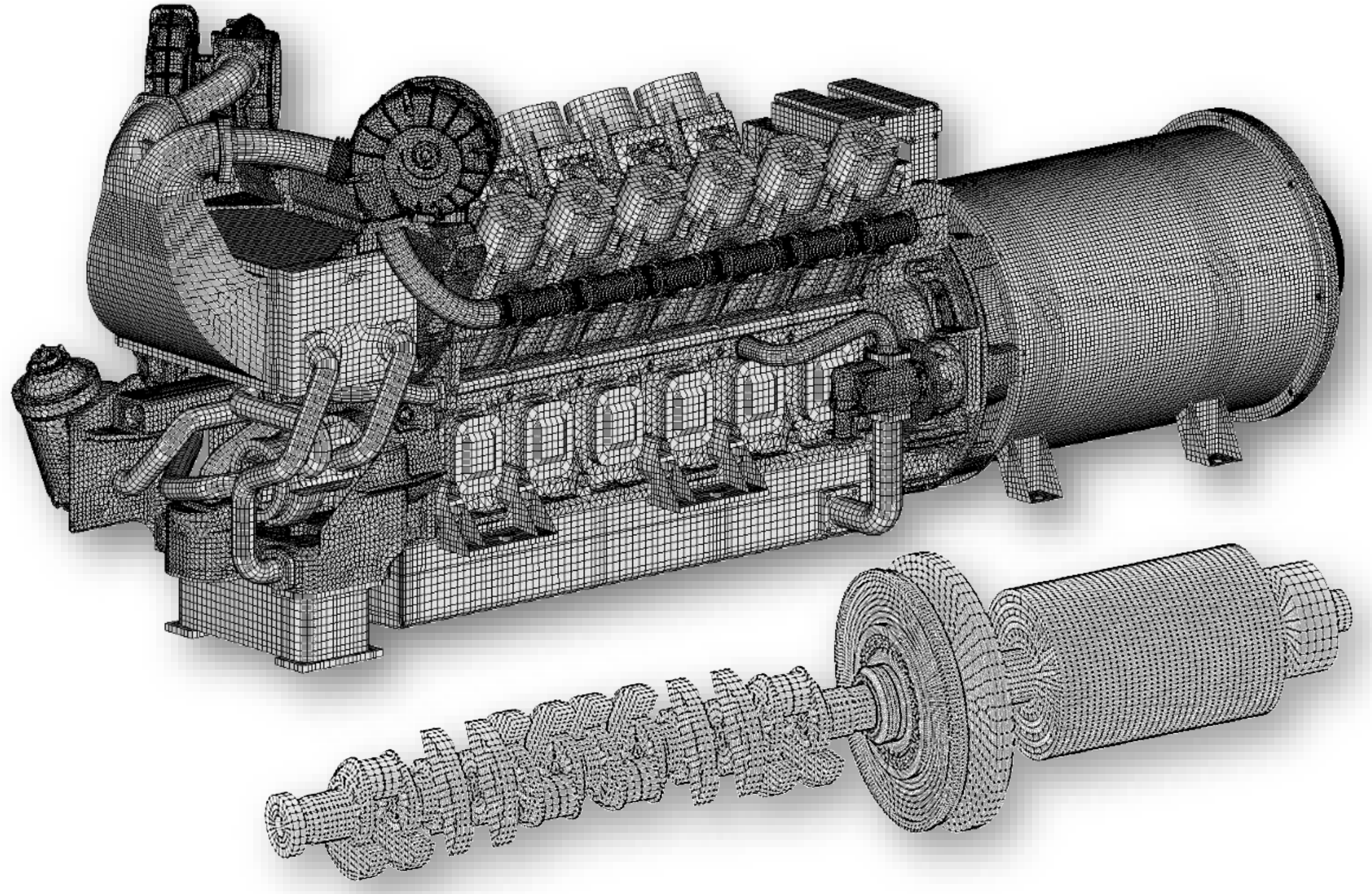


VIRTUAL PRESENTATION

AGENDA

FEV has developed a calculation process based on the two classic simulation types: Finite Element Method (FEM) and Multi-Body Simulation (MBS)

TYPICAL GLOBAL VIBRATION ANALYSIS MODEL



BASE ENGINE DATA

- Cylinder configuration: V12
- V-angle: 60°
- Displacement: 7l per cylinder
- Peak firing pressure: 230bar

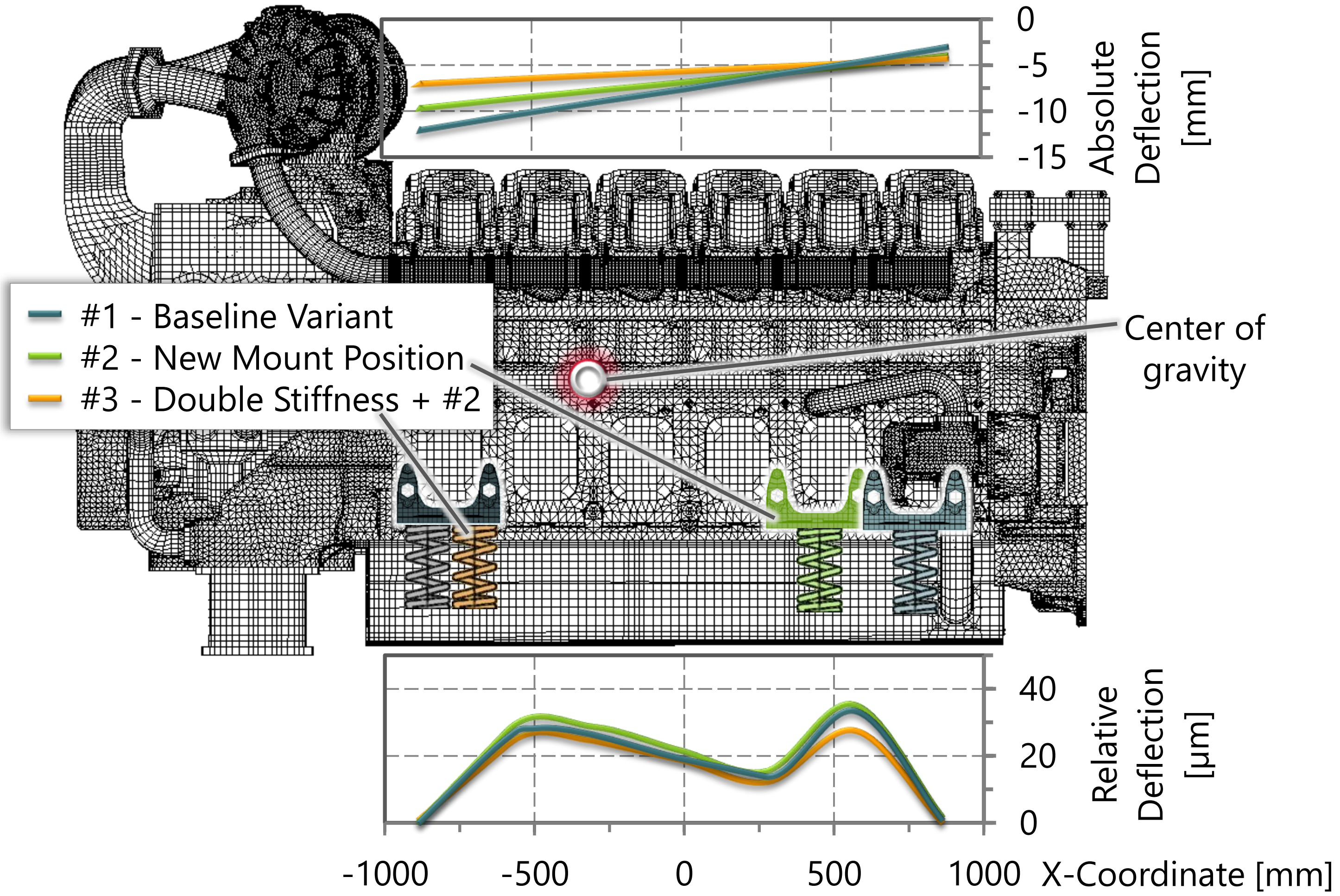
FE MODEL

- 2.0 million nodes
- 1.5 million elements

The first analysis step is a static FE analysis considering the gravitational acceleration in order to optimize the engine mount positions and properties

FEV

ABSOLUTE AND RELATIVE ENGINE DEFLECTIONS CONSIDERING DIFFERENT MOUNT GEOMETRIES



GRAPH 1 (TOP)

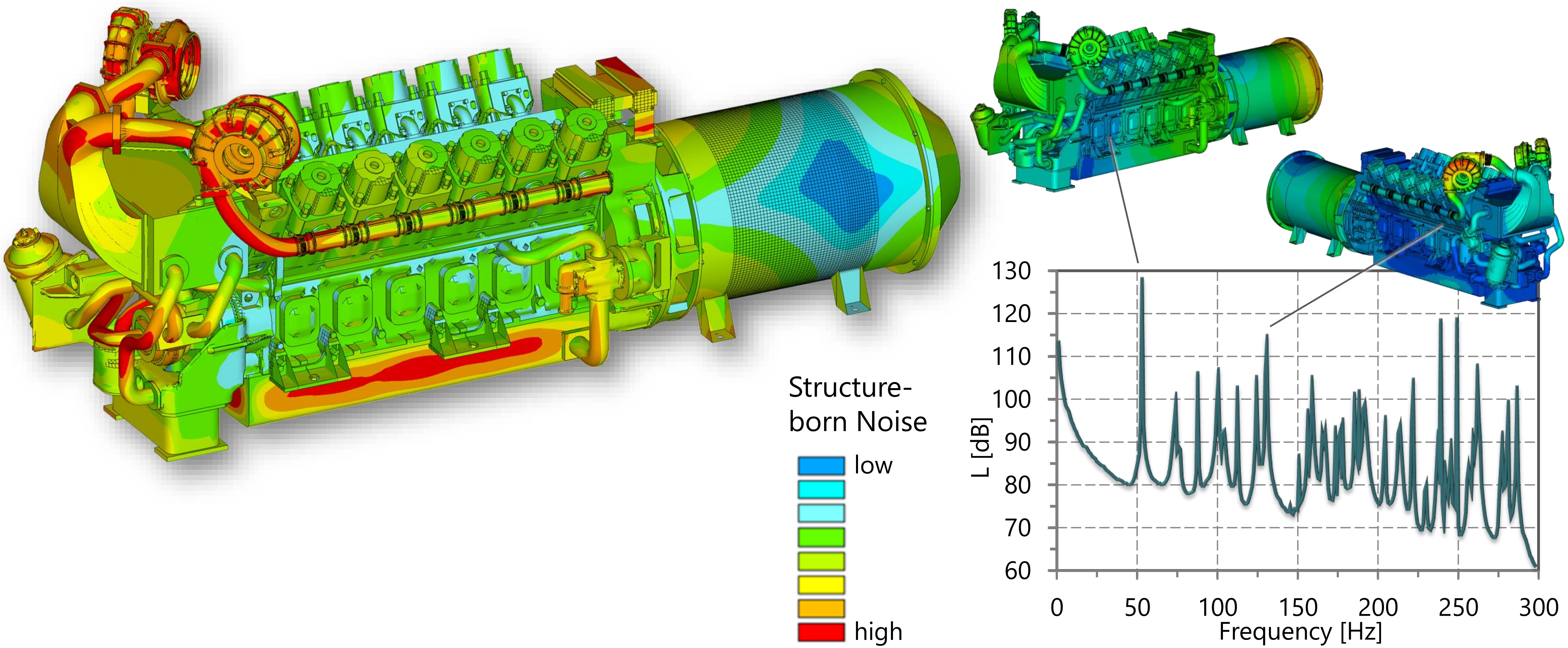
- Absolute deflections in [mm] measured in main pin centroids
- The mount layout #3 which combines position #2 with double mount stiffness shows the least absolute deflection

GRAPH 2 (BOTTOM)

- Deflections relative to the straight line between the first and last main bearing centroid in [µm]
- All investigated mount layouts show acceptable relative deflections, which are smaller than the main bearing clearance. The differences are rather small

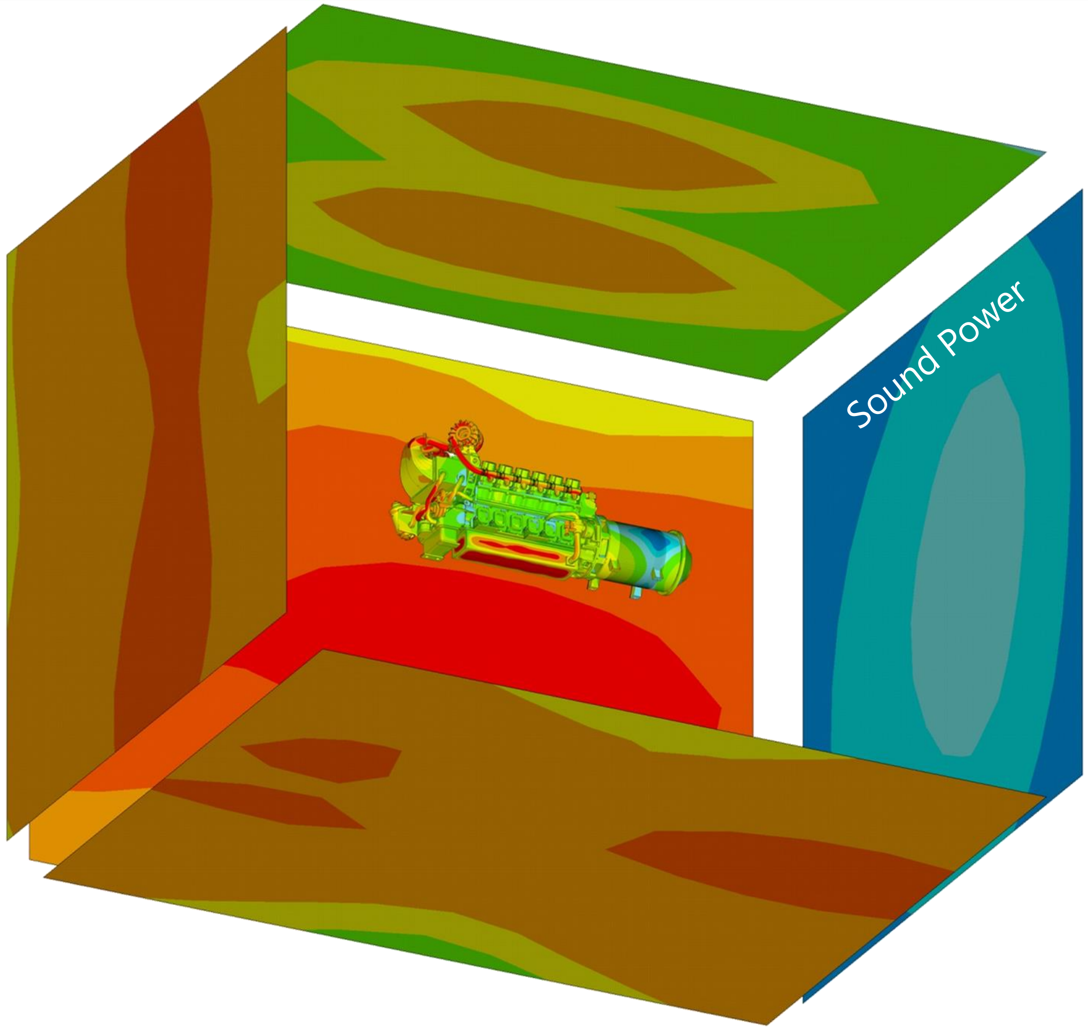
FEV's Dynamic Impact Response Analysis (DIRA) method was developed for the efficient analysis of surface movements and sound transfer paths

THIS DIRA PROCEDURE IS SUITABLE FOR THE IDENTIFICATION OF WEAK SPOTS IN THICK WALLED AND STIFF STRUCTURES



With FEV's Fast Estimation of Radiated Sound Power method (FERS) the surface velocity-based sound emission is estimated at a desired distance

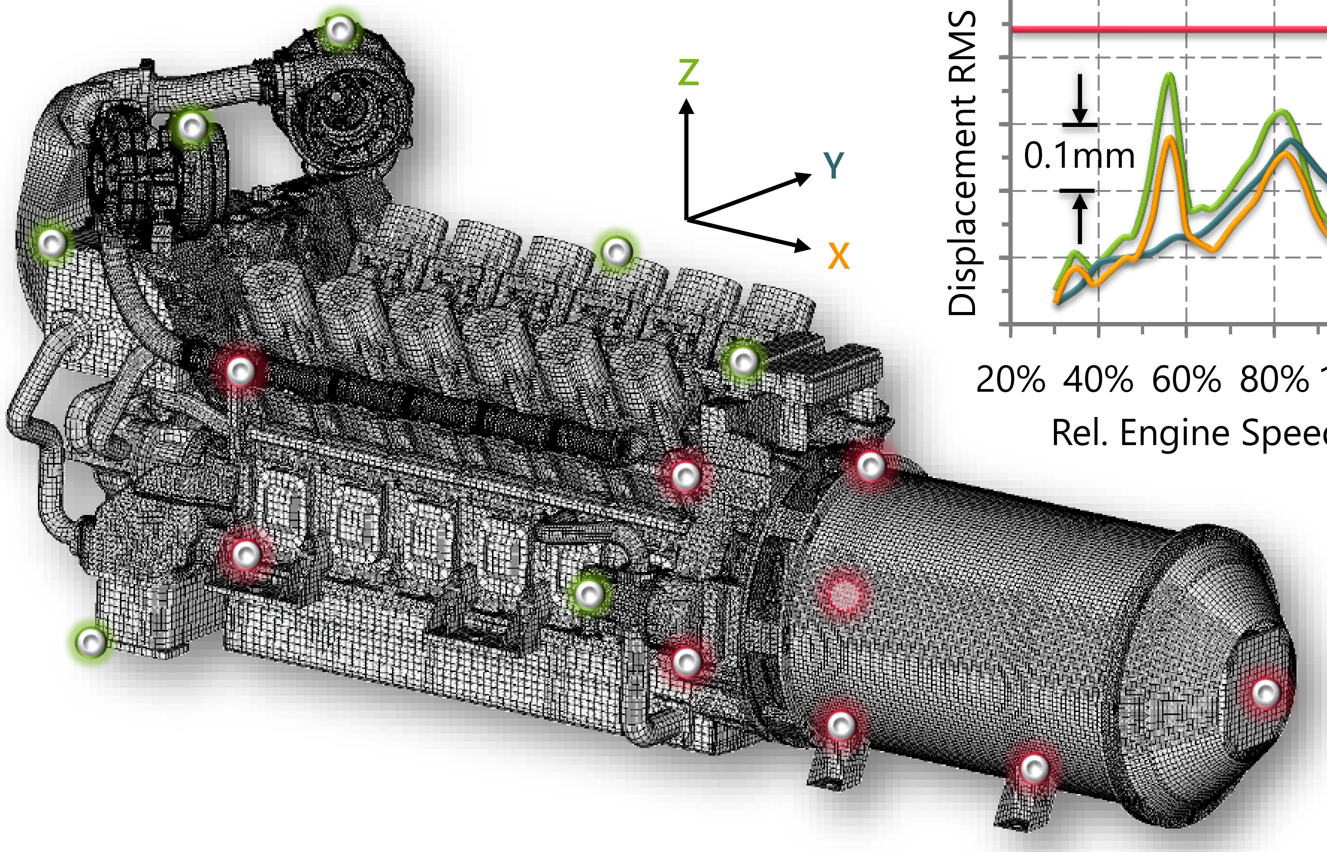
AT THIN-WALLED PARTS LIKE OIL PAN THE RADIATED SOUND POWER CAN BE LOW DESPITE HIGH SURFACE VELOCITIES

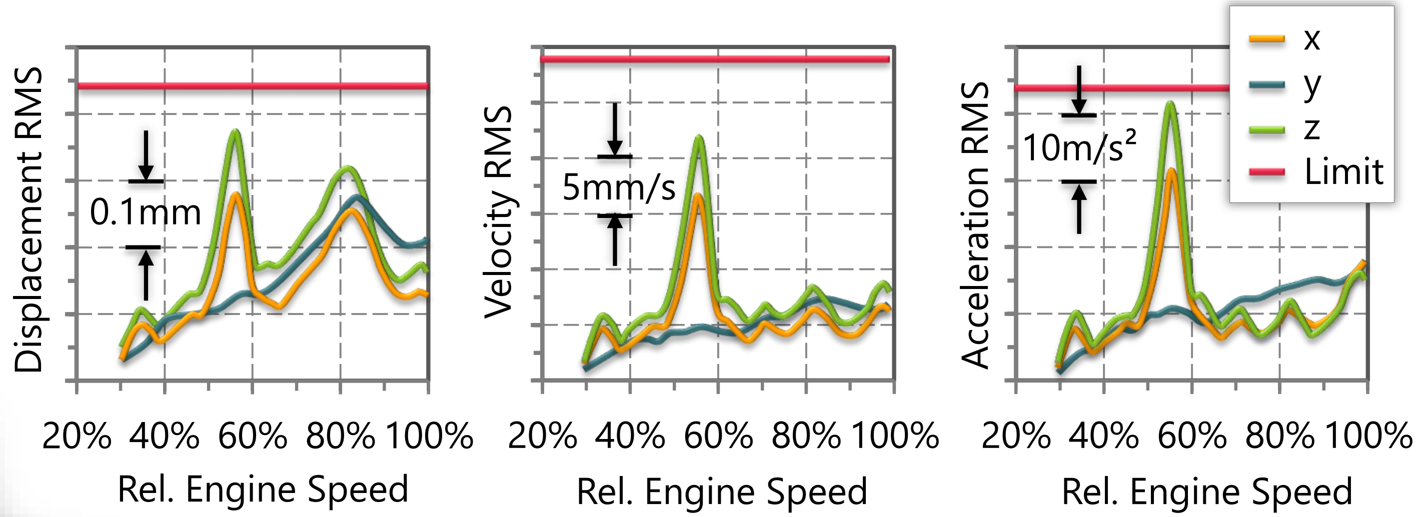


Structure-born
Noise /
Sound Power

Based on MBS a virtual validation of the vibration behavior of drive train components can be carried out before the first prototype engine is built

THE VIBRATION ASSESSMENT CAN BE PERFORMED ACCORDING TO METHODS DEFINED BY DIN / ISO STANDARDS



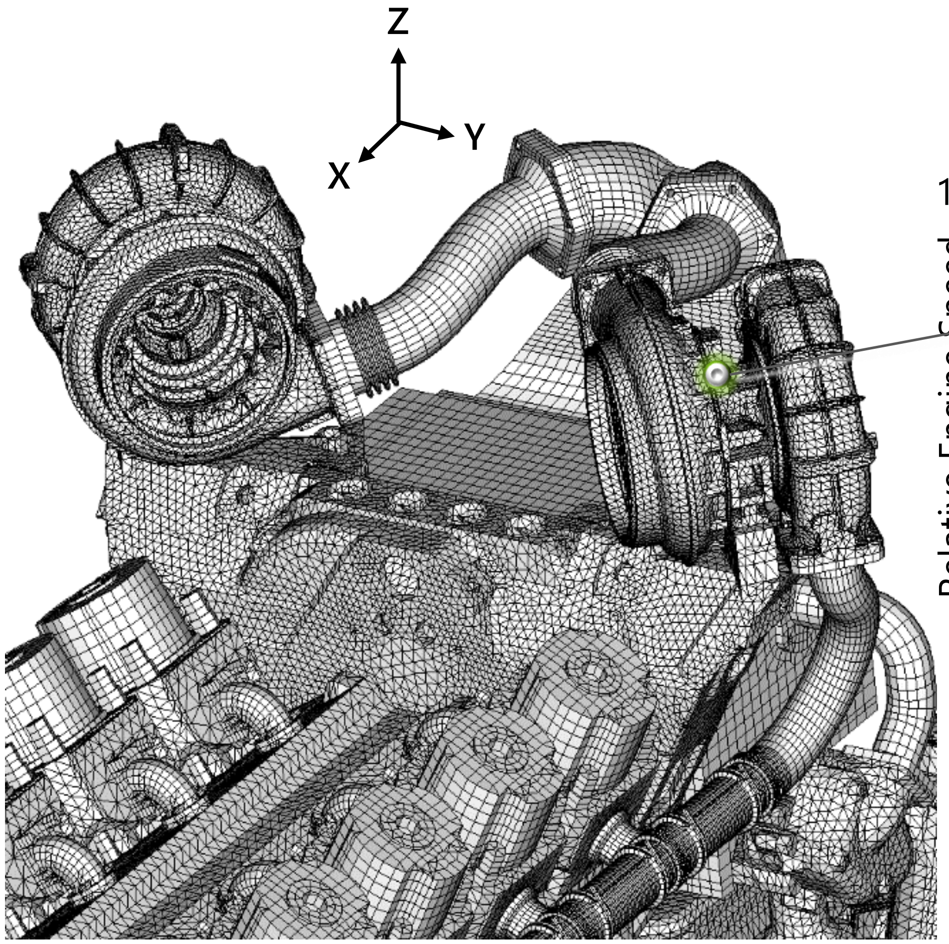


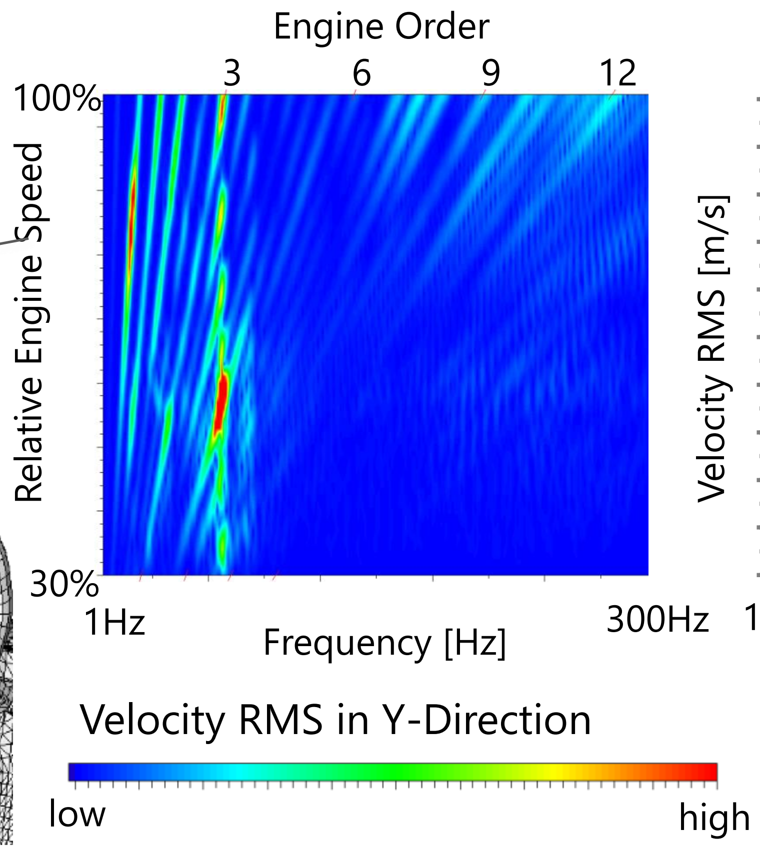
Evaluation Points

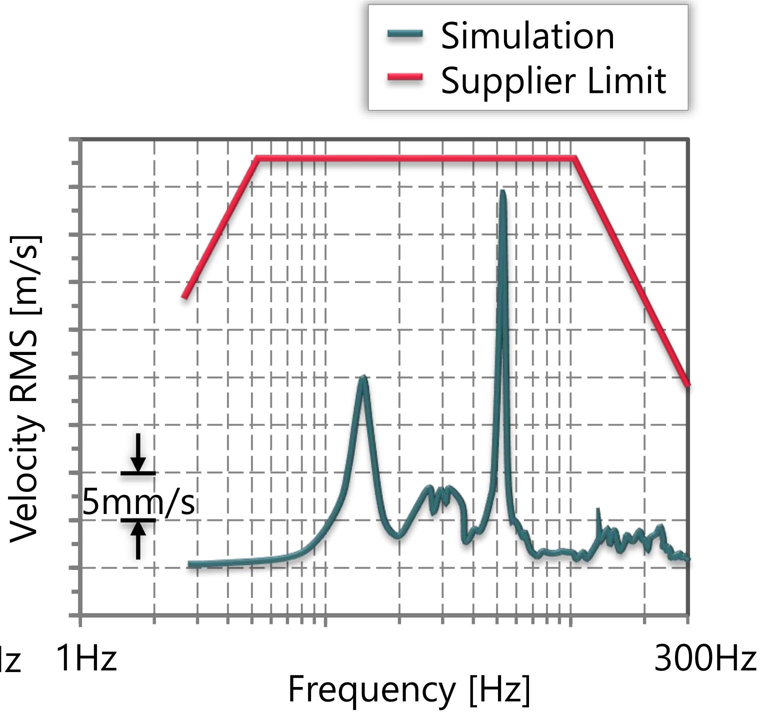
- DIN/ISO Standard
- Additional Points

The local vibrational behavior of add-on parts e.g. brackets, auxiliaries, filters or pipes can be analyzed in detail

ASSESSMENT OF COMPONENT VIBRATIONS BY COMPARISON WITH SUPPLIER GUIDELINES

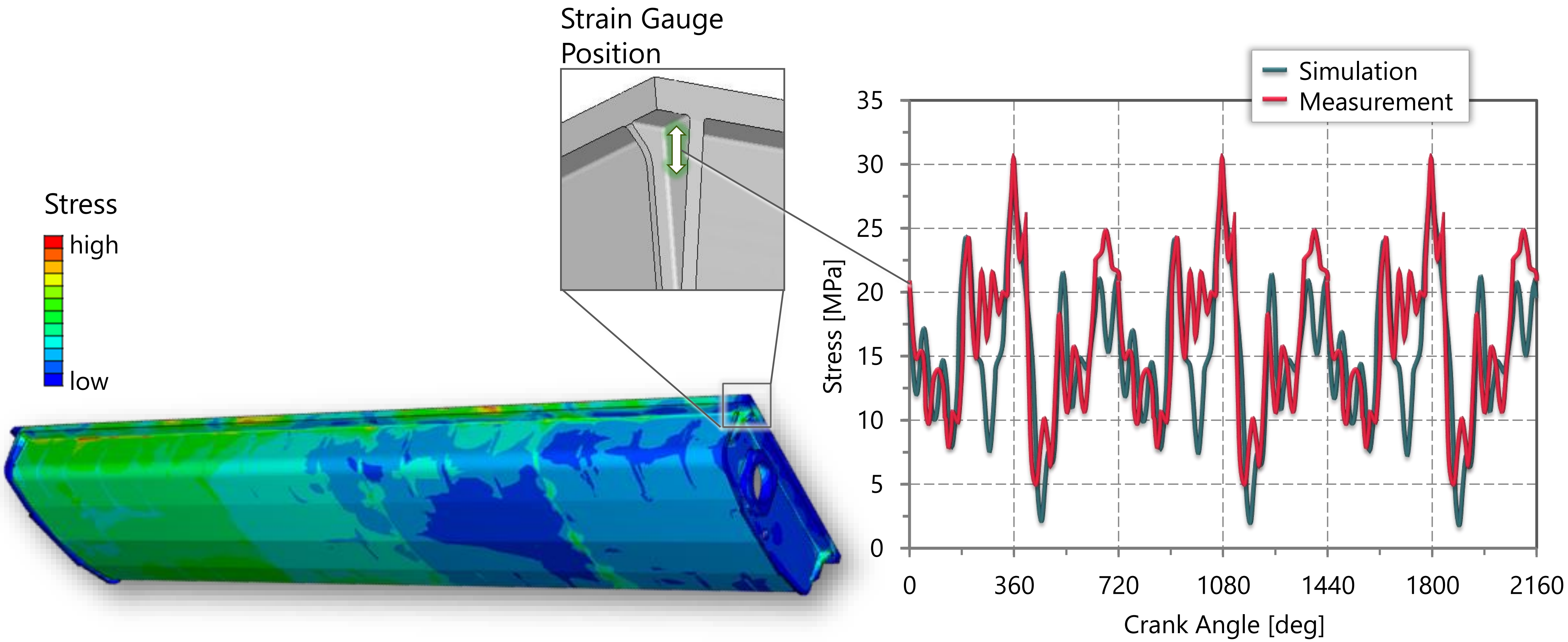






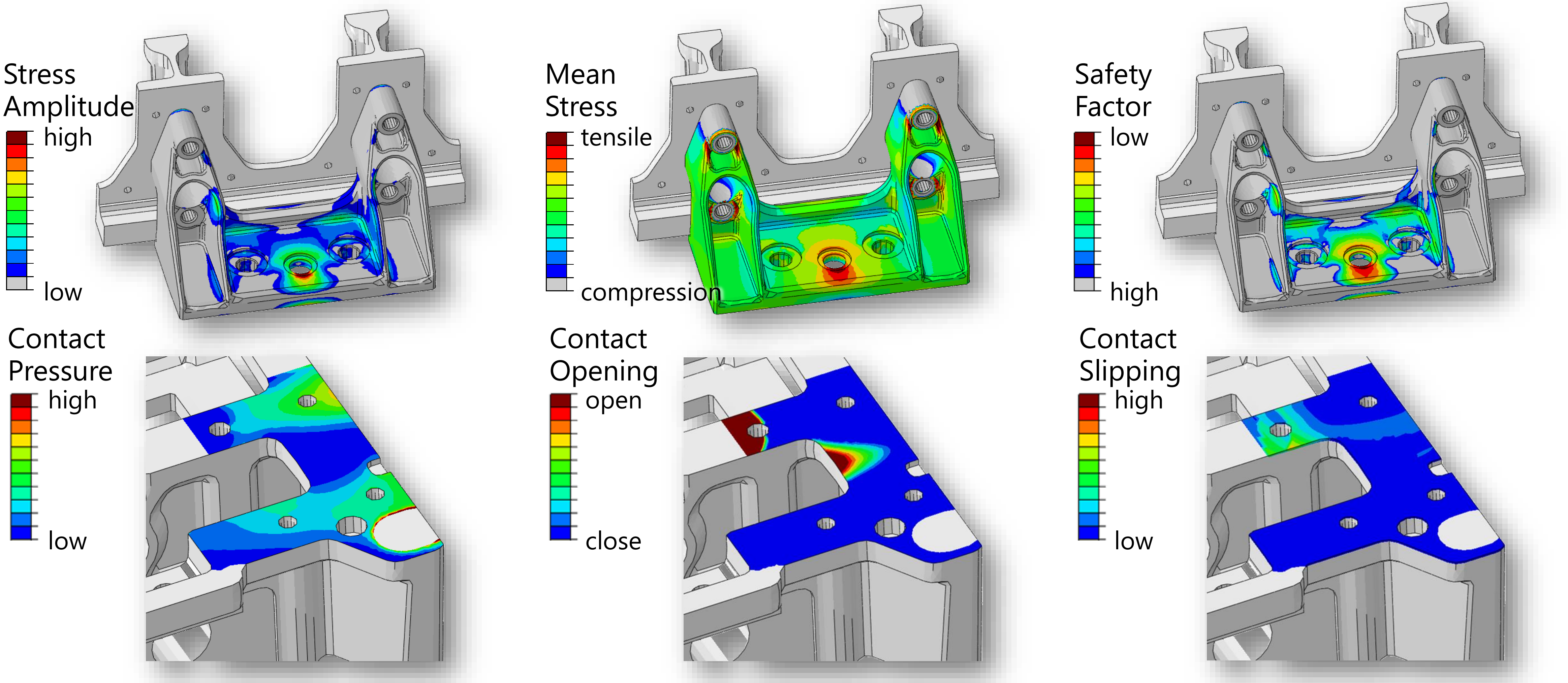
FEV's Global Vibration Analysis Methodology has been successfully validated for several large bore engines in the past

COMPARISON OF MEASURED AND CALCULATED OIL PAN STRESSES



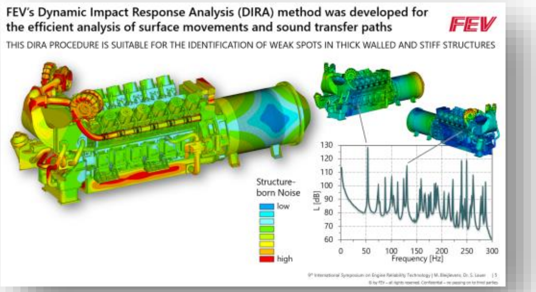
For the analysis of non-linear effects such as local sliding or separation of contact points a non-linear FE analysis is performed in the last analysis step

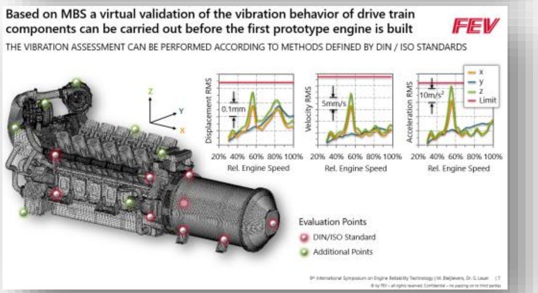
STRESS & SAFETY FACTOR EVALUATION OF AN ENGINE MOUNT AND ASSESSMENT OF CONTACT BEHAVIOR

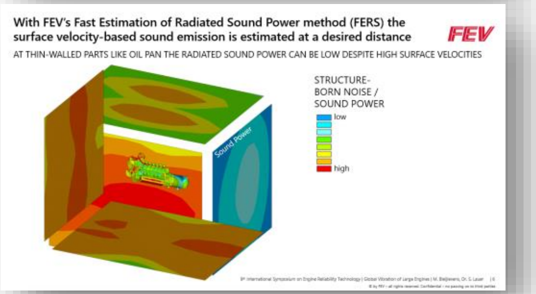


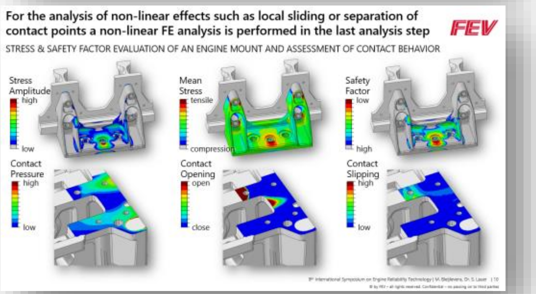
SUMMARY

Global Vibration Challenges of Large Engines



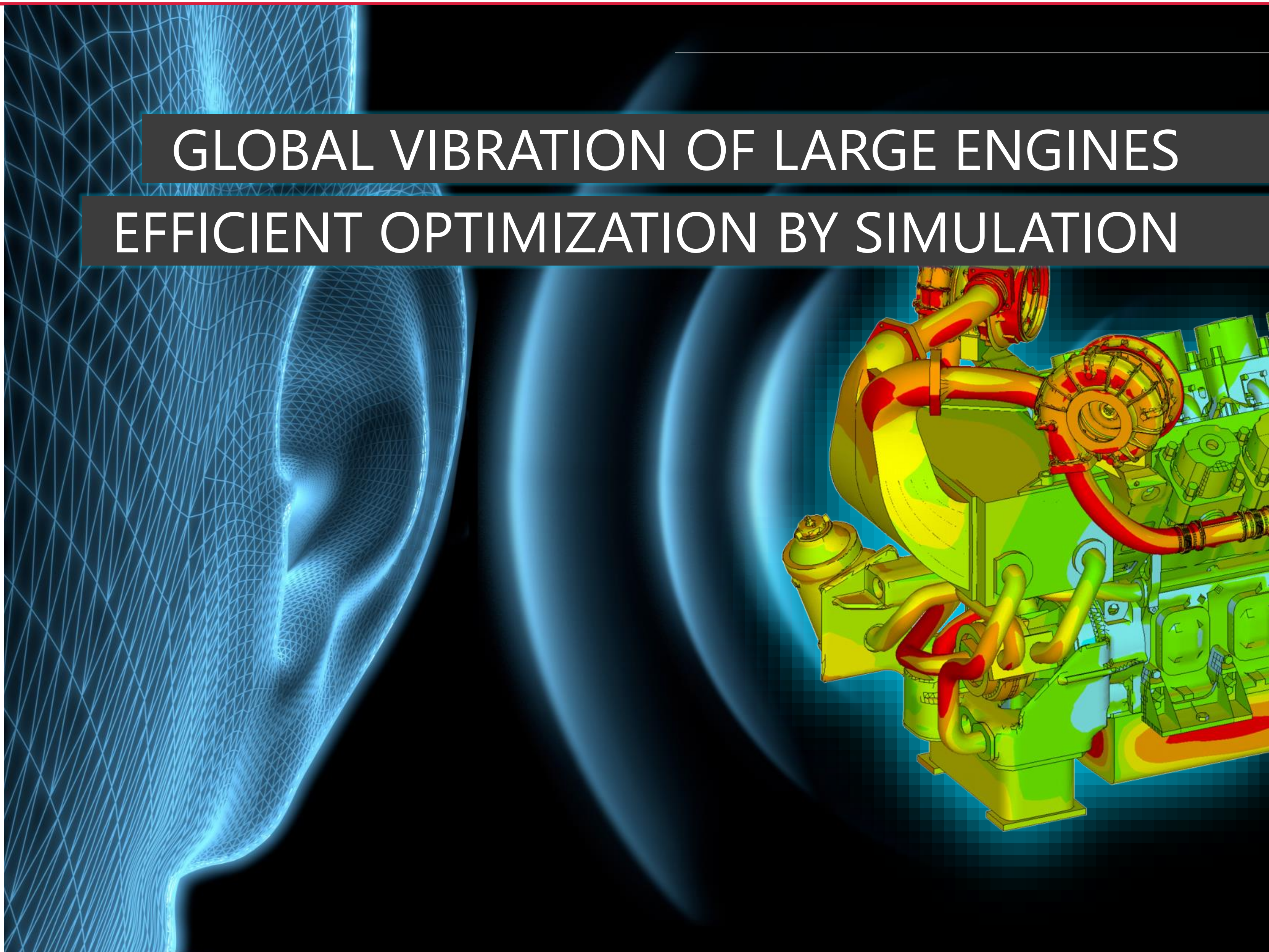






- Modal analysis at the initial design stage to determine the impact of structural measures on the vibration very early
- To identify NVH weaknesses, the structural transfer behavior is analyzed using the FEV DIRA method before detailed MBS simulation are performed
- By means of MBS simulation a virtual validation of powertrain vibration is carried out according to ISO standard before the first prototype engine is existing
- In a further analysis step the radiated sound power is estimated at a definable distance from the engine, which helps to optimize thin-walled components
- For the analysis of non-linear effects such as local sliding or separation of contact points a non-linear FE analysis is performed in the last analysis step

GLOBAL VIBRATION OF LARGE ENGINES
EFFICIENT OPTIMIZATION BY SIMULATION



JINAN CITY, NOVEMBER 1ST, 2020

M. BLEIJLEVENS
DR. S. LAUER

PREPARED FOR

9TH INTERNATIONAL SYMPOSIUM ON ENGINE RELIABILITY TECHNOLOGY

THANKS FOR YOUR INTEREST!

谢谢

PRESENTER & CO-AUTHOR

MARC BLEIJLEVENS
Technical Specialist NVH - Diesel Powertrains

- Bachelor of Eng. (Applied Physics) Hogeschool Heerlen, Netherlands
- From 1999 until 2014 Simulation Engineer NVH at FEV
- From 2014 until 2018 Technical Specialist NVH, Diesel Engine Powertrains at FEV
- Since 2018 Project Manager CAE, Diesel Engine Powertrains at FEV Europe GmbH

DR. SVEN LAUER
Department Manager - Diesel Powertrains

- PhD in Mechanical Engineering, RWTH Aachen, Germany
- From 1999 until 2004 Development Engineer at Institute for Internal Combustion Engines / RWTH Aachen
- From 2004 until 2006 Senior Simulation Engineer at FEV
Valve and Timing Drive Systems
- From 2007 until 2009 Manager Structural Simulation at FEV
- From 2010 Manager for Mechanical Simulation and Test of Diesel Engine Powertrains at FEV
- Since 2014 Global Chief Engineers Mechanical Simulation at FEV