

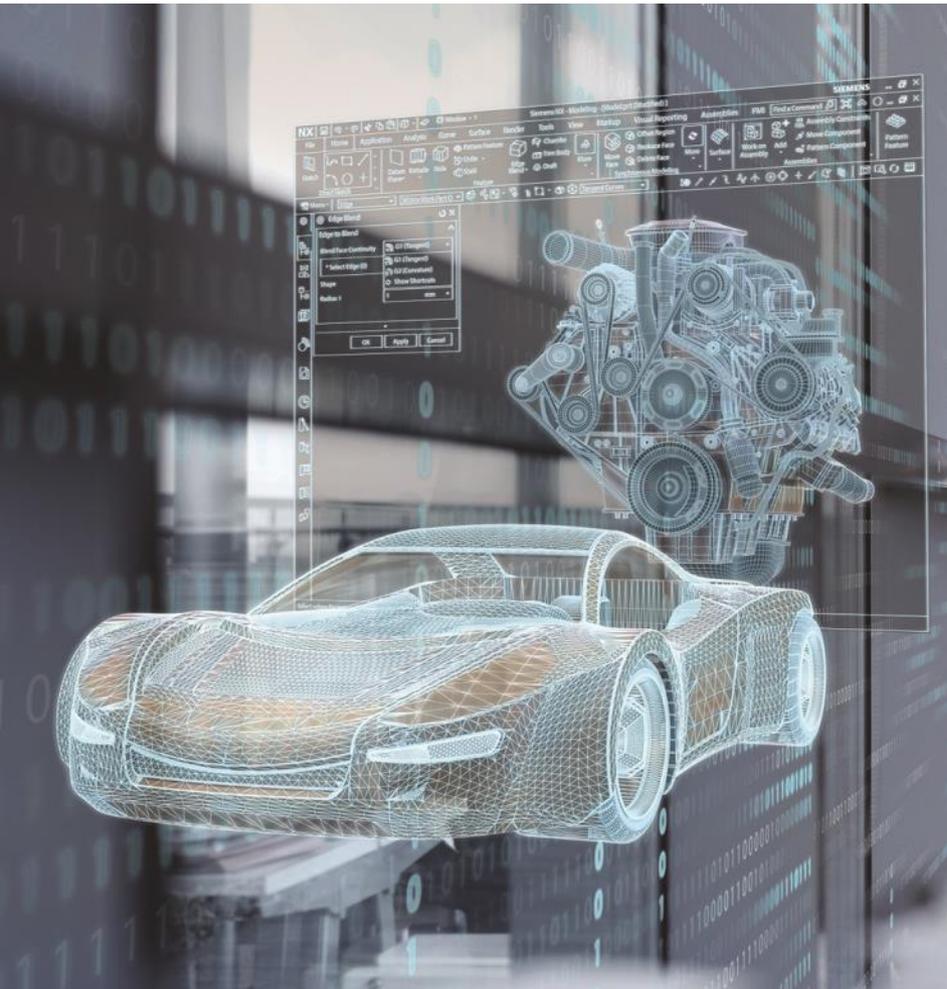
SIEMENS
Ingenuity for life

Introduction to vehicle NVH and Acoustics

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Realize innovation.

Agenda



Introduction to NVH

Powertrain NVH analysis

Interior vehicle NVH

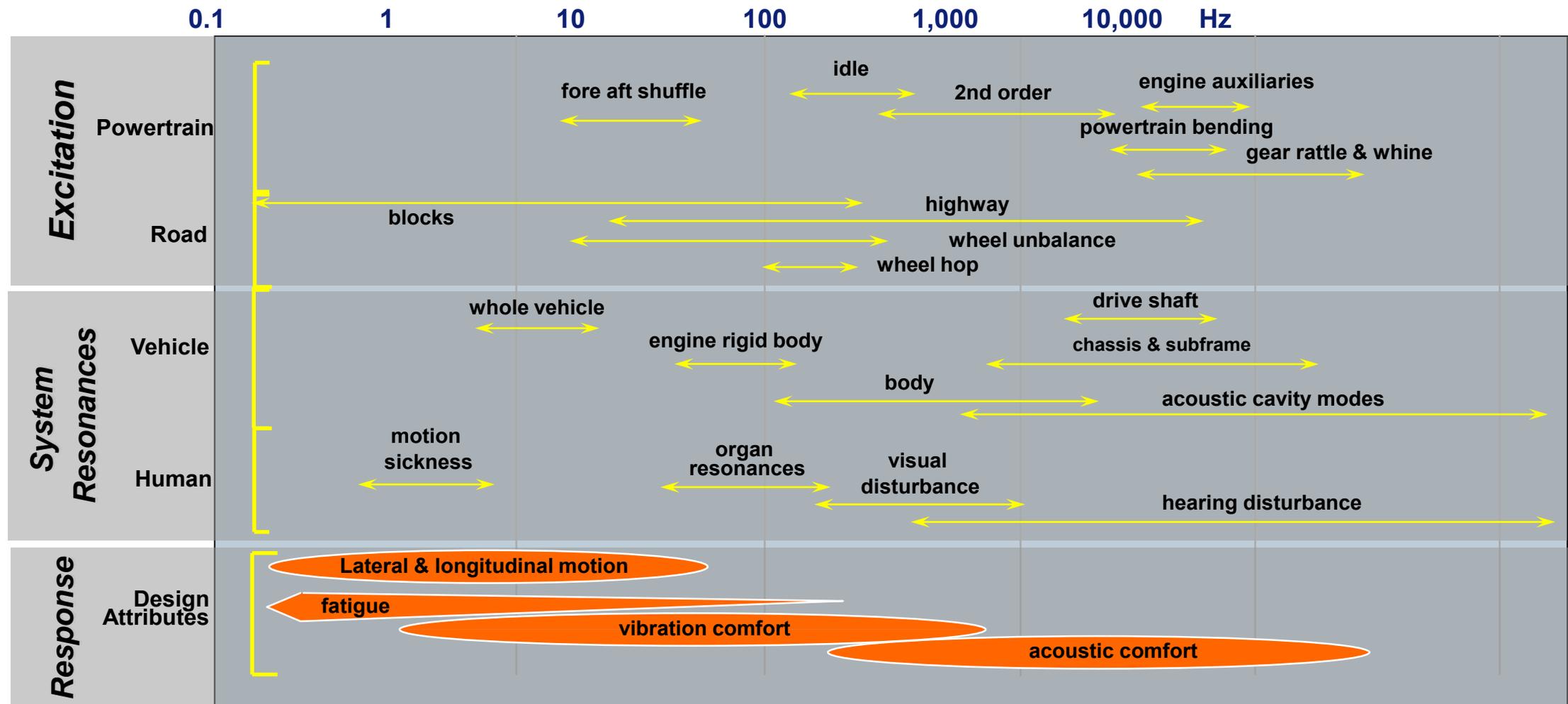
Exterior acoustics

Conclusion

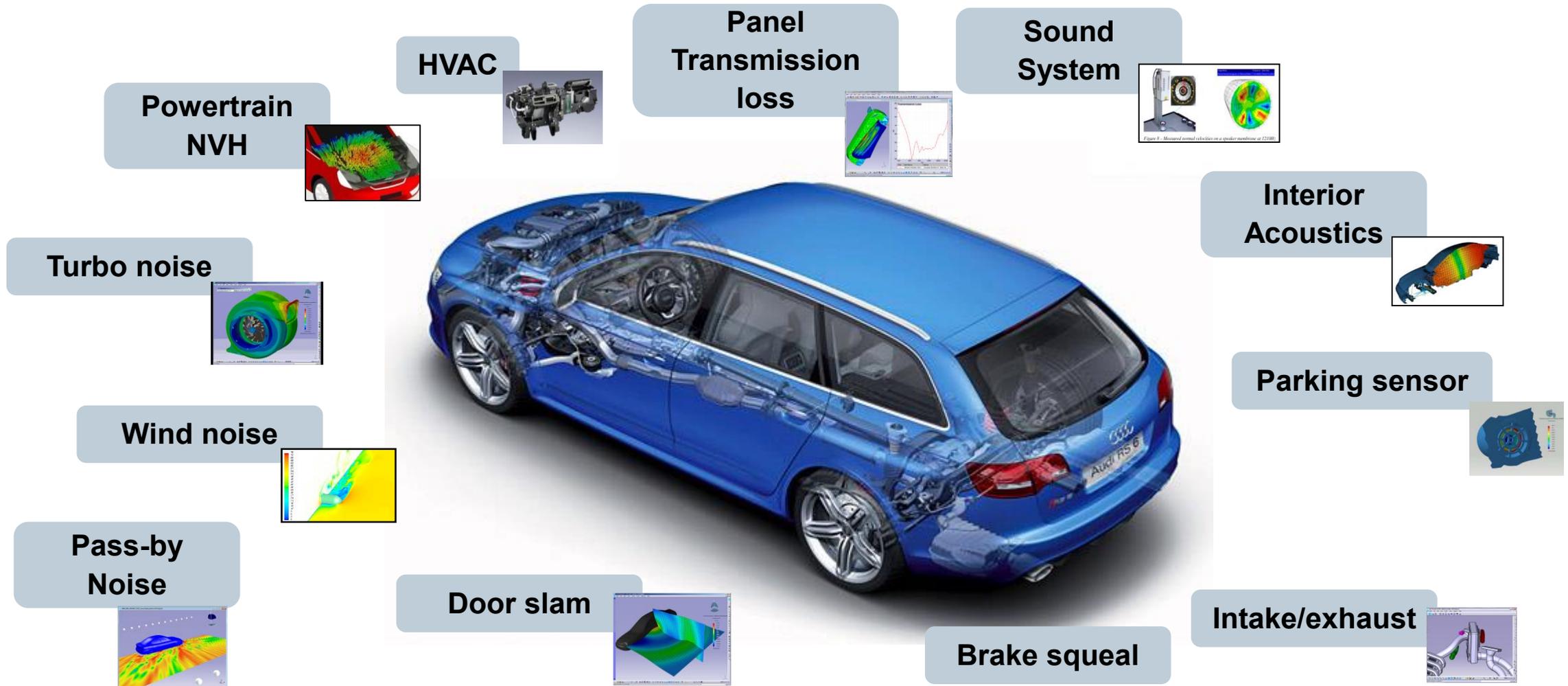
What is NVH?

- **Noise**
 - Audible disturbance mainly in the 20 Hz – 5000 Hz frequency range.
 - Characterized by frequency, level and quality
- **Vibration**
 - Motion sensed by the body mainly in the 0.5 Hz – 50 Hz frequency range.
 - Characterized by frequency, level and direction
- **Harshness**
 - Rough, grating or discordant sensations associated with the combined effect of noise and vibration.
 - Principally associated with road surface excitation

The Spectrum of NVH Phenomena



NVH Applications overview



Overview of NVH Applications

What is the problem? quantitative analysis needed

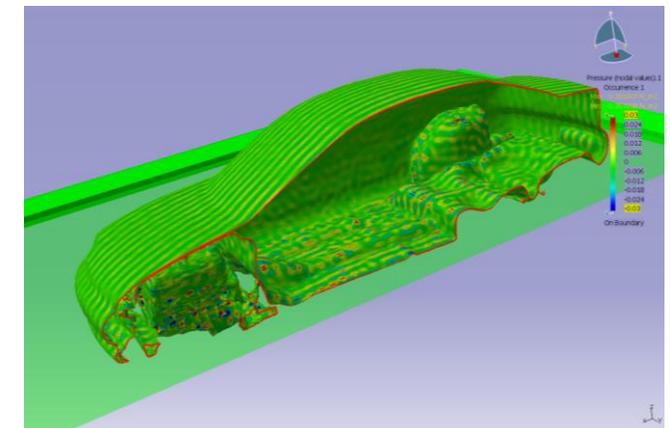
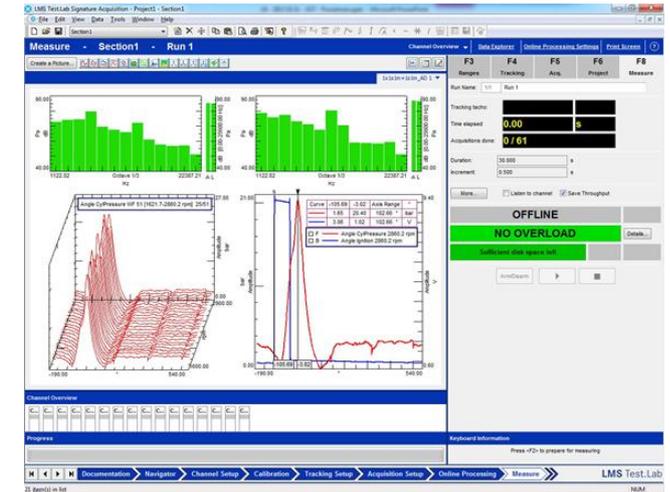
- Analysis of vibration levels
- Analysis of noise level
- Assessment of human impact

Where does it comes from?

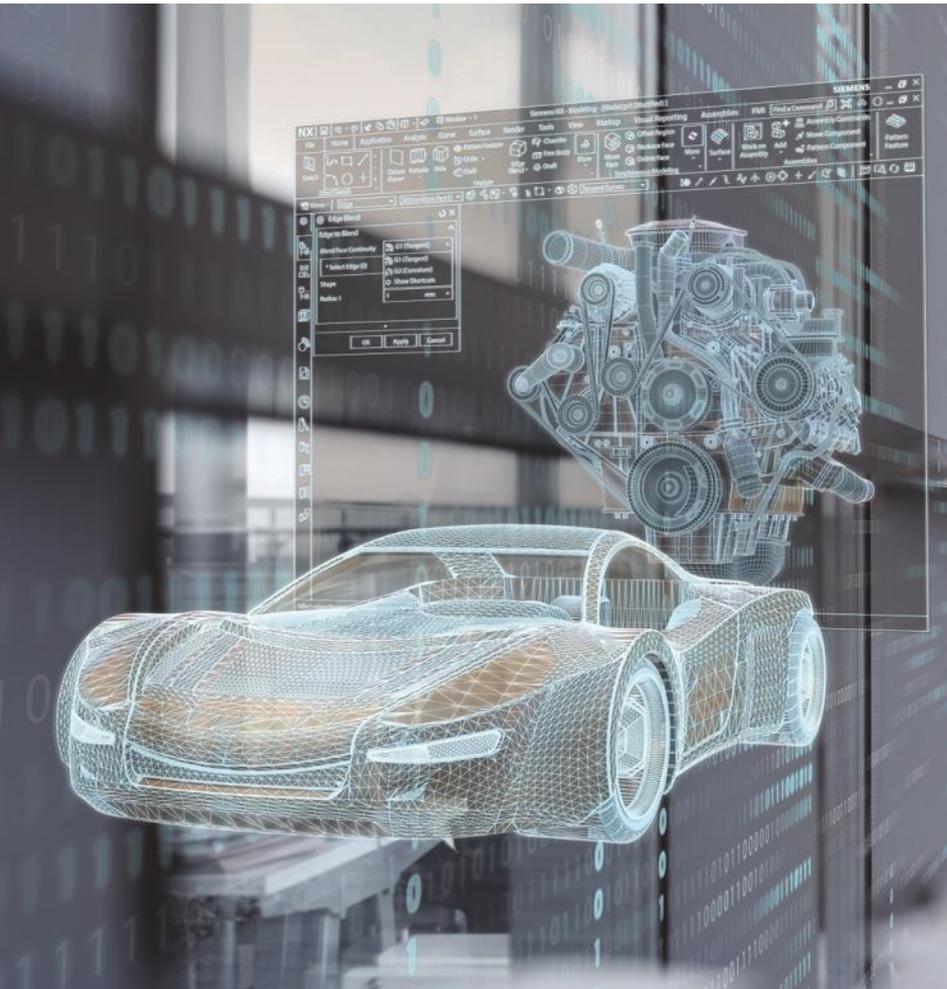
- Spectral analysis: which frequencies contributes
- Spatial analysis: which parts of the structure contribute?
- Is it a source or transfer problem?
- Where are the actual sources?
- What is the noise transmission process?
- What is the influence of the structure itself?

What can we do about it?

- Engineering analysis
- Modification assessment
- Build models so you can work with simulations



Powertrain NVH analysis



Introduction to NVH

Powertrain NVH analysis

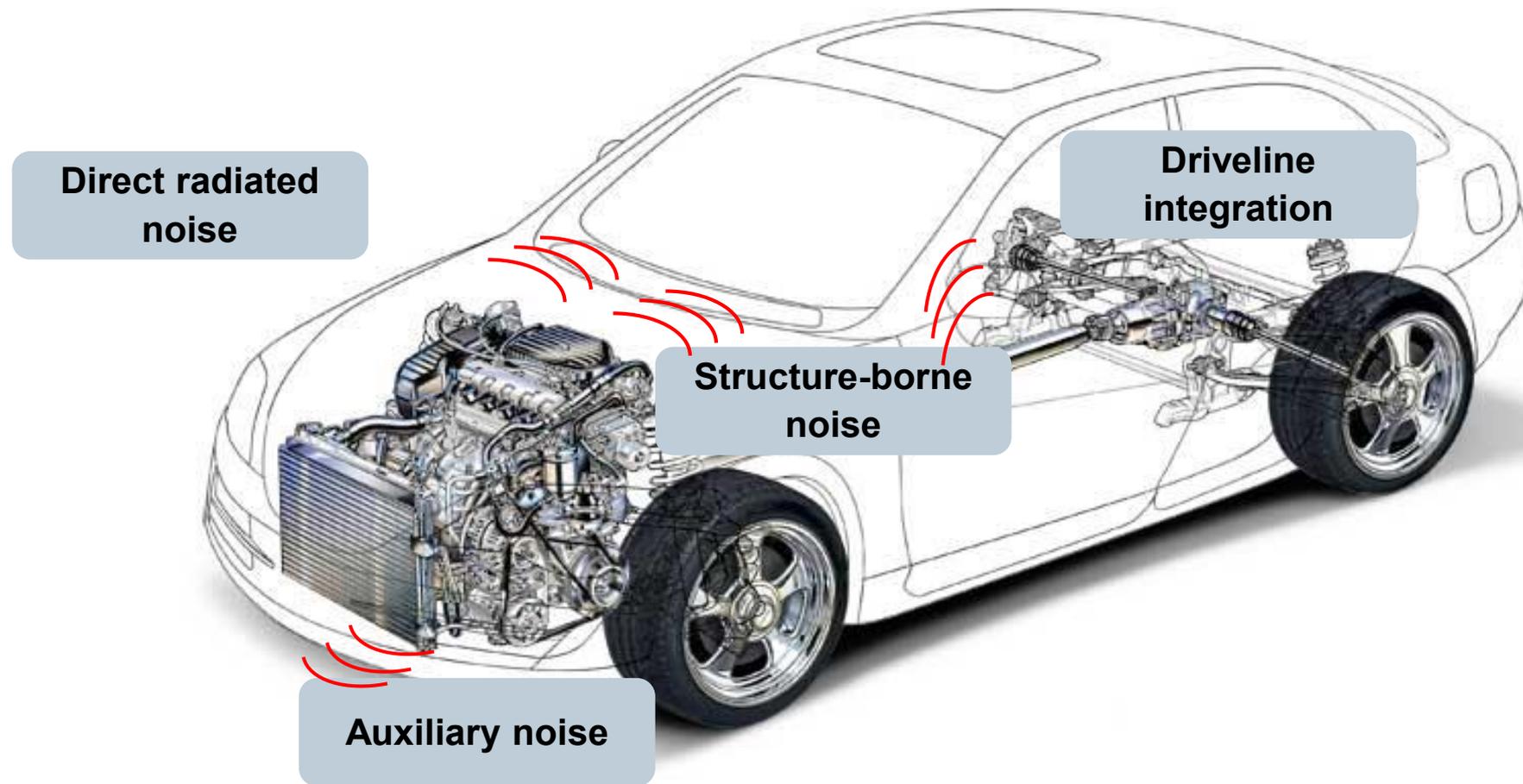
- Structure-borne and air-borne noise
- Sound Source Localization
- Powertrain integration
- Component analysis: Gear box, Turbocharger, injectors...
- ICE and Hybrid engine
- Electric motors
- Combined use of test solutions and simulation analysis

Interior vehicle NVH

Exterior acoustics

Conclusion

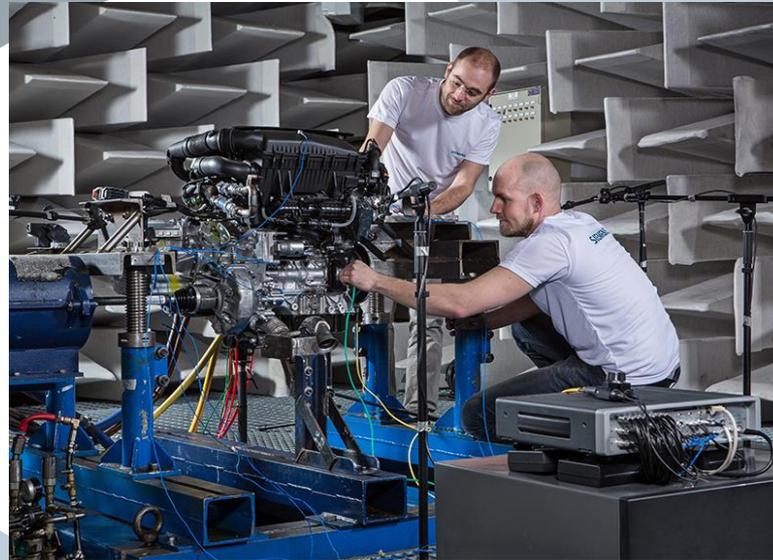
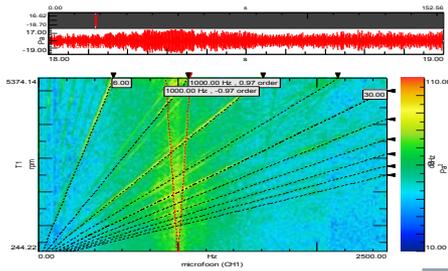
Powertrain related NVH



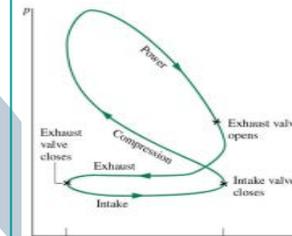
Fuel Economy programs impact NVH

Integrating for productivity

NVH Analysis

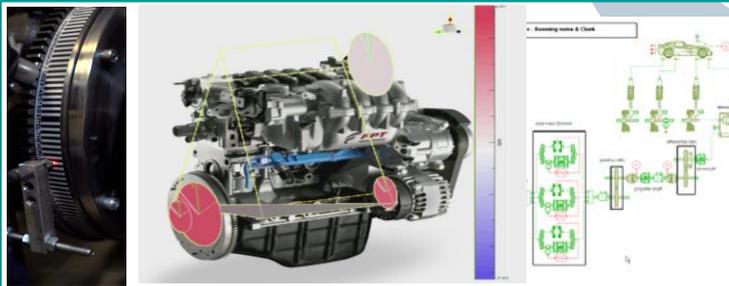


Online Angle Domain / Combustion Analysis



- Pegging
- PV diagram
- IMEP
- Customized metrics

Torsional Vibration Analysis



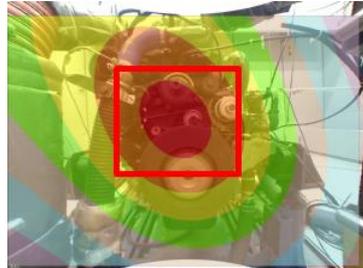
ECU Communication CAN / FLEXRAY / CCP / XCP



Engine radiated noise

Measurement using
Acoustic camera

Beamforming (50cm)



500Hz 1/3 octave

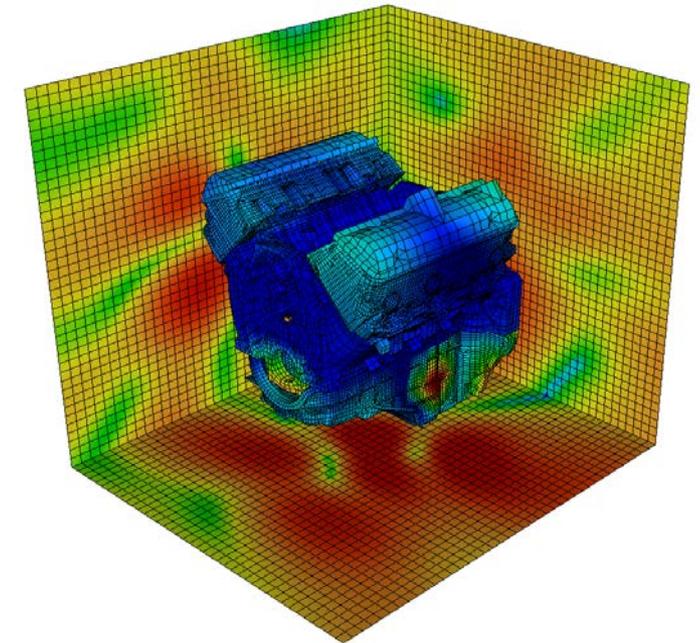


1250Hz 1/3 octave



4000Hz 1/3 octave

Simulation with
acoustics solvers



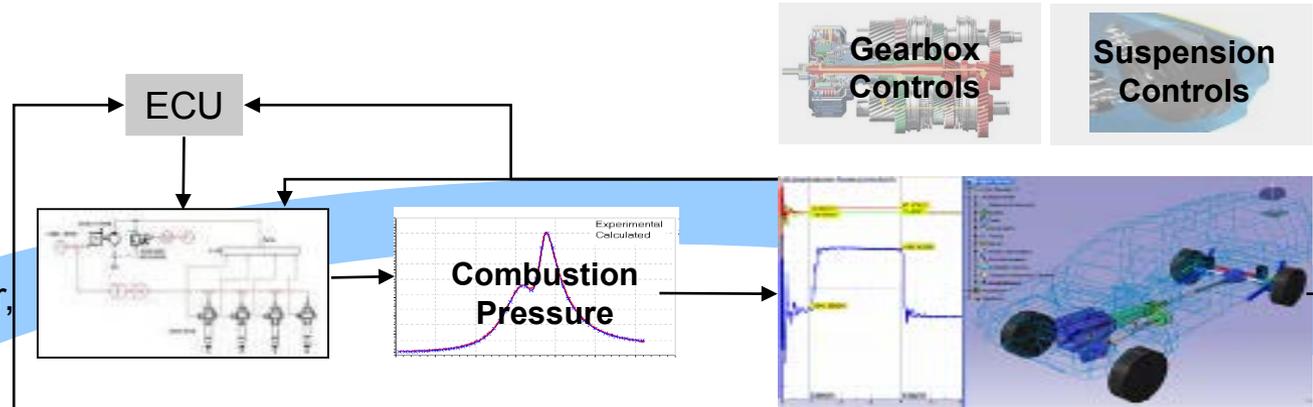
Drivability optimization in context of fuel economy

Early concept phase investigations of powertrain/vehicle behavior



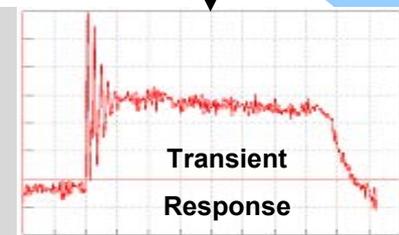
1D Simulation

- Combustion process and parameters
- Coupling to ECU
- Control models for gearbox, torque converter, active suspension

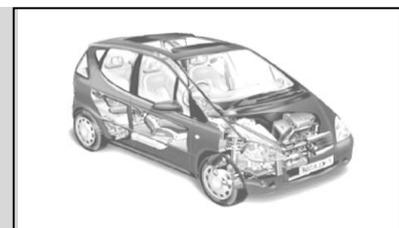


3D Simulation

- Detailed MBD model: powertrain, driveline, chassis and suspension
- Integrated controls for gearbox, active suspension



Driveability:
Tip-in –Tip-out, WOT
Gear shift...



Driver Input - Throttle



ECU Controller
Combustion parameters
Suspension controller
Gearbox controller

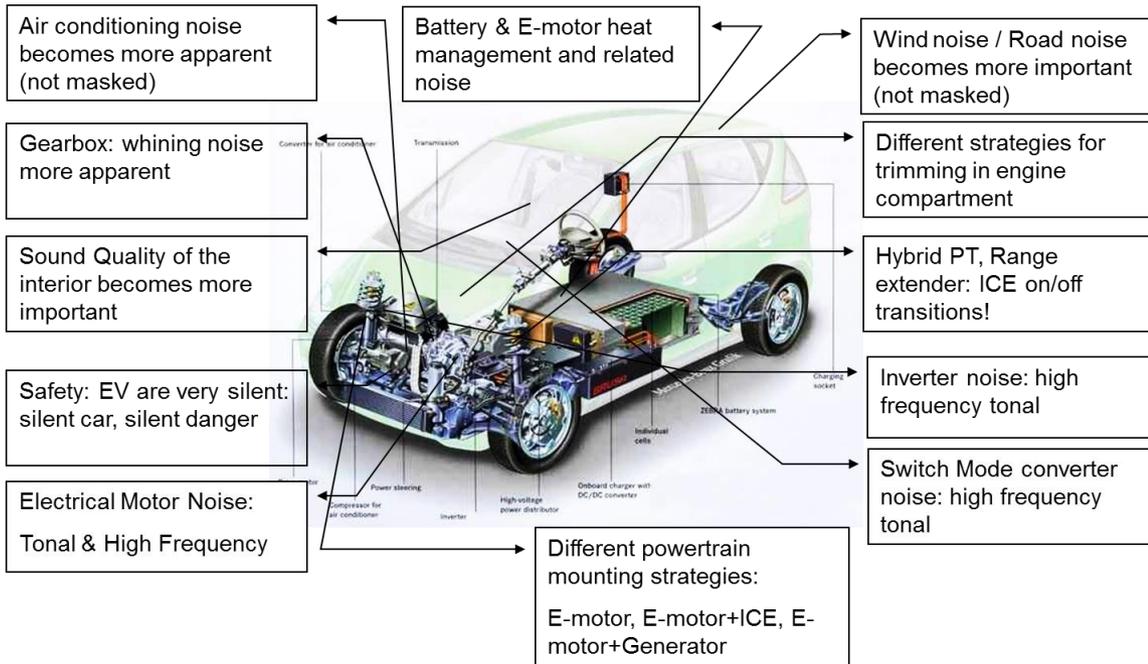
Combined Optimization Driveability
Combustion - Controls – Vehicle

Engine Mount layout
Driveline stiffness
Suspension layout

“Development of High-Fidelity Combustion Driven Vehicle Models for Driveability Using Advance Multi-Body Simulations”, JSAE 2007-1-1634

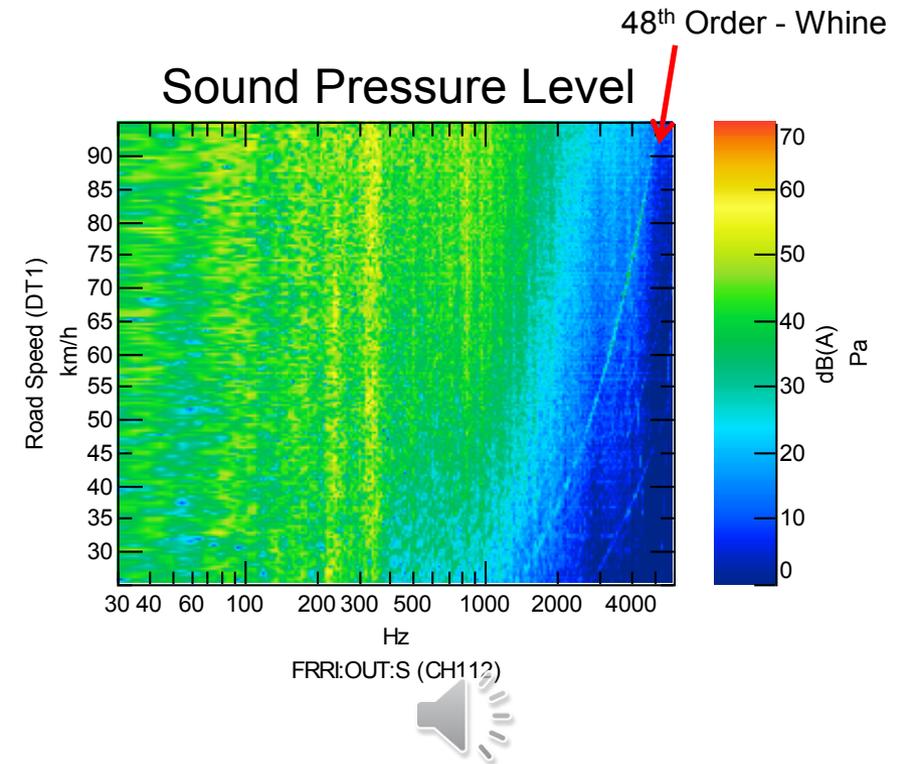
Hybrid / Electric Car NVH Analysis

- New challenges posed by EV/ HEV

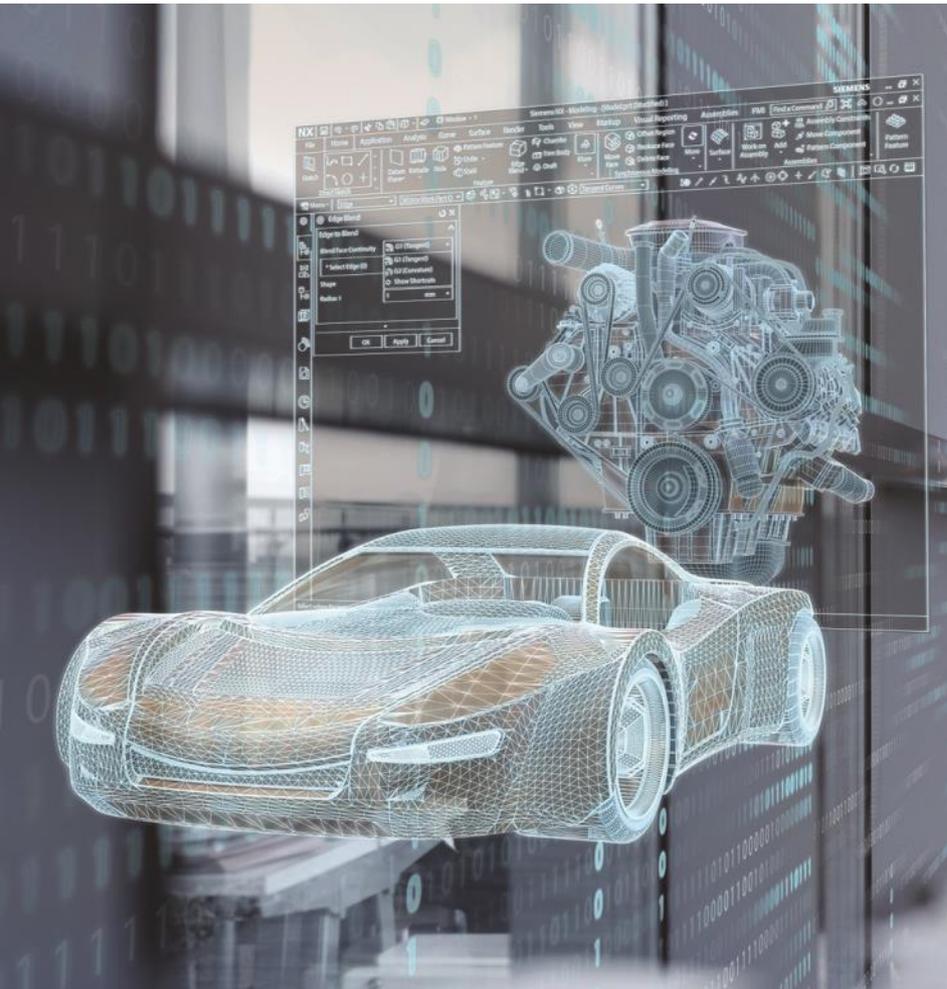


- How does an electric vehicle sound like?

Full load run-up 25 to 95 km/h



Interior Vehicle NVH



Introduction to NVH

Powertrain NVH analysis

Interior vehicle NVH

- Transfer Path Analysis
- Modal Analysis
- Component analysis: HVAC, Wind Noise, Sound system...
- Vehicle comfort
- Complementary offering between test, simulation and engineering services

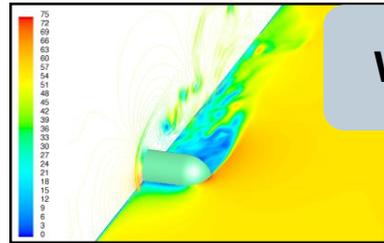
Exterior acoustics

Conclusion

Interior related NVH



Engine noise & vibration



Wind noise

Sound System

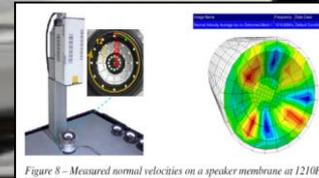
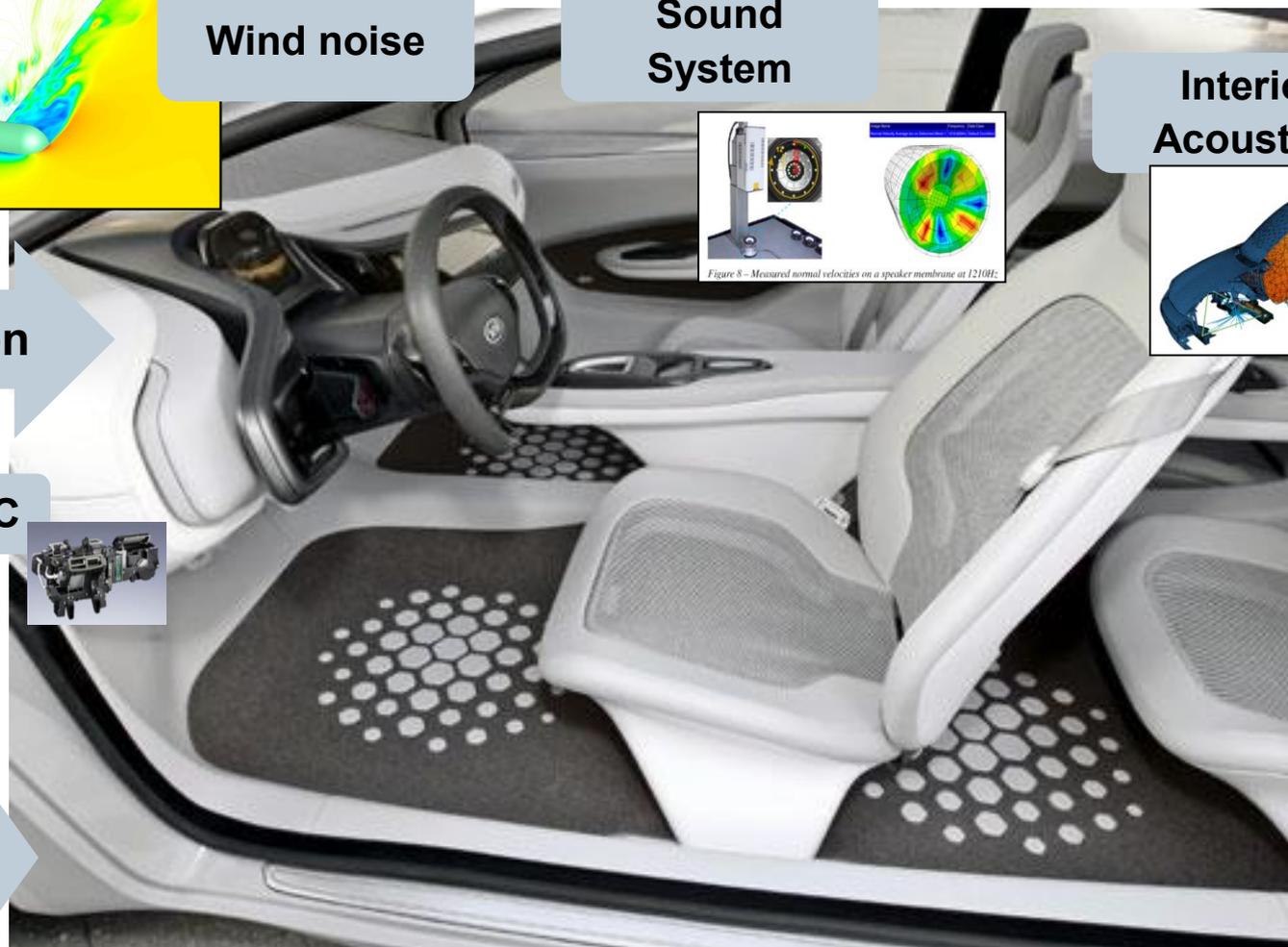
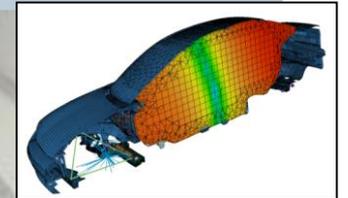


Figure 8 - Measured normal velocities on a speaker membrane at 1210Hz

Interior Acoustics



HVAC

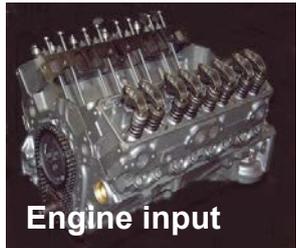


Road Input



Source-Transfer-Receiver Model

Given a set of excitations in frequency domain ...

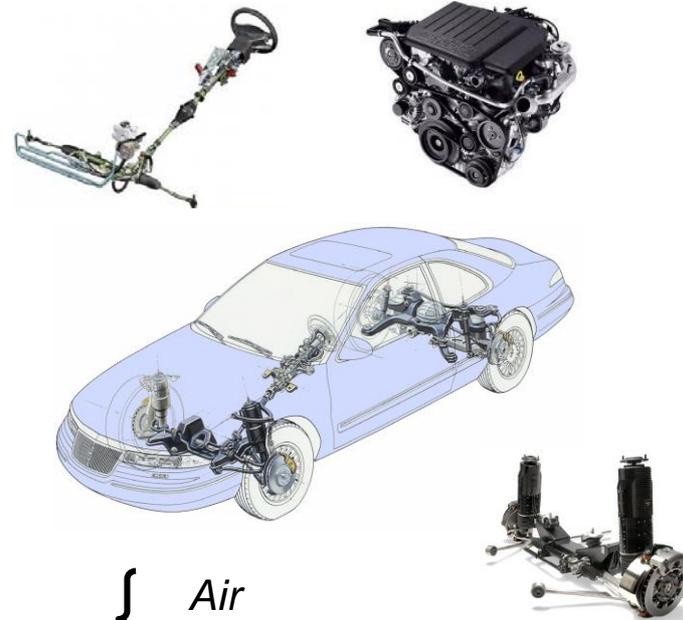


{ Mechanical
Structural



X

Given the structural model of a car or its components ...



{ Air
Structure



=

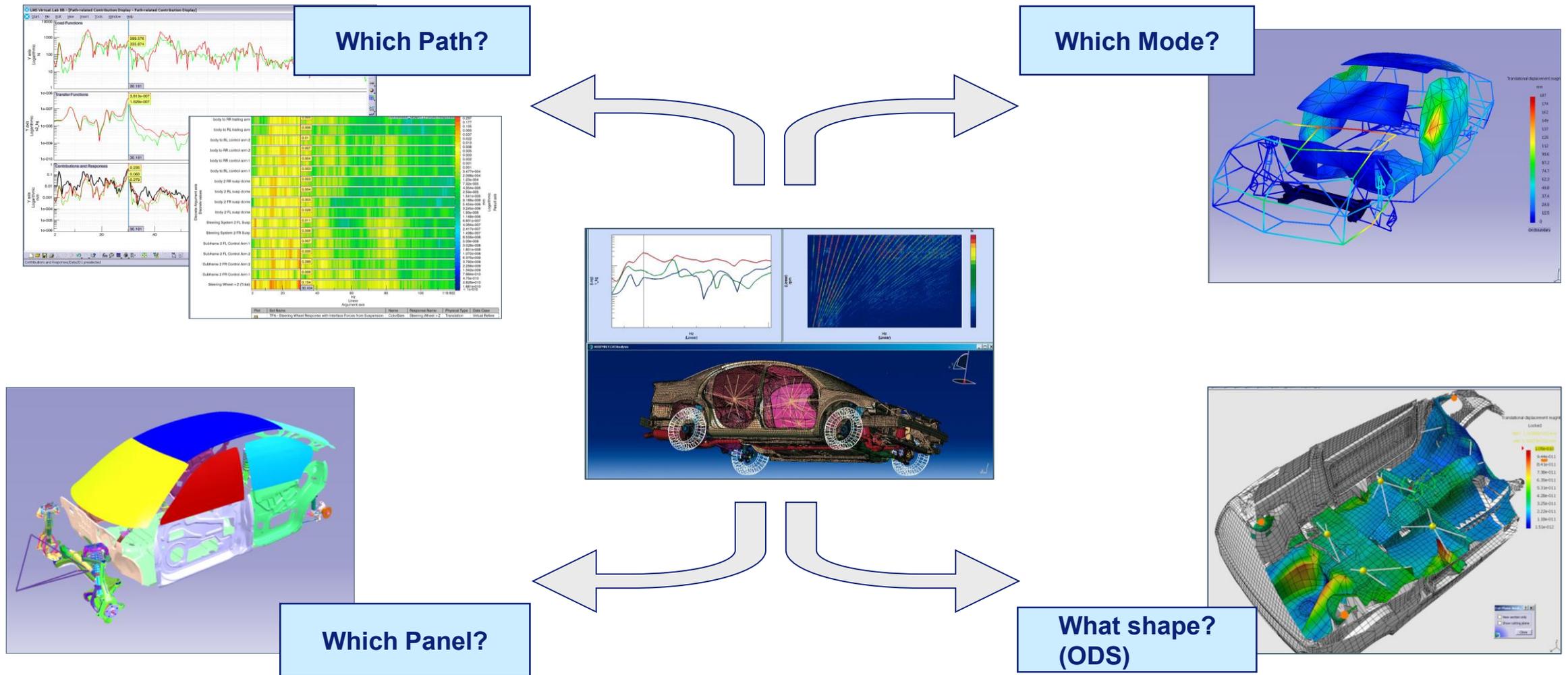
Predict and optimize the NVH Performance



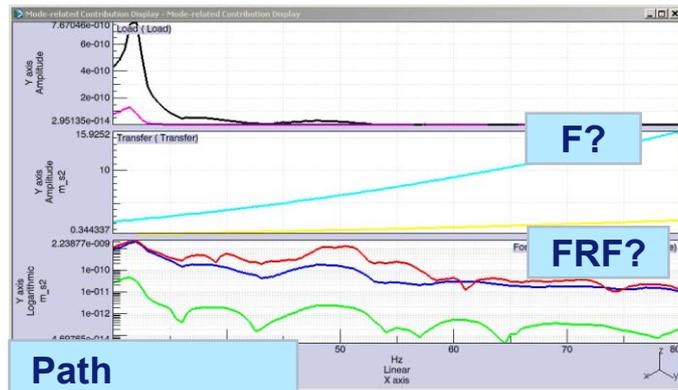
{ Sound Pressure Level
Structural Vibrations



Response and contribution analysis (1/2)



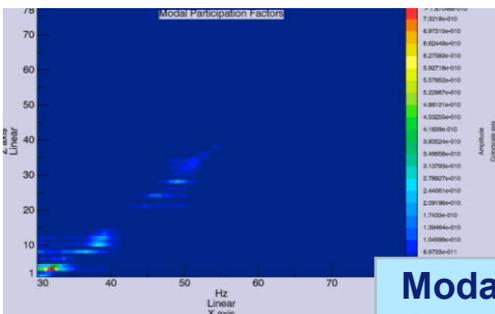
Response and contribution analysis (2/2)



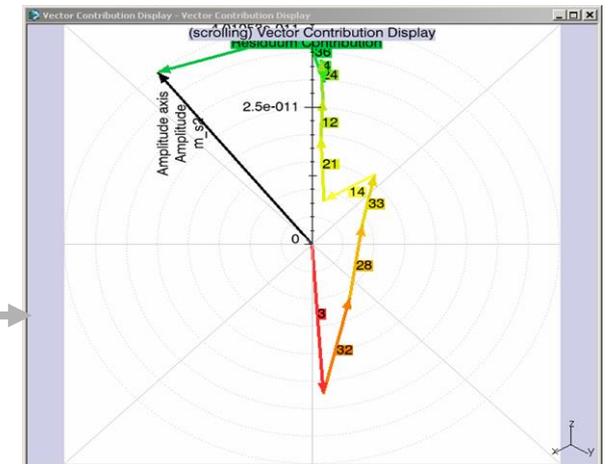
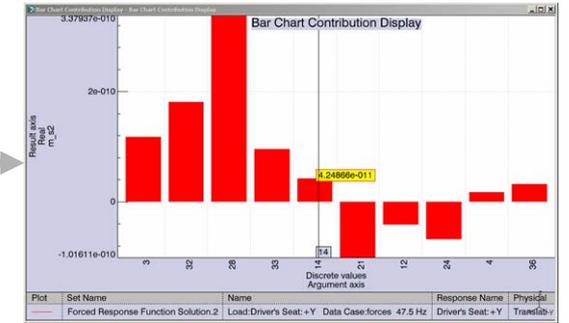
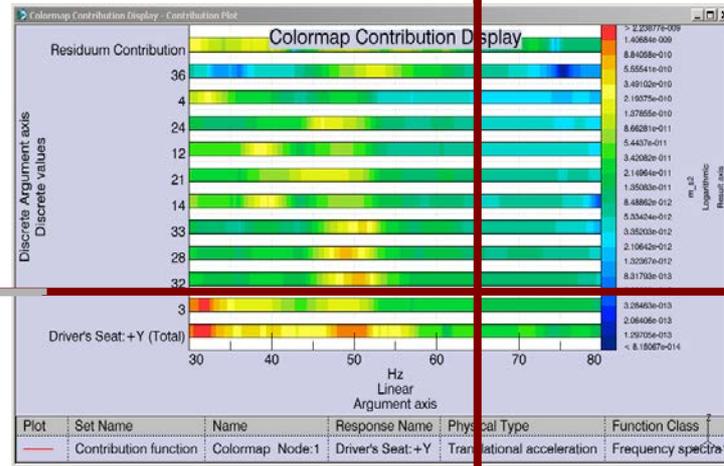
Path Contributions

Over Paths?

Over frequency?

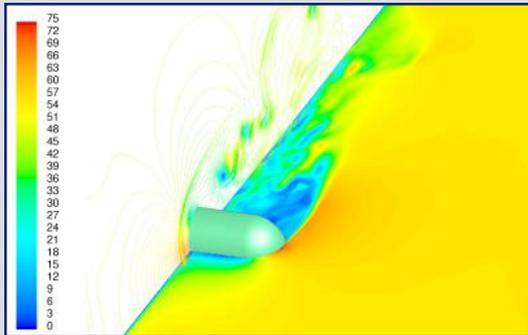


Modal Contribution

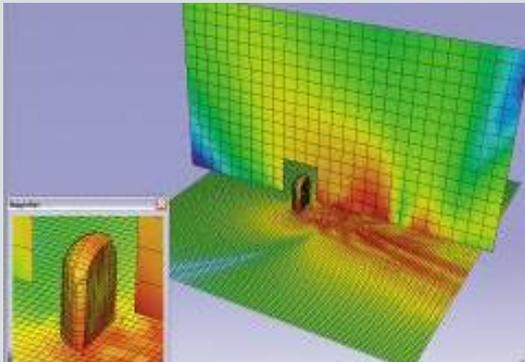


Measurement and Analysis Methods for Wind Noise

Simulation

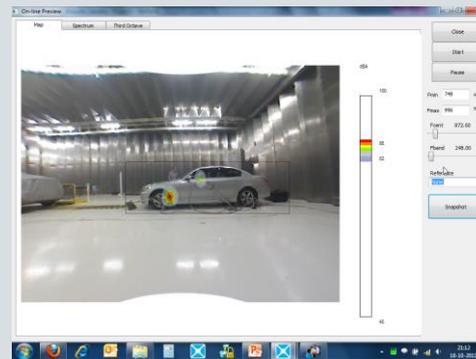
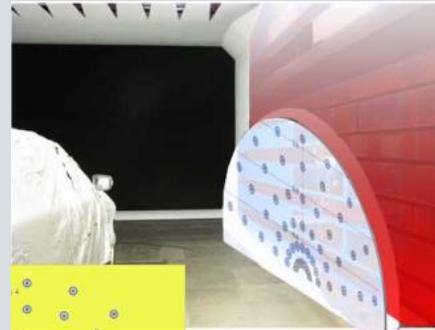


CFD results to Acoustic response



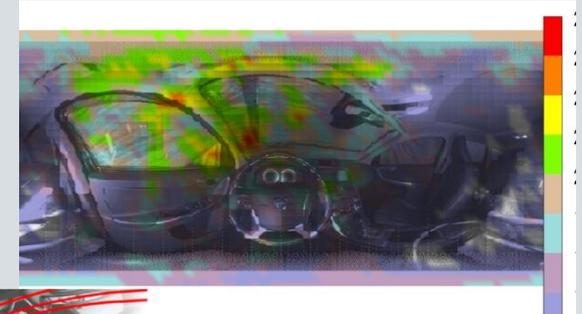
Exterior

Build a detailed map of exterior flow generated noise including coherence to interior sound levels.

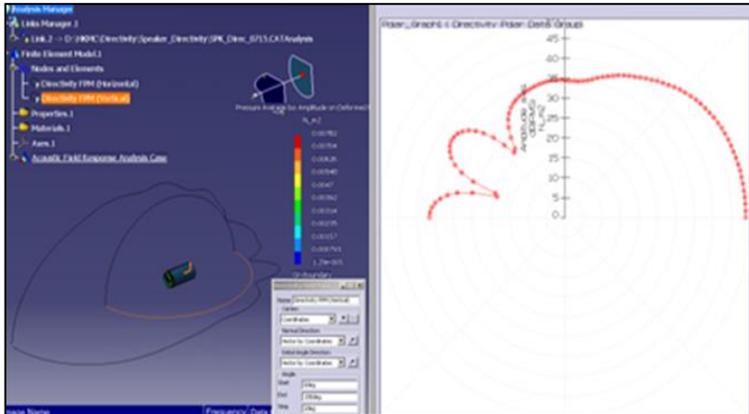


Interior

Reduce wind tunnel testing time, identify dominant sources & plot results on CAD geometry.

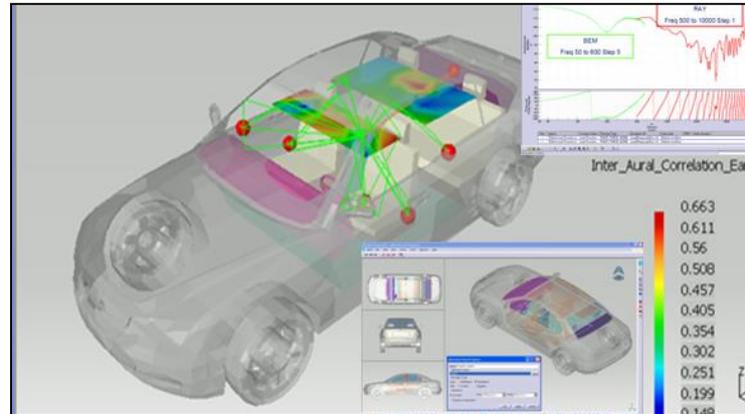


Sound system engineering



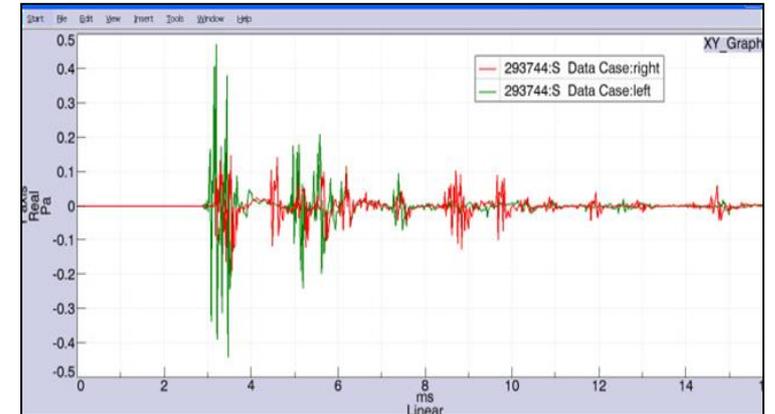
Sound source definition

- Frequency-dependent
- Source Power
 - Directivity



Cabin

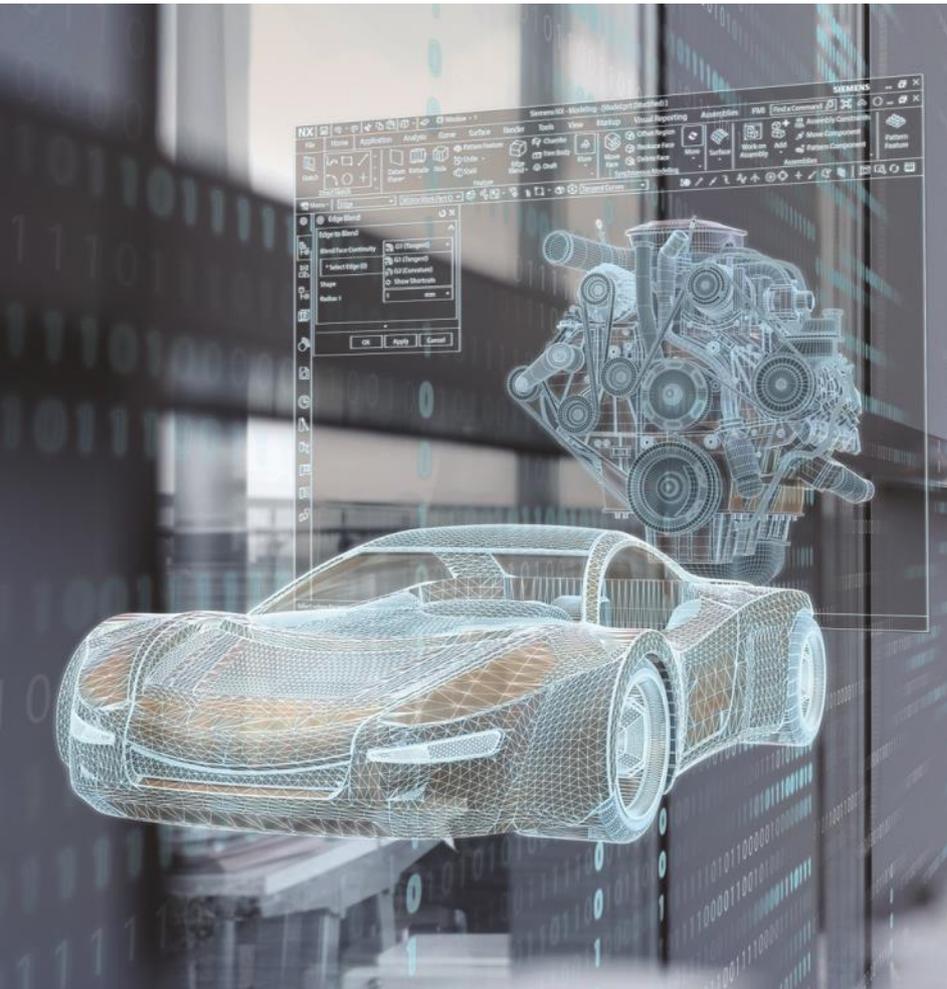
Interior modeling including trim influence



Receiver

- Sound quality indicators (IACC, ILD, ITD, etc.)
- Auralization of results

Exterior acoustics



Introduction to NVH

Powertrain NVH analysis

Interior vehicle NVH

Exterior acoustics

- Pass by noise simulation
- Pass by noise testing: Indoor, Outdoor, Certification
- Sound power analysis
- Exterior warning sounds
- Parking sensors

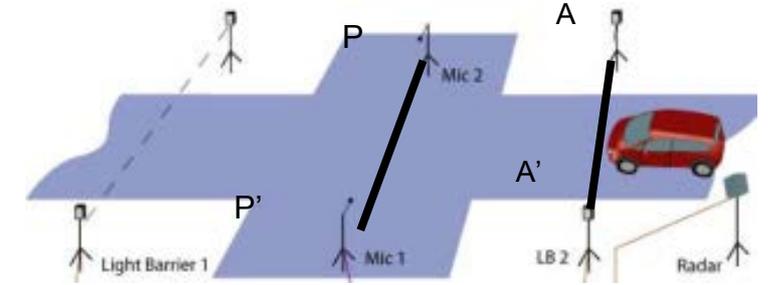
Conclusion

NVH Applications overview



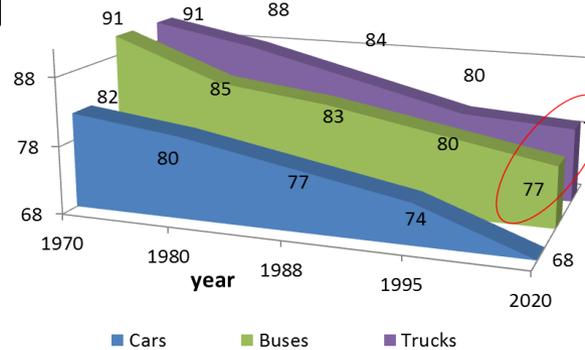
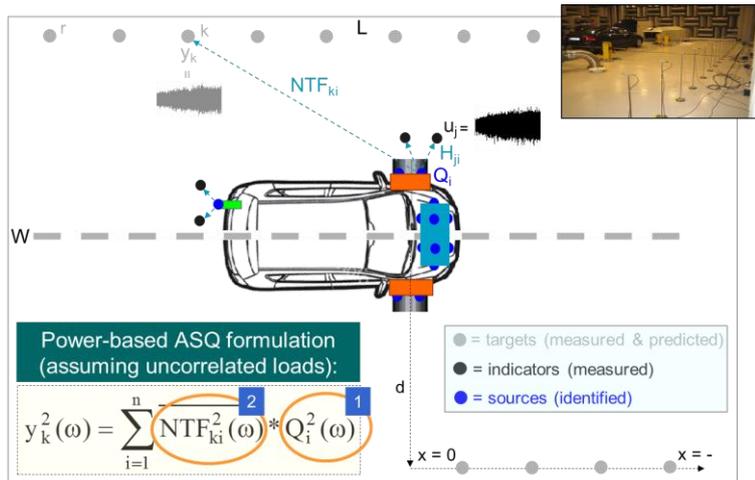
Pass By Noise homologation

- Key exterior noise qualification for vehicles
- Compliance with ISO standards and for competitive performance
 - Exterior noise test; 2 microphones and standard acceleration profile
 - Compliance to ISO standard
 - Interior noise test with multiple microphones to analyze the problem
 - Processing into octave spectra
 - Identification of contributing frequencies and components

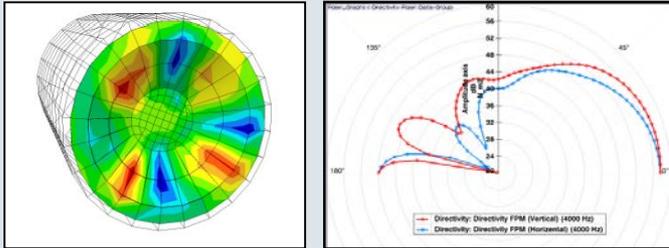


New ISO 362-1 (ISO 362-1:2007: Summary)

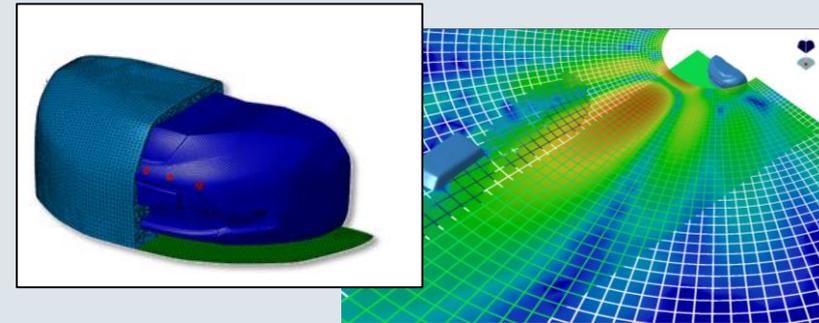
	ISO 362:1981	ISO 362:2007
Test Approach speed	50 km/h at entrance AA'	50 km/h at centerline PP'
Test Operating Condition	Full Load (WOT)	Combination of 2 tests: <ul style="list-style-type: none"> • Full Load (WOT) • Constant speed
Tested Gears	Gear 2 and 3	Gear depend of mainly power to mass ratio Often gear 4 and even gear 5 need to be tested



eVADER – Exterior sound of EV (EU Project) System engineering approach - Sound Synthesis & Propagation



Speaker Directivity

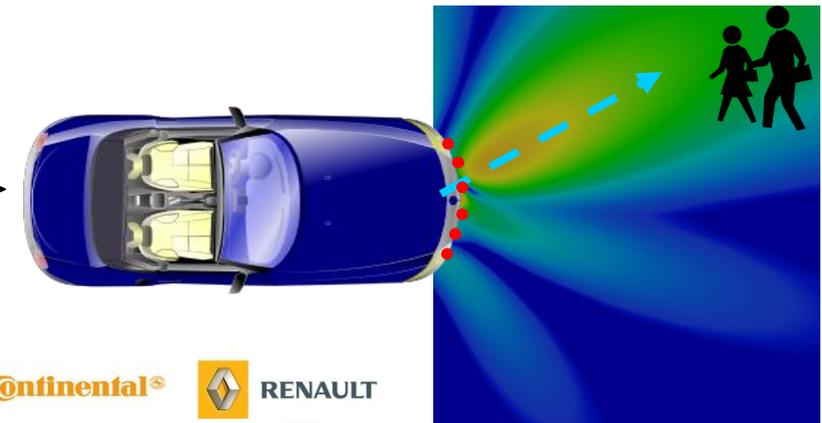


Sound Reflection and Propagation

Multiple speakers in bumper
Combined with sound environment
And Beam-forming (phase shift)

=> Directional warning sound field

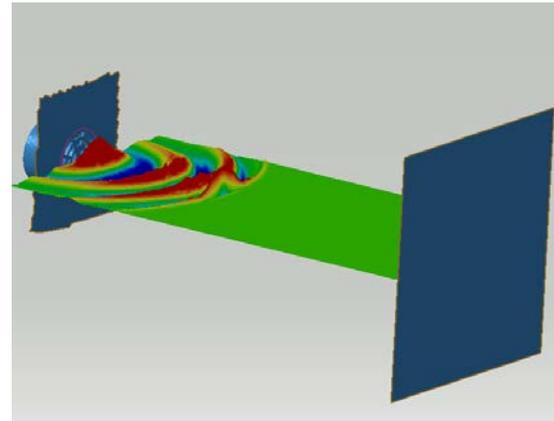
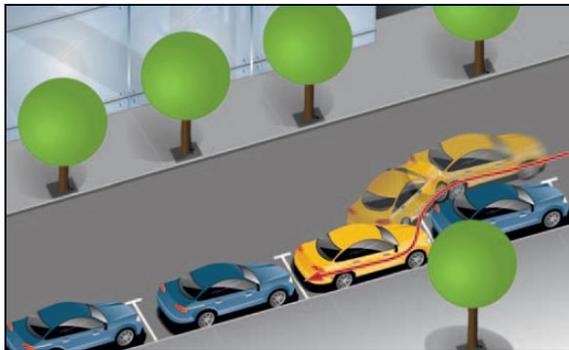
EC Project eVADER - SCP1-GA-2011-285095
Electric Vehicle Alert for Detection and Emergency Response



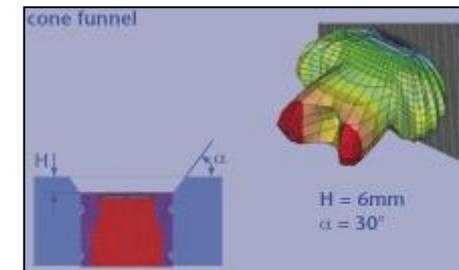
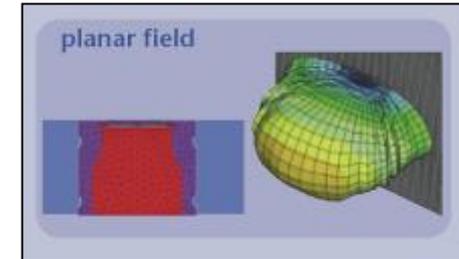
Parking sensor Pulse emission and reflection simulation



Parking Assistance



Ultrasonic 40 kHz
pulse simulation

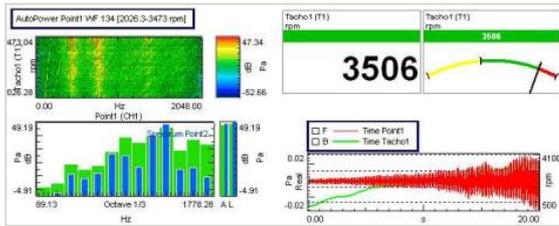


Ultrasonic sensors send out short pulse at particular frequency, which hits an obstacle and is reflected back to the sensor. The entire phenomenon is naturally run in the time domain both for computational efficiency and analysis capability

Solution for Vehicle NVH in testing

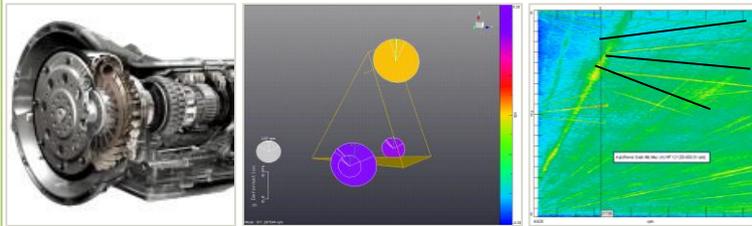
Target related testing

Target setting & validation
Orders, Octave, Sound Power, Mount force validation, radiated noise quantification, ...



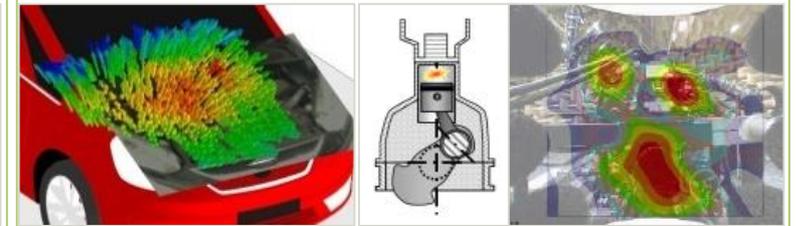
Functional performance

How to meet functional performance?
Running mode, torsional vibration, angle analysis & combustion analysis, dynamic balancing, ...



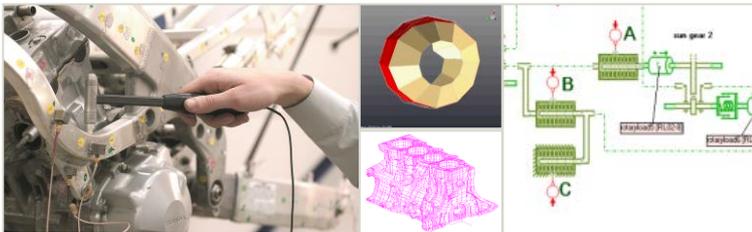
Advanced Acoustics

How to meet acoustic performance?
Sound source localization and ranking, combustion noise analysis, sound transmission loss, ...



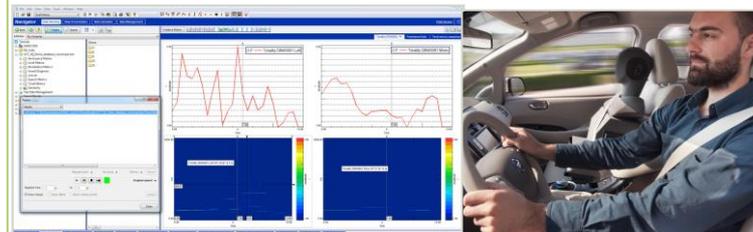
Model Validation

Optimize Simulation models
Modal testing & correlation, inertia data, load input assessment, ...



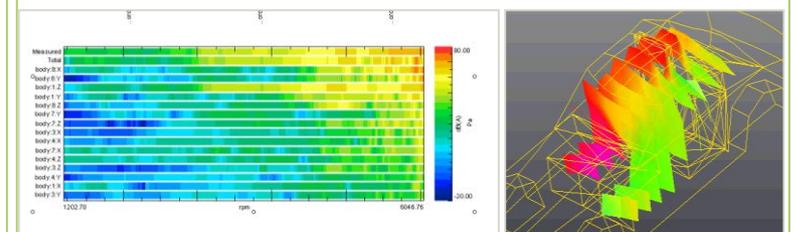
Powertrain Integration

How to meet vehicle targets?
Sound Quality & Sound Synthesis, Transfer Path Analysis & ASQ, In-vehicle recording, ...



Vibro-Acoustic Engineering

What is the root cause? Source? Path?
Transfer path Analysis - Acoustic Source Quantification
- Vibro-acoustic modal analysis

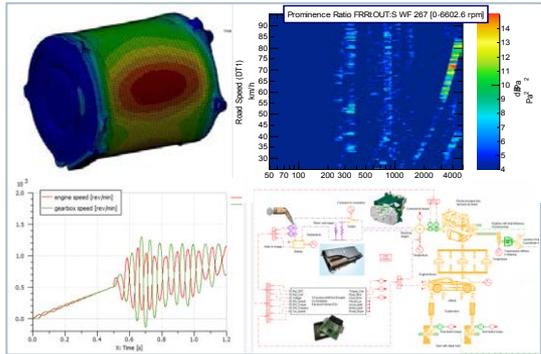


Engineering services

Smart technologies. Unique solutions.



Highly skilled engineers



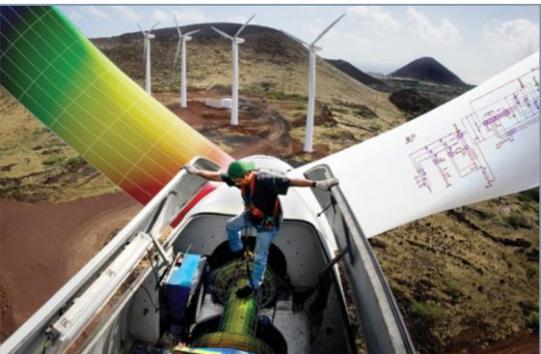
Process & technology



Multi-attribute engineering



Troubleshooting



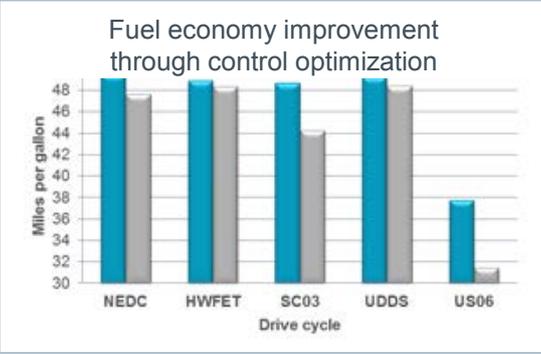
Expertise & know how



Infrastructure & tools

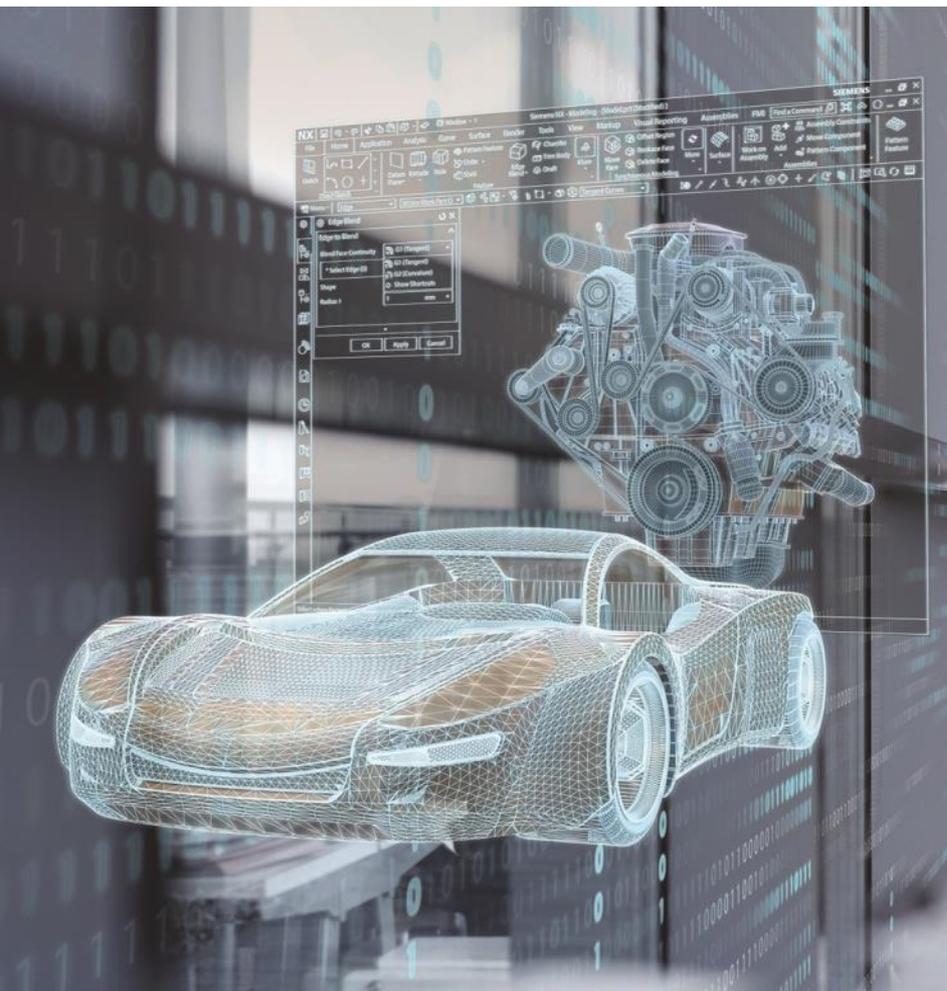


Technology transfer



Co-development

Exterior acoustics



Introduction to NVH

Powertrain NVH analysis

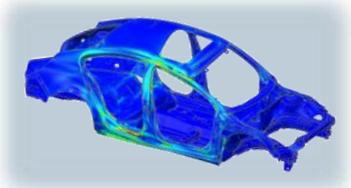
Interior vehicle NVH

Exterior acoustics

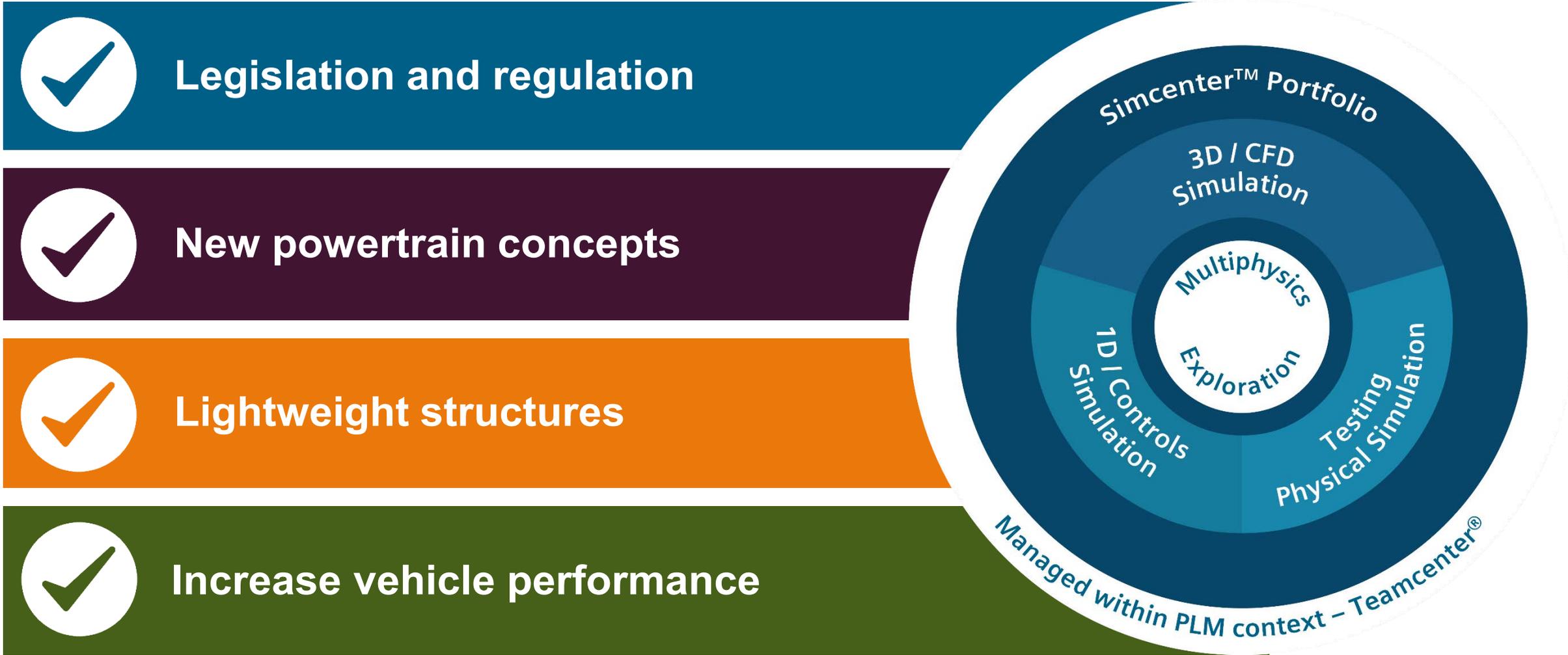
Conclusion

Siemens PLM Software delivers value across the Automotive NVH Process

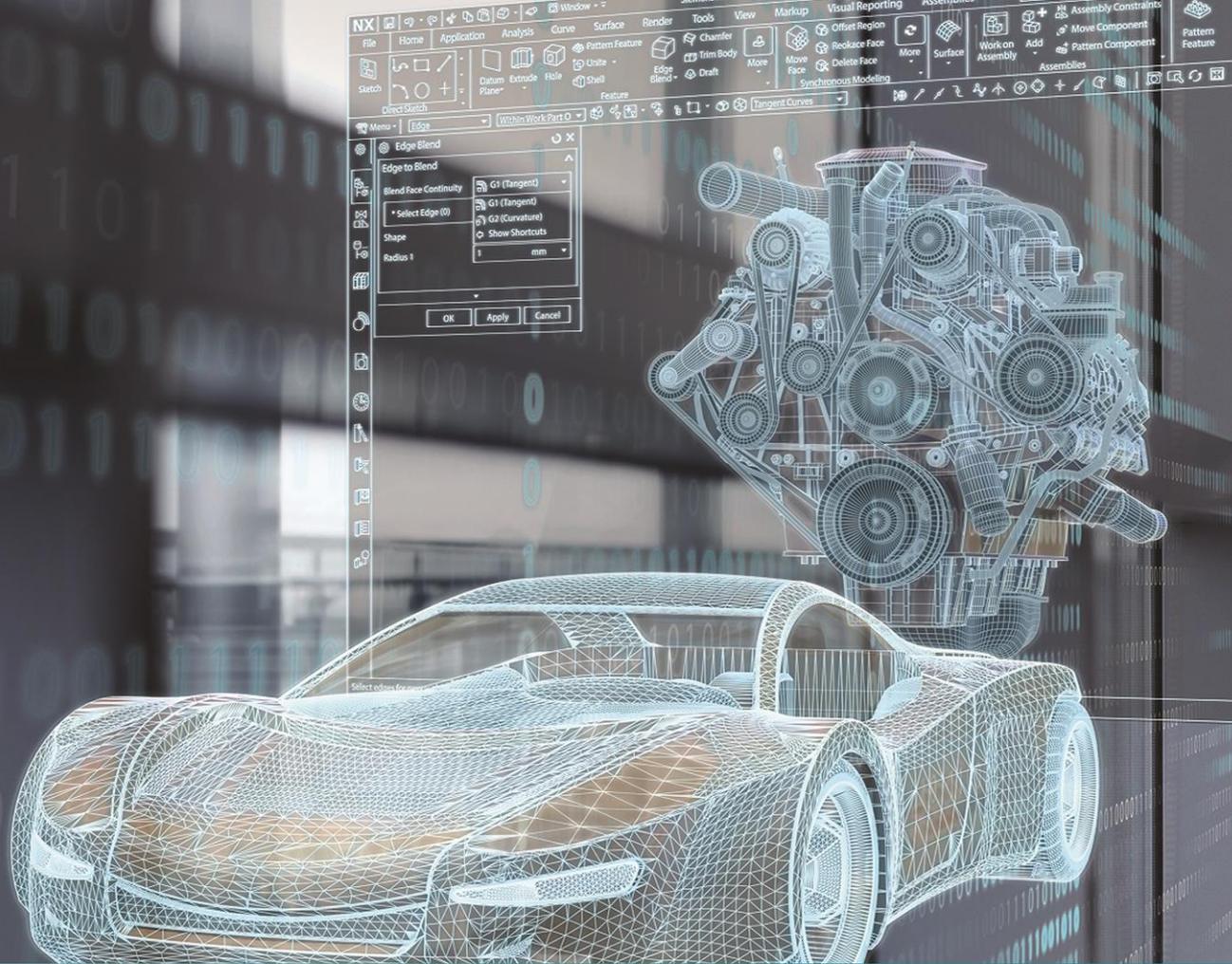
- Enable a consistent, model-based engineering process
- Benefit from 30-years expertise
- Support accurate simulation and test solutions
- Provide access to a complete range of product performance solutions
- Enable faster and more frequent design/analysis optimization iterations
- Make design changes transparent and reduce change cycle times
- Reduce time to create product documentation and digital manufacturing data
- Support customer with best-in-class multidisciplinary team of experts
- Facilitate rapid communication of detailed design, analysis and manufacturing data across the supply chain



Simcenter solutions for Automotive NVH & Acoustics



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