

# Bertrandt*magazine*

The Customer Magazine of the Bertrandt Group  
No. 16 | September 2016



## ACOUSTICS:

DEVELOPING INDIVIDUAL SOUNDSCAPES FOR  
MODERN CARS

PORSCHE MACAN: DEVELOPMENT ACROSS ALL  
COMPETENCE CENTRES

RENAULT ESPACE: COMPLETE VEHICLE DEVELOPMENT

RENAULT "NEXT TWO":  
AUTONOMOUS AND CONNECTED DRIVING

THE FORD GLOBAL COMMERCIAL VEHICLE PROGRAMME:  
INTERIOR DEVELOPMENT

THE DIGITAL FACTORY: MODULAR SOFTWARE

V-ZUG TOP-LEVEL CUISINE: TOLERANCE MANAGEMENT

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**Printing**  
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pronoun "he" is used in general references to  
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discriminate against female employees.

**Acoustic development**  
What will the car of the future sound like? Our  
acoustic specialists are working on this subject  
and in other related areas.  
Find out more from page 34 onwards.

## EDITORIAL



Dear reader, our development activities are shaped by current trends, which include environmentally friendly vehicles, safety, connectivity and digitisation. Concepts such as autonomous driving, Vision Zero, protecting the environment and lightweight design, but also Industry 4.0, the energy transition, smart grids and the ageing society are under discussion everywhere. The factor which they all have in common is high-tech products of exceptional quality.

As development specialists, we can help to create forward-looking products and solutions of this kind. For this purpose, we have built on our existing skills and moved into new and innovative areas. For example, our two acoustics centres in Ingolstadt and Sassenburg are overcoming the new sound-related challenges of modern vehicle concepts, such as electric cars. Acoustics is a field that brings together traditional mechanical systems and subjective perception. This is the central theme of this issue of our magazine: acoustics as an interface in complete vehicle development. It covers a wide range of areas from electric cars and vehicle interiors and exteriors to gearbox noise and brakes. On the route towards autonomous driving, our engineers have focused on system adaptation and human-machine interaction on the basis of a characterisation of driving styles, with the aim of increasing the acceptance of driver assistance systems. In the field of building automation, our software developers have tested and implemented an algorithm that understands speech and interprets it correctly.

We were particularly pleased to win a number of awards, including Innovator of the Year 2016. The Stifterverband awarded us its "Innovativ durch Forschung" seal and, in the trendence Graduate Barometer, students once again ranked us among the top 100 employers in the field of engineering. This is encouraging feedback for our more than 12,500 employees in their day-to-day work on customer projects.

I hope you enjoy finding out about the world of Bertrandt.

Dietmar Bichler



ACOUSTICS

DEVELOPMENT  
ACROSS ALL  
COMPETENCE  
CENTRES

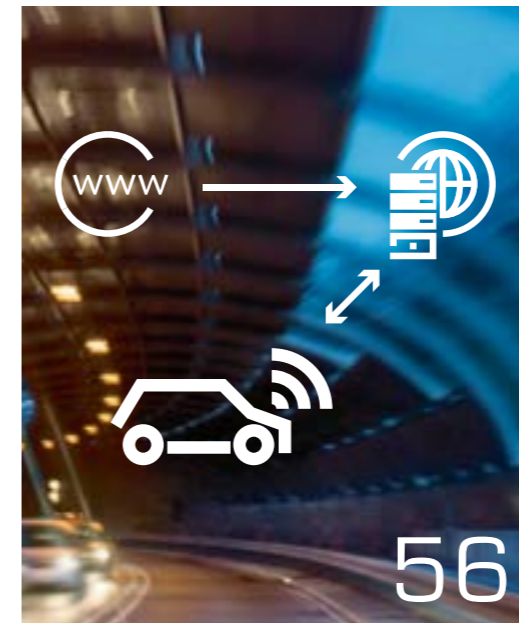


AUTONOMOUS  
AND CONNECTED  
DRIVING



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TESTING CENTRE IN  
MÖNSHEIM



SMART HOME



ADAPTIVE SYS-  
TEMS AS A KEY  
TECHNOLOGY

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<http://www.bertrandt.com/en/references.html>

Testing

## VEHICLE CONVERSION



A very special driving experience

At the Hahnenkamm ski race in Kitzbühel, Audi organised the Audi quattro #SuperQ event. Bertrandt was responsible for preparing and converting the Audi RS3 cars that took part in the competition.

We fitted the cars with a fly-off handbrake, converted the braking systems and adapted the underbody panelling. In addition, we modified the exhausts and equipped the cars with fire extinguishing systems. We installed roll cages inside and adapted the interior trim, furthermore fitted aluminium foot rests. After completing the conversion work, we were also responsible for running the cars and carrying out a safety check.

The 367-bhp Audi RS3 Sportback models competed in Kitzbühel on a track that had been specially prepared by Audi. The Audi works driver Matthias Ekström showed a group of enthusiastic celebrities and athletes how to drive a car close to its limits on ice and snow. In addition to their role in the Audi quattro #SuperQ event, the cars were also used for transporting prominent guests. ■



Interior development

## TRIM SHOP FOR INDIVIDUAL SEAT DEVELOPMENT

As a result of the complexity of the development work involved in current seat projects, sample seats have to be produced, along with prototypes for seat testing. In order to meet the high standards of seat production required, the Bertrandt Group has expanded the facilities at two of its sites: Wolfsburg and Montbéliard. Our specialists develop customised solutions for seats and vehicle interiors. By providing high-quality services and products, they also guarantee that the components they produce will be both comfortable and safe. A combination of the best materials and high levels of expertise results in exclusive products – unique items made by craftsmen. ■

Testing

## INNOVATIVE BRAKE TEST FACILITY

NVH inertia brake dynamometer for measuring brake noise

The NVH version of the GIANT Evo inertia brake dynamometer provides a robust, fully automatic, high-precision simulation and measurement environment for carrying out a wide range of NVH tests under differing climatic conditions. The focus is on eliminating the irritating squeaking noises produced by brakes for a wide variety of reasons. The brake systems are tested in a frame attached to the suspension strut and a complete or partial axle structure.

Inertia brake dynamometer tests the performance and ease of use of brake systems

The GIANT 6200 brake dynamometer can be used to test disk and drum brakes from road vehicles together with their components and original suspension systems, including original axles, from all types of cars and vans. The dynamometer offers single stop and drag braking processes that apply the same stresses to the brake systems as they would be subjected to in road use as a result of the mass and speed of the vehicle being braked. The test bench offers a comprehensive range of functions for fully automated dynamic testing of the performance, wear, service life and disk thickness variation of brakes, as well as tests in wet and foggy conditions. The fundamental physical parameters, such as pressure, torque, speed and temperature, are measured and logged. The test programmes are fully automated and reproducible. ■



A complete front axle is installed ready for testing in the new test chamber.



On the new inertia brake dynamometer, disk brakes are exposed to the same stresses as in road use.

## Testing

## TEST BENCH FOR PRESSURISED ALTERNATING TEMPERATURE TESTS

The Bertrandt Technikum introduces an innovative process

The specialists in gas and fluid dynamics from the dynamics/mechatronics testing department in Ehningen have been running tests with hot gas on EGR systems and intercoolers on behalf of a number of major manufacturers for many years. A new generation of hot gas test benches has now been developed on the basis of their extensive expertise.

The innovative system allows hot gas to be passed through the test specimen while exposing them at the same time to static pressure. The concept, based on an enclosed, recirculating pressure system, allows this type of test, which is highly energy-intensive when run using conventional methods, to be carried out efficiently. The compressed air and electricity consumption is kept to a minimum and this is directly reflected in the attractive prices charged to customers. A condition-

ing unit for passing coolant through the test specimen was developed at the same time as the hot gas test bench, in order to be able to meet customers' individual requirements. A PLC with a touch screen makes the process of entering the necessary parameters simple and flexible. In addition to hot gas testing, the bench also has other operating modes, such as leakage testing and flow resistance measurement. The new dynamometer represents a significant phase in the evolution of an important field of testing and guarantees the competitiveness of the department. ■



## Testing

## ALTERNATING CLIMATE TESTS FOR COMMERCIAL VEHICLES



New salt spray chamber for corrosion testing

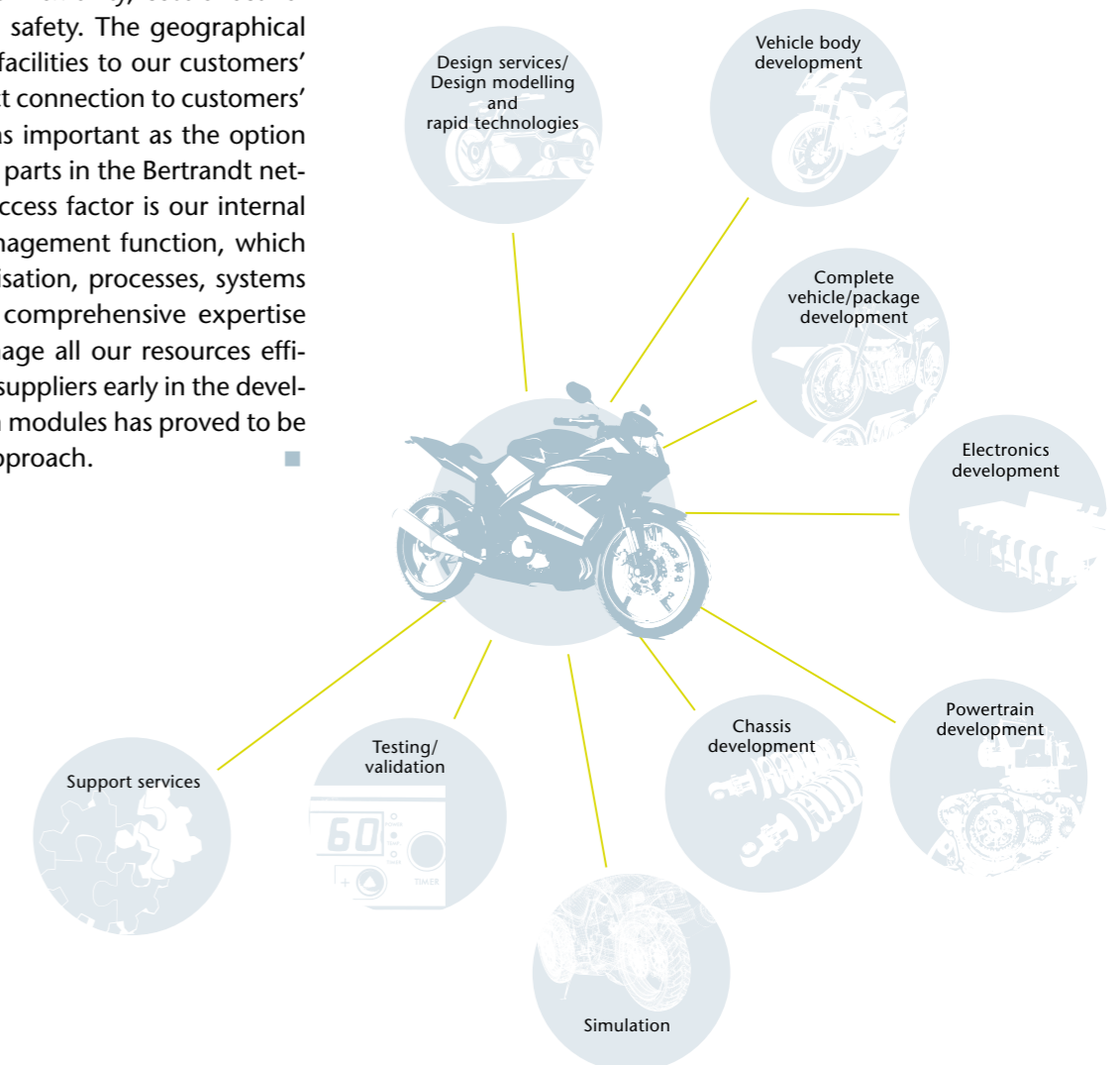
Bertrandt's Tappenbeck site has expanded its range of testing services with the addition of the Köhler HKB 8000 test system which meets the requirements of the VDA 233-102 test procedure. In addition to salt spray testing, it also offers low temperature phases, in order to reproduce real-life conditions as closely as possible. The test cycles give rise to types of corrosion that have only previously been seen in road testing. Furthermore, the chamber can be freely programmed, which means that it can run complex test cycles, as well as meeting the requirements of the conventional salt spray testing standards. The test system has a volume of 8,000 litres and this allows it to accommodate large and heavy components from commercial vehicles. ■

## Motorcycle development

## CREATING CONCEPTS ON TWO WHEELS

The emotional relationships between people and machines are rarely as close as those between riders and their motorcycles. Riding a bike is not always just about getting from A to B, but also about the sensation, the experience of freedom and the direct contact with technology. Our job is to respond to this challenge in engineering terms and the engineers and technicians in Bertrandt's central motorcycle development department have extensive expertise in this area. They develop and implement sophisticated concepts on two wheels to meet individual customers' requirements.

The structure of the department allows us to respond quickly to new demands and to offer high levels of flexibility, cost-effectiveness, quality and safety. The geographical proximity of our facilities to our customers' sites and our direct connection to customers' systems are just as important as the option of manufacturing parts in the Bertrandt network. Another success factor is our internal coordination management function, which covers our organisation, processes, systems and teams. Our comprehensive expertise allows us to manage all our resources efficiently. Involving suppliers early in the development of system modules has proved to be a very valuable approach. ■



## THE MACAN AND BERTRANDT: LIFE, INTENSIFIED

### DEVELOPMENT ACROSS ALL COMPETENCE CENTRES

Maximum acceleration and braking values, vast engine power, extreme agility and optimum steering precision – all these are teamed with a high level of comfort and everyday suitability. The SUV is unrivalled in its flat and broad profile on the road. The wraparound bonnet and gently sloping roof line accentuate the overall impression of sporty elegance and powerful dynamics. Bertrandt provided support for almost the entire product creation process. >





Occupant safety played an important role in Function Development Greenhouse.

### Bertrandt supports Porsche in its new development

With the launch of the Macan compact SUV, Porsche is expanding its range to include a whole new class of vehicle. The smaller brother of the Cayenne combines the typical handling characteristics that Porsche has represented right from the outset. Many of the design elements have been taken from other Porsche sports cars and enhanced for the Macan. It is clear from the very first glance that the Porsche Macan is the first sports car in the compact SUV segment.

Its name comes from the Indonesian word for tiger. And the Macan really does live up to its name: powerful and ready to pounce at any time, yet light-footed and tenacious on off-road terrain. In launching the Macan, Porsche offers sporty all-wheel-drive vehicles across an unprecedented range.

Our many years of creative cooperation with Porsche and the successful support provided by Bertrandt in recent years enabled us once again to take part in complete projects for Porsche. We covered almost the entire product creation process in the development and design of the Macan, which allowed us to offer comprehensive support to our customer. Our experts from almost all Competence Centres were involved in the creation of the Macan: including Body Development, Electrics/Electronics, Powertrain, Interior, Testing, Modelling, Development-Supporting Services, Simulation and Greenhouse Function Development.

An important role in Greenhouse Function Development was played by occupant safety and interfaces to the body in white. Bertrandt was involved above all in the development and construction of the body in white, acting as a solution-finder, idea-provider and imple-

## IN BRIEF

### PORSCHE MACAN



#### Body – body in white

- Wings and side walls
- Roof
- Front and rear end
- Doors
- Adaptation to the platform
- Exterior scopes

#### Body – components

- Integration of air conditioning components
- Cockpit integration
- Air ducts
- Heating circuit
- Integration of auxiliary heating, incl. fuel lines

#### Electrics/electronics

- Diagnosis development
- Commissioning/support for engine electronics, vehicle diagnosis and measuring systems
- Change management in wiring harness development
- Off-board diagnosis for Porsche tester

#### Powertrain

- Test support – integration of Group sub-assemblies
- Support for project management/change management
- Development/design of engine peripherals

#### Interior

- Greenhouse function development
- Lower pillar trim
- Carpets, damping materials and functional parts

#### Testing

- Curtain and thorax airbag development
- Testing of longitudinal trim and bumpers

#### Simulation/calculation

- Body in white – strength/abuse
- Doors/closures – stiffness/strength
- Complete vehicle – pendulum calculation/driving simulation

#### Modelling

- Construction of photo and film vehicles
- Assembly support for vehicle construction
- Coating of interior and exterior components

#### Development-supporting services

- Prototype logistics
- Project procurement
- Greenhouse project management, incl. project management support, to achieve schedule, cost and performance targets
- Technical documentation



Powerful and ready to pounce at any time: the Macan.

menter. State-of-the-art technologies were integrated, and interfaces and processes were optimised. Our aim was to be a reliable development partner and system integrator in order to consistently improve the process from the initial idea to the finished product. In the field of simulation, Bertrandt was able to apply its many years of experience and the targeted use of virtual CAE tools even at early stages of development, thus preparing the ground for achieving the functional targets. In this way, we made sure that simulation improved efficiency in the Macan project.

Macan and Bertrandt: our specialists responded to the challenge and successfully supported Porsche along the entire product development process of the Macan. ■

*Dr. Holger Müller, Achim Theurer, Mönshheim*

# RENAULT ESPACE: COMPLETE VEHICLE DEVELOPMENT

COMPREHENSIVE PROJECT MANAGEMENT  
FROM THE PRE-PROJECT PHASE THROUGH  
DEVELOPMENT TO PRODUCTION

Because of Bertrandt's extensive experience of automotive engineering, the company was chosen by Renault as one of its partners for the development of the new Espace. The challenges faced by the team included the high standards set for the car itself and the class of cars in general, combined with ambitious cost-saving targets. >







The fifth generation of the Renault Espace: travelling in French style.



Modern design combined with the latest technology: the full-LED headlights.



The Renault Espace: a revolutionary cockpit and a large panoramic roof.

### Renault is once again a leader in the premium class

When it was first launched in 1984, the Espace was a pioneer in the people carrier segment, offering plenty of space for a family and its luggage. The concept of the Espace and its equipment were innovative, including, for example, the variable seats, which at the time were a revolutionary development. The fifth generation Espace provides added comfort and high-tech features, together with a new type of modularity in crossover form. The Bertrandt team was involved in developing the rear seats, which are equipped with an electrical control system that allows them to be folded automatically and fully lowered into the luggage compartment. The headrests can also be lowered at the press of a button. Our specialists also developed the massage function for the front seats and the state-of-the-art seat rail position sensors. The Espace V puts Renault back in the premium segment.

### Development activities including the new platform

In the very early project phases, Bertrandt was tasked with creating the test vehicle that would be used later for designing and defining prototype components. Our design work for the front and rear axles also involved us in the development of the new CMF1 platform. Because of the electrical and electronic systems, a variety of different minor adjustments had to be made to the mechanical components and the engine in order to meet the customer's expectations. In addition, our engineers were responsible for developing many exterior, interior, engine and chassis components. We also worked on these components right through to the production phase on the new CMF1 platform in Douai.

## IN BRIEF

### RENAULT ESPACE



- Body and interdisciplinary activities
- Interior and exterior equipment
- Chassis
- Architecture
- Electronics, electrics
- Cost, quality and competitive analyses
- Project management
- Supplier management

### Central interface role


During the development of this luxury car, the focus was on customer quality. The manufacturer set very high standards for its suppliers and partners. In this respect, Bertrandt acted as a central point of contact between the customer and its suppliers. We took on the responsible role of acting as the key interface, which involved managing the milestones that are a standard feature of Renault's work package project management system. New follow-up tools were developed to make project management and communication easier and to shorten the response times of the teams.

### End-to-end project management

For many components, Bertrandt took full project management responsibility from development through to production. For the chassis, the emphasis was on ease of assembly, which involved the effective coord-

ination of all the activities and detailed adjustments to parts from different departments. Supporting the suppliers was also an important task. One example of this is the development of the panoramic roof where the supplier needed support in the form of Bertrandt's in-house expertise in developing doors and closures. Bertrandt provided help with the construction and start-up of new machines, in particular test benches. In order to meet the manufacturer's quality requirements, perfect interdisciplinary coordination and communication was needed to allow solutions to be developed for minimising noise and for improving ergonomics and the bonded joints. We were also able to reconcile Renault's design requirements with the technical specifications in the case of the tailgate and other exterior and interior components, such as the full-LED headlights and other lighting and visibility elements. ■

*Sylvie Fourny, Paris*

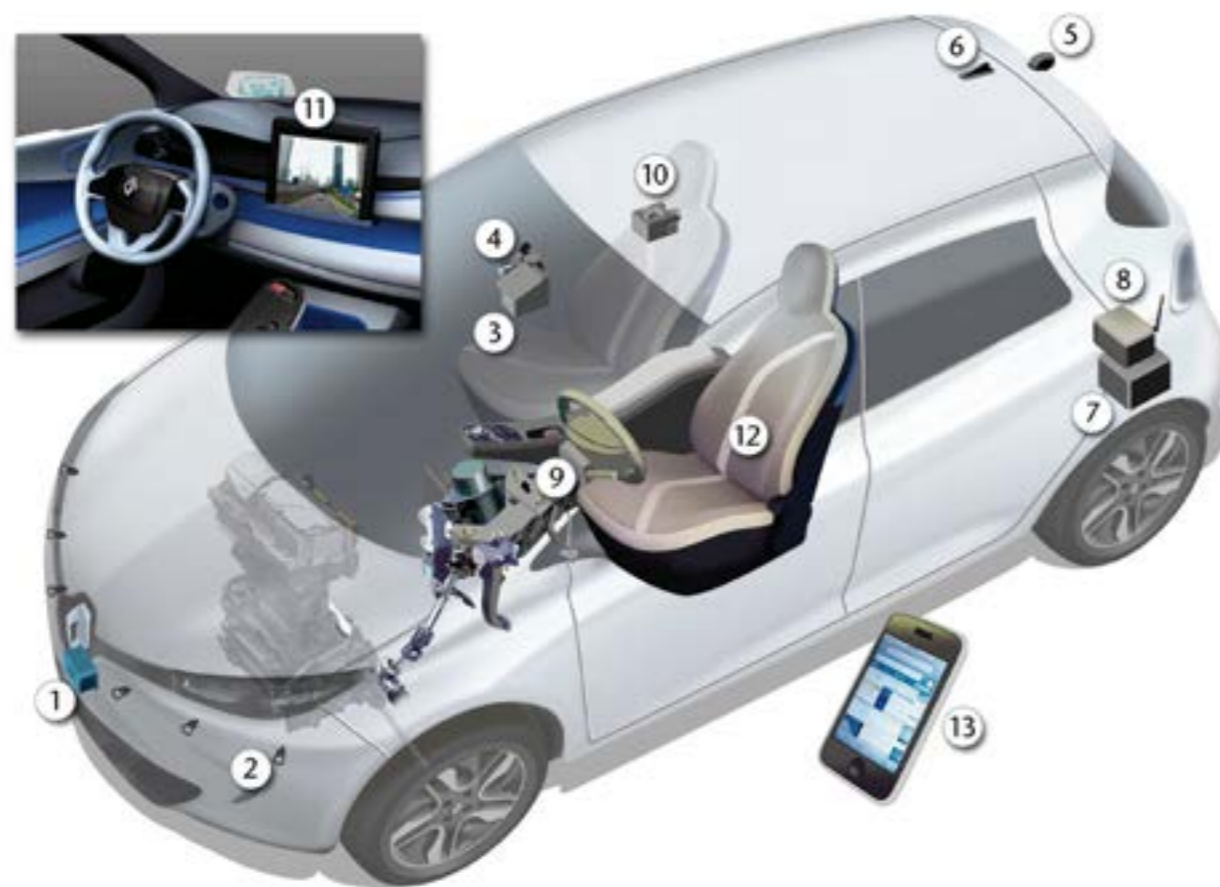


## THE RENAULT "NEXT TWO": AUTONOMOUS AND CONNECTED DRIVING

### DEVELOPING ELECTRONICS SYSTEMS FOR THE VEHICLES OF TOMORROW

The "Next Two" prototype is Renault's vision of an autonomous car, which is likely to be launched in 2020 and is based on the electric production model, the Renault Zoé. The very first driver assistance systems were wired, but recent rapid advances in the field of electronics have made it possible to introduce completely new in-car connectivity functions, even in medium-sized models. The requirement was to develop a reliable system at a price suitable for volume production. Bertrandt was responsible for designing and implementing the software for the central control unit. >





#### Based on assistance systems

The “Next Two” prototype can detect its environment using sensors that have been added to the basic version of the Zoé. The long-range radar sensor in the front bumper identifies the vehicles ahead, their speed and other obstacles over a distance of up to 200 metres. An infrared camera on the windscreen detects the road markings and helps to position the vehicle in its lane. The direct environment is evaluated by ultrasonic sensors all around the car. These are sensor models that are close to production readiness and have already been used in driver assistance systems. This means that they meet the requirements for cost-effectiveness.

#### Switching to autonomous driving

The driver can activate automated driving mode manually, if the car is on a motorway where there are no pedestrians or cyclists. The top speed is currently restricted to 30 km/h and the system will not make any

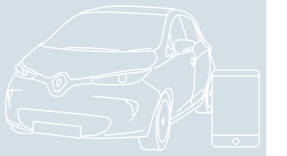
automatic lane changes. These restrictions are designed to represent a traffic jam on a motorway or a city ring road. In autonomous mode, the driver can take over control again at any time. The “Next Two” will also suggest to the driver that it switches to autonomous mode if the conditions are right.

#### Short development times

Bertrandt designed and developed the software for the central control unit in the autonomous drive function. The overall development process focused on three functions: longitudinal guidance, lateral guidance and the control strategy. Bertrandt based the longitudinal guidance function, which is responsible for acceleration and deceleration, on an existing radar-based adaptive cruise control system and added braking and stopping functions to it. This allows the vehicle's speed to be adapted depending on the road conditions, in particular by restricting the acceleration permitted on bends. One of the challenges involved using and integrating

## IN BRIEF

### ELECTRONICS DEVELOPMENT



- Software and architecture design
- Development of control algorithms (software) using Matlab/Simulink
- Creating an MiL (model-in-the-loop) including MiL approval
- Rapid prototyping and approval in the car

- 1 Radar
- 2 Ultrasonic sensors (front/rear)
- 3 Front camera for autonomous driving mode
- 4 Front camera for navigation and augmented reality
- 5 Rear camera
- 6 Multiband antenna: GPS, Wifi, Wave, 2G to 4G
- 7 Control units for autonomous driving mode management
- 8 Secured modem
- 9 Automated vehicle's operating controls (steering, pedals ...)
- 10 Video-conference camera
- 11 Distributed HMI: semi-transparent mirror for augmented reality, large tactile multifunction display, customisable instrument panel
- 12 Connected massaging seat
- 13 Driver's smartphone

production components, most importantly the engine control units. These were not designed for use in an autonomous system, which meant that a particularly complex control function had to be developed.

The lateral guidance function is responsible for the vehicle's electric steering. In this area, Bertrandt had full responsibility for the control algorithm. The aim was to develop a robust strategy which was not sensitive to brief interruptions or a temporary lack of sensor data. The overall control system, which brings together all the car's control strategies, was defined using finite state machines. Particular attention was paid to developing the transitions between the states to ensure a smooth and flowing driving style. A fault management system and emergency functions were put in place for all three functions in order to ensure the safety of the car in all driving states and situations.

Despite the complexity of the system, the development of these functions took only nine months. The engineers provided services covering the entire V-model from the

specifications to the functional testing on the road. The software was developed as a model-based design using Matlab Simulink. The concept phase required an MiL (model-in-the-loop) simulation environment to evaluate the dynamic driving style. All the integration and validation phases were kept short by using an HiL rapid prototyping toolkit.

Since the prototype was first built, a number of functions have been developed further. These include the lateral guidance function which will form the basis for the new lane departure warning system in the Renault's latest models. ■

*François Caresche, Paris*

THE FORD GLOBAL COMMERCIAL VEHICLE PROGRAMME:

# INTERIOR DEVELOPMENT



## CROSS-SITE PROJECT MANAGEMENT SKILLS OFFER ADDED VALUE

The high-quality network that links the individual Bertrandt sites is an essential feature of the company's projects. Our customers are increasingly expecting greater flexibility in the implementation of projects, which results in project work being carried out at different Bertrandt facilities. Because of the creative solutions they offered, the competitive prices, their geographical proximity to the customer and the expertise of the Bertrandt Group, the sites in Cologne and Turkey were awarded a contract by Ford Otosan to develop a variety of interior components for the cabs in Ford's global commercial vehicle programme. >



Ford global commercial vehicle programme: a reliable partner for long-haul transport.

#### Development partner

Cooperation across national borders was the key feature of an attractive interior project for our customer Ford Otosan. In line with the "one for all" management strategy, the Bertrandt sites in England and Turkey, together with the Cologne site which played the leading role, cooperated on developing new solutions. The balance between the technical and project experience of the teams in Cologne and Dunton as well as the process expertise of the specialists in Turkey has resulted in a number of positive synergies during the course of the project, which is still underway. The internal Bertrandt project management organisation guaranteed the use of standardised processes and, at the same time, provided support for all the organisational issues on the project. In addition, our internal knowledge database allowed the project team to access the lessons learned from other projects at any time, but also to add their own experiences on a daily basis.



The cab is clearly laid out with an attractive design and a high level of functionality.

#### Developing the interior of the Ford Cargo

The development of the interior features that Bertrandt was responsible for consisted mainly of the CAD design of new, attractive and functional interior trim components and rest areas for the driver across a range of different vehicles. The Bertrandt project engineers also took charge of managing the interfaces with all the relevant development departments to ensure that the components were suitable for manufacture and met the cost and scheduling requirements.

## IN BRIEF

### FORD GLOBAL COMMERCIAL VEHICLE PROGRAMME



#### Interior:

- CAD development of side trim components and storage facilities in the cab
- Interface management by project engineers for the development components

#### Project management:

- Project guidance and controlling
- Internal and external reporting
- Adhering to the project schedule and quality requirements in accordance with the customer's development plan

#### Bertrandt sites:

- Cologne and Turkey



Perfect interior: ergonomic design for easy driving, well-designed compartments and storage areas for greater safety on the road.

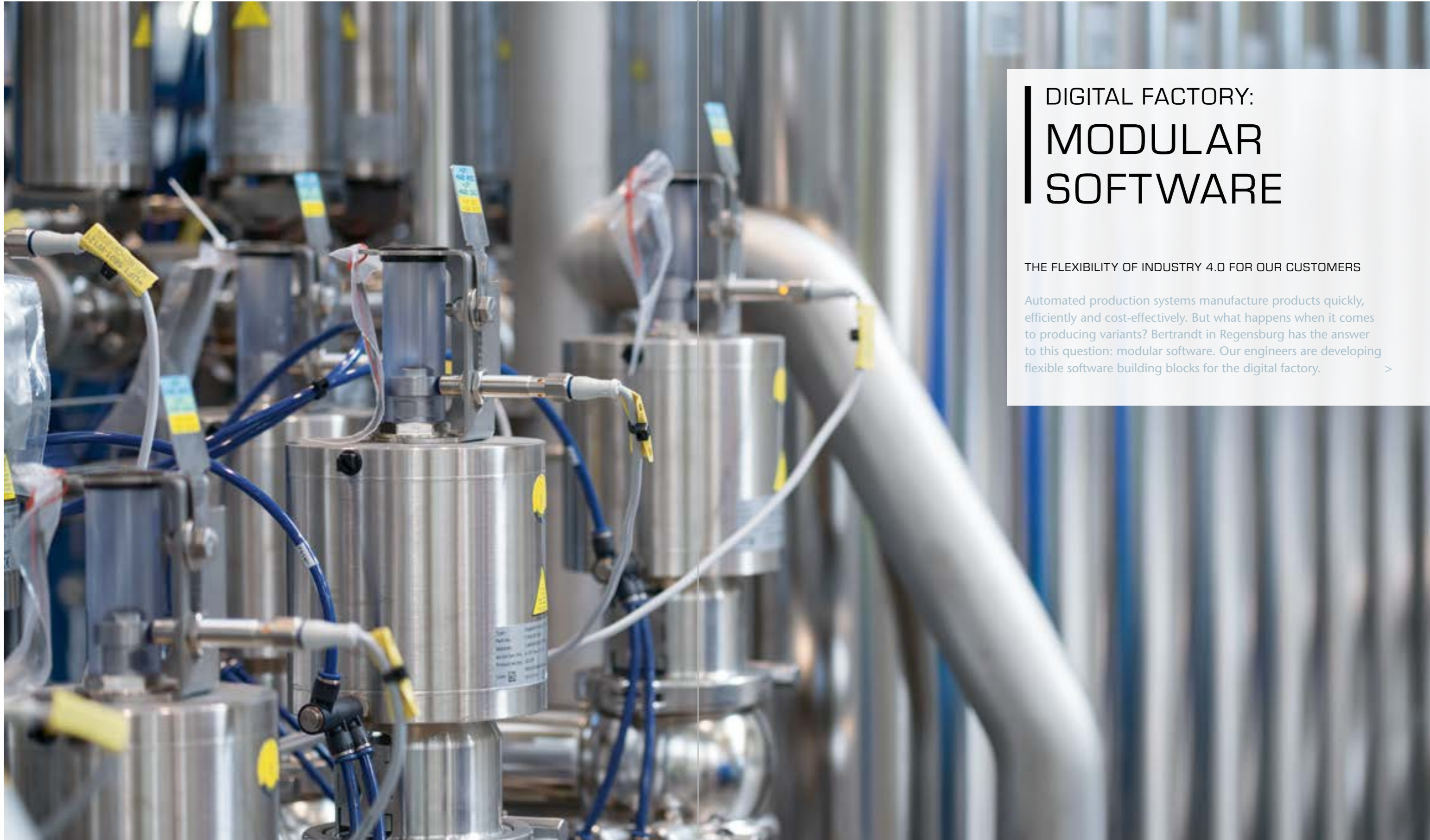
#### Project management

The tasks of the project management team included managing all Bertrandt's project activities and weekly reporting on the progress of the project to the customer. In addition, adhering to the customer's development plan, together with its scheduling and quality requirements, was mandatory. Well-organised, confidence-giving weekly management meetings were held to track project progress.

#### Conclusion

In this project, Bertrandt has once again had the opportunity to offer a customer its entire range of services across different sites. The promising progress made so far on the Ford global commercial vehicle programme project strengthens our resolve to develop our network further. ■

*Kay Schrader, Cologne; Salih Yilmaz, Turkey*



## DIGITAL FACTORY: MODULAR SOFTWARE

THE FLEXIBILITY OF INDUSTRY 4.0 FOR OUR CUSTOMERS

Automated production systems manufacture products quickly, efficiently and cost-effectively. But what happens when it comes to producing variants? Bertrandt in Regensburg has the answer to this question: modular software. Our engineers are developing flexible software building blocks for the digital factory. >



Sophisticated production methods: all the processes must interact seamlessly.



The filling, closure and labelling processes can be preceded by the manufacture of the plastic bottles.



Digital software modules control the plant components.

#### Industry 4.0 increases flexibility

Industry 4.0 is an important trend in high-tech industries. It involves combining production facilities with modern information and communication technology. In future, people, machines, logistics systems and products will be able to interact directly with one another, with the aim of making the value-added process more efficient and more flexible. The technical basis consists of networked digital systems, which are used to create self-organised production facilities in smart factories. This brings significant benefits, such as the ability to produce different variants of a product using just one machine. The goal is to make automation more flexible, for example in the complex production machines built by the machinery manufacturer Krones for drinks bottling companies.

#### Digital modules for the smart factory

One requirement for a machine could be the ability to bottle different alcoholic and

non-alcoholic drinks. The containers would include cans, PET bottles and glass bottles. The solution is a bottling machine that covers closure and labelling systems. In the best case, a system of this kind can produce a variety of products or enable the company to add to its product portfolio without the need to build a new production facility. It allows for flexible automated manufacturing without costly conversion work, long changeover times or the complex redesign of the control software. This is where our team of developers comes in. They ensure that the right software is available to allow the hardware, which can consist of individual machines or complete plants, to meet all the requirements. IT specialists create the digital building blocks for the smart factory: software programs that control the plant components. The different modules are highly flexible and this enables plants to perform a variety of tasks at short intervals or to process different products.

## IN BRIEF

### MODULAR SOFTWARE FOR THE DIGITAL FACTORY 4.0

- Developing and adapting software modules
- Mechanical design with Solid Edge
- Electrical design with E-Plan and RACOS
- Machine start-up
- Software library maintenance
- Process engineering

#### Thinking and planning in functional terms

From a project perspective, the sequence of events is as follows. The customer plans a new bottling plant. Sometimes it will just fill the bottles, fit the closures and apply the labels. At other times, it is connected to the production line for plastic bottles, which is directly upstream. The product that the bottles are being filled with is not one substance, but a mixed drink, and this means that an additional machine, the mixer, is required. At the end of the process, it is not only the products themselves that will leave the production line. They must be packed and stacked on pallets, made ready for dispatch and picked for delivery to different customers. All of this must be done at a reasonable cost by one machine.

#### Designing modular software

Standard software cannot provide the necessary flexibility and writing the code from scratch every time is too costly. For this reason, the Bertrandt team has developed an efficient

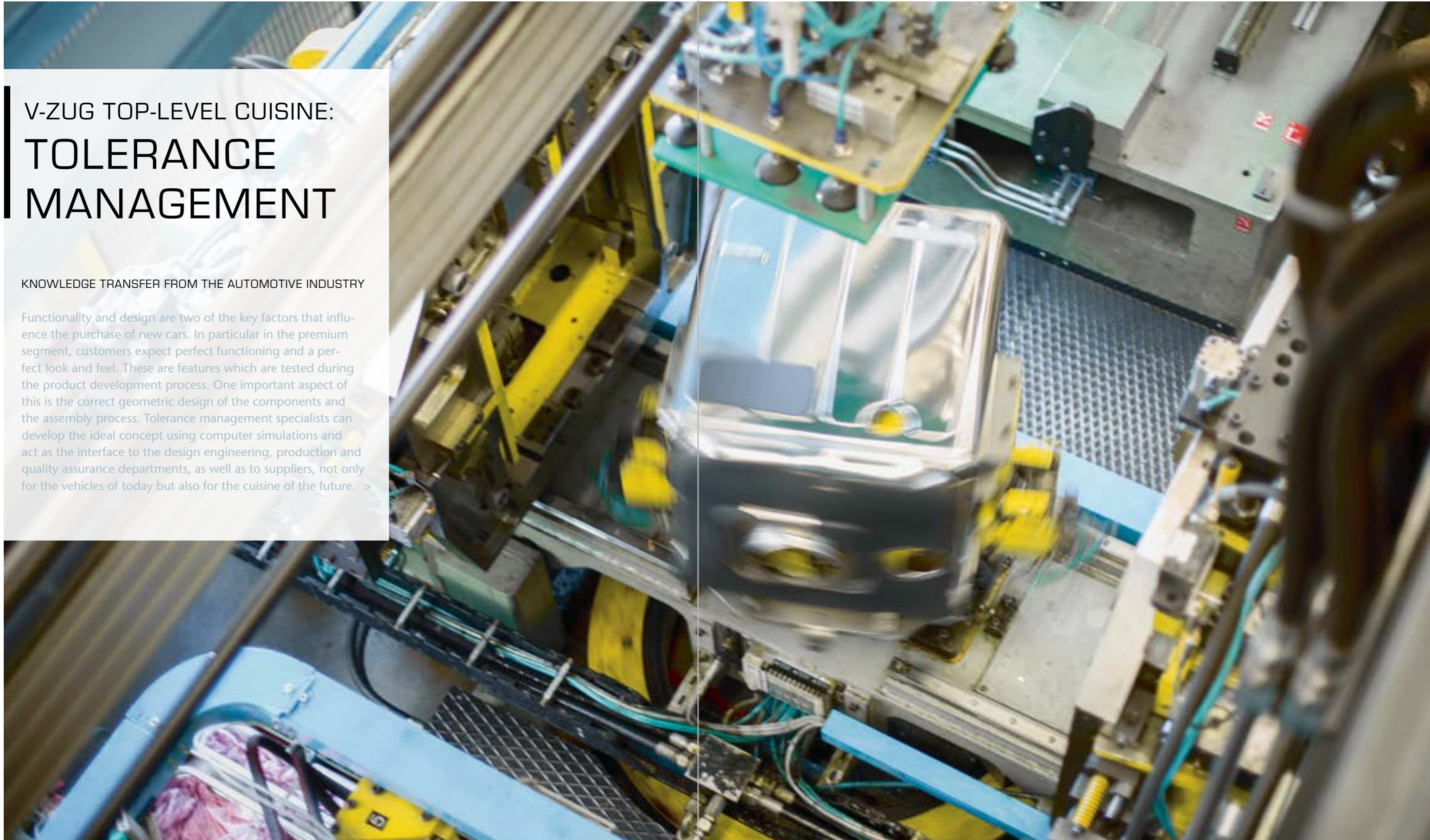
strategy which involves controlling the individual components of the machine with software modules. Each of the modules can only perform one task, but they do so highly reliably and without the involvement of other areas of the program. Using machine parameters, for example the conveyor belt speed required, and type parameters, such as the filling pressure, the modules can be set up specifically for their individual task. Because they are customised to meet particular requirements, a set of type and machine parameters is produced for each product and these sets of parameters can be accessed from the software library every time the machine is changed over to a new product. The result is a series of software modules which allows soft drinks, mixed drinks, beers and mineral water to be bottled in a single plant with very short cleaning and changeover phases. The software library is constantly maintained to ensure that it is always up-to-date. In conclusion, it is clear that the software building blocks offer the necessary flexibility to meet the requirements of Industry 4.0. ■

Norbert Wagner, Regensburg

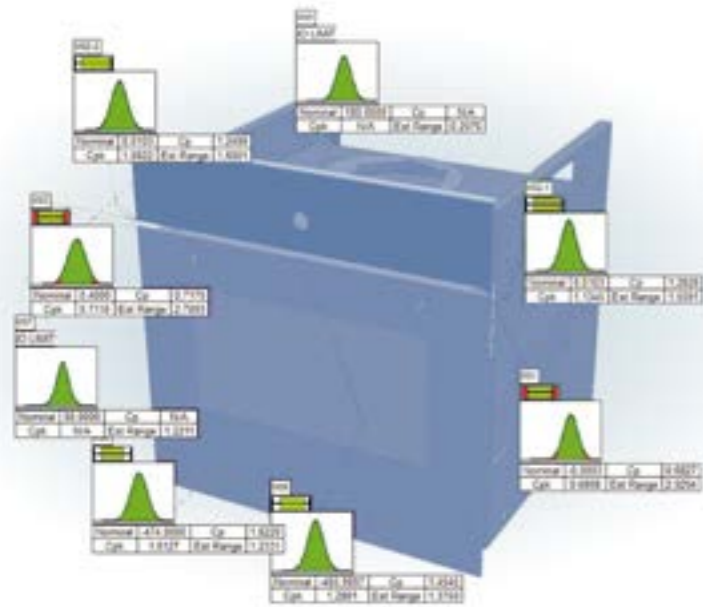
## V-ZUG TOP-LEVEL CUISINE: TOLERANCE MANAGEMENT

### KNOWLEDGE TRANSFER FROM THE AUTOMOTIVE INDUSTRY

Functionality and design are two of the key factors that influence the purchase of new cars. In particular in the premium segment, customers expect perfect functioning and a perfect look and feel. These are features which are tested during the product development process. One important aspect of this is the correct geometric design of the components and the assembly process. Tolerance management specialists can develop the ideal concept using computer simulations and act as the interface to the design engineering, production and quality assurance departments, as well as to suppliers, not only for the vehicles of today but also for the cuisine of the future. >







Tolerance management: a preventive method which ensures high levels of quality and functionality. The relevant components are coordinated with one another in the early phases of development.



Close cooperation between the development, production, assembly and quality assurance departments during the introduction of tolerance management.

The Swiss company V-ZUG AG realised that the requirements of the automotive industry could be transferred to other products. For more than 100 years, V-ZUG has stood for Swiss quality. This high-tech company has over 1,400 employees who develop and manufacture high-quality household appliances which make people's lives easier and fulfil all the requirements for a premium product. More than 4.5 million appliances are currently in use throughout Switzerland, which makes V-ZUG the market leader in the white goods sector. Alongside pioneering world exclusives, such as the GourmetSteam programme and cooking sensors for the kitchen, and world records in energy efficiency, the Swiss manufacturer also has comprehensive design expertise which leads to a harmonious combination of function and aesthetics.

#### Pilot project highlights potential

In order to make further technological progress and set new standards of product quality, V-ZUG is relying on expertise from the

automotive industry. As an engineering service provider, Bertrandt is closely involved in the development of a new generation of ovens. Bertrandt's role is to integrate tolerance management into the product development process. The aim is also to improve the quality assurance and production processes. All of these changes began in the development department where the employees realised that the tolerances on the drawings no longer provided adequate or complete descriptions of the components and assemblies or met the company's new and higher standards for the technology and appearance of its products. During a training course, we were able to show the kitchen development team the current tolerancing options and explain their possible applications. In the course of another pilot project, Bertrandt investigated the component and assembly concepts of the current generation of ovens using 3D tolerance simulation. The potential identified during this investigation led V-ZUG to introduce tolerance management into the development process for its next generation of ovens.

## IN BRIEF

### V-ZUG TOP-LEVEL CUISINE



#### Tolerance management

- Process implementation
- Training on form and location tolerancing
- Functional dimensions
- Assembly concepts
- Fixture concepts
- Tolerance simulation



High standards for premium products: tolerance management brings together function, design and quality.

#### Introducing tolerance management

Since early 2015, Bertrandt has been closely involved in the development of the new generation of products. A number of templates and guidelines were produced in time for the project kick-off meeting in consultation with the management of the design engineering department. The aim of these was to make it easier for the teams to become familiar with the subject and to ensure that a complete documentation set was available. The design engineers were introduced to the project goals and the contents of the training during special events. The completely new tolerance concepts and process stages called for closer cooperation with the production, assembly and quality assurance departments. For this reason, introductory events were also held in these areas to simplify the coordination process as well as the feasibility studies and to ensure that the change was widely accepted.

After the successful start of the project, the tolerance management process began with the definition and description of the functional

dimensions in order to transform the visual and technical requirements into measurable figures. Compliance with these functional dimensions was also an important factor in evaluating the success of the project. During the next stage of the project, Bertrandt produced a concept for the assembly sequence on the basis of the styling data. The concept was used to carry out the first feasibility studies and to identify dependencies between the components. After this, the position of the components in relation to each other was defined by means of fixture concepts. The initial evaluation of the concepts took the form of a tolerance simulation in which several variants were compared. The interpretation of the results provided valuable information about the quality of the different concepts in relation to the functional dimensions that had to be complied with. Tolerance management has improved the quality of the development process at an early stage. The next objective is to increase the maturity of the components and to make further progress with integrating the tolerance management process. ■

Martin Pflieger, Ehningen

## DEVELOPING INDIVIDUAL SOUNDSCAPES FOR MODERN CARS

### 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

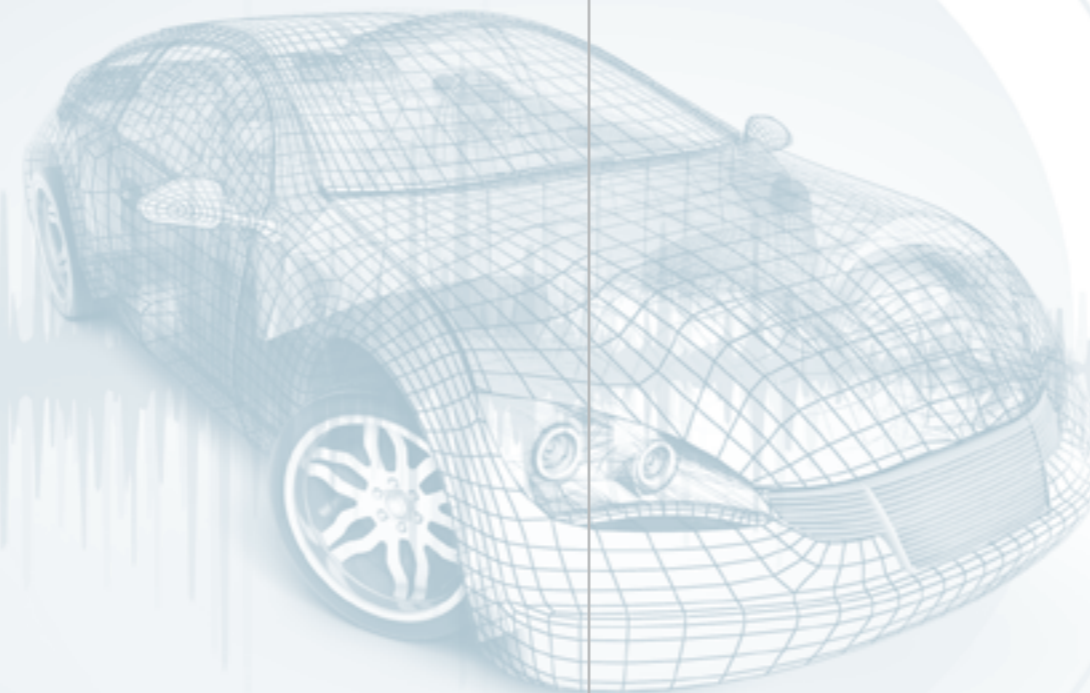
- Sounds of doors closing/other shutting noises
- Wind noise
- Combinations of materials

#### 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



#### 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

#### WHEELS/TYRES

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



## “WHAT WILL THE CAR OF THE FUTURE SOUND LIKE?”

AN INTERVIEW WITH MATTHIAS TRESCHER, HEAD OF THE ACOUSTICS DEPARTMENT IN MUNICH



**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.

Our customers always benefit from what the entire Bertrandt network has to offer.

ordinator agreed the dates with the customer and defined the precise scope of the tests. Subsequently, the testing package was passed to our specialists who ran the entire project,

**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.

We play a very active role in the workshop and in preparing the vehicles. We are also involved in structural analysis and dynamics, modal analysis and vibration comfort. In addition, we work on the powertrain. A good example of a project was the first prototype of a new model derivative that needed to undergo structural dynamic testing. Our project coordinator

agreed the dates with the customer and defined the precise scope of the tests. Subsequently, the testing package was passed to our specialists who ran the entire project, including organising the vehicle, ensuring that it was suitable for testing and equipping it with acoustic and vibration measuring equipment. They then carried out the tests, documented the features agreed with the customer and produced a test report. After this, the vehicle and the measurement results were returned to the customer.

**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.

**How important do you think acoustics will be in the next ten years?  
Which areas will you need to focus on?**

In the premium segment in particular, comfort will remain the key differentiating factor.

”

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 SASSENBERG SITES

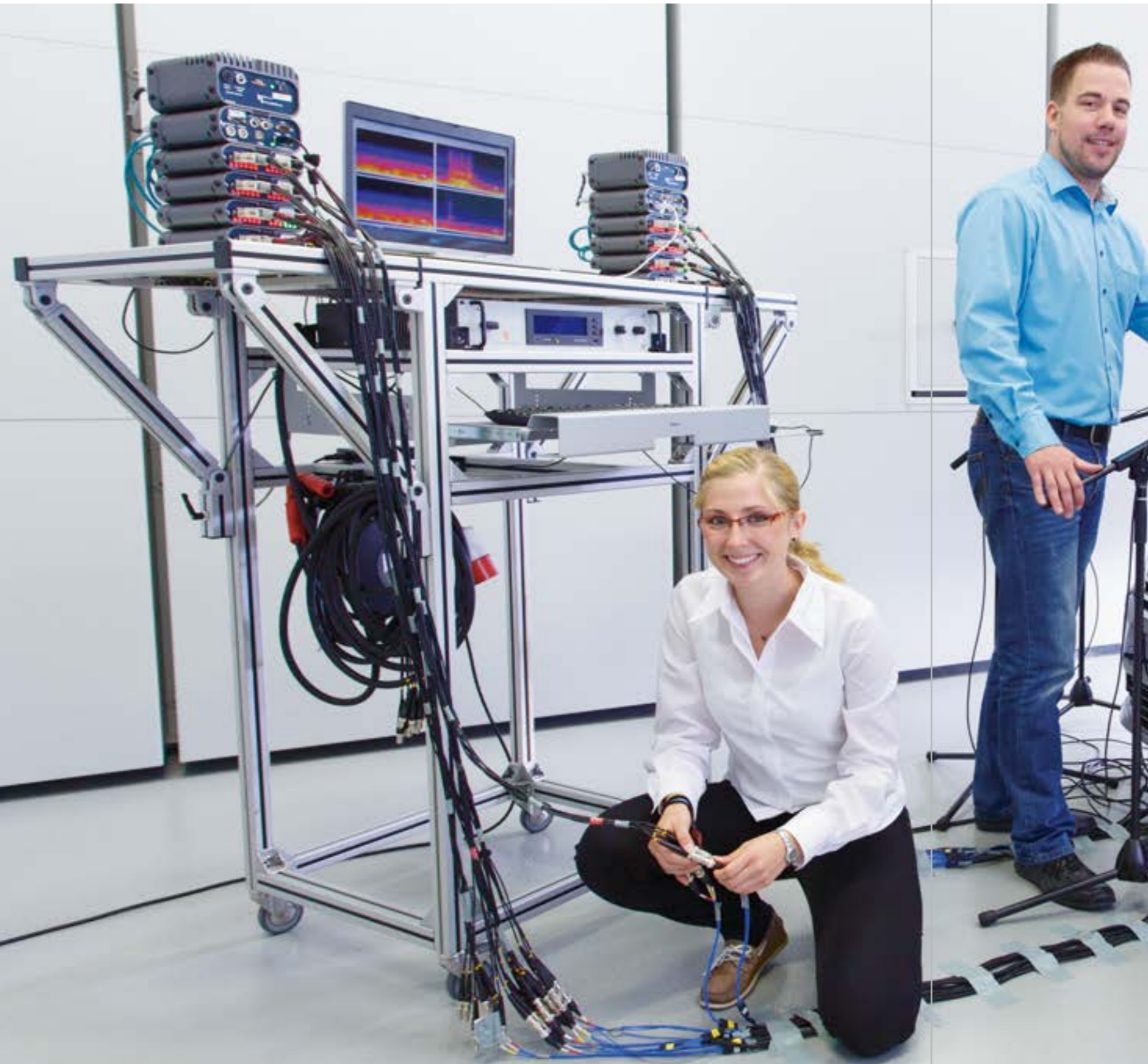


**The role of acoustic development services has changed significantly over the last 20 years. What are the main trends that influence your work?**

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.

### Individuality is an important factor.

experience in the field of acoustics. We can offer everything from traditional development services and simulation to extremely well-equipped testing facilities, which

#### 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

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 Apamat 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 interviewer was Gudrun Remmlinger.*



## 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 build-

ing 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. ■



## LOW-FREQUENCY SIMULATION OF COMPLETE VEHICLE ACOUSTICS

PREDICTING INTERIOR NOISES FROM THE SOURCE TO THE EAR

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 representation of the air spaces plays an important role in evaluating the acoustics of complete vehicles. Vibrations spread through the structure of

the vehicle, influence the air inside and reach the ears of the occupants in the form of pressure waves. Simulation enables the waves to be traced and produces an accurate prediction of the noise level inside the occupants' heads.

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*





## NVH IN COLOGNE

### ACOUSTIC SERVICES FOR COMPLETE VEHICLES

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. 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.

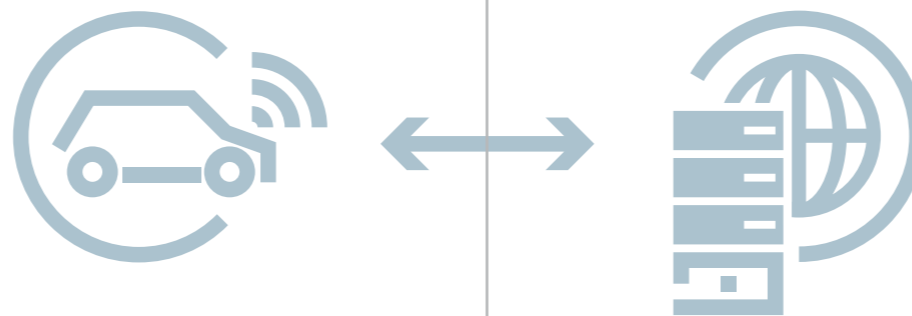
*Jochen Göbels, Cologne*



## THE ROUTE TOWARDS AUTONOMOUS DRIVING

### BERTRANDT DEVELOPS ADAPTIVE SYSTEMS AS A KEY TECHNOLOGY

On the basis of a characterisation of driving style, Bertrandt has improved human-machine interaction with the aim of increasing the acceptance of driver assistance systems and gaining the confidence of vehicle occupants. The results of this process show that the recognition of a car's environmental conditions and the ability of the car to adapt to the driver are two important aspects of fully autonomous individual transport. In future, adaptation to the driver will help driver assistance systems to become more widely accepted and to make autonomous driving a permanent part of our everyday lives.



Assistance systems are intended to support the driver with the longitudinal and lateral guidance of the car and to ensure that he or she has a safe and comfortable journey. One of the most familiar systems is cruise control, which keeps the car at a constant speed chosen by the driver. A further development of cruise control is automatic distance control. This uses radar sensors to identify vehicles on the road ahead and to ensure that the car remains a specified distance away from them. Oncoming traffic and stationary obstacles are ignored by the system. If predictive route data are included in the evaluation, the car's speed can already be adapted to the road topography. This allows the system to act autonomously on bends and hills so that the car can be driven more fuel-efficiently. Alongside the road topography – features such as bends, roundabouts, junctions and inclines – speed restrictions are identified using map data and camera sensors. The predictive automatic distance control system can therefore respond to the situation on the road ahead by reducing or increasing the

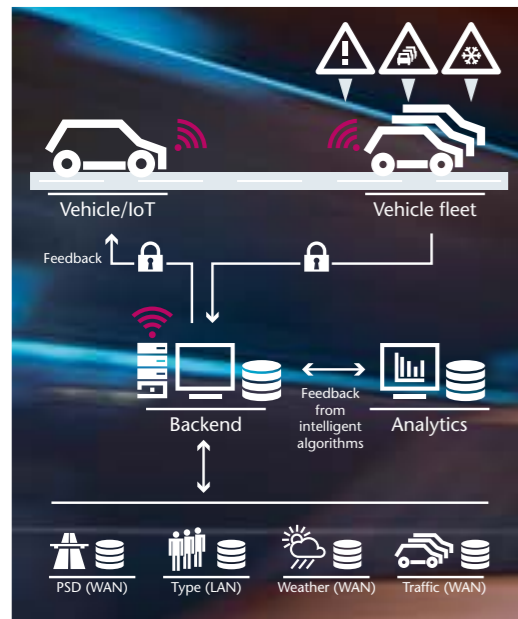
car's speed, which means that the driver can have a stress-free journey without the need for intervention. In order to ensure that the car moves smoothly and easily between different speed areas, which are determined by the road topography and the speed limits, the system uses the best possible combination of braking, acceleration and coasting.

### Adaptive driver assistance systems increase confidence

Studies have shown, however, that most people prefer conventional driving to autonomous driving. Despite this, the public's views on the development of self-driving cars have been largely positive over the last three years. In order to increase public acceptance of driver assistance systems and to gain the confidence of vehicle occupants, the driver must be included in the control process. This involves analysing the car's environmental data and the driving style, so that the assistance system can be adapted to the driver's behaviour. The combination of intuitive interaction with the assistance system and its improved responses to new situations will help the driver to feel that the car "understands" him or her. At the same time, the driver will perceive the system to be more reliable.

### Environment detection and analysis

Firstly, the car's environment is analysed by means of data fusion and data enrichment. The enrichment process helps to group the environment data and to create logical links in order to generate a higher information content (smart data). Radar, cameras and acceleration sensors are used for this purpose. The signals from these different sensors allow the road conditions, traffic information, time of day and season to be identified. As a consequence, the assistance system can, for example, increase the distance from the car ahead in poor visibility or reduce the speed on bends when there is snow on the road. >



Data protection and data security play a central role in the processing of big data and are also key considerations in the design of the system architecture.

### Driving style analysis

The second part of the system's adaptive functions relates to the analysis of the driver's driving style. It allows the driver to be characterised using key attributes such as sportiness, safety consciousness and fuel efficiency. In order to continue assessing the driving style, the system monitors the driver's behaviour in specific situations. A range of different measurements are used for this purpose, such as acceleration from a standing start, average speed on motorways without speed restrictions, average lateral acceleration on bends and distance from the vehicle ahead.

### Adapting to the driver

Algorithms are used to bring together the information about the environment and the driving style data. The combination and the interaction of the two areas enable the driver assistance system to adapt to the driver. The goal is for the system to behave in a range of different situations in the same way as the

driver would have done. As a result, the driver will feel that the system "understands" him or her.

### Backend and data security

As the control units in the car currently do not have enough computing power to process the data and run the different algorithms, a modern vehicle architecture with a powerful backend system is needed. Firstly, the data are recorded, fused and enriched in the car and certain time-critical calculations are made. All of this information is then sent to the backend, which carries out the complex and non-time-critical calculations that allow the system to adapt to the driver. However, it must be possible for the system in the car to function at all times without a connection to a server. This functional safety requirement must be taken into consideration during the design of the system architecture. In order to make the processing of big data manageable, the data are enriched to form smart data by filters in the car, algorithms



The three factors which allow driver assistance systems to adapt to drivers: an analysis of driving style, driver identification and the recognition and evaluation of the car's environment.

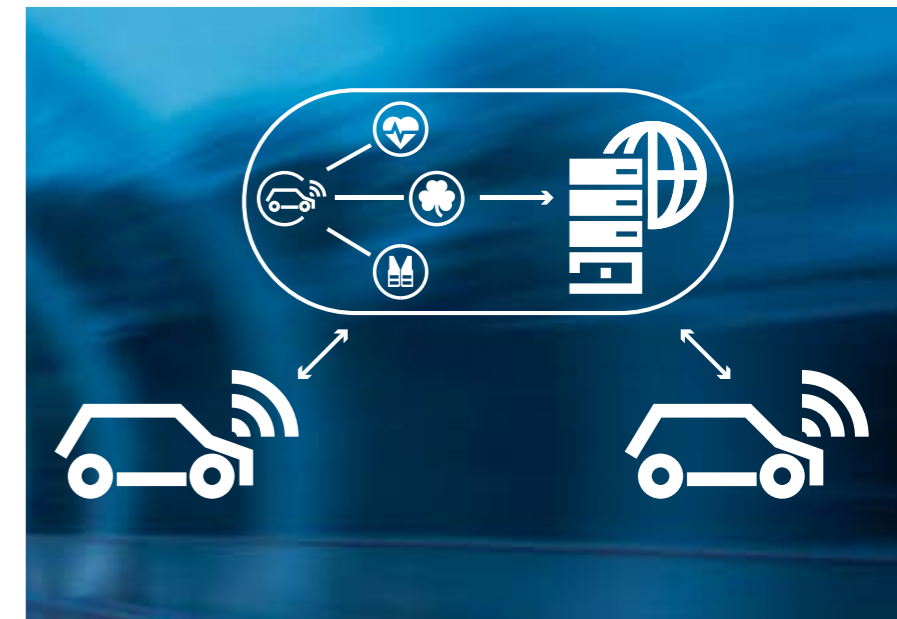


Information from the web, such as traffic details and weather forecasts, can be used to further enrich the vehicle data in the backend system.

in the communication control unit and the backend system. This process makes the data traffic more efficient and improves security. Factors such as data protection and data security play a key role in this respect, because it is essential to prevent attacks on the path taken by the data between the car and the backend. Unauthorised access to the data could lead to a third party taking over control of the car, to the car carrying out incorrect manoeuvres or to sensitive data being stolen. For this reason, this subject needs to be taken into careful consideration at the start of the development process and all the risks and functions must be thoroughly evaluated.

### On the road to autonomous driving

Bertrandt has already worked in the past with driver assistance systems and the centralised processing and interpretation of sensor data. It has also been involved in human-machine interaction on the basis of the characterisation of driving style. The results indicate that the identification of a car's environmental



Sporty, safety-conscious or fuel-efficient? In order to identify each driver's style, a backend system is added to the standard vehicle architecture and is used to run non-time-critical calculations.

conditions and the car's ability to adapt to the driver are two fundamental factors in the development of self-driving vehicles.

Bertrandt is currently running a study in cooperation with a university of applied sciences which is investigating to what extent drivers' own assessment of their driving style corresponds with an external evaluation and with measurements of driving dynamics. The ability of driver assistance systems to adapt to individual drivers and the accompanying increase in data security will improve the acceptance of the systems. This key technology represents an important step towards making autonomous driving a permanent part of our everyday lives in future. ■

*Ulrich Haböck, Janina Klier, Stefan Maier,  
Jochen Schwenninger, Regensburg*



## NEW LIGHTING FUNCTION IN FOCUS

### BERTRANDT PRESENTS THE SIDE MARKER CONCEPT

There are two trends which are relevant to our future mobility. More and more people are living in cities and bicycles are becoming an increasingly important means of transport in urban areas. One of the most common causes of accidents at junctions involving bicycles are vehicles which are turning right (or left in countries which drive on the left). A possible solution to the problem would be to improve the side visibility of the vehicles, something which has already been done in the case of trucks. This concept was presented for the first time at the International Symposium on Automotive Lighting (ISAL).



Side marking lights are the only functional lights which are required in the USA by the Federal Motor Vehicle Safety Standard 108 (FMVSS 108), but are not specified in the ECE regulations.

### Design follows function

Daytime running lights and third brake lights, which have been introduced comparatively recently, have become design features that exploit the possibilities offered by the latest LEDs and are used to create a brand signature. The aim of our concept is to determine to what extent the side marker can be introduced as a design element.

Our investigation into the approval aspects of this issue showed that current legislation allows for the possibility of implementing a concept of this kind. For cost reasons, side markers normally only meet the minimum statutory requirements. A design which lies just within the maximum possible requirements opens up a whole new range of options. The only major restriction is the colour, which must be yellow.

### Positive response to the designs

During the process of choosing suitable designs it became obvious that developing a single version would not allow us to represent this wide range of options. As a result, we took a different approach and used a projector to show different variants on a scaled-down model of a car.

Over the last year, the team in Tappenbeck has designed the complete outer surface of a car independently of OEMs. This is the ideal solution in this type of case, where a customer design cannot be used for confidentiality reasons. The projector was operated wirelessly from a tablet, which allowed us to present our exhibit to the visitors to the symposium in the form of a dialogue. As discreet on/off animations are permitted by law when the vehicle is stationary, all the variants were shown with on/off scenarios. Our concept aroused a great deal of interest. ■

*Patrick Wegener, Wolfsburg*



The exhibit: Variants of the animated design for the side marker concept.



## NEW TESTING CENTRE IN MÖNSHEIM

### BERTRANDT TECHNOLOGIE GMBH EXPANDS ITS RANGE OF TESTING SERVICES

In June 2015, a new testing centre was opened at the Bertrandt site in Mönsheim, which is located in close proximity to the site's main customer Porsche. Complete vehicles and components will be tested in the new facility, which covers an area of 6,000 m<sup>2</sup>. This includes testing in the fields of environmental simulation, electric vehicles and power-train/engine components. In close cooperation with the Bertrandt network, Bertrandt Technologie GmbH offers services covering the development of components, modules and complete vehicles. The testing centre offers a wide range of services relating to the validation of future transport solutions. The construction of the testing centre represents an investment of around 20 million euros in the Mönsheim site which will provide added value for customers.

- **Complete vehicle testing:** We offer our customers a full range of services from planning, managing and supporting worldwide testing through to the full documentation of the process.
- **Vehicle construction:** We build and convert vehicles to meet our customers' requirements and carry out assessments of different functions and their potential areas for improvement. Our services also include disassembling, evaluating and documenting complete vehicles.
- **Heating, ventilation, air conditioning and measuring:** One of the key considerations in reducing CO<sub>2</sub> emissions is finding the right balance between the performance and the efficiency of cooling and air conditioning systems. Bertrandt provides a comprehensive range of services in this area, including setting up test benches, testing systems and components and installing and managing measurement equipment.
- **Endurance testing:** Test benches with robotic systems are used to validate the functions of bodywork, interior and exterior components. Fatigue strength tests are carried out using electro-dynamic shakers, for example in the case of engine parts.
- **Occupant/pedestrian protection:** An FMH (free motion headform) test bench allows additional passive safety testing services to be provided. Potential impact areas of the head in the vehicle interior are tested according to the US FMVSS 201u testing standard.
- **Design check areas:** The special lighting facilities in cubing rooms allow vehicle models to be subjected to precise assessments. These rooms are also equipped with high-quality measuring systems to enable accurate measurements to be made of the model surfaces, for example.



- **Environmental simulation:** In our accredited test laboratory, customer-specific tests can be carried out, such as sunlight simulation, vibration and mechanical impacts, alternating temperature and climate tests and thermal shock tests on components and complete vehicles.
- **Standard airbag tests:** Airbag modules, vehicles and components of all kinds are tested and the tests are documented using videos and images.
- **Electronics development:** Using diagnostic testing machines developed in-house, the functionality of the software in cars is tested before the cars are driven.
- **Optical 3D measurement systems:** Several project rooms are equipped with state-of-the-art equipment for measuring electrical and physical properties to allow complete vehicle tests to be carried out.

Karsten Schmidt, Mönsheim

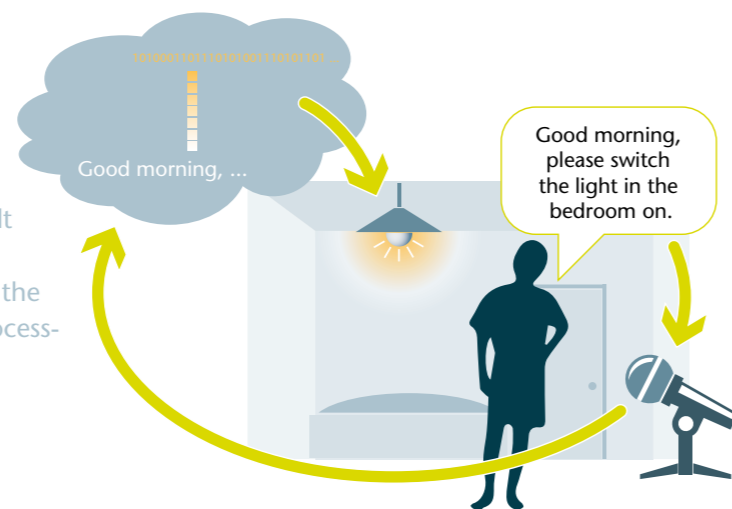




## SMART HOMES – AN INNOVATIVE APPROACH TO BUILDING AUTOMATION

### MACHINE LEARNING AND CLOUD COMPUTING CREATE INTELLIGENT HOMES

The automation and software development team at Bertrandt in Düsseldorf has successfully completed a project involving the understanding and correct processing of human speech.



Voice interfaces in smartphones, computers and cars are used to manage both simple and complex tasks. As a result, it seems appropriate to make use of this type of interface for everyday activities, such as turning the light on in the bedroom in the morning without having to get up and press the switch. All you would need to say is "Good morning, please switch the light in the bedroom on". A Swiss company specialising in home automation systems has also begun working in this area and has introduced a voice control option in its products. One obstacle was the large number of different languages that could be used. At the time, the interface only responded to input in German and was unable to distinguish between commands and questions. An algorithm set up to process the German language often did not provide the desired results in English. Our team in Düsseldorf was commissioned to select, test and implement an algorithm that understands and correctly interprets language and that functions independently of the language in question.

### A new approach: machine learning

One widely used method of solving this type of problem is machine learning. This involves not only searching sentences for keywords such as "switch on" and "bedroom", but also teaching the computer patterns using training data and setting up an artificial knowledge base. In the home automation example, the training data consist of a large number of sentences that people have actually said when controlling functions in their house. The model replaces the algorithm in order to identify recurring structures in the training data. This allows as yet unknown sentences to be identified and the most likely result to be predicted. The more training data that are available, the more likely it is that the model will interpret the spoken sentence correctly. In order to explain the meaning of a sentence to a computer, it can be separated into the intention and the accompanying parame-

ters. In the example, the model will recognise the intention "switch the light on" and a parameter, in this case the room "bedroom". Every sentence can be broken down into a simple structure which is optimised for further processing. The key consideration was to enable the model to identify the intention: does the user want to know whether the light is switched on or to have the light switched on? In order to distinguish between a question and a command, a large quantity of reference data was needed.

### Cloud computing

One important aspect of this approach is obtaining a comprehensive range of training data. A large volume of data is required to achieve a high level of accuracy when interpreting the input and individual households cannot generally provide enough information. Instead cloud computing is used to ensure that good results are achieved. A cloud functions as a central reference point which processes the requests from all users and also records enough data to make the models more accurate. Training data is collected and provided on the cloud. Another advantage is that only an Internet connection is needed to send the request to the cloud. In contrast to conventional server models of the kind used by companies, applications in the cloud can be scaled up in size and computing power. This ensures that the response time remains constant as the number of requests increases.

### Successful home automation system

The combination of cloud computing and machine learning allows intelligent, self-learning voice control functions to be added to home automation systems. ■

*Alexander Fellmett, Düsseldorf*



## FULL FLEXIBILITY FOR VEHICLE DEVELOPMENT

### HIGHLY EFFICIENT MILLING MACHINE FOR DESIGN MODELLING PROJECTS

Increases in the size of projects in the design modelling department have led to the need for state-of-the-art facilities. Therefore, the Technikum in Ehningen has invested in a new Fooke gantry milling machine. This is the Endura 904LINEAR, one of the largest machines used for creating vehicle models. The new mill came into operation in December 2015. Its benefits include high levels of flexibility, precision machining and cost and time savings during the development process.



### A large, high-performance machine

The figures are impressive: the machining area is 7.5 m long, 3.5 m wide and 2.5 m high. This allows even large models, such as SUVs, to be milled in one piece. In addition, the Endura 904LINEAR can be loaded via a door or from above using a crane. This is particularly practical given that some of the components for milling can weigh up to eight tonnes. The Endura 904LINEAR can also perform precision tasks, which means that it covers the whole range of milling requirements. Components 7.5 m in length and those only 20 cm long do not present a problem for the new Fooke mill. In addition, the machine works to a tolerance of only 0.05 mm.

### Dynamic drive for efficiency and flexibility

A dynamic linear drive motor, similar to that of a high-speed train, leads to shorter processing times, increased efficiency and more reliable processes. Projects where up to 400 components have to be milled for each vehicle require flexibility, an increased capacity and a high throughput. Because of its multiple clamping option, the new machine has also led to time savings of up to 50 percent. It is programmed offline in the office where the CNC programs are activated. A new simulation program for the Endura 904LINEAR ensures that there are no collisions. The entire machining process is simulated in advance to prevent impacts between the milling tool and the component. As a result, costly downtimes are now a thing of the past.

### Equipped for all types of materials

The special feature of the Endura 904LINEAR is that it is one of very few milling machines of its size which can be used for both dry and wet machining. The machine simply needs to be switched over to enable it to work with either plastics or metals. Wet milling guarantees a perfectly smooth finish on components made from metal, such as aluminium, and also keeps them cool. Dry milling is used



The Endura 904LINEAR can be used for both dry and wet machining.

for softer materials, such as polyurethane. The building where the milling machine is located is kept at a constant temperature of 22 °C, which allows for precision milling with micrometre accuracy.

The design modelling department in particular is benefiting from the Fooke milling machine, because many model components need to have a perfect fit. The frame used as the basis for vehicle models consists of a large aluminium or steel skeleton. This is milled in one piece and cannot be produced in separate slices. This milling process alone can take up to three days, depending on the size of the model. SUVs, which are becoming increasingly popular, have large components and therefore require a large milling machine with a big machining area. The new Fooke machine allows Bertrandt to offer its customers a more flexible vehicle development service. But that's not the end of the story. In spring 2017, a new component mill will also be installed in the design modelling department in Ehningen. ■

Matthias Sturm, Ehningen

Light and visibility development

## | IN THE SPOTLIGHT



The market for vehicle lights is undergoing rapid and dramatic change. In the past indicators and headlamps were simply components that helped to improve road safety. Nowadays they are increasingly becoming key aspects of vehicle styling. The introduction of new technologies is also reflected in the safety, design and dynamic features of the lights.

The central design modelling department in the Technikum in Ehningen plays a major role in lighting development, because, in addition to the materials and the form, the important factors in the design of light prototypes are the high-precision geometry and surface of the lenses. The recent development of a full-LED headlight as an exhibit for trade fairs represented the perfect combination of theory and practice. Teams from across the different Bertrandt sites worked

together to transform the light from a concept into a fully functioning lighting system and it has aroused significant interest among Bertrandt's customers.

Now the Bertrandt lighting specialists are designing and manufacturing a range of different lights, including interior lighting, brake lights and headlamps, suitable for use in cars and commercial vehicles on the road and in racing cars on the track. The lights are manufactured in special production runs using an injection moulding process and are in great demand. Up to 200 can be produced in each run and these are often used by customers for summer and winter testing. The interdisciplinary cooperation with the electronics development and design departments and the cross-site expertise represent genuine added value in the lighting development process. ■

Technikum in Ehningen

## | ACOUSTIC TESTING IN THE SEMI-ANECHOIC CHAMBER

It is not only the noise of a car's engine that contributes to a harmonious acoustic effect, but also sounds that we only register subconsciously, such as the movement of fuel in the vehicle's tank. Only a few decades ago, this type of noise went unnoticed because cars were generally much noisier. However, nowadays the engine and wind noise levels are much lower, which means that we notice other previously less obvious sounds either consciously or subconsciously. Reducing the volume of these sounds makes a significant contribution to improving the overall acoustic impression made by the car. The test benches that we have developed in-house represent fuel tanks in moving vehicles and allow acoustic evaluations to be carried out in the absence of external influences. The third generation of tank test facilities has been specially designed to meet our customers' requirements and is equipped with a number of microphones, acceleration sensors and high-speed cameras. They can be used to produce an accurate analysis of the flow effects and the acoustic impact. ■



Technikum in Ehningen

## | A DIFFERENT APPROACH TO ACOUSTICS



The acoustics specialists from the testing department at the Technikum in Ehningen were recently confronted with a very different type of challenge. They were asked to reduce the noise produced by a climbing frame and slide constructed by parents for the Rasselbande children's nursery, because the vibrations in the wood caused by the children jumping up and down were being transmitted to the neighbouring rooms.

The task involved identifying a solution to reduce the noise produced by the slide and the frame which were made from sheets of plywood. The acoustic panels that had already been fitted to the walls of the room failed to have the desired effect. There was only one thing to be done: take measurements in the nursery and analyse the airborne sound in the room and the structure-borne sound in the slide and the frame. Therefore, microphones and measuring equipment were set up and the noise levels and dominant frequencies were measured at play time. The solution was to dampen the vibrations caused by the children's feet by fitting a cork floor to the frame. This also reduced the risk of the children slipping over and improved the overall safety of the climbing frame. In addition, the acoustics specialists recommended applying an acoustic foam bonded with felt. The result was that the noise levels were reduced and the children were able to run about and play without causing any disturbance. ■

Bertrandt Group

## INNOVATOR OF THE YEAR 2016

Bertrandt is among the most innovative companies in Germany. In a survey of experts carried out by brand eins Wissen and Statista, Bertrandt received the innovator of the year 2016 award and was ranked 20<sup>th</sup> in the automotive and commercial vehicle suppliers category. Bertrandt was also considered to be particularly innovative in the fields of products and services, processes and corporate culture. ■



Bertrandt Group

## A LEADING EMPLOYER IN THE ENGINEERING SECTOR

trendence, a research institute specialising in employer branding and personnel marketing, surveyed more than 37,000 students shortly before they graduated to find out about their career plans and preferred employers. For the fifth year in a row, Bertrandt was among the top 100 employers for prospective engineers in Germany. ■



Bertrandt Group

## “INNOVATIV DURCH FORSCHUNG” SEAL AWARDED

One of the largest private organisations that promotes science in Germany is the Stifterverband. It specialises in increasing investment in research and development and in ensuring that Germany is fit for the future. Since 2014, the organisation has been presenting its award to companies that take part in research and development. We are pleased to receive the award this year. ■

Regensburg

## SECOND SITE OPENED IN REGENSBURG

Bertrandt's second site in Regensburg opened for business on 1 March 2016. In addition to its building in nearby Neutraubling, Bertrandt has now rented office, laboratory and workshop facilities in the TechBase innovation centre. Located not far from the local university of applied sciences and the University of Regensburg, the innovation centre is home to a network of high-tech companies and research institutions. The services provided by the new site will include software and electronics development, with a focus on the latest trends in the automotive industry: electric vehicles, driver assistance systems as well as safety and security. ■

Interdisciplinary cooperation in the fields of car connectivity and IT security is an important factor in the development of assistance systems. The Bertrandt engineers will also be developing industrial software for use in production models and will work on in-house and pre-development projects for vehicle manufacturers and suppliers. ■

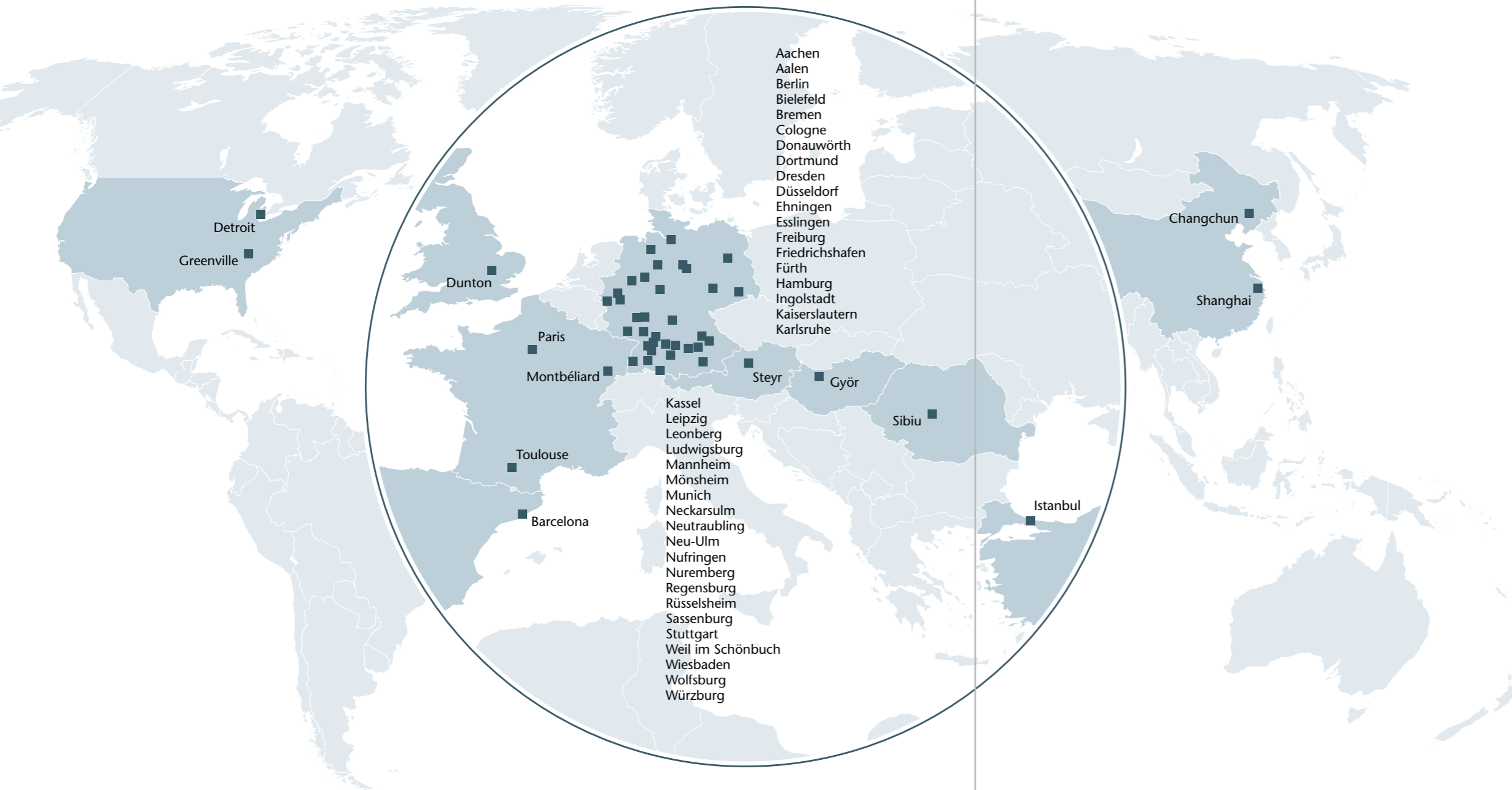


Bertrandt Group

## BERTRANDT SUPPORTS AN SOS CHILDREN'S VILLAGE



Helping children and young people to grow and develop is a cause that Bertrandt has supported for many years. Once again this year we made a donation to an SOS Children's Village, in this case the young people's welfare group in Welzheimer Wald (Juwel) near Neckarsulm. The money will be spent on educational computers, bicycles and sports equipment to encourage the young people to be more active. ■



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More detailed information about our entire portfolio of services is available on our website at:

<http://www.bertrandt.com/en/range-of-services.html>



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