Automotive
Optical measurements that drive progress
Competence field

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Become the benchmark of tomorrow

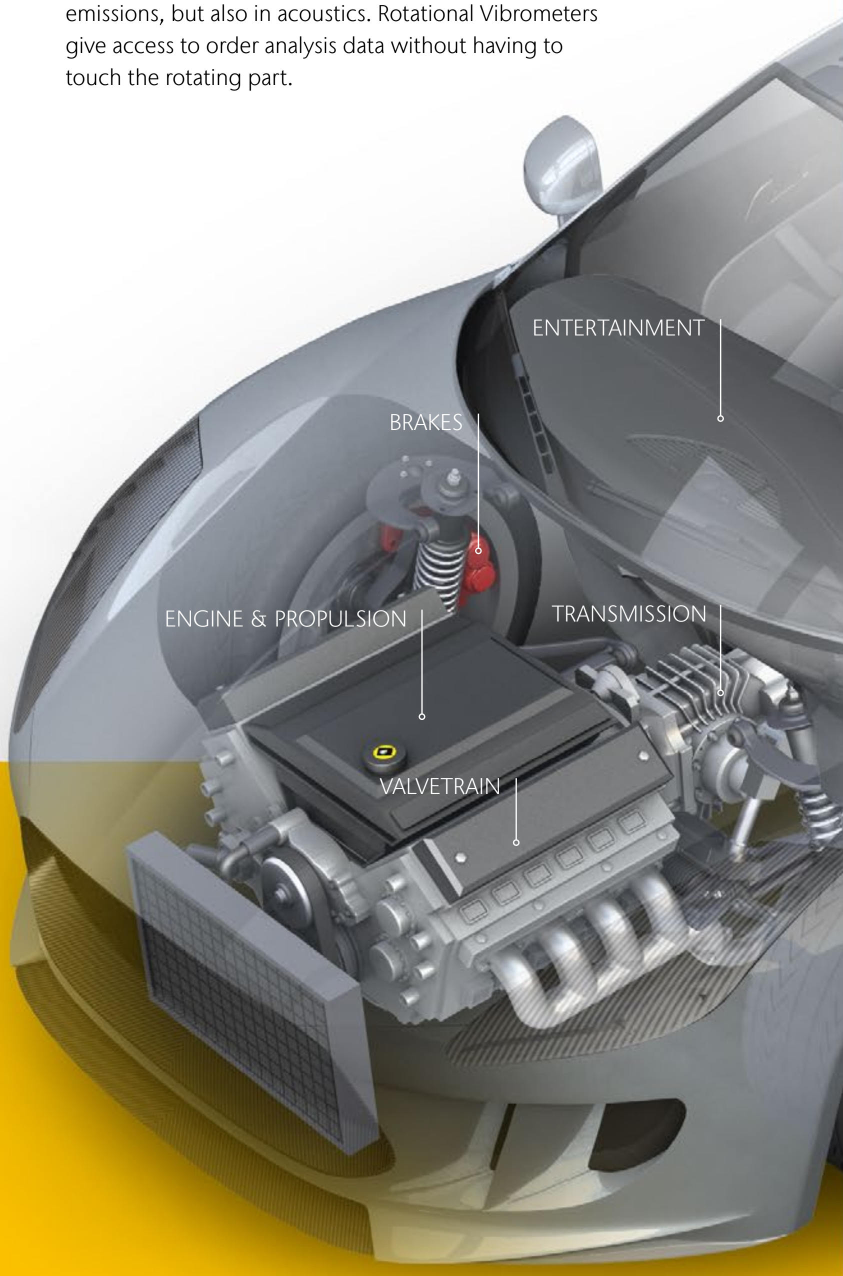
Automotive transportation is part of our freedom. Polytec laser measurement technology is fundamental to engineering quiet, comfortable, and economical vehicles.

In the development of vehicles contradictory goals need to agree with each other. The quiet, lightweight, comfortable vehicle with minimal emissions, high reliability, low cost with a short time to market is an almost unattainable goal. Polytec's precision measurement techniques help to achieve these goals more quickly and efficiently.

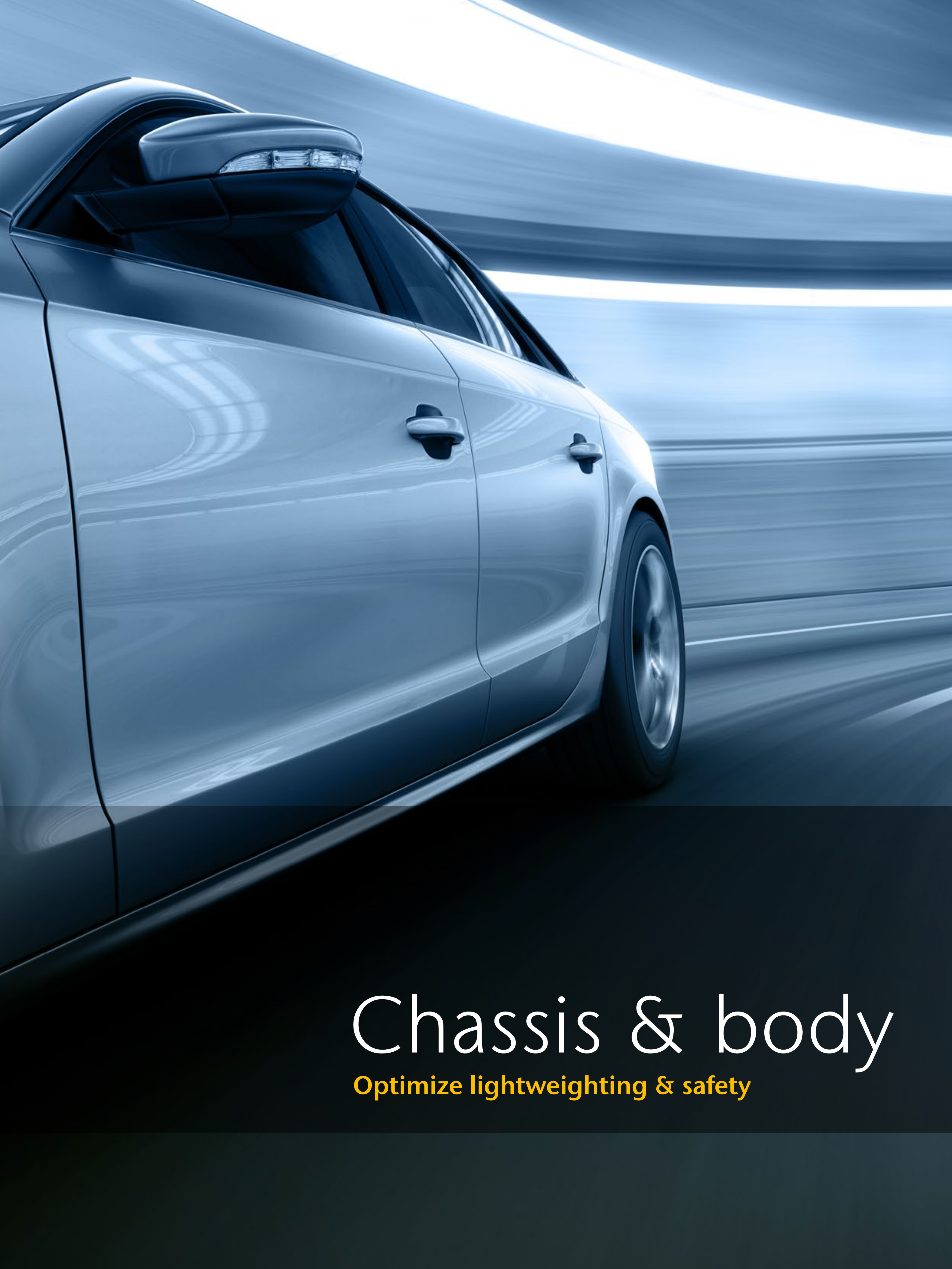
The technology of optical non-contact vibration measurement makes dynamic properties of engineering components visible. It allows not only for a quick validation of models, but also rapid troubleshooting.

Depending on the technical need, basic vibration and displacement measurements at single points or full surface are possible. Measuring the full-field using scanning laser Vibrometry has become an indispensable tool in the quantification and visualization of deflection shapes in structural dynamics and acoustics.

The drive train is of great importance in reducing emissions, but also in acoustics. Rotational Vibrometers give access to order analysis data without having to touch the rotating part.



There are many areas where Polytec technology helps evolve the automobile from classic Noise, Vibration and Harshness (NVH), durability topics concerning chassis, power train to even electronics. Our solutions pave the way for optimization of the development processes and integration into the workflow of Computer Aided Engineering (CAE). Some questions we will share the answers to in the brochure are: Which automation potential exists in experimental modal analysis? How can non-contact measurement technology be used to better understand the acoustic properties of components? How to access the drive train dynamics with downsized engines?



Chassis & body

Optimize lightweighting & safety

Body

The heart of the design and branding of any vehicle is in its body. Not only does it have to look right, but also take the lead in passenger safety and comfort while providing the foundation for NVH excellence. For a manufacturer having the right tools to avoid expensive retooling iterations is as critical as getting the design right up front so as to not carry over false CAE assumptions into future generations.

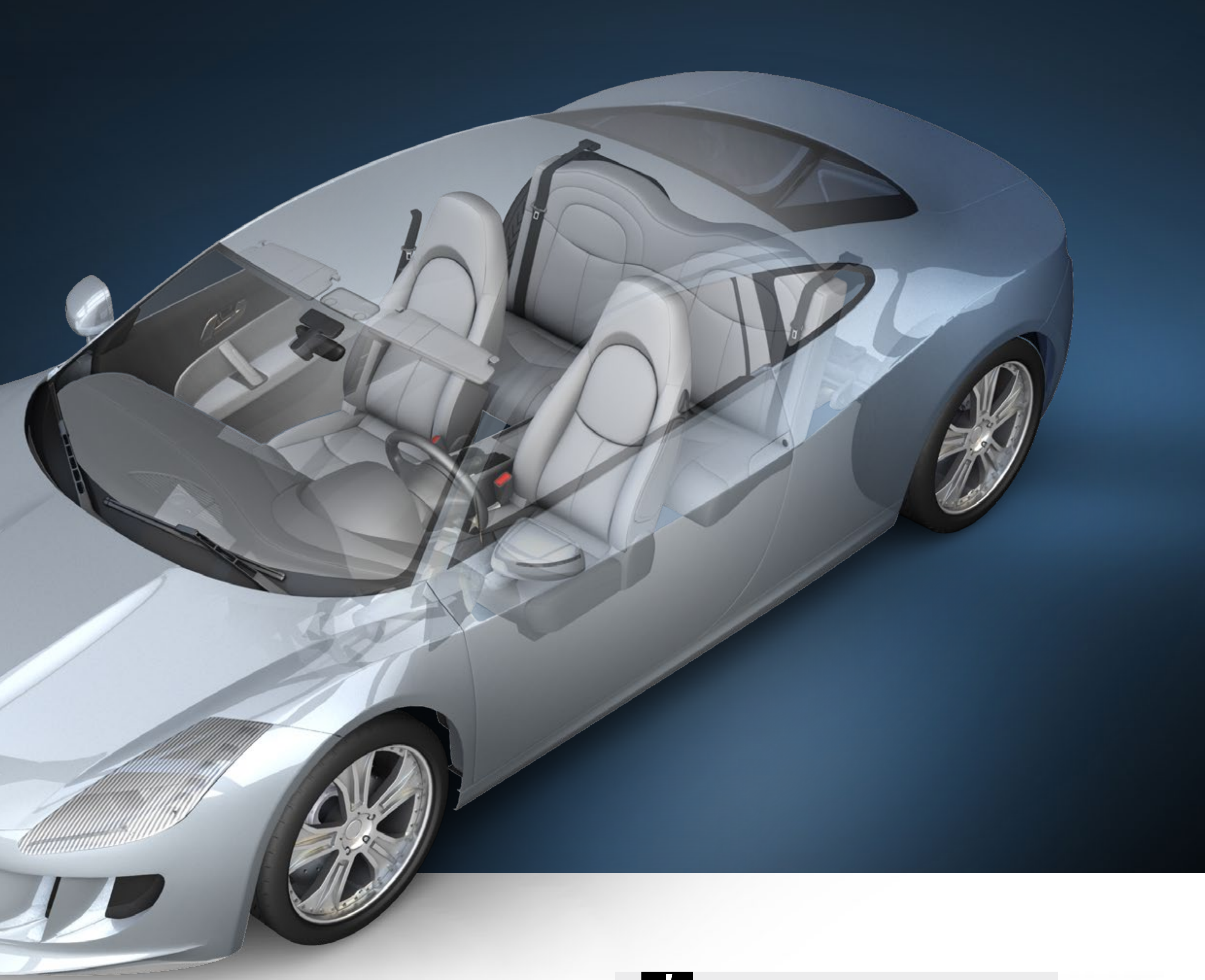
Lightweighting is the goal of many optimizations in the vehicle.

Body lightweighting

With the stringency of gas mileage standards rising rapidly, there comes a required shift in the engineering process applied to body structures. Lightweighting is one of the keys to meeting these rising standards. Lightweighting with new materials and bonding techniques can have adverse effects on NVH performance creating new challenges for NVH Engineering. This is further compounded by the difficulty in modeling these new body structures with CAE. The adoption of rapid CAE validation and updating tools from Polytec is critical to the rapid development of new vehicles for structural and NVH performance. Whether you are interested in having Polytec perform these measurements as an Engineering Service or acquiring the technology, Polytec has the capacity to greatly improve your Engineering capabilities.

Body-in-White (BiW)

A major focus of weight-reduction efforts is on the Body-in-White. Pulling material out the primary safety structure must be done carefully. Safety can only be assured with a combination of analytical planning and experimental verification. Today this challenge is greater than ever. With new lightweight materials and different bonding techniques such as gluing and riveting boundary conditions are less understood. CAE techniques make approximations that must be verified in real applications to ensure that the BiW follows the design. This is particularly critical in today's rapid design-to-build process where each manufacturer is adapting a previous body and model to create the new one. The better the analytical process is verified up front on today's model the more accurate future models will be. In a modal test Polytec's 3D Scanning Laser technology allows for better



insight into this process than ever before.
Precise Finite Element Analysis (FEA) node locations can be fixed through both analytical and experimental measurements allowing a quick and accurate update of the FEA model avoiding costly long term errors.

While lightweighting is important to meet fuel economy standards, manufacturers differentiate brand values through NVH and driving dynamics. In this day and age, consumers don't want to compromise on one for the other and efficient engineering is the key to delivering on both. With lightweight BiW structures, NVH concerns now extend into the mid-frequency range. Classically the acoustic response up to the kHz range was dealt with by adding mass in order to block noise transmissions, which is clearly not possible with the goal of lightweighting.

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Drive progress:

- Reliable predictions: by updated Finite Element (FE) models
- Reliable data: no massloading affects the lightweighted body
- Reduce errors: no mismatch of sensor coordinate systems
- Save time: light as a sensor makes automation in modal testing come true
- Look into the future: enough spatial resolution to reveal critical local modes prior to troubleshooting
- Convincing results: FE like visualization of test results

RoboVib® opportunities

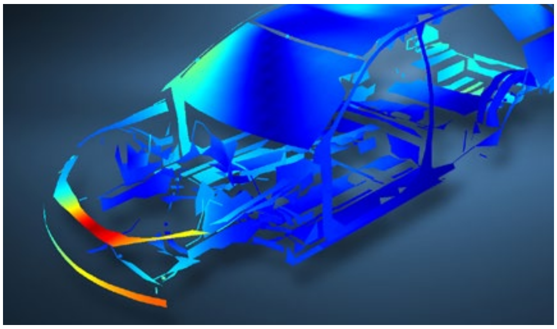
- Automation of the test procedure
- Acceleration of the development process
- Time reduction in prototype binding
- High spatial resolution at no extra cost
- Relevant data for structural dynamics and acoustics in the same test

Automated Experimental Modal Analysis on a BiW in the RoboVib® Test-Center in Waldbronn, Germany

This is even more difficult to address since these frequencies are impossible to quantify with contact transducers, however by using a laser, the test engineer is not only able to avoid spatial aliasing but also no mass loading errors are imparted in the measurements scheme reducing uncertainties in the final product. New Buzz, Squeak & Rattle (BSR) concerns also come into play in particular with riveted structures. Finding these areas of concern early in the process allow a rapid fix instead of expensive warranty claims.

At the same time, the process using a laser can be automated allowing rapid comparison of the same automobile or structure with different treatments resulting in faster optimization of damping and other NVH inhibiting remedies. The results from laser measurements are easy to understand, saving time in the engineering process. CAE information can be accumulated allowing for a closer final product on the first design when uncertainties of the past are removed from the process allowing model optimization for not only structural but also NVH response.

Interior panel vibration assessment



BiW deflection shape from automated test (6342 DoF)

Damping material placement

Lightweighting and cost reduction of noise dampening materials is an important goal for sound package design. The high spatial detail of Scanning Laser Doppler Vibrometer (SLDV) measurements unveils local modes which are prone to radiate sound into the cabin. Having this localized information available turns a trial-and-error process into a defined design process.

Trimmed body

Weight reduction programs have adverse effects on the final trimmed body. Whenever material is removed and mass is reduced, the transfer paths can change. The effects can be heard as driveline booming, transmission gear whine, increased Heat, Ventilation and Air Conditioning (HVAC) sounds, induction noise, and BSR. The interior is full of materials that cannot be quantified with contact transducers. A Polytec laser vibrometer is capable of measuring on soft and difficult surfaces, giving direct measurement input for acoustic simulation and BSR troubleshooting. HVAC systems made from lightweight plastics can be optimized to minimize the acoustic influence in the cabin. A laser also enables effective and productive end-of-line testing for fans and housings to ensure quality throughout the build process. Whether measuring modal parameters on soft surfaces or the effects of seals on panel contributions, the results can be directly compared allowing accurate updates to Finite Element (FE) simulations.

Acoustics for car entertainment

The easiest way to improve the sound of an infotainment system is to have it functioning in a low noise environment. The speaker's interaction with the environment and especially the door panels is critical to achieve these properties. The ability of SLDV to separate the critical deflection shapes of a door or dashboard assembly in frequency is an asset for the acoustic engineer. Improper tuning of the components from unwanted modal coupling is instantly seen in the data visualization.

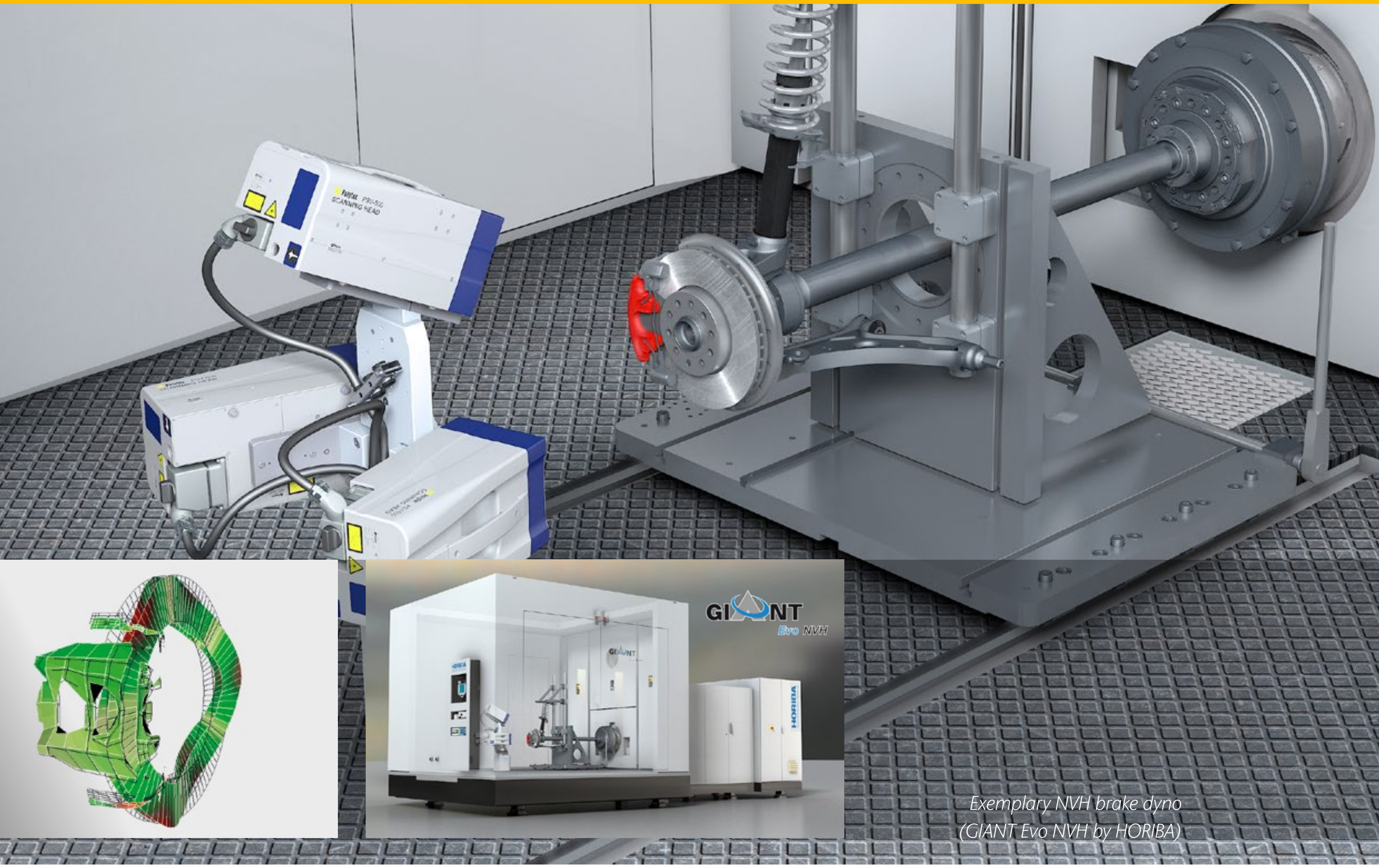
Buzz, squeak & rattle (BSR)

BSR represents annoying noise sources inside the passenger cabin, which need special attention from the beginning of the interior design. Due to the higher frequencies, lightweight components involved and the fact that most BSR events are caused by two structures rubbing in an in-plane direction, 3D scanning vibrometer data is a great tool for finding the sources that create the concern.

Heating, ventilation & air conditioning (HVAC)

Moving a high volume of air through a lightweight plastic structure with coupled fans and AC compressors generates a source and transfer path of noise. Integrated late in the development process, these components are often a topic for troubleshooting close to the start of production. Noise source identification at radiation surfaces is made easy with a quick scan of the components under operational conditions. SLDV measurements reveal the noise source.

Brake



Exemplary NVH brake dyno (GIANT Evo NVH by HORIBA)

In order to stop a car effectively brakes convert kinetic energy into heat. From a simulation perspective the energy conversion task is well understood, but the ancillary task of minimizing noise and its associated warranty costs is very difficult. This is compounded by the harsh conditions that occur under braking loads. These conditions are not only difficult to model but are also very hard to test. This creates a difficult challenge for the manufacturers in that they must balance complex design and operation parameters to avoid brake noise while ensuring safety.

Brake noise

For a design engineer, the brake system represents an infinitely complex structural dynamic system that is a highly non-linear and always changing with varying temperature, rotor or pad thickness and brake load. This complicates the understanding of its NVH response. To optimize the design a combination of simulation and test must be used to tune the brake components. In 2003, there was a technological breakthrough that provided a major leap in capability. This was the release of the Polytec 3D scanning Vibrometer. This made it possible for the first time to combine simulation data with Complex Eigen Value Analysis (CEA). The net result demonstrated that brake squeal noise was caused by the coupling between friction-induced in-plane motion and noise-radiating out-of-plane disk modes. With this understanding, countermeasures could be designed for the first time.

Brake modeling & validation

To design a modern brake, a bottom-up strategy validating component models should be done to ensure that the complete system will have an accurate CAE model. This requires Experimental Modal Analysis (EMA) testing on the component level. By measuring the components individually the uncertainty in the final structure is minimized. Since the squeal phenomena is at higher audible frequencies, this EMA work must be tested and visualized using a technique that is non-contact, with no mass loading, and with high spatial resolution. SLDV perfectly meets these requirements.

Testing on the assembly level

For the final model, the experimental modal damping from the each sub-component should be used as measured. The most accurate method for doing this is to import data points for SLDV measurements using FE geometry node locations and definitions and then export data at those same points back into the model. This nearly eliminates any risk for errors and approximations. Scaling this to even smaller sub-components using high density Frequency Response Functions (FRF) guarantees the accuracy of the final model.

Brake dyno testing

The final verification of a brake design is performed on an NVH brake dyno. The brake system and axle assembly are run under standard operating conditions. High density modal data are acquired with an SLDV, allowing for fine tuning of the model comparing operational and modal data. This helps rapidly minimize residual instabilities in the dynamic model avoiding time consuming trial-and-error procedures.

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Highlights

- Reliable predictions by updated FE models
- Reduces test complexity for operational and experimental modal analysis
- Break typical limits:
  - High spatial definition supports high frequencies and small components
  - Vibration testing in hot conditions
  - Vibration testing of rotating brake disks
- Reliable data: no mass-loading on light-weighted support structures
- Save investment: established test method with all tier 1 suppliers

Driven components

The suspension components play a critical role as a transfer path for road noise. Besides the propulsion system, the tire-road interaction is the prominent source for pass-by and interior noise. Component level optimization is an essential part of the Research and Development (R&D) work toward a silent and comfortable vehicle.

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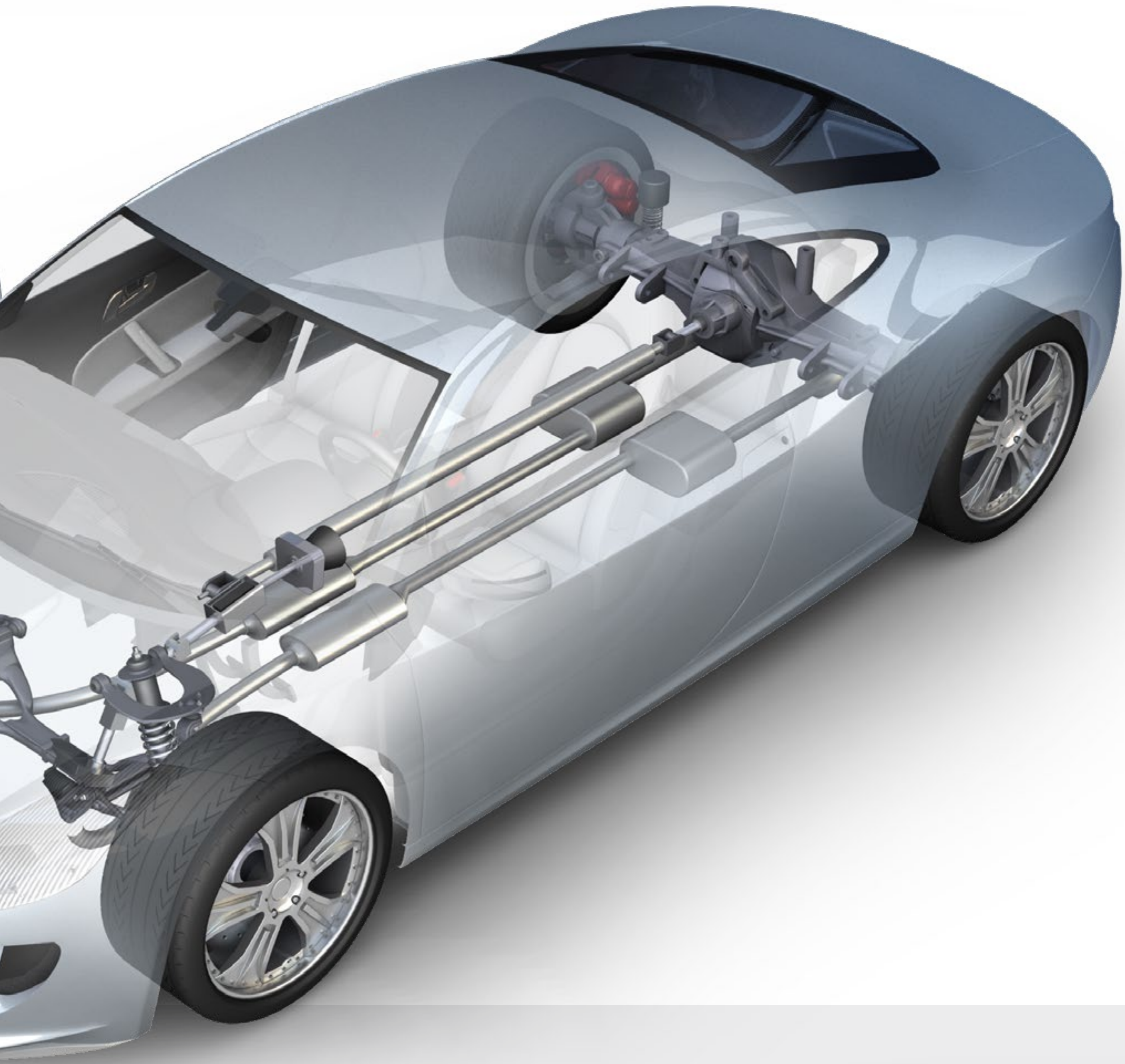
Highlights

- High spatial definition supports high frequencies
- Vibration testing of rotating brake disks
- Faster identification of noise source
- Reliable readings: linearity guaranteed

Drivability, dampers, connection to the road. We care about the details so drivers can enjoy their driving experience.

Tires

Developing tires to further the pursuit of the silent car requires efficient tools. FE Models of tires are complex and non-linear due to the material mix and assembly. Models suitable for acoustic predictions need validation into the hundreds of Hz. Understanding the mix of rotation and clamped modes is also critical. The SLDV is capable of not only doing the modal analysis but can also track the rotating tire allowing the quantification of mixed modes.



Axle and steering components

Lightweighting of the axle and steering components aims at reducing the weight while retaining stiffness and durability. Avoiding catastrophic modes and noise sources is critical. Reducing weight on shafts and the utilization of electric power steering means that designs must be validated to higher modes. The complex higher frequency modes from toothed belts and cogs create longitudinal and bending vibrations which lead to increased wear, disturbing noises, degraded performance as well as torsional modes and beat frequencies that create boom and other unwanted noises. All of these phenomena can be easily measured with Polytec's Vibrometers.

Production variances on parts can create noise sources. Measuring structure borne noise without contact during production with a Polytec Vibrometer guarantees no unforeseen noise due to production variations.

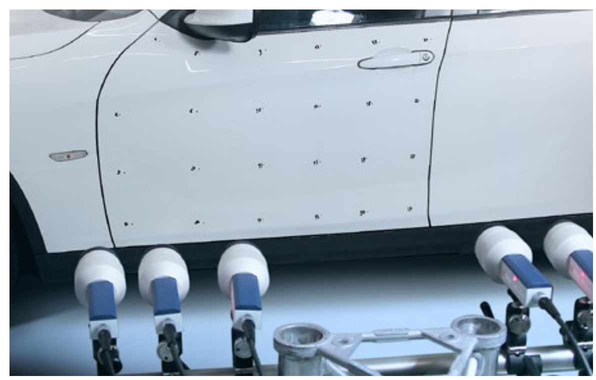
Dampers

Polytec provides topographic inspection tools to verify that piston and shim flatness tolerances are achieved in manufacturing, ensuring as-designed shock performance and good tire contact with the road to maximize vehicle safety.

Complete vehicle

While optimizing each component of a car is important, the buying public does not evaluate these individual parts, they judge the complete vehicle. This finished product is what defines the final benchmark for quality. The difficulty for the manufacturer is that while all the parts may be optimized independently, once they are all interacting with each other new concerns can be exposed.

Full-field vibration analysis with a Scanning Vibrometer



Synchronous optical vibrometry with a MPV Multipoint Vibrometer for acoustic analysis in door-slam tests or to study other transient or unstationary phenomena.

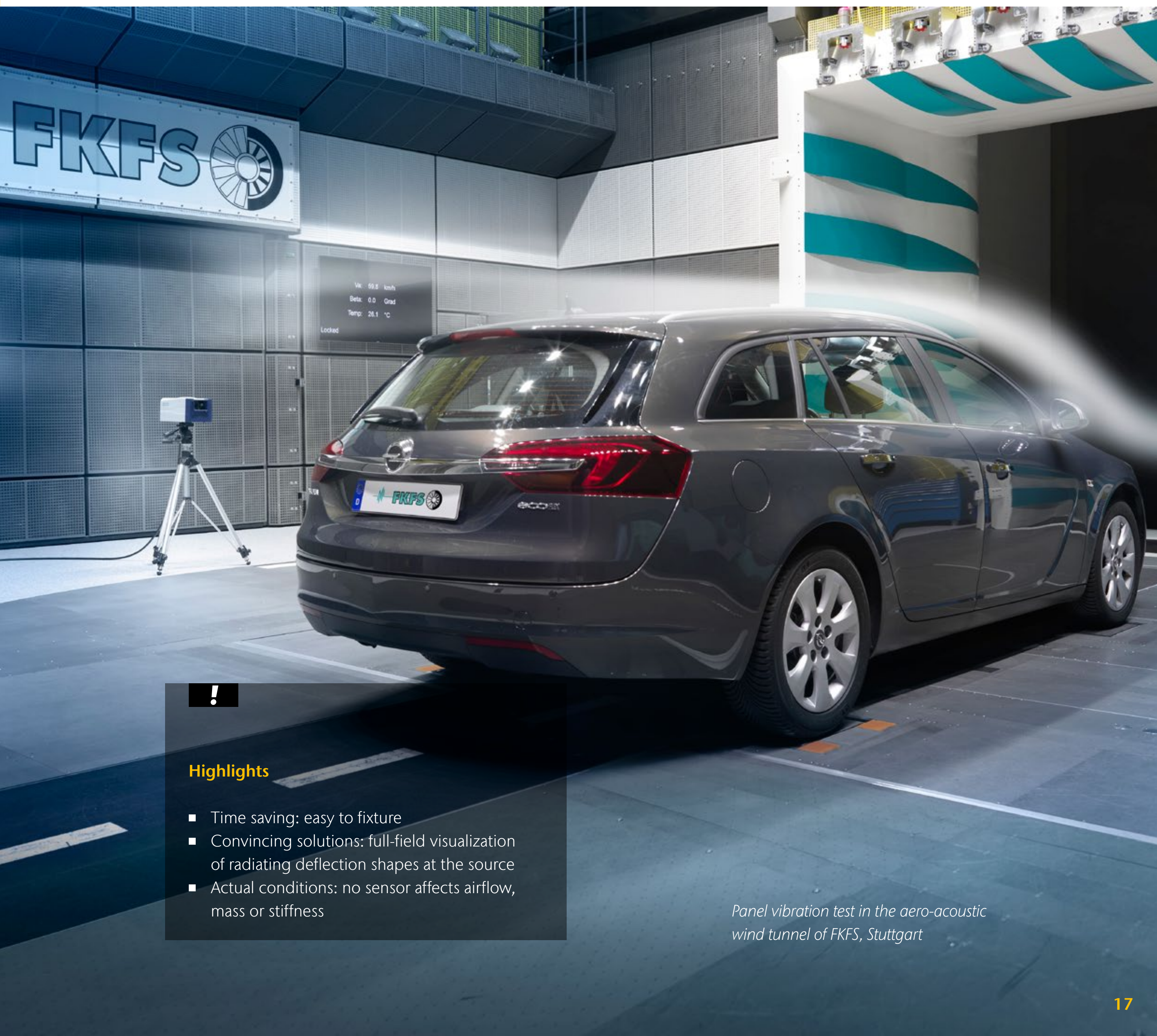
Aero-acoustics

In an aero acoustic wind tunnel, extensive tests measuring acoustics, forces, pressures, air speeds and flow take place under operational conditions. Panels vibrate, potentially being a major contribution to acoustic noise, which the SLDV or Multipoint Vibrometer can measure without disturbing the air flow. These measurements unveil the wind-excited vibration modes of the complete vehicle. This can only be done measuring at a distance and on the underbody, which is a large contributor to interior noise, through a glass window.

Troubleshooting

Measurement results from airborne sound measurements reveal imperfections in the NVH design. Identifying booming noise sources in the lab is easy with SLDV. Surfaces are quickly scanned for critical frequencies. The contributing modes and noise source identification are clearly visualized and work as a guide for the acoustic engineer to enable a quick and cost effective solution.

Finding the root cause of a NVH problem close to the start of production is challenging and requires the right instruments and expertise. Polytec's Engineering Services add those necessary resources exactly when needed without high capital investment. Trained measurement experts team up with in-house NVH specialists to achieve the best solution in the shortest possible time. Utilizing the clear visualization of the results in the Polytec software gives clear guidelines for the best remedies to make the car as quiet as the driver requires.



Highlights

- Time saving: easy to fixture
- Convincing solutions: full-field visualization of radiating deflection shapes at the source
- Actual conditions: no sensor affects airflow, mass or stiffness

Panel vibration test in the aero-acoustic wind tunnel of FKFS, Stuttgart

To guarantee a good driving experience for the customer it is necessary to have a deep understanding of the powertrain components' dynamic behavior. This understanding is achieved by making measurements on components on a dynamics test rig or with a vehicle on a dynamometer.

Powertrain

Maximize efficiency

Engine & propulsion

To minimize noise and extend operational life, understanding the dynamic behavior of transmissions, differential gears, and dual mass flywheels is necessary. The causes for torsional resonances or transmission rattle in the drive shaft need to be evaluated before the start of production to guarantee best driving experience for the customer.

Engine & motor acoustics

The R&D engineer today has to deal with various types of vehicle propulsion. Combustions engines feature excitation patterns that not only excite the body structure but also radiate sound from their surfaces. The higher revolutions per minute of electric motors result in higher order excitation, and change the testing paradigm. In both cases, the sound transfers into the passenger cabin as well as the environment. This requires measurements of the deflection shapes of critical parts like the oil pan or the intake. Laser scanning techniques and order analysis are applied to find resonances and sound radiating surfaces. Polytec's optical instruments are able to measure both on hot and rotating surfaces.

Rotational dampers

Reducing the number of cylinders is part of the mileage improvement strategy. To maintain NVH excellence the rotational characteristics of harmonic dampers and dual mass flywheels need to be tuned. Rotational Vibrometers work with very simple mounting, providing the necessary data at exactly the right locations of the drive train.

Fuel injection

The lift height and duration of the injector pintle determines the injected fuel quantity. Using Polytec Vibrometers to measure needle lift allows optimization of fuel usage and emissions to meet standards such as EURO 6 or CARB. This measurement also highlights undesirable behavior such as needle bounce and injector firing timing problems.

End-of-line test

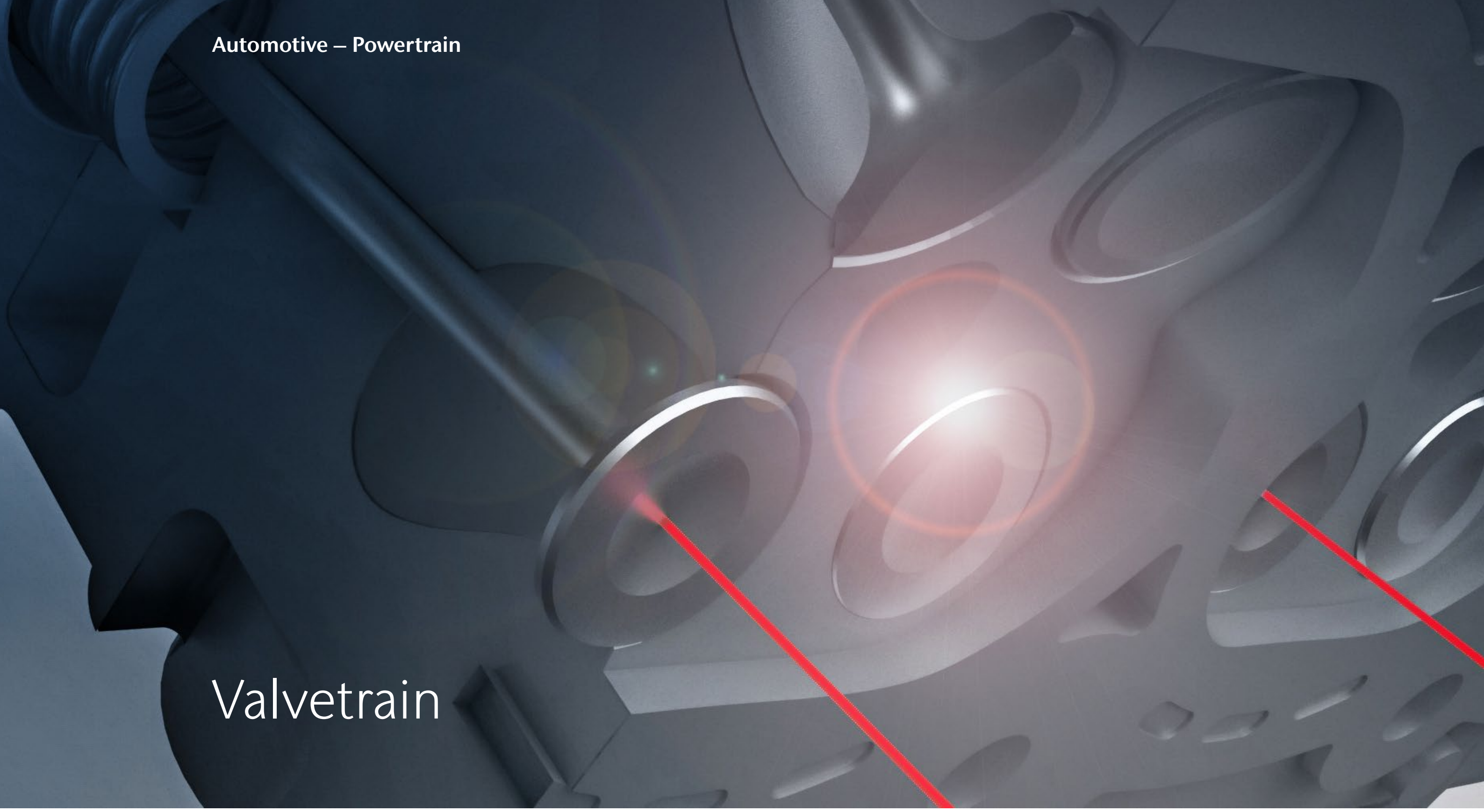
With alternative propulsion strategies auxiliary accessories (compressors, fans, pumps) become a new noise source. Measurements reveal the quality of design during the R&D process as well as the in the end-of-line test in production. Components are 100% tested before integration to guarantee customer satisfaction and traceability. The LDV fits into the design and test 3 ways: In the development process, second by identifying the best measurement points in an EOL test and third by measuring these features without a handling system and with large, variable working distances. Since the surface is not touched by a sensor wear, dirt or contact forces don't influence the reliability and repeatability. This leads to better yield with less false rejects.

Benefits

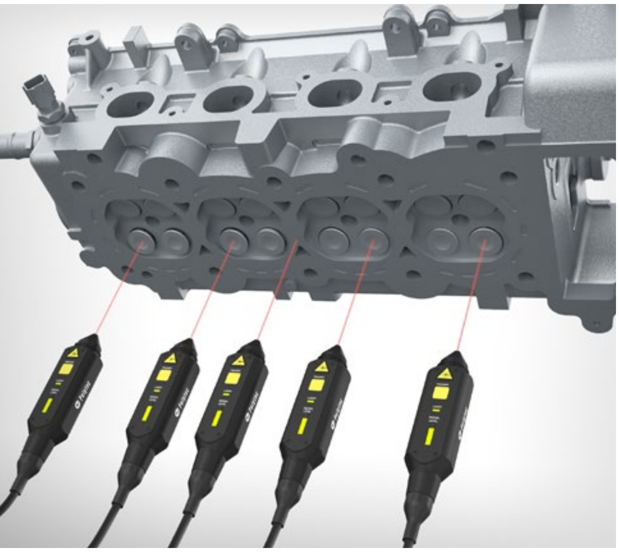
- Precise: LDV resolves nanometer displacements
- High spatial definition supports high frequencies
- Vibration testing in hot conditions
- Don't miss a detail: µm laser spot pinpoints all components
- Reliable predictions by updated FE models
- Saves money in QC: no wear, always reliable readings

Exhaust systems

The suppression of critical resonances in the exhaust system and optimization of mounting points are crucial to building a quiet vehicle. Operational deflection shapes and amplitudes are measured by an SLDV. This data allows the optimization of the exhaust system and decoupling from the engine. With the right measurements in hand, it is much easier for design engineers to optimize the design.



Valvetrain



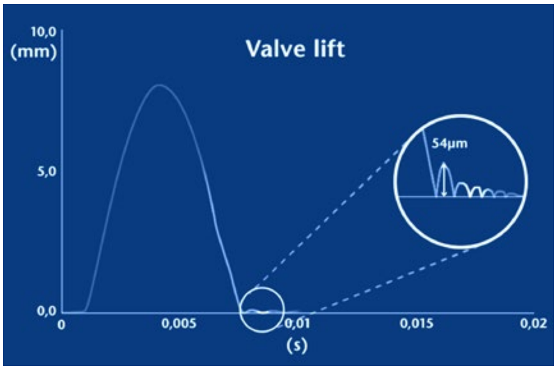
Multi channel measurement setup for simultaneous timing assessment

Fuel efficiency engines require the precise control of air flow. In order to control this flow, accurate measurements must be made.

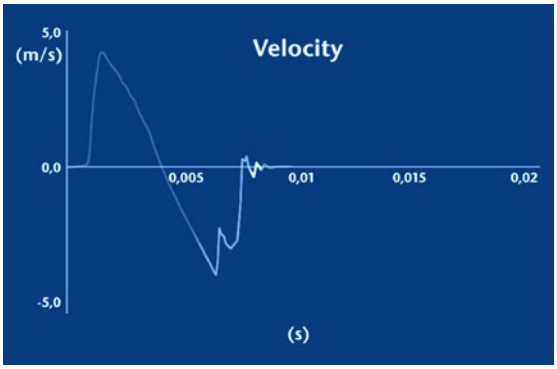
Valvetrain optimization is critical for meeting fuel economy and power goals. Engine efficiency is largely determined in the cylinder heads. In order to optimize valve, spring, and cam interactions, it is critical to measure what they do during operation. Before Polytec released the High Speed Vibrometer (HSV) valve measuring system there were many unanswered questions. Does the valve head follow the cam geometry or does it start to float? Are the closing dynamics held in check or is the valve bouncing in its seat? A multi-channel Polytec laser Vibrometer reveals this information about the dynamics of the whole valvetrain at once. Valve lift curves plotted over camshaft angles show how accurately the valve follows the cam and the phase consistency between valves indicating the overall performance of the valvetrain system. Adding in the unique capability to measure µm displacement and velocity concurrently reveal information about the closing speed and valve bounce, addressing durability issues.

Laser vibrometers help finding the perfect timing for close control

Measurement of valve lift and valve closing speed



Valve lift curve with highlighted bouncing



Velocity plot highlights bounce and closing speed

Transmission

The way torque is transferred from the propulsion system to the wheels has a big influence on the drivability, efficiency, durability and sound quality of a vehicle. Dampers, dual-mass flywheels, gearboxes and transmission cases are components where torque and energy is converted. With this energy conversion, each of these components can act as an excitation and radiation source affecting durability and NVH.

Gearboxes/differential

Gear mesh produces high frequency excitation to the gearbox surfaces. With a single gear, electric propulsion drives the harmonics of the meshing frequencies into the high kHz range. High bandwidth and linearity are two of the main requirements for a sensor like the laser vibrometer, used for Order and Operational Deflection Shape (ODS) Analysis.

Sound radiation is an undesired audible outcome of high frequency excitation from the gear mesh. Tuning the radiating surfaces such that they are not excited by the mesh is the most straight forward way to reduce the sound level. Polytec SLDV data visualization of the ODS give a strong indication of the required engineering solution. Acoustic simulations based on the test data allow for a prediction of the effect of a proposed modification. This rapid test reduces the number of iterations and expedites troubleshooting.

After the design engineer's job is done the quality depends on manufacturing. To prevent unwanted noise and associated customer complaints, 100% of the assembled gearboxes are tested inline. In this stage non-contact LDV based production testing has proven to be the most effective method.

Shaft and dampers

Non-contact measurements add flexibility to existing measurement technologies. Order analysis at any accessible point of the power train is made easy with rotational vibrometers. Being non-contact the torsional oscillations can be measured at any point of a shaft without altering the shafts moment of inertia or modifying the shaft geometry. The Rotational Vibrometer delivers data from the source conveniently as a standard voltage signal to be fed into existing data acquisition systems. Thus torsional beat frequencies from shaft to shaft and torsional resonances are detected. The technology is easily applied to all kinds of shafts in all configurations of modern gas, diesel, hybrid or electric cars.

By coupling side loads into the structure, some shaft bending modes can affect the durability and also the NVH behavior of a drive train. Scanning Laser Vibrometers offer the unique capability to measure on rotating shafts. The results visualize the shaft bending modes up to higher orders giving the Simulation and NVH Engineer feedback of this otherwise hidden phenomenon.

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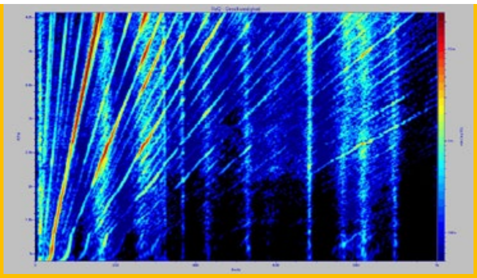
Highlights

- Break typical limits:
  - supports high frequencies
  - linear response in full bandwidth
- Time saving: no fixturing required on rotating shaft
- Add flexibility: choose measurement location without constraints
- Reduce time-to-market: quick FE model update based on high fidelity test data
- Convincing solutions: full-field visualization of radiating deflection shapes at the source



Spectrogram of an engine run-up

Torsional resonance assessment of a drive train on a rolling road.
courtesy IPEK, KIT Karlsruhe, Germany

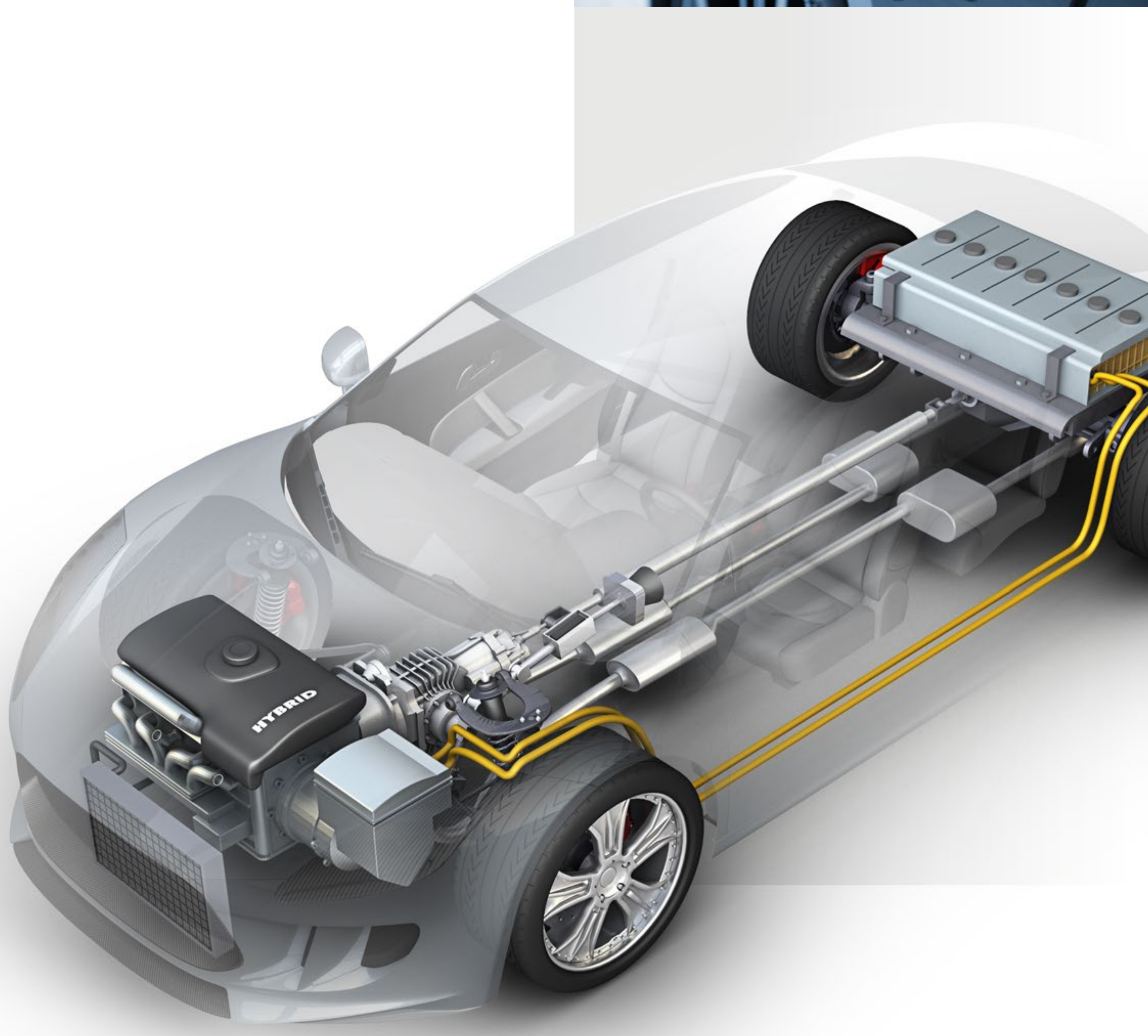
New global standards being implemented may not be forcing a technology revolution, but they are definitely bringing into effect a major evolution of the automobile. Gas mileage standards are creating a research boom into different propulsion techniques. Electric assist or pure electric power is no longer a fantasy, but now a reality. Today there are numerous computers and controllers telling for example which injector to fire and for how long as well as keeping the car directly on the road in inclement weather or with poor driver input. This electronic evolution is paving the way for a safe technology filled environment to enhancing the passengers' experience. With these new technologies, shortcomings are also found as new sources of NVH concerns become prominent.

Electric vehicle & electronics

Drive technology integration

Electric propulsion

When electronics take over the whole car...



Synchronous vibration measurement with multi-channel vibrometers capturing transient events like engine run-ups.

Electric vehicle

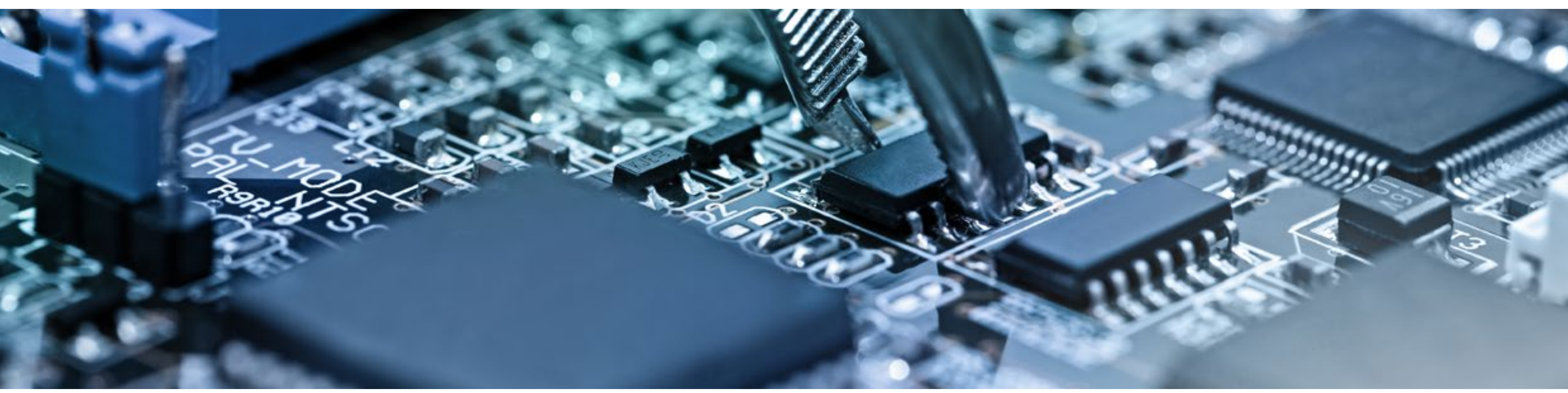
Electric vehicles (EV) epitomize many of the changes that are occurring in vehicle design today. Without a combustion engine creating low frequency noise sources, higher frequency noise sources are exposed. Optimization of road and wind noise, inverter & battery cooling, transmission whine, HVAC fan and other electric motors must be done with more fervor than ever before. Focused efforts in Engineering are required. Historical acoustic response information linking the CAE and experimental results together is critical to producing class leading vehicles that are optimized through the mid-frequencies.

Battery inverter

With no combustion noise, new sound sources are exposed. In electric vehicles it is necessary to optimize the battery cooling fans and high frequency inverter noise. Structural borne noise sources in the kHz range can be directly measured and visualized using a laser vibrometer. With the advent of electric propulsion there is also renewed research going into batteries. Much of the battery development and road reliability can be better understood with a vibrometer. With its high spatial resolution, it is possible to make measurements on small components and even bonding wires quantifying the product to minimize failures in the field.

Circuit board & ECU

The power of electric doesn't stop with propulsion systems. There are an ever increasing number of computer controlled systems in today's vehicles. These vary from engine control, making sure that the vehicle stays on the road, to creating a comfortable and technology filled environment for the operator and passengers. To ensure reliability and prevent expensive failures understanding each of these subsystems is critical.



There are a plethora of printed circuit boards in each car today. In a Stability Control System there are sensors on these circuit boards to control the vehicle in case of poor road conditions or bad operator input. Polytec offers a system optimized for these measurements. Measuring directly on the Printed Circuit Board (PCB) to understand mode shapes and stress on components, finding crosstalk between mounting modes and vehicle movement, as well as using the tiny laser spot to measure on small bonding wires directly allows for an optimization to ensure passenger safety and vehicle reliability.

Sensors

With the advent of more advanced Engine Control Units (ECU), operator comfort and stability control comes the need for more advanced sensors. Micro Electric Mechanical Systems (MEMS) are the core of these sensors. Characterization of performance of the MEMS acceleration, gyroscope, or pressure sensors is critical to making sure the car behaves as expected. This characterization can be done with a microscope based LDV from Polytec. To guarantee the function of an inertial or acceleration sensor, the mounting of the packaged sensor must represent the actual vehicle dynamics. Crosstalk from local modes will lead to wrong readings. Studying the local dynamics of the sensor on impact or structural excitation allows proper design of the packaging and mounting strategy. There are many of these sensors in today's cars: acceleration sensors for air bag operation, pressure transducers for measuring air & hydraulic pressures, gyroscopes for stability control systems and even motion imparting systems for operator feedback to vibrate car seats when a lane change sensor or proximity sensor needs to warn the driver of an obstacle.

The quantity of proximity and locating sensors is also ever increasing in vehicles. Having a car that tells you when you are about to hit a deer, another car or even a parked obstacle increases the safety of the vehicle. Polytec offers Vibrometer solutions that reach into the ultrasonic frequency range to help with these developments. For ultrasonic parking proximity sensors it is critical to understand the acoustic fields that the transducers output. Optimizing this response in R&D as well as ensuring repeatability in the production domain is critical to making sure that once installed in a vehicle their operation will warn of impending obstacles. These measurements can only be made with Polytec Vibrometers.

Entertainment

Haptic and haptic feedback make the operator experience unique

Cars used to be just forms of transportation. These days, with the computer revolution, comfort and convenience are at an all time high. Drivers' and passengers' expectations grow every year. Integrated computers and navigation systems are now at the heart of every car. Ensuring a pleasant operator environment is critical to product branding. Quality can be felt in the force feedback from the push of buttons, the haptic feedback of touch screens and of course in the fidelity of the audio included with the vehicle.

Polytec's laser Doppler vibrometers are used to quantify the response of these different systems, instead of having to be content with inaccurate subjective interpretation in design. Measuring the feedback and response of the button feel and speaker integration helps manufacturers promote their quality and branding.

Polytec is the world's leading developer and manufacturer of optical measurement systems for the characterization of vibrations. We are also specialists in the field of optical surface profilometry and non-contact length and speed measurement. Polytec has been certified according to ISO since 1994, and most recently according to DIN EN ISO 9001:2008. Numerous national and international awards attest to our technological leadership and expertise.

PolyXpert Services

Reach your goals faster

With PolyXpert Services you achieve your goals more quickly

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Are you developing a new product and need **high-precision measurement data as fast as possible** to better evaluate fundamental parameters and performance characteristics?

Then Polytec is your partner.

Do you need **highly qualified specialists** for a project with urgent time constraints, e.g. in the field of troubleshooting?

Then Polytec is your partner.

Do you want to broaden your knowledge base and benefit from the experience of first class experts?

Then Polytec is your partner.

Furthermore, do you want to **stay within budget** and push your project through the approval process quickly and easily?

Then Polytec is your partner.

As you can see, Polytec is far more than an equipment manufacturer. We offer you a comprehensive range of services with industry-leading technologies and products:

- Vibration measurement and structural analysis
  - From planning to evaluation
  - From microscopic to macroscopic structures
  - From 1D to 3D

- Modal test and experimental modal analysis
  - Optimization of structural dynamics and acoustics
  - For model validation
  - Ideal for a bottom-up strategy
  - Determination of local modes and damping

- Operational deflection shapes
- Acoustic quality testing
- Torsional irregularities and order analyses
- Analysis of torsional vibration
- Measurement of transient events
- Dynamic displacement measurement
- Dynamic strain studies
- Analysis of microstructures

What other benefits do PolyXpert Services provide you?

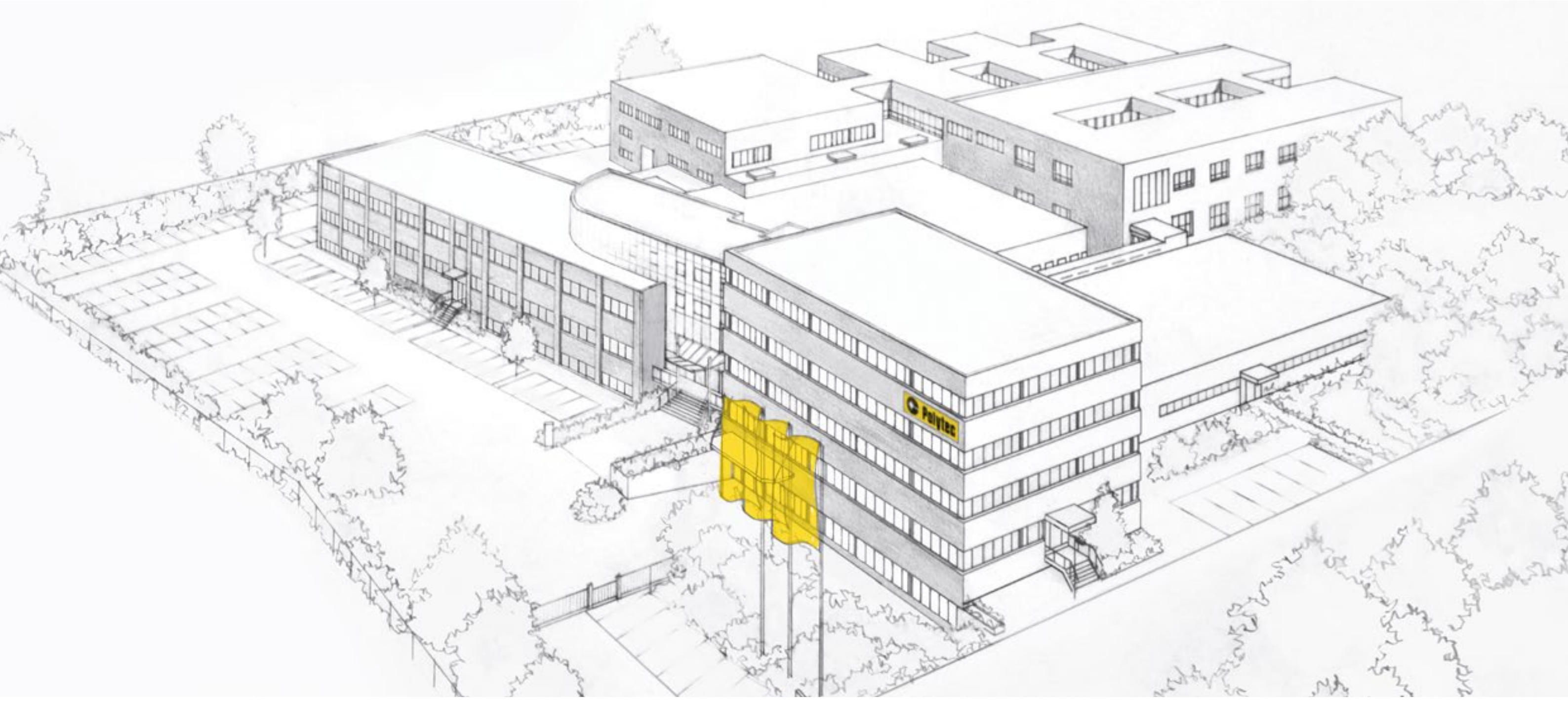
Quite simply – many:

- Our highly advanced measurement technologies provide optimal data quality, leading to a deeper understanding of the static and dynamic properties of your products.

- Simplify your process by outsourcing your measuring demands.

- If your requirements are only occasional, engineering services are be easier to justify than the outright purchase of a system.

- You can evaluate the measurement technology to prepare for a planned project or to help build a case for a future investment in our instrumentation.



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