



High-voltage- and NVH-Measurements in Electric Vehicles

CSM web seminars

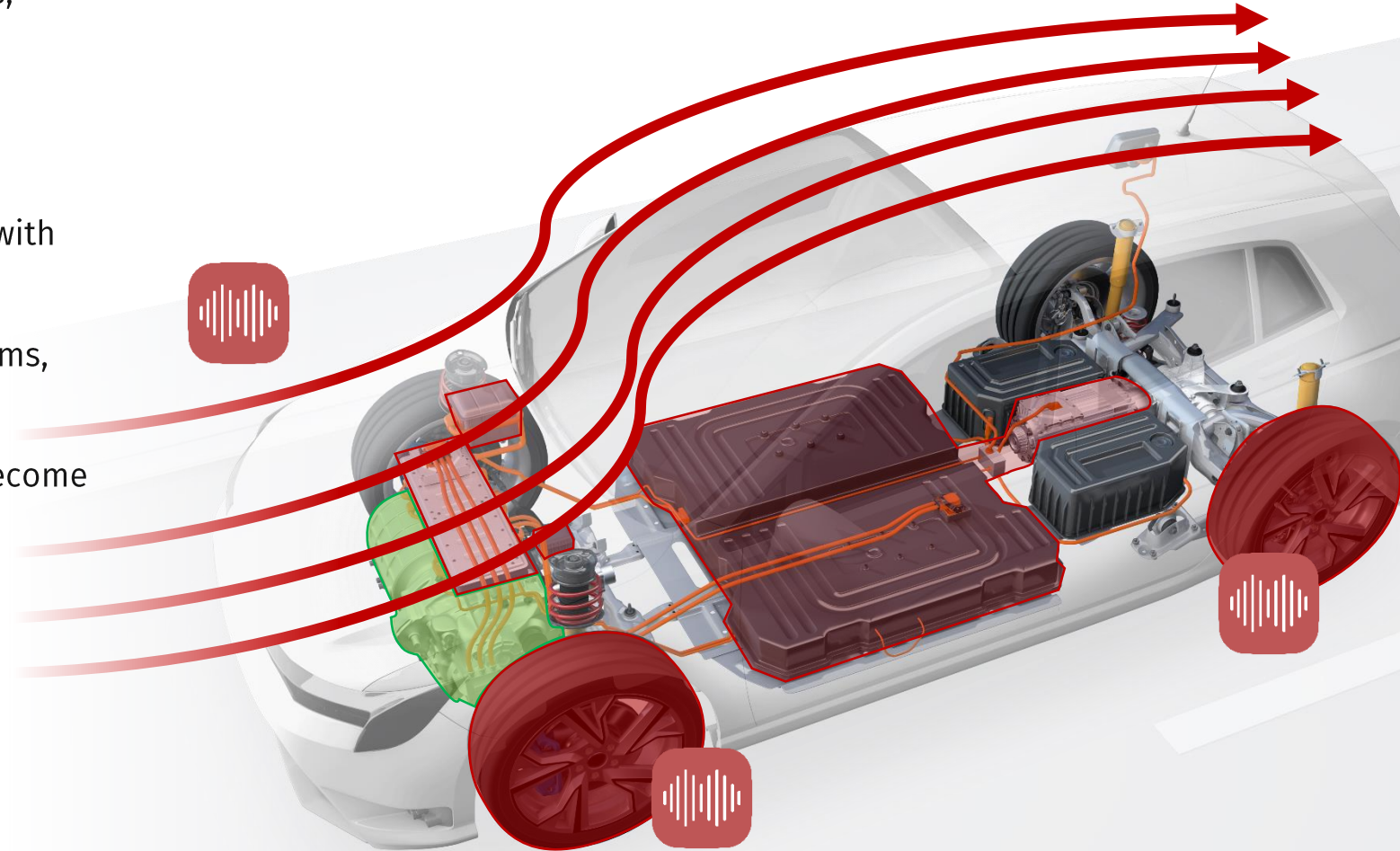
CSM **Xplained**
measurement technology



Innovative Measurement and Data Technology

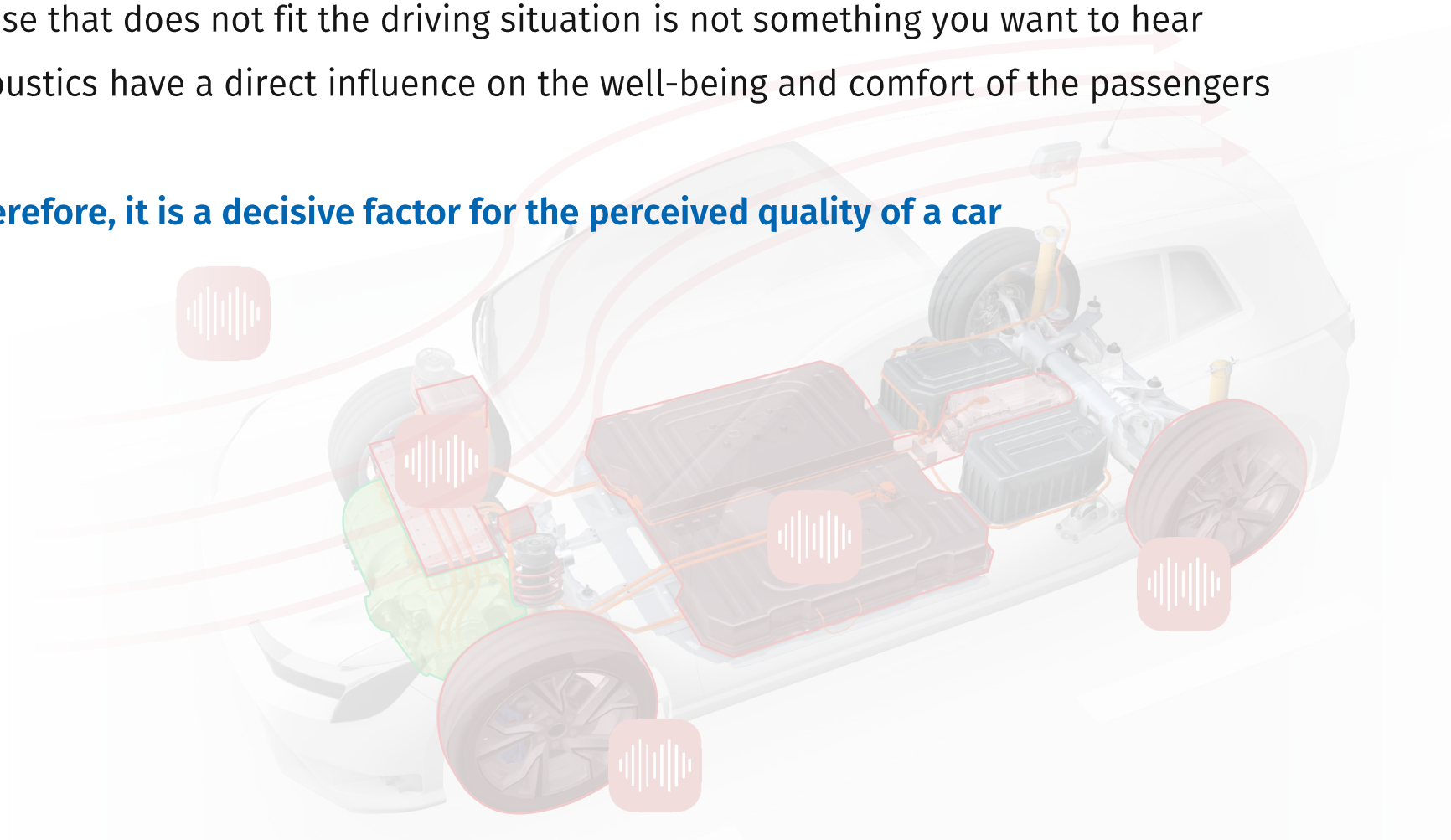
Challenges in the vehicle acoustics of electric vehicles

- ▶ An electric motor causes hardly any oscillations, vibrations and mechanical noises
- ▶ **Other noise sources also come to the fore**
 - ▶ Electric power trains generate tonal noises with higher frequencies due to their design
 - ▶ Noise from gearboxes, pumps, cooling systems, hydraulics and power electronics
 - ▶ Aeroacoustics as well as tire rolling noise become more dominant



Challenges in the vehicle acoustics of electric vehicles

- ▶ Noise that does not fit the driving situation is not something you want to hear
- ▶ Acoustics have a direct influence on the well-being and comfort of the passengers
- ▶ **Therefore, it is a decisive factor for the perceived quality of a car**



Müller-BBM VibroAkustik Systeme

Know-how leader in testing for interpretation of dynamic and physical data
with focus on NVH, strength and comfort



Smart solutions for testing and data management

- ▶ Part of the internationally operating Müller-BBM Group
- ▶ Spin-off of Müller-BBM in 1997 in Planegg, Germany
- ▶ VAS Turnover: 24.5 Mio EUR, employees: 100+
- ▶ Worldwide network of subsidiaries and distributors
- ▶ Memberships: ASAM ODS, openMDM®, EtherCAT
- ▶ Powerful tools for measuring and analyzing: PAK family



Our products & solutions

Holistic solution for the acquisition, analysis and management of physical data.

NETWORKING

Smart data networks
Interdisciplinary
workflows

DATA ACQUISITION

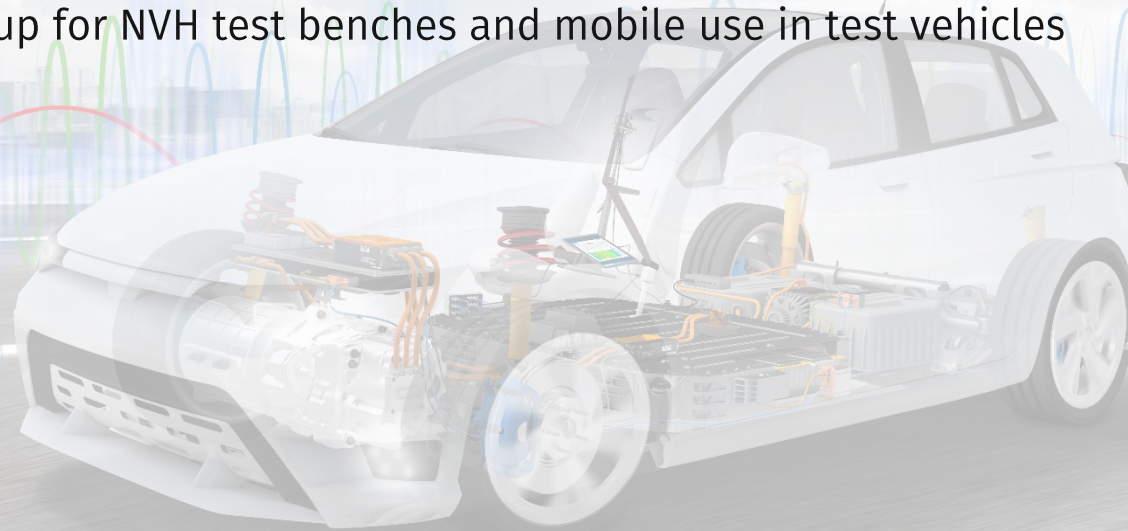
Hardware
PAK-Software

DATA MANAGEMENT

PAK cloud
Cloud Services

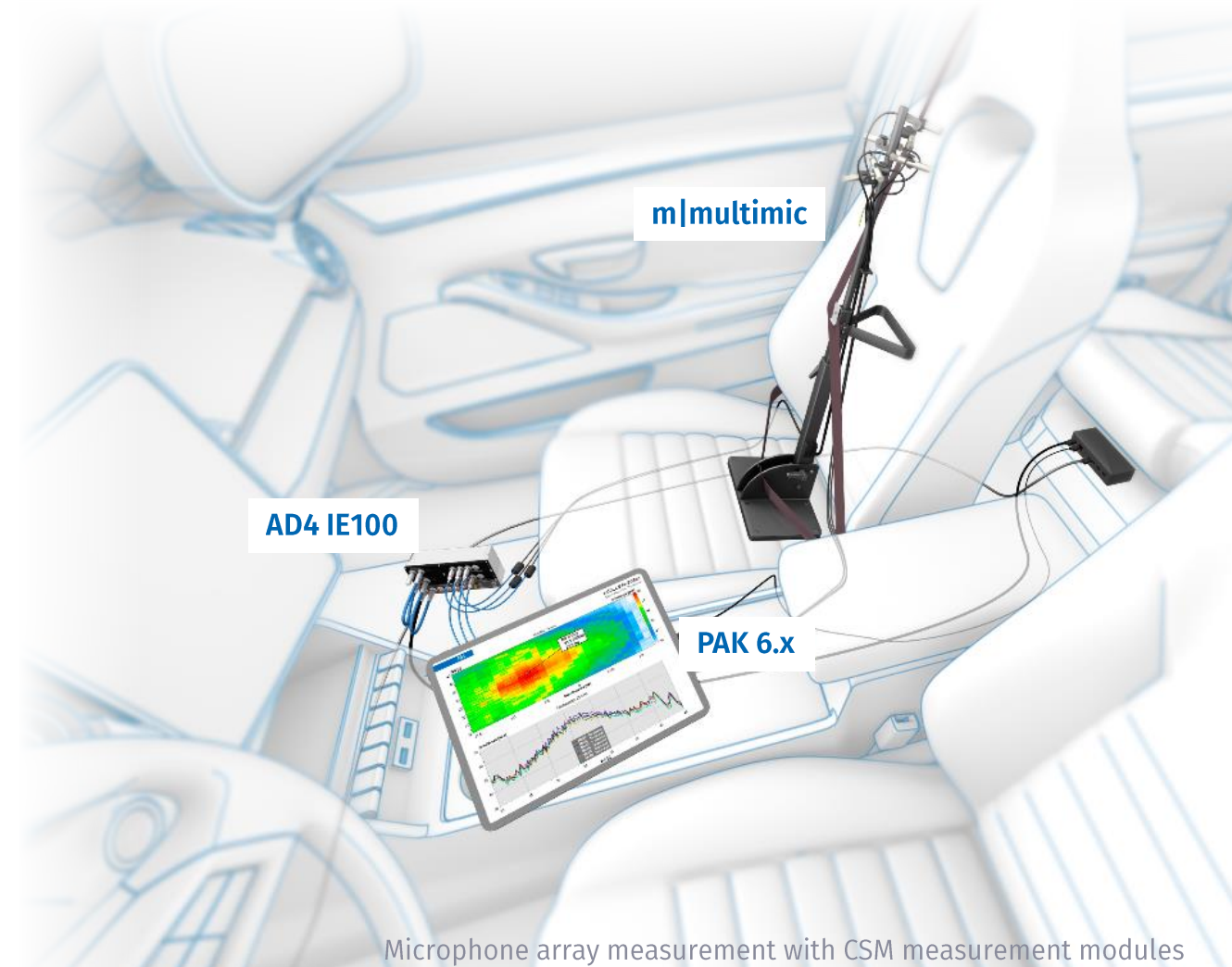
Partnership CSM and Müller-BBM VibroAcoustic Systems

- ▶ New and increasing requirements for acoustics in electric vehicles
- ▶ High-voltage-safe, compact measurement technology for e-NVH analyses
- ▶ PAK-live technology for dynamic data acquisition, analysis, evaluation and management
- ▶ The same measurement setup for NVH test benches and mobile use in test vehicles



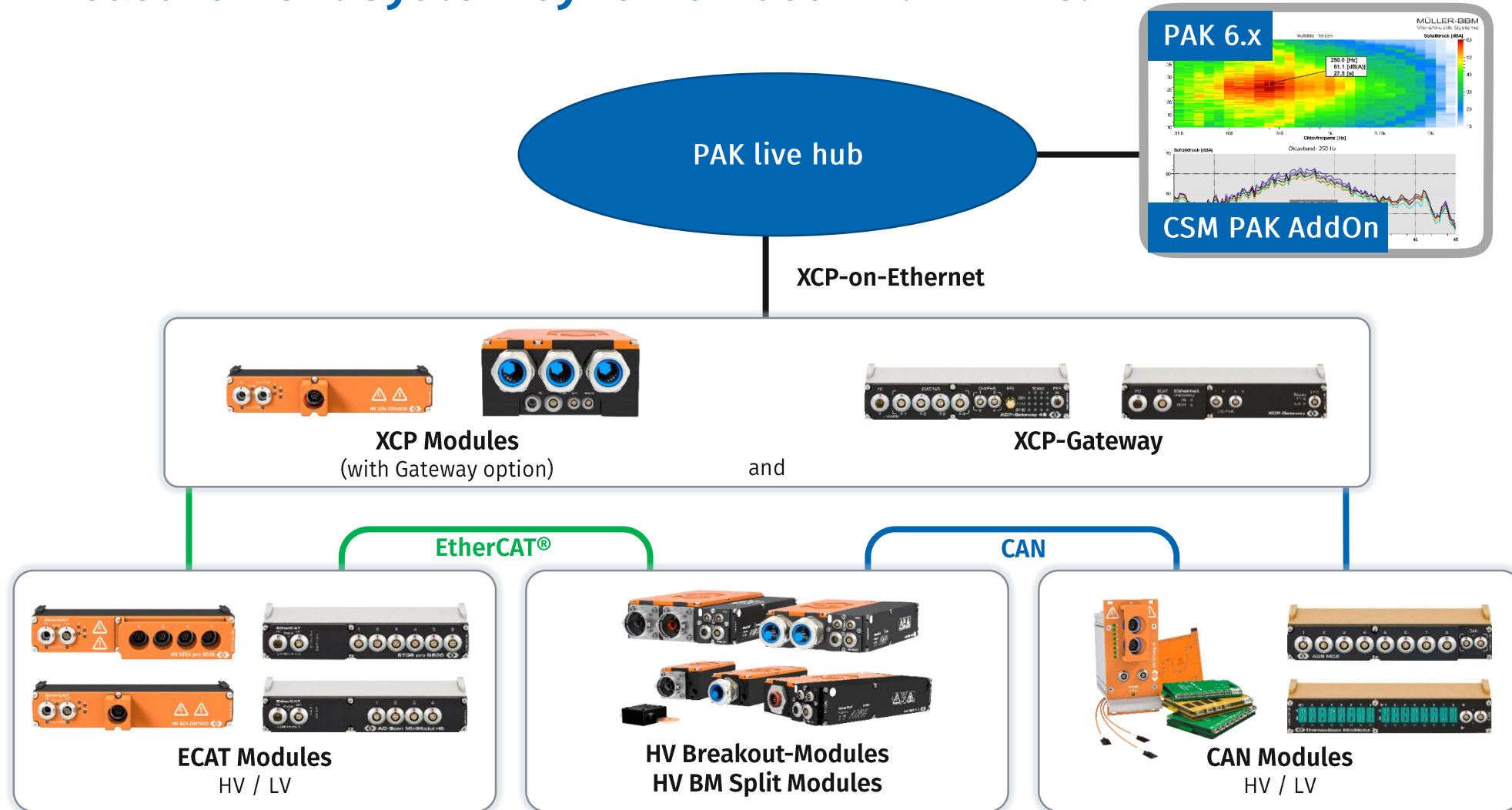
PAK live ecosystem with customised analyses

- ▶ Basic analyses: raw time data, spectral analyses
 - ▶ Sound power and intensity
 - ▶ Sound source localisation
 - ▶ Exterior and interior noise
 - ▶ Sound quality
 - ▶ Analyses on rotating systems
 - ▶ Rotational and torsional vibrations
 - ▶ Analysis of PWM signals
 - ▶ Order analyses
 - ▶ and much more ...
-
- ▶ Measurement with CSM measurement modules

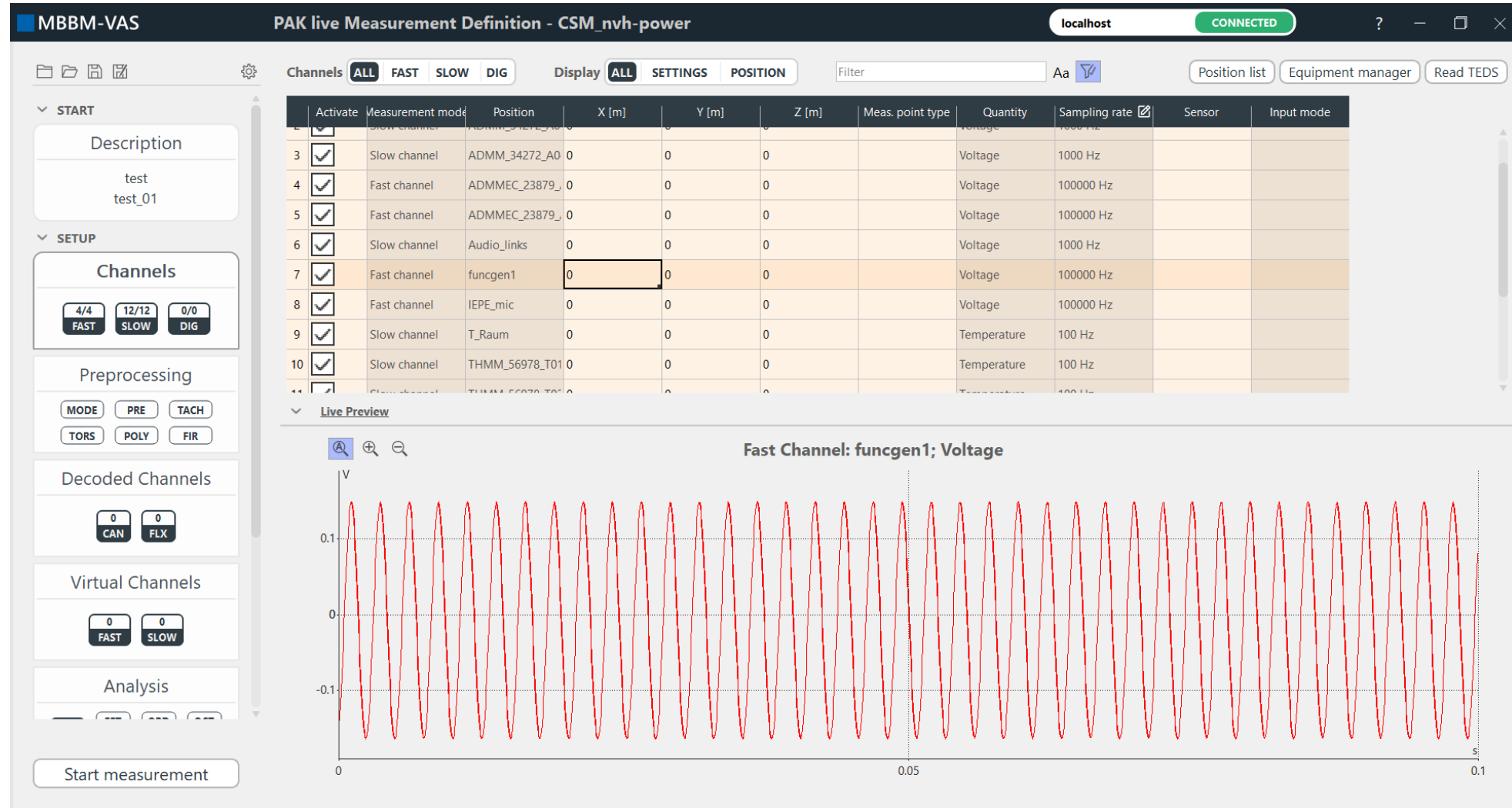


Microphone array measurement with CSM measurement modules

CSM Measurement System synchronised with PAK 6.x



Measurement interface in PAK 6.x

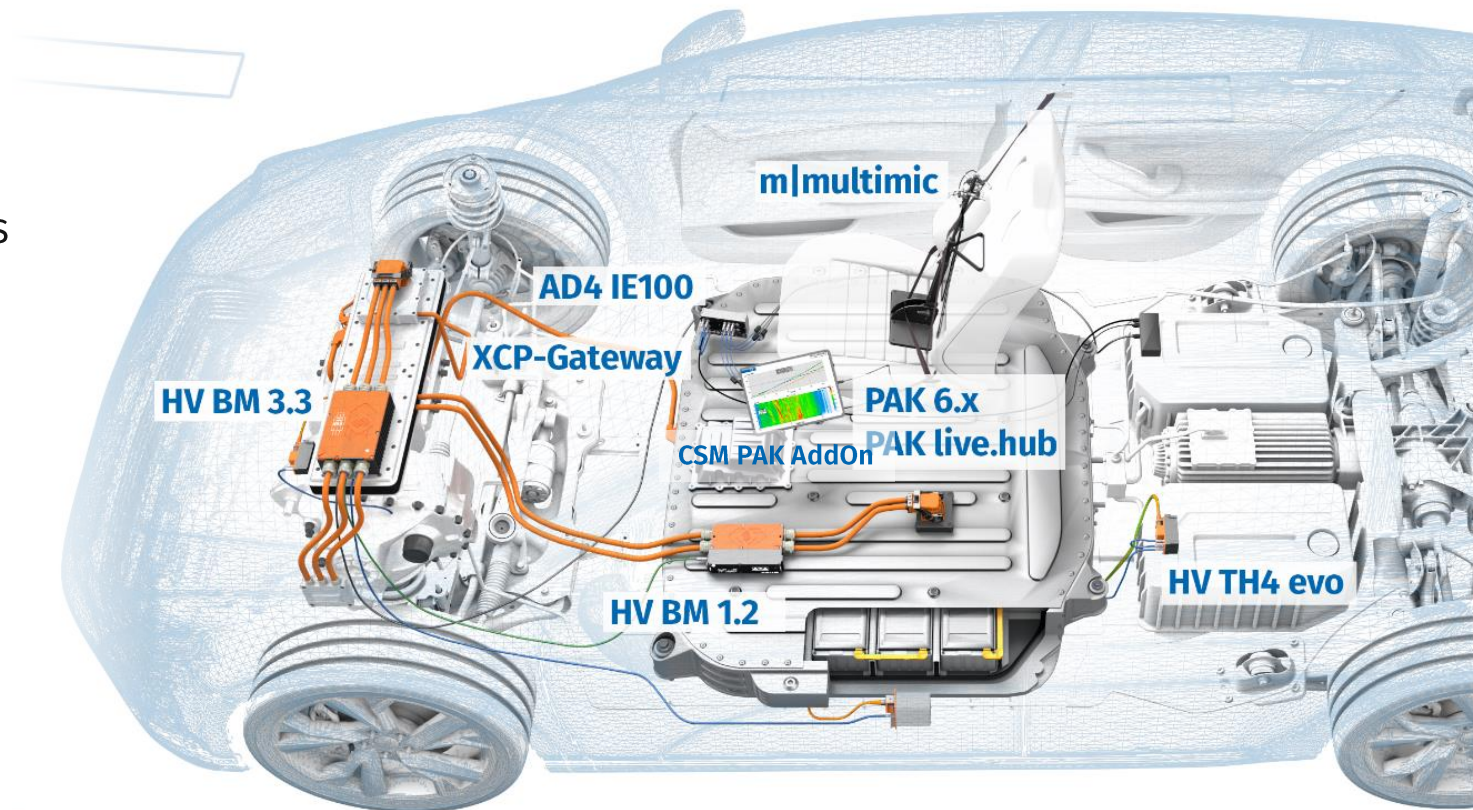


One measurement set-up for mobile measurements or permanently installed in the test bench

Read the use case
on www.csm.de

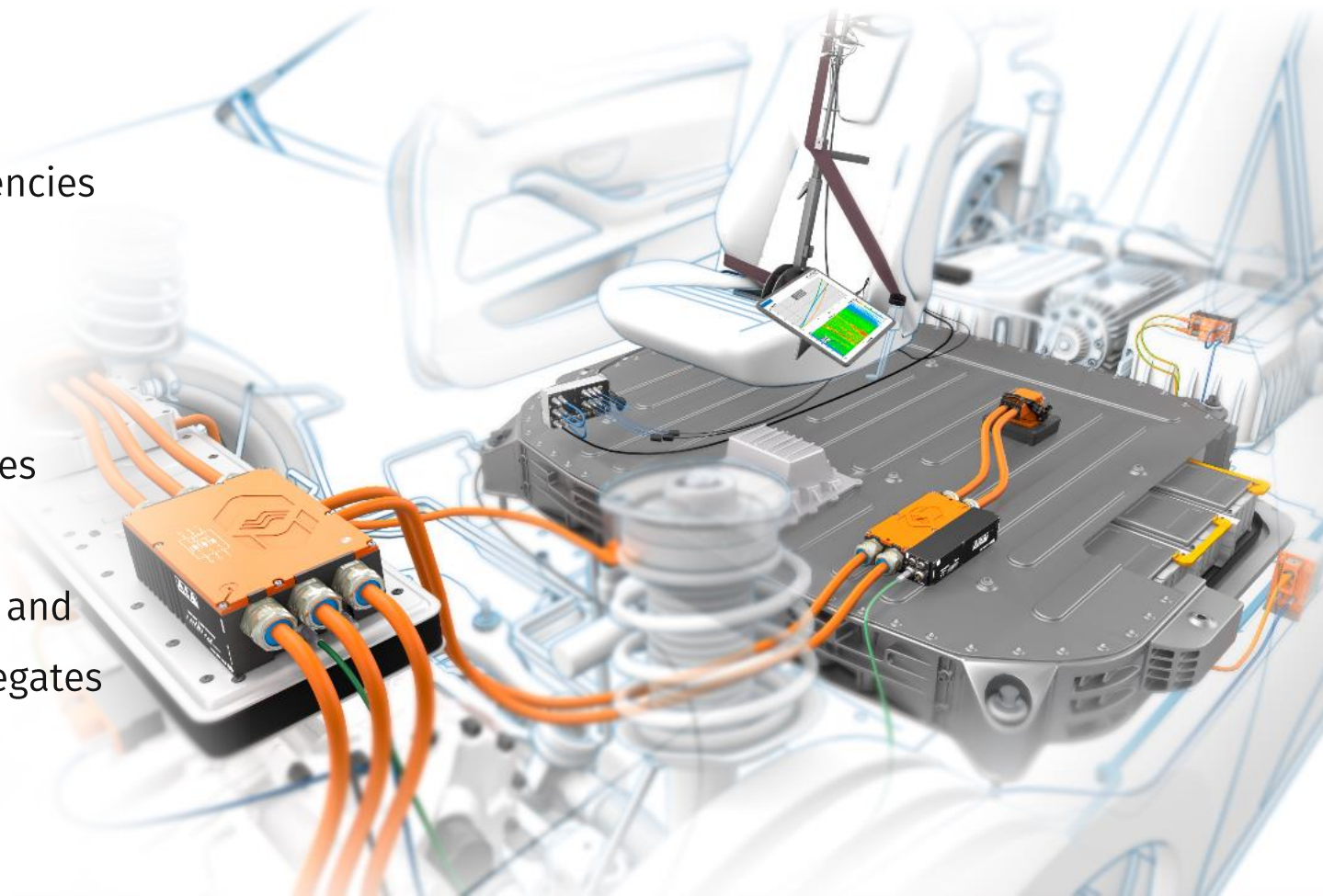


- ▶ Decentralised distributed measurement set-up with sensors and CSM measurement modules
- ▶ Acquisition of
 - ▶ Currents, voltages and power
 - ▶ Speed, torque and forces
 - ▶ Acoustic signals, oscillations and vibrations
 - ▶ Temperatures and humidity
 - ▶ Flow rates in cooling and heating paths
 - ▶ and much more
- ▶ Data acquisition with
 - ▶ PAK live.hub
 - ▶ PAK 6.x
 - ▶ CSM PAK AddOn



Synchronous acquisition of NVH and performance data on the powertrain

- ▶ Investigation of performance, efficiency, acoustics and NVH performance of the powertrain
- ▶ Clarification of operating mode phenomena
- ▶ Analysis of rotating field parameters and frequencies of power electronics
- ▶ Calculation of electrical power
- ▶ Non-masked noise source analysis
- ▶ Investigation of high-frequency noise, resonances and vibration excitations
- ▶ Detection of phenomena of tonal noise sources and structure-borne noise excitations of other aggregates



Measurements in the high-voltage electrical system with the HV Breakout Module 1.2

- ▶ Working voltages up to $\pm 1,000$ V
(measuring range up to $\pm 2,000$ V)
- ▶ Currents up to $\pm 1,000$ A (nominal value),
 $\pm 2,000$ A (peak)
- ▶ RMS values (**TrueRMS**) of U and I respectively
- ▶ Active power **P**
- ▶ Apparent power **S**
- ▶ Reactive power **Q**
- ▶ Power factor **λ**



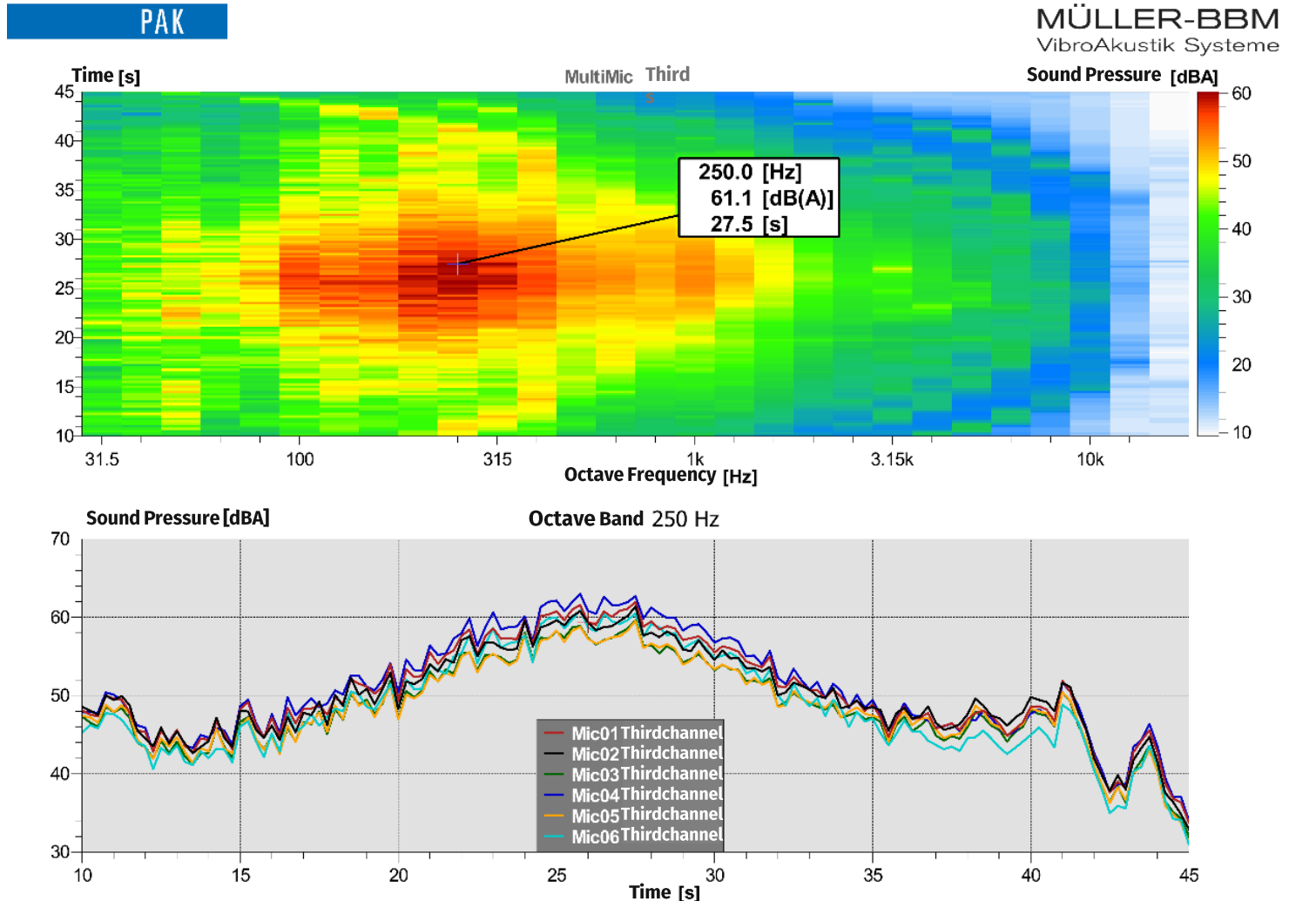


3-phase measurement with the HV Breakout Module 3.3

- ▶ Power measurement between inverter and electric motor
- ▶ Measurement of voltages U_{12} , U_{23} , U_{31} and internal conductor currents (I) of L_1 , L_2 , L_3 .
Working voltages up to $\pm 1,000$ V (measuring range up to $\pm 2,000$ V)
- ▶ Currents up to ± 800 A (nominal value), $\pm 1,400$ A (peak)
- ▶ Real time Power calculation
- ▶ GBit/s XCP-on-Ethernet interface, measurement data rate up to 2 MHz per measurand
- ▶ XCP Gateway: connection of CSM ECAT (fully time-synchronous) and CAN measurement modules
- ▶ PTP slave



Spatially averaged sound pressure level in the vehicle interior

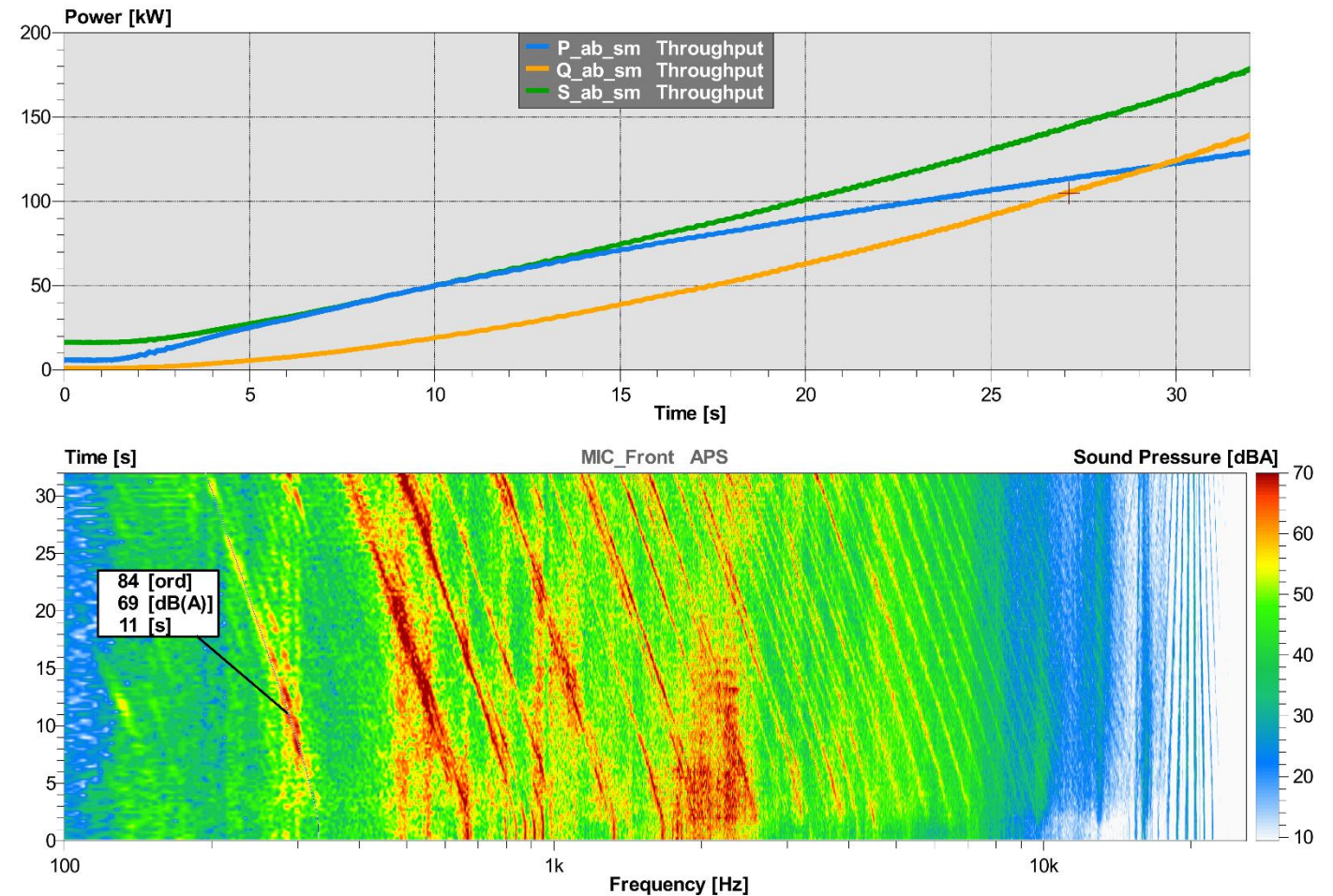


Performance and NVH testing

- Comfort measurement of the drive

PAK

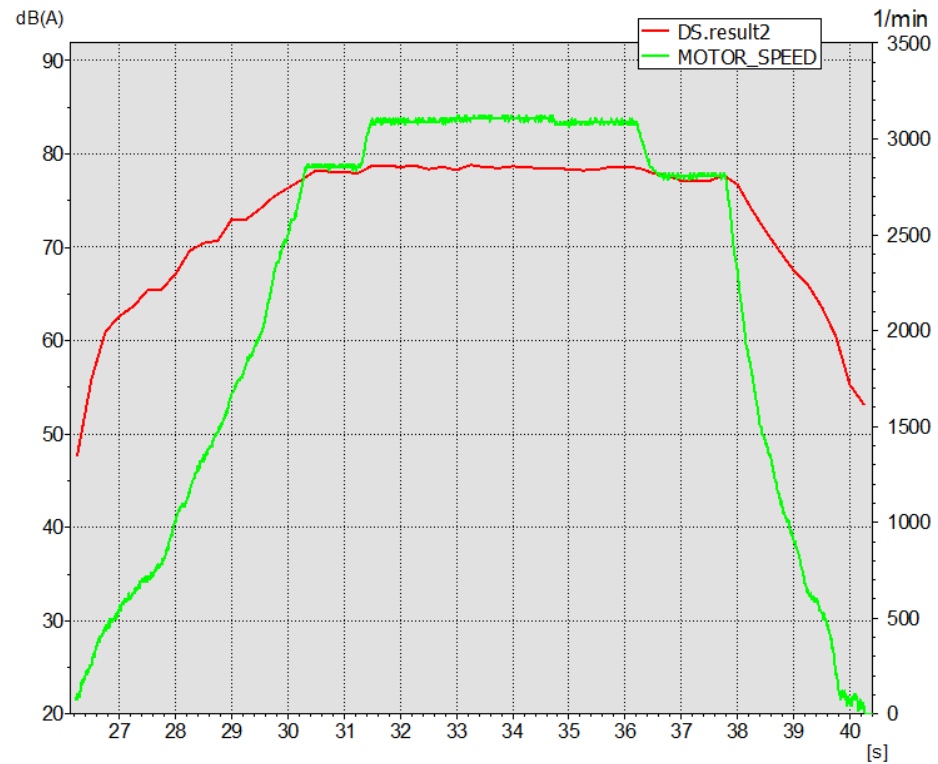
MÜLLER-BBM
VibroAkustik Systeme



Acoustic emission measurement of electric drive - analyse tonal noise

PAK

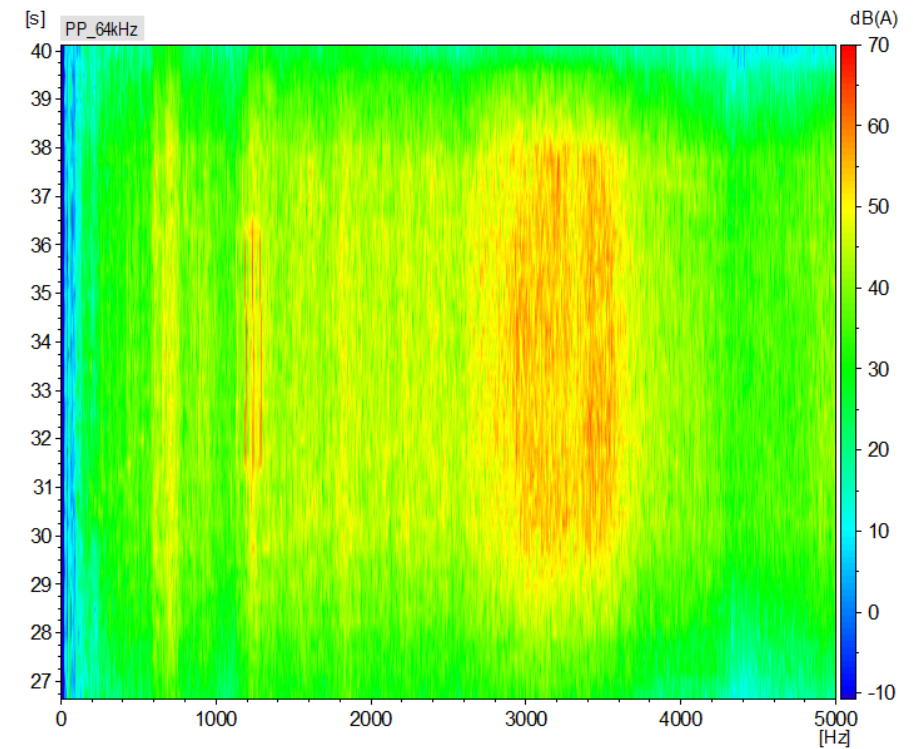
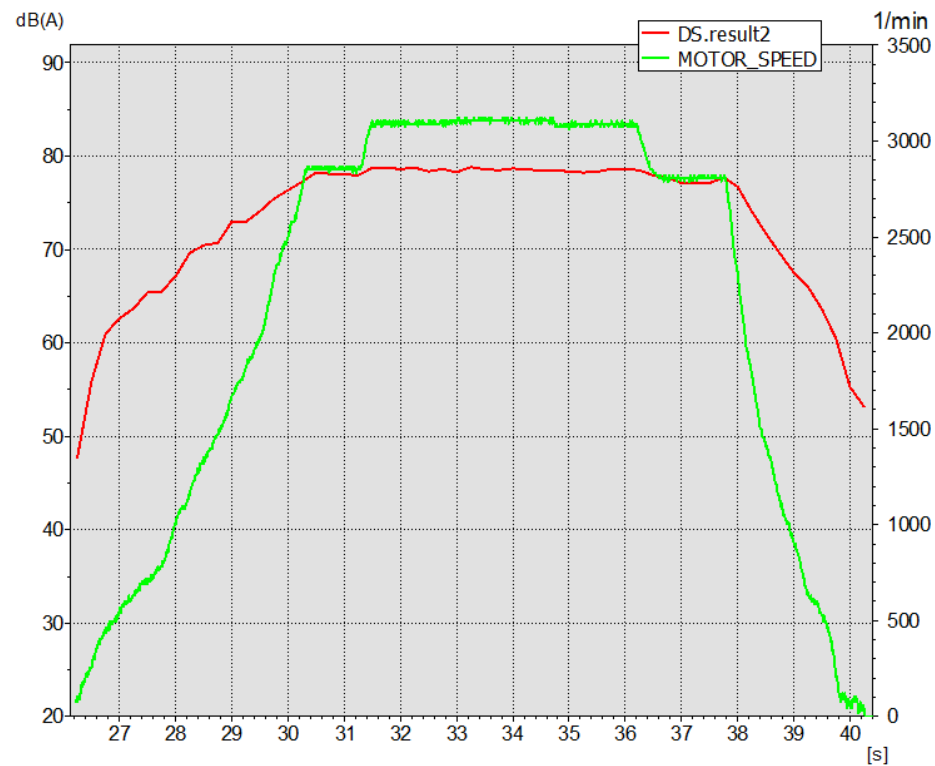
Sound pressure total level and motor speed



Acoustic emission measurement of electric drive - analyse tonal noise

PAK

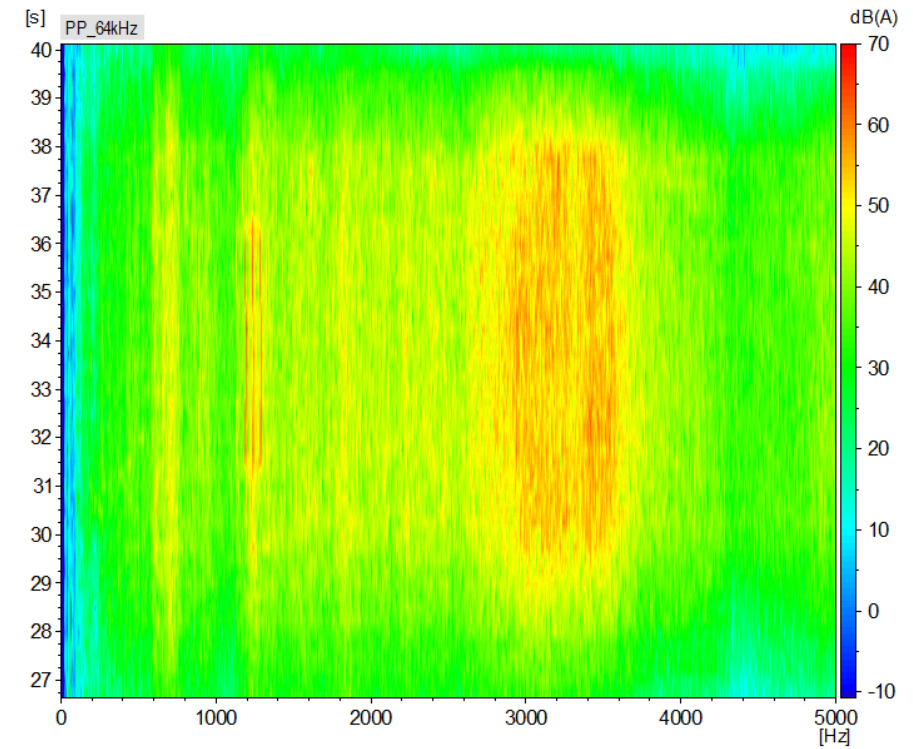
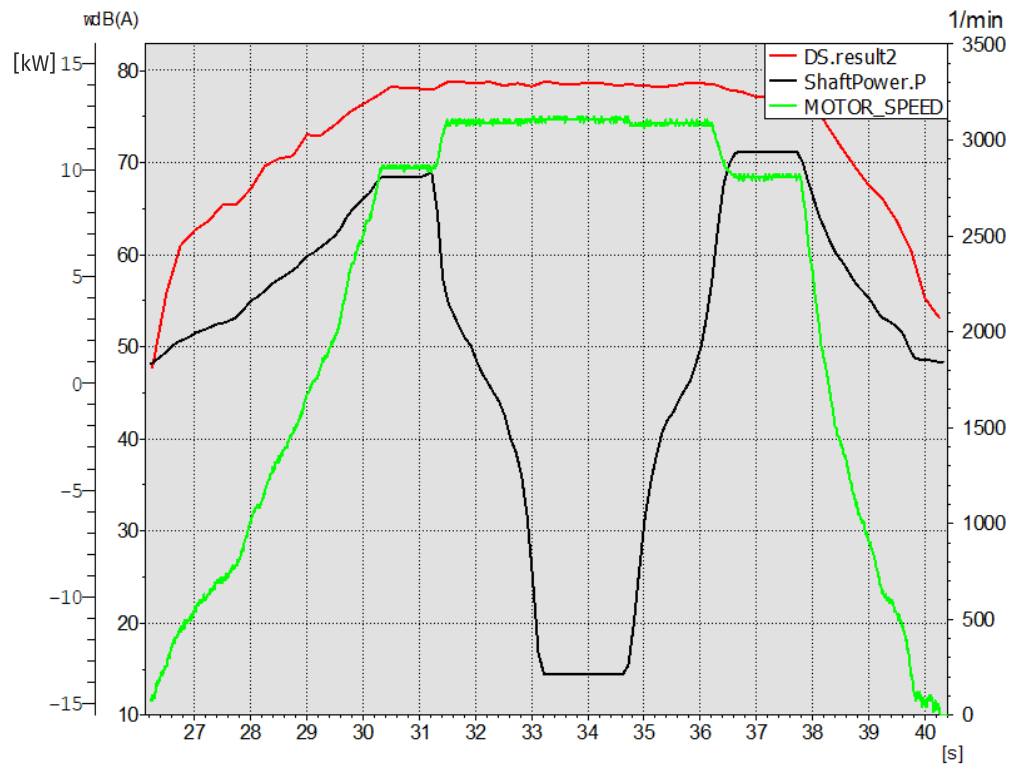
Sound pressure total level and motor speed



Acoustic emission measurement of electric drive - analyse tonal noise

PAK

Mechanical Power P_{mech} Vector eMobilityAnalyzer with CSM CNT4 evo



Advantages of PAK-live networked with CSM high-voltage measurement technology

- ▶ Fast, mobile measurement with robust measurement technology for validation of acoustic and performance phenomena
- ▶ High-voltage-safe, PTP-synchronous data acquisition of analogue and digital measured variables directly at the relevant sources
- ▶ Decentralised, compact measurement setup for safe data acquisition in harsh environments
- ▶ Direct measurement of current, shield current, voltage and power in high-voltage lines
- ▶ Current, voltage and power measurement in the electrical drive train with synchronised NVH analysis for correlation of acoustic and electrical phenomena
- ▶ Real-time analysis of the measured data stream
- ▶ Powerful graphical reporting online & offline
- ▶ Increased added value around measurement data through contextual engineering
- ▶ Integrated measurement data management based on cloud technologies
- ▶ Acceleration of testing

Products, contact and outlook

- ▶ CSM Measurement Modules and Sensors
- ▶ PAK 6.x NVH Software
- ▶ CSM PAK AddOn
- ▶ XCP Gateway Option “CSM PAK AddOn”
- ▶ Option PTP-Support (IEEE1588) for synchronisation
 - also with other XCP gateways or third-party hardware
- ▶ Contact via CSM sales and Müller-BBM VibroAkustik sales
 - <https://www.csm.de/en/contact>
 - info.de@mbbm-vas.com <https://www.mbbm-vas.com/>

About CSM

CSM has been setting technological standards for decentralized measurement technology in vehicle development for over 35 years. Our CAN bus and EtherCAT® measurement devices support worldwide renowned vehicle manufacturers, suppliers and service providers in their developments.

Continuous innovation and long-term satisfied customers are our guarantee for success. Together with our partner Vector Informatik, we have developed an easily scalable and powerful E-Mobility Measurement System for hybrid and electric vehicles and are constantly expanding the areas of application. With our high-voltage safe measurement systems designed for fast and synchronous measurements and power analyses, we actively accompany the change to **E-Mobility**.

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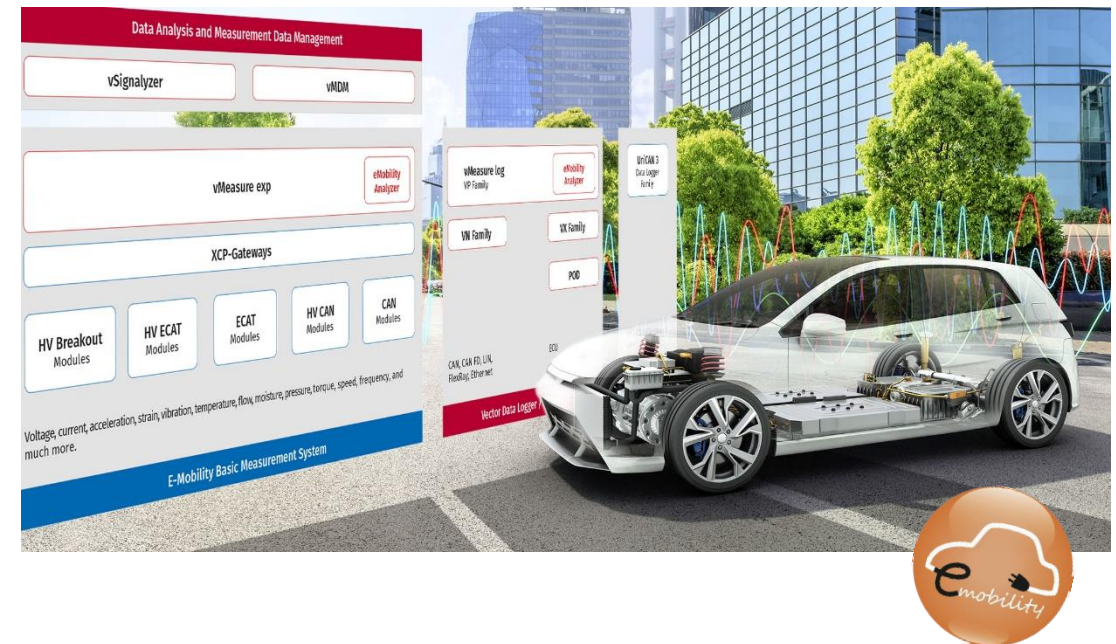
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of CSM Xplained, please visit

www.csm.de/webseminars



CSM Xplained
measurement technology