NEW CHALLENGES IN VEHICLE ACOUSTICS

Acoustics is becoming an increasingly important discipline in the automotive industry, because vehicle noise and sound design have a powerful influence on customers’ purchase decisions. Manufacturers that produce cars whose acoustics and low levels of vibration elicit the strongest positive emotional response from customers will have a significant competitive advantage. Vehicle acoustics plays a central role in the interaction between traditional mechanical systems and subjective perception, in other words in complex physical contexts. Bertrandt is expanding its portfolio of acoustic services in order to provide every customer with individual support on the basis of its flexible approach and in-depth specialist knowledge. The Bertrandt network with its cooperation across different sites and disciplines brings considerable added value for customers.
THE PORTFOLIO OF ACOUSTIC DEVELOPMENT SERVICES

ACOUSTIC TESTING

ACOUSTIC SIMULATION AND ENGINEERING

ELECTRIC TRANSPORT
- Noise patterns of electric motors, inverters, battery cooling systems
- Sound design for electric vehicles
- Combinations of materials

EXTERIOR ACOUSTICS
- Sounds of doors closing/other shutting noises
- Wind noise
- Combinations of materials

ENGINE ACOUSTICS
- Downsizing
- Vehicles’ new NVH behaviour
- Impulse noises from injection systems
- High-frequency whistling from turbos
- Bearings, intake pipes
- Low-frequency acoustics
- Drive shaft imbalances

GEARBOX ACOUSTICS
- General gear-changing noises
- Gear selectors
- Running noises and gearbox howling and rattling

WHEELS/TYRES
- Rolling noises
- Transfer function
- Road surface noise
- Noise of vehicles passing

INTERIOR ACOUSTICS
- Rattling and creaking noises
- Unwanted noise
- Contact analysis
- Passive acoustics
- Sound design

COMPONENT ACOUSTICS
- Aeroacoustics
- Electrical noises (adjusters, motors etc.)

BODY
- Modal analyses
- Composite materials (structure-borne noise)
- Lightweight structures (frequencies)

EXHAUST SYSTEM
- Sound design
- Passing vehicle noise
- Roaring noise

BRAKES
- Brake noises (squeaking)
- Vibrating brake discs

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IN FOCUS ACOUSTICS

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Your team in Munich has many years’ experience in the field of acoustic development. How has your portfolio of services been built up?

In Munich, we have been working since the mid 1990s on becoming established as a service provider in the wide-ranging field of acoustics. Our initial projects related to functional noises, for example designing drive units for window regulators and seat adjusters from an acoustic perspective. Another project that we worked on involved coordinating door seal systems. As well as creating an “expensive” closing sound and reducing aeroacoustic wind noise, we also had to prevent water from entering the vehicle. We soon developed additional areas of expertise, which included taking responsibility for one of Bertrandt Munich’s first operational support packages. We operated several test benches to measure airborne sound and ensured that the entire vehicle produced no unwanted noise.

Your specialists develop individual engineering and test solutions and this involves planning, validation and testing for large- and small-scale projects. Can you describe what they do?

The customers for our acoustic services range from start-ups that need a more practical approach to OEMs that want us to make millions of standardised measurements. Every customer is given a tailor-made solution. Our experience of many different projects enables us to combine the relevant requirements, such as direct knowledge of the customer...
and the process, with our existing testing capacity. In addition, our customers always benefit from the skills and testing resources of the entire Bertrandt network.

You are responsible for an interesting test bench project in Munich. Can you give us a brief description of it?

The project involves operating test benches for structural dynamics and vibration comfort. We are sharing our test labs and our testing facilities with our customer. The project is made up of a wide range of activities and Bertrandt is responsible for the organisation and for ensuring that the tests are completed to the required technical standard and on schedule.

Can you explain to us in more detail what is involved?

The measurements we make are not only used to evaluate the status of all the components during the development process right through to the start of volume production. They are also a decisive factor in the investigations into new vehicle concepts and in the creation of future vehicle architectures for new model ranges. In addition, they allow the modular systems in the customer’s portfolio of vehicles to be validated.

Where does the added value for your customer lie?

After the customer places the order for the work package, the entire process right through to the handover of the results is managed by Bertrandt. Most importantly, this saves our customer time. Freeing up the customer’s employees enables them to focus instead on research and on developing new strategies and concepts. In addition, by grouping the validation activities together, we can reduce the customer’s development costs and, at the same time, ensure that our test bench capacity is used as efficiently as possible.

Tell us more about the members of your team.

Our team is made up of people with a range of different skills, including traditional mechanical engineers, graduates with a doctorate in engineering, vehicle mechanics and IT specialists. But they all have one thing in common: they are experts in acoustics and vibration. This interdisciplinary field requires skills in different areas of mechanics,
physics, electrical engineering, information technology and mechanical engineering. This includes understanding and being able to operate the hardware and software measurement systems and the signal analysis tools, together with experience of how noise is created, transmitted, perceived and processed. On the basis of this expertise and the results of the tests, we can help to ensure that products are developed which meet the customer’s acoustic requirements. Examples of our work include evaluating the functional noises produced by components and designing noise insulation, damping and absorption solutions for subsystems. We are also responsible for eliminating unwanted noises, such as rattles and creaks, together with aeroacoustic, wind noises, airborne and structure-borne sound from engines, for carrying out modal analyses. In areas such as structural analysis and dynamics, vibration comfort and powertrain functions, our specialists work as part of a network across different disciplines and teams.

In relation to the automotive industry, we are asking ourselves: “What will the car of the future sound like?” In the premium segment in particular, comfort will remain the key differentiating factor. And one aspect of this is acoustics. The changes taking place in drive systems with electric and hybrid powertrains and in vehicle design with GFRP, CFRP and lightweight components present new challenges in the field of acoustics. Because vehicles are becoming quieter, unwanted noises will be more noticeable and more irritating. In addition, the demand for personalised solutions calls for flexible sound design concepts and sound image strategies. And that’s by no means all. At Bertrandt we need to be prepared to manage the increasingly small differences in the differentiation of acoustic features and to identify them in the early stages of development. As a result, we are building on our existing skills and adding the necessary measuring systems to our range of equipment. We are also pushing ahead with the development and use of simulation functions to accompany our tests and with model-based design methods. This will ensure that our customers regard us as specialists in every aspect of acoustics and vibration engineering and as their first point of contact in these areas.
“ACOUSTICS IS AN IMPORTANT INTERFACE WITHIN THE OVERALL VEHICLE DEVELOPMENT PROCESS.”

AN INTERVIEW WITH CHRISTIAN HEINZ, HEAD OF THE ACOUSTIC TESTING DEPARTMENT AT THE WOLFSBURG AND SASSENBURG SITES

The role of acoustic development services has changed significantly over the last 20 years. What are the main trends that influence your work?

During the last 20 years, we have been influenced by a number of different factors. If you compare my VW Golf I, which had a naturally aspirated diesel engine, with the Golf of today, you will see how rapid the pace of change has been. Nowadays cars with much smaller engines can produce a lot more power. The downsizing process has led to the development of largely turbocharged engines, some of which have fewer cylinders. This indicates some of the challenges that we face, which include whistling turbochargers, rotational irregularities and a reduction in the damping masses in the entire system. The rigidity of the vehicle body, which directly affects both safety and comfort, has increased. This, together with improved insulation and damping packages and other measures, has led to a noticeable reduction in the level of noise inside vehicles. The German government’s objective of having one million electric vehicles on the country’s roads by 2020 will mean additional work for us. When it becomes quieter inside the car, the occupants will suddenly notice other sounds that had previously been masked by the engine noise. Riding in the back of a car in a rainstorm could be a completely new experience. In addition, other road users must not be put at risk by the difficulty of hearing an electric vehicle against the existing background noise. This could lead to the development of concepts for individual soundscapes for electric cars.
And individuality is an important factor. Ultimately every user or customer will come up with their own judgements on the essential subjective quality of their vehicle. This is where psychoacoustics comes in, which represents a completely new challenge.

What influence does European legislation have on vehicle acoustics?

The legislation has both a direct and an indirect impact. Downsizing is a consequence of the emissions limits set by the European Union and has an indirect effect on acoustics. For a long time, the ISO 362 standard has had a direct influence on the external noise produced by vehicles and this has led to constant modifications and adaptations. The subsidy for electric vehicles announced by the German government at the start of this decade gave rise to rapid developments in the field of electric transport which have also had an impact on acoustics. In addition, a new piece of legislation has been introduced to reduce the noise made by motorcycles. It was amended in January 2016 and will be made even more stringent in 2020. It’s clear that there are many different interfaces between the field of acoustics and European legislation.

What changes have been made to Bertrandt’s acoustic services in that respect?

When I began working for Bertrandt 18 years ago, acoustics was a blank page. Only our Munich site had some expertise in this area and provided a few services. Today we have several hundred employees with extensive experience in the field of acoustics. We can offer everything from traditional development services and simulation to extremely well-equipped testing facilities, which allow complex issues to be dealt with independently and as part of a wider context. Acoustics has become an important interface in the overall development process which allows our teams to work together in a more focused and efficient way. For example in bodywork development, it can identify dynamic body rigidity parameters and provide natural vibration analyses that enable the noise of components to be damped. In the field of powertrain and chassis development, acoustic measurements of the powertrain and the exhaust system can be made and transfer path analysis can be used to allow joint solutions to be developed. We work with electronics specialists on the creation of infotainment systems. On our customers’ test tracks we push their vehicles to the limits in specific driving situations on an almost daily basis. All of this shows that our customers see us as a competent partner. They have put increasing trust in us over the years and are now happy to give us the responsibility for complex and unusual tasks and projects.

In 2015, Bertrandt Technologie GmbH (BTG) was founded in Sassenburg. This is another acoustics centre. Which areas will you be focusing on there?

We need a vision! We want to make BTG into the key acoustics centre for northern Germany. We are focusing on the energy and medical technology sectors as well as the automotive industry, because many different types of companies are facing acoustic...
challenges. Our aim is to develop comprehensive solutions for our customers. However, we will be starting in familiar areas which include the powertrain test bench, insulation and damping in the echo chambers and in the material lab and investigations in the psychoacoustics lab. There we will identify and define the individual feelings of test subjects and customers to produce objective acoustic parameters. This is a very interesting area because it is influenced by intercultural semantics.

What are the key infrastructure features of the Sassenburg site?

The BTG is a very well-equipped acoustics centre. At its heart is our all-wheel-drive dynamometer, which is installed in a semi-anechoic chamber that is 17 m x 19 m in size. This allows us to measure the effects of a vehicle driving past, as described above, under laboratory conditions. With a power output of 424 kW per axle, the dynamometer can be used to measure high-performance vehicles. Another interesting feature of the centre is the window and ceiling test facility. This consists of echo chambers with openings in the walls which allow sections of the bodywork or vehicle components to be adapted so that sound insulation measurements can be made. We also have two laboratories. The first is used for investigating poroelastic materials and has special facilities such as a Kundt's pipe, AlphaCabins, an Apmat and a flow resistance test bench. The second is a psychoacoustics lab, where we help customers to define their individual subjective requirements.

What are the benefits for your customers?

The main benefit is our close proximity to the development site in Wolfsburg. It only takes around 15 minutes to get from there to Sassenburg. The complete vehicle department at our Wolfsburg site covers every aspect of building and converting vehicles to produce prototypes under secure conditions, including a special entrance and a certified specialist waste disposal company. The department also has the logistics systems needed to transport prototypes securely. This reduces the number of potential interfaces, which means that we can also run projects efficiently for customers with a little further to travel.

Can you describe any sample projects or give us references?

Unfortunately, I can’t tell you about any specific projects. What I can say is that it is always really interesting when the work involves more than one department and when we can bring together all our internal strengths. For example, when we need to collaborate with our experienced electricians and ideally also use the equipment in our electric motor test facility to achieve the necessary results with high-voltage vehicles. Or when we are cooperating with our colleagues from the vehicle safety department to produce high-speed camera shots which allow us to see and evaluate highly dynamic excitation processes. And it’s always good to work on unusual vehicles to develop solutions for our clients or for their highly discerning end customers. Recently we’ve been involved with cars from Bentley, Aston Martin, Audi and, of course, VW. I’d like to take this opportunity to thank all the dedicated members of our team who have successfully completed customer projects with tight deadlines and those who have taken part in testing on test sites throughout the world or have spent several weeks in other countries laying the foundations for new projects at these sites. It’s clear that acoustics is a very important interface with all areas of vehicle development.
THE BEST SOUND FOR EVERY CUSTOMER

THE ACOUSTICS CENTRE IN INGOLSTADT HAS STATE-OF-THE-ART TEST FACILITIES

The acoustics centre at the Bertrandt site in Ingolstadt offers its customers modern testing equipment and a team of experts who have extensive experience in overcoming the latest acoustic challenges in the vehicle development process. We spoke to Hannes Ullmann, head of the component testing and acoustics department.

The objective is a realistic sound

One of the most important tools available to the team in Ingolstadt is the all-wheel-drive dynamometer, which makes it possible to investigate vehicles from an acoustic perspective. For Hannes Ullmann, the key feature of this system is its ability to represent the internal and external acoustics of cars more realistically. The use of dynamometers in acoustic testing is not new. However, until now the exhaust gases from the vehicle engine had to be extracted via a hose on the end of the exhaust pipe. As a result of this extraction system the air intake and exhaust noise could not be heard. In contrast, the new test bench allows the engines to run normally inside the building. A special incoming airflow – referred to by experts as an aeroacoustic wind tunnel – provides a supply of fresh air as if the vehicle were being driven on the road. An almost silent ventilation system in the roof of the test facility prevents exhaust gases from building up inside. The difficulty lay in designing this air circulation system in such a way that it did not drown out or distort the noise inside or outside the vehicle.

The test facility has been in regular operation for two years, supplying our engineers and their customers with acoustic analyses that are as realistic as possible. An analysis of this kind can involve up to 18 months’ work. This is because a new vehicle model is made up of between 1,000 and 1,500 individual components, all of which have different acoustic features and interact with one another. The dynamometer helps the engineers to carry out comprehensive acoustic tests of individual components and subsystems. Vehicles can also be run without the use of their engines. The four rollers turn the wheels and can simulate speeds of up to 250 km/h. This means that the test can focus on the mechanical noises made by the car in the absence of the overpowering engine noise.

Focusing on an individual sound

There is certainly no lack of interesting subjects and new questions to be investigated. Customers who drive sports cars usually want the sporty character of their vehicles to be audible. But sports models are increasingly being used for longer journeys and over a period of several hours the noise of the exhaust can become irritating. This is where sound design comes into play. It is now possible to produce a sound that cancels out the exhaust noise at the press of a button or to activate valves and resonators in the exhaust system which result in an exhaust note that is easier on the ears. Special attention needs also to be paid to new materials that are used in the interior and the body in order to keep weight to a minimum. They all have an influence on the vehicle acoustics and require a detailed analysis. The result of all our efforts is the best sound for every customer.
Components that produce less noise, increasing demands for a more comfortable ride and new drive concepts: simulation can predict the acoustic properties of complete vehicles long before the individual components are available in hardware form.

The process allows different sources of interference, such as vibration caused by the chassis or the engine, to be applied to the structure of the vehicle and makes it possible to simulate the way in which they spread. In the later stages of development, acoustic simulation can be used as a tool to identify the causes of unwanted noise in specific road situations and to validate possible solutions. While NVH and modal analyses only cover structural vibrations, the realistic representation of every detail of the vehicle interior, including the seats, instrument panel and trim, makes the generation of a fluid grid a complex process. The geometric properties of sound-reflecting and damping components have a decisive influence on the spread of the pressure waves. As a result, the insulating, damping and sound-reflecting characteristics of trim and other interior components play an important role in acoustic simulation. The way in which the noise spreads allows problem areas to be identified and the vehicle structure and specific individual components to be improved.

Dr. Alexander Löwer, Ingolstadt

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A customer project involving the benchmarking of a complete vehicle laid the foundations for a new department. A reference car was compared with its competitors to identify the quality requirements for new models.

Bertrandt was responsible for every aspect of this project from the purchase of the vehicles and the measurement process to the functional testing of the reassembled cars. The test vehicles were prepared by experienced car mechanics and mechatronics specialists in Bertrandt’s in-house workshop. This involved removing the entire powertrain and the chassis. Special excitation adapters were fitted to the connection points of the disassembled components, which allowed the measurements to be made. These adapters were also developed and produced in-house.

High-performance measurement systems

A special truck was designed and built by Bertrandt to transport the vehicle from the workshop to the test facility to guarantee the highest possible levels of security. The test specimen was placed on specially made bearing blocks so that the data could be recorded correctly. This enabled the chassis to be supported on four vibrating mounting points each with an air bellows. After this the work on installing the measuring equipment began. The sensors were needed to identify the transmission of vibrations to the interior from the different excitation points. For this purpose, all the points where vibrations could be transferred to the vehicle interior were excited with an impact hammer.

In order to enable the quality of the measurements to be assessed, good coherence function values were needed. When the measurement data from all the points were of an equivalent level of quality, they were processed and incorporated into a global database. The services also included documenting the process with photographs of every measurement point. Once the measurements had been completed, the vehicle was transported back to the workshop and returned to its original condition.

Quiet room increases the range of acoustic services

The Cologne site has added a modern quiet room to its acoustic facilities, which allows transfer functions to be measured on complete vehicles. The new quiet room reduces the level of external noise by more than 35 dB(A) and therefore offers the ideal sound backdrop. It is large enough to accommodate all types of vehicles up to large vans. The internal dimensions are 10 m x 6 m x 3.8 m. In addition to the project referred to above, it can also be used to provide other services such as investigating air conditioning systems, measuring and analysing noises in powertrains, carrying out modal analyses and evaluating squeak and rattle problems. These noises are produced inside the vehicle by unwanted movements of components that are located next to or in contact with one another. The new quiet room ensures that end customers will be happy with the noise levels inside their new cars.

Jochen Göbels, Cologne