Automotive Technologie in Bavaria +e-Car

GLOBAL PARTNER

We shape the future of mobility

With microelectronics enabling clean, safe, smart cars

For leading solutions in automotive electronics from the pioneer in the industry, turn to Infineon Technologies. Choose our semiconductors for your body, powertrain, safety, and hybrid and electric vehicle applications and profit from products resulting from nearly 40 years of experience in automotive applications and standards. Our commitment to innovation and high quality means you can count on us to successfully drive your applications into the tomorrow and beyond.

- Car IT-security and connectivity
- Hybrid and electric powertrain
- Safety and ADAS
- Body and convenience
- Powertrain

www.infineon.com/automotive

Editorial

Let's talk about the future of mobility

Diesel crisis, blue badges, traffic bans, air pollution control, fewer emissions – the list is endless.

The challenges facing modern and sustainable mobility are enormous.

Changes in the global markets and society necessitate new technical developments and business models.

A world with emission-free mobility raises fundamental questions:

- What is the future for luxury class vehicles?
- What role will automated driving functions play in future technological developments?
- What does remote laser welding mean for car body construction?
- How do we overcome challenges in the on-board value added chain?
- What can we expect from the emotional and powerful architecture of e-mobility?
- Can we meet the requirements of the automobile industry in terms of costs, quality and reliability?
- How can we avert the dangers that near-silent electric motors pose to inattentive pedestrians?

Many recent articles show us the way to a better quality of life and a greater understanding of the technologies of the future.

Walter Fürst, Managing Director

Masthead:

Publisher:	media mind GmbH & Co. KG Hans-Bunte-Str. 5 80992 Munich/Germany Phone: +49 (0) 89 23 55 57-3 Telefax: +49 (0) 89 23 55 57-47 E-mail: mail@media-mind.info www.media-mind.info
Managing director:	Walter Fürst, Jürgen Bauernschmitt
Design + DTP:	Jürgen Bauernschmitt
Prepress:	media mind, München
Responsible editor:	Ilse Schallwegg
Published annually:	1 x annually

Dear Readers,

For Audi, 2018 is the year of electric mobility. In the second half of the year, we will present our first electric car: the Audi e-tron, an SUV that combines a range that is suitable for everyday use with a sporty driving experience. We are committed to electrification, and we are pursuing a clear e-roadmap: The Audi e-tron is the first in a long line of new electric models. By 2025, we will have over 20 electrified models in our product range. More than half of them will be fully electric, with the rest being plug-in hybrids.

The Audi e-tron will roll off the production line in Brussels, followed one year later by the derivative Audi e-tron Sportback. The batteries will be fitted directly in Brussels, while the e-motors will come from our engine plant in Győr in Hungary. In addition, we are already preparing our two main German plants for electrification, with Neckarsulm and Ingolstadt each set to produce two Audi electric cars. Audi Sport will also release a Granturismo as an electric RS model – manufactured at our factory in Heilbronn. We are working with Porsche on the design of the premium electrification architecture for our midsize and full-size electric cars over the coming decade. We are accepting no compromises, which is why we are actively avoiding a multi-traction strategy and instead using an architecture that is specially tailored for electric drive systems. This gives us considerable freedom when it comes to technology and interior design.

By 2025, we expect one-third of the cars we sell to be powered by electricity. In other words, our company is already in the middle of a huge transformation. We have redefined our core competencies and we are establishing new expertise and training our employees for the future topics of electrification, digitalization and conditional automated driving. We have worked with a wide range of Bavarian suppliers for many years now. We greatly appreciate their technological innovations and the “made in Bavaria” quality they deliver. Let‘s shape the future of mobility together!

Dr. Bernd Martens

Member of the
Board of Management of
AUDI AG, Procurement

Automobiltechnikum Bayern GmbH in Hof

Founded by the Bavarian Ministry of Economic Affairs, Infrastructure, Transport and Technology, the test laboratory is accredited according to EN 17025 and situated within the Automobilzulieferpark (= Automotive Supplier´s Park) Pole Position at Hof-Gattendorf. It performs tests and experiments in accordance with customerspecific test instructions and requirements. As regards concepts, the tests are supervised by competent staff. Engineering services and solutions to problems as well as constructional adjustments are offered individually.

Concerning service strength, three Occubot seat test robots made by KUKA are available at ATB. Using a system for changing test dummies does not only provide an automated programme process, but a continuous picture documentation as well. At the same time the test loads are constantly observed and readjusted. The area of service strength comprises as well four spring testing machines, versions "Schenck" and "Reicherter Short and Long Stroke".

The servo-hydraulic testsystem with a total of 8 hydro-pulse cylinders operates with loads of up to 40 kN and mximum strokes of 400 mm.

Two electric stroke cylinders with loads of up to 20 kN and maximum strokes of up to 350 mm can also be operated in connection with a climate chamber of 1,5 m^3. Tests with lower loads may be run by using various pneumatic stroke cylinders.

The area environmental simulation disposes of 14 climate chambers with sizes ranging from 240 litres to 30 m3, the latter being accessible by vehicles. Temperature ranges lie between -70 °C and 180 °C, the relative humidity can be programmed continuously between 10 % and 97 %.

Forschung und Entwicklung

The two heating furnaces with a volume of up to 720 litres allow tests up to 300 °C. The salt spray fog chamber with a test volume of 2 m^3 complies with all established test standards, also for condensation tests.

The measuring laboratory contains a material testing machine for tensile and pressure tests, several digital tracers by HBM with up to 8 measuring channels per system, an infrared camera and a digital light optical microscope with up to twohundredfold enlargement. Furthermore, photogrammetric surveys are offered, thereby using a system produced by AICON respectively a stripe light scanner produced by Steinbichler.

The 90 kN shaker is fitted with a Head expander measuring 150 cm x 150 cm. The frequency range goes from 5 Hz to 3000 Hz. Maximum acceleration is achieved at 150 g. In addition, the control system enables tests in multisinus mode.

In addition, a climate chamber of 15 m^3 may be positioned over the support plates.

For further informations please see our homepage:

www.atbayern.de

Author:

Peter Rüpplein
Automobiltechnikum
Bayern GmbH

Ferdinand-Porsche-Strasse 10
95028 Hof/Haidt
Tel.: +49 9281 85019 0
Fax: +49 9281 85019 500

pru@atbayern.de

Open for greater comfort

When cars drive autonomously in the future, it goes without saying they will have doors that open and close automatically. But this function will already be seen in more and more cars in the next few years, making vehicle access more comfortable and convenient than ever before. The mechatronics specialist Brose offers a complete system for this that encompasses everything from drives to a soft-close feature.

The car recognizes the driver, the door opens without human activation and the side bolsters on the front seat lower to facilitate vehicle entry. This is how automotive supplier Brose presented the intelligent interaction between its door and seat functions at the International Motor Show 2017 in Frankfurt am Main. The central element of this new access experience is an electric drive that automatically opens and closes side doors. This function will be commonplace in the age of autonomous driving – and it can already provide useful services today in car sharing: if the user does not close the door properly when exiting, the vehicle must be able to do this itself before it drives off or after it has stopped. But first applications of the drive will offer greater comfort for entering and exiting vehicles – and enable carmakers to set themselves apart from their competitors with this function. ■

The compact side door drive by Brose can adapt to different customer and vehicle requirements. Series production starts in 2020. ■

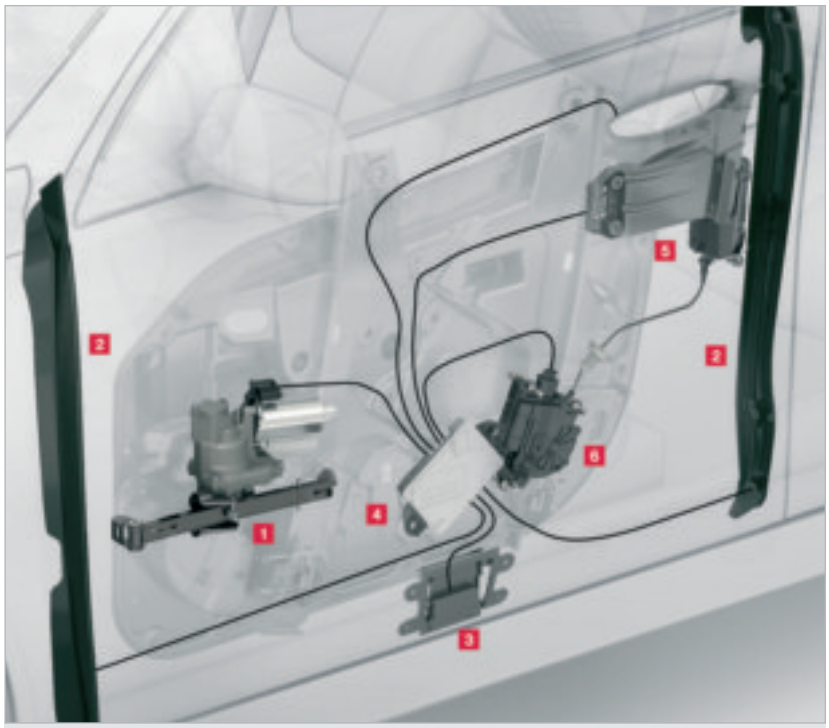
Significantly enhanced comfort

Brose introduced its side door drive concept in 2015, building on its expertise as a world market leader in systems for automatic opening and closing of liftgates. The automotive supplier systematically further developed this innovation until it was series ready: the first production ramp-up is scheduled for 2019; various uses in luxury vehicles and mid-range cars are confirmed from 2025 on. The hinged car door opens and closes via remote control, smartphone or gestures and can even be operated on slopes and at an angle of up to 15 degrees.

Manual operation is still possible, but it is even more convenient: the electronics sense a manual movement and disengage the drive so that the door can move freely. If the movement stops, the integrated currentless door check securely holds the door in any position. ■

Flexibility cuts costs

The Brose concept is unique thanks to its compact and modular design, which makes it possible to flexibly adapt the side door drive to different customer or vehicle requirements. This not only shortens development time, the use of standard components also keeps



The Brose door drive system comprises the (1) drive, (2) anti-trap and (3) collision protection sensors, the (4) control unit and (5) open-by-wire latch with (6) power cinching unit. ■

costs low. Brose's product uses existing door interfaces, so it can be offered as an option without modifications to the vehicle body. The drive works directly at the door check strap. If the required space is not available there, the optional connection via Bowden cables allows for flexible positioning of the unit in the door.

Brose's power side door drive makes vehicle access more comfortable and convenient than ever before. Reliable collision protection is essential if doors open automatically. ■

Brose has expanded its expertise in the interaction of mechanical, electric and electronic systems and offers its door drive as a complete system from a single source: this includes a power opening latch with soft-close feature and the door control unit. Capacitive sensor strips on the hinge and latch side increase safety as contact-free anti-trap protection and can also be used as switches. This technology is based on Brose's proven liftgate systems that have been in use for years. ■

New sensor technology for collision protection

There is currently still one constraint in comfort: the user must keep an eye on the opening movement and hold a button the whole time, e.g. on a remote control. The reason for this – and at the same time the greatest technical challenge for the series readiness of doors that open fully automatically – is collision protection. Collisions with obstacles such as posts or other motorists must be ruled out. A module for this is the so-called "sensor cocoon" – the sum of lidar, radar and camera systems that OEMs use to prepare their vehicles for automated driving. Reliable environment monitoring is also essential when the computer takes control. There's just one catch: the area directly in front of the door is not recognized accurately enough.

Brose presented a near-field radar sensor developed specifically for this purpose. It is currently the only solution on the market that reliably recognizes even narrow obstacles with a monitoring angle of 180 degrees thanks to high-resolution technology. The family-owned company is the only automotive supplier to offer this sensor technology in its integrated mechatronic system. Intensive collaboration between vehicle manufacturers and system suppliers is still essential, however: ultimately, only the interaction between the sensor cocoon and the near-field sensors provides comprehensive collision protection. ■

brose
Competence in Mechatronics

Authors

Rainer Weichel,
Director Product Group Door Drives
Brose Group

Thomas Schindler,
Vice President Electronics
Brose Group

Brose Fahrzeugteile GmbH & Co.
Kommanditgesellschaft, Coburg

Max-Brose-Str. 1
D-96450 Coburg
Phone: 09561/21-0
info@brose.com
www.brose.com

The new Audi A8: future of the luxury class

- *New design language and a pioneering touch operating concept*
- *Piloted driving functions to be rolled out in production Audi A8 versions from 2018*

In its fourth generation, the flagship model again provides the benchmark for Vorsprung durch Technik – with a new design language, an innovative touchscreen operating concept and a systematically electrified drive. The Audi A8 is also the first production automobile in the world to have been developed for highly automated driving. From this year on, Audi will gradually be taking piloted driving functions such as parking pilot, garage pilot and traffic jam pilot into production.

Doyen of style: the exterior design

The Audi A8 is stylistically defining – it signals the dawning of a new design era for the entire brand. The front end with the wide, upright Singleframe grille and the fluid, muscular body symbolize sporty elegance, sophistication and progressive status. The new A8 delivers on the promise made by the Audi prologue design study. The luxury sedan possesses a powerful presence – whether in the 5.17 meter (17.0 ft) standard version or the A8 L, which has a 13 centimeter (5.1 in) longer wheelbase.

The Audi brand is renowned worldwide for sports appeal, lightweight construction and quattro permanent all-wheel drive – and the design of the new A8 conveys these values. The balanced proportions emphasize all four wheels in equal measure. Muscular shapes above the wheel arches give visual expression to the quattro drive. Viewed side-on, the upright front end combined with the gently inclined rear create visual tension. The flagship model proclaims its identity both day and night, drawing on both the striking HD Matrix LED headlights with Audi laser lighting, and the LED light strip combined with OLED technology rear lights. These produce unique light animations as the driver approaches and leaves the car. ■

Audi A8 - Front view ■

Fingertip response: the controls

The luxury sedan's interior deliberately adopts a reductive design; the interior architecture is clear and with a strictly horizontal orientation. Audi carries its high quality standards into the digital age with a radically new operating concept. It does away with the familiar rotary push-button and touchpad of the predecessor model. The instrument

Audi A8 - Cockpit with MMI touch response ■

panel is kept largely clear of buttons and switches. At its center is a 10.1-inch touchscreen display which, when off, blends almost invisibly into the high-gloss black surround thanks to its black-panel look.

The user interface appears as soon as the car is opened. The driver controls the Infotainment system with fingertip control on the large display. They can use a second touchscreen display on the center tunnel console to access the air conditioning and comfort functions as well as make text inputs. When the driver activates a function in the upper or lower display, they hear and feel a click by way of confirmation. The glass-look operating buttons respond in the same way. The combination of acoustic and tactile feedback along with the use of common touch gestures such as swiping make the new MMI touch response especially safe, intuitive and quick to use.

The A8 can also engage in intelligent conversation. The driver can activate an array of functions in the automobile using a new, natural form of voice control. Information on destinations and media is either available on board or is delivered from the cloud at LTE speed. The extensive Audi connect range also includes traffic sign recognition and hazard information – innovative car-to-X services that draw on the swarm intelligence of the Audi fleet.

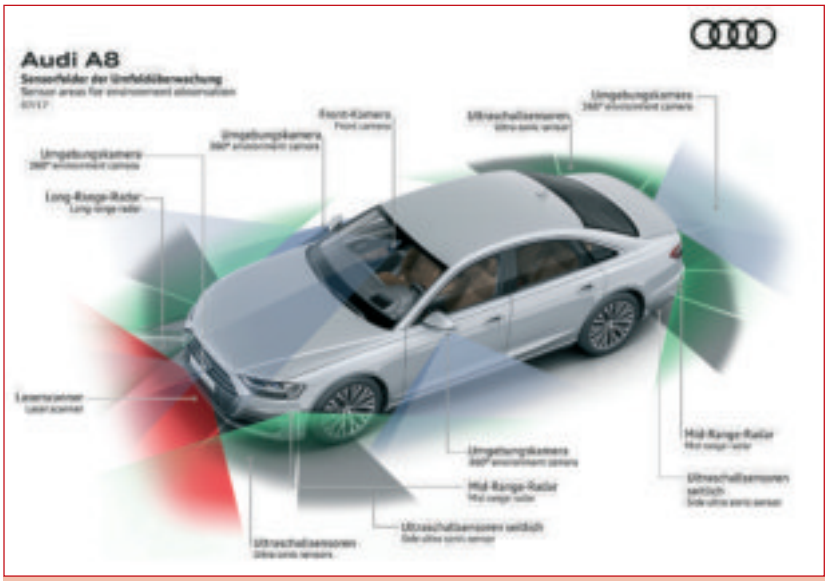
The extensively optimized navigation is another new feature: It is self-learning, based on the route just driven. This provides the driver with intelligent search suggestions. The map also incorporates highly detailed 3D models of major European cities. ■

World premiere: the pilot-driving Audi A8

The new A8 is the first production automobile to have been developed specially for Level 3 automated driving. The Audi AI traffic jam pilot takes charge of driving in slow-moving traffic at up to 60 km/h (37.3 mph) on freeways and highways where a physical barrier separates the two carriageways. The system is activated using the AI button on the center console.

Because traffic jam pilot is capable of handling the full driving task – acceleration, steering and braking – when certain conditions are met, drivers can take their hands off the steering wheel until the car requires manual driver control again. This takeover request occurs before the system nears the limits of its capabilities.

From a technical perspective the traffic jam pilot is revolutionary. During piloted driving, a central driver assistance controller (zFAS) now permanently computes an image of the surroundings by merging the sensor data. As well as the radar sensors, a front camera and the ultrasonic sensors, Audi is the first car manufacturer also to use a laser scanner. The introduction of the Audi AI traffic jam pilot means the statutory framework will need to be clarified in each individual market, along with the country-specific definition of the application and testing of the system. The brand's high quality standards are equally applicable in the realm of highly automated driving. In addition, a range of approval procedures and their

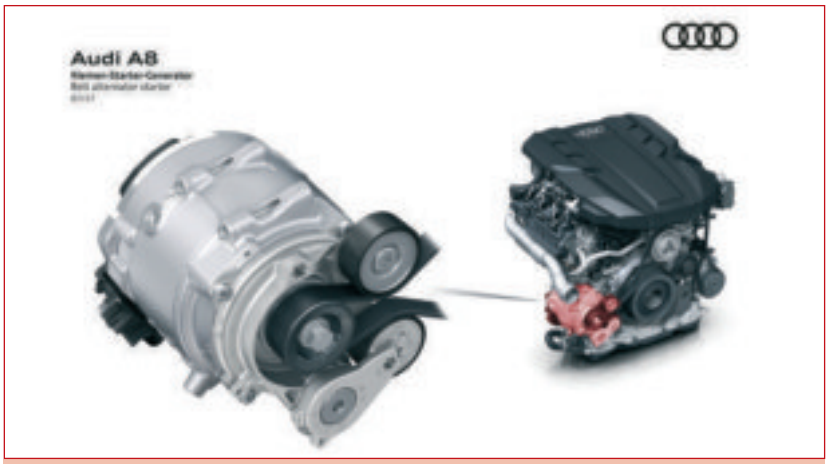


Audi A8 - Sensor areas for environment observation ■

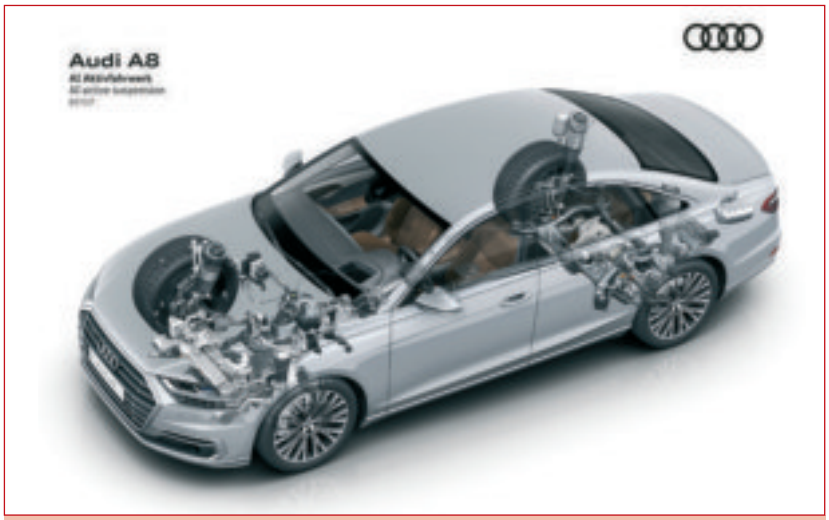
corresponding timescales will need to be observed worldwide. Audi will therefore be adopting a step-by-step approach to the introduction of the traffic jam pilot in production models.
The Audi AI remote parking pilot and the Audi AI remote garage pilot autonomously steer the A8 into and out of a parking space or a garage, while the maneuver is monitored by the driver. The driver need not be sitting in the car. They start the appropriate system from their smartphone using the new myAudi app. To monitor the parking maneuver, they hold the Audi AI button pressed to watch a live display from the car's 360 degree cameras on their device. ■

New dimension: the suspension

With a whole package of innovations, the suspension revisits the very limits of what is physically possible. One such innovation is dynamic all-wheel steering, which combines direct, sporty steering with unshakable stability. The steering ratio for the front wheels varies as a function of speed; the rear wheels are turned in or against the direction of steering depending on the speed range. The car's handling becomes even more dynamic and precise with the sport differential. This actively distributes the drive torque between the rear wheels, complementing the quattro permanent all-wheel drive that is now standard in the new A8. The second new technology, Audi AI active suspension, is a fully active suspension system. Depending on the driver's wishes and the driving situation, it is capable of raising or lowering each wheel separately with electric actuators. This flexibility imparts the driving characteristic with huge latitude – ranging from the smooth ride comfort of a classic luxury sedan to the dynamism of a sports car. In combination with pre sense 360°, the car is raised with lighting speed if there is an impending lateral collision, reducing the potential consequences of the accident for all occupants.
This highly innovative suspension system obtains the energy it requires from a 48-volt electrical system. Audi now for the first time fits it as the primary electrical system in all model versions of the A8. In conjunction with the advanced air suspension for the A8, the innovative suspension concept delivers an utterly new driving experience. ■



Audi A8 - Belt alternator starter ■



Audi A8 - AI active suspension ■

Mild hybrid: the drives

The new A8 is available with two extensively reengineered V6 turbo engines since market launch in November 2017. Both engines operate in conjunction with a belt alternator starter (BAS), which is the nerve center of the 48-volt electrical system. This mild hybrid technology (MHEV, mild hybrid electric vehicle) enables the car to coast with the engine switched off, and to restart smoothly. It also has an extended start/stop function and an energy recovery output of up to 12 kW. The combined effect of these measures is to bring down the fuel consumption of the already efficient engines even further – by as much as 0.7 liters (0.2 US gal) per 100 kilometers (62.1 mi) in real driving conditions. ■

Contact:

Christoph Lungwitz

AUDI AG
I/GP-P3
D-85045 Ingolstadt
Tel.: +49-841-89-33827
Fax: +49-841-89-90786
christoph.lungwitz@audi.de
www.audi.com

Multisensor calibration for sensor data fusion

Automated driving functions are of enormous importance for the future technological development of the automotive industry towards driverless vehicles. Without a doubt, a highly accurate environmental model of the vehicle's surroundings is one of the central themes. This requires knowledge of the exact positions and viewing directions of all installed sensors on the vehicle. This is an area where ESG is working on innovative solutions.

Optical Algorithms

The extensive range of driver assistance functions and the development towards highly automated driving already place high technical demands on the sensors and algorithms installed in modern vehicles.

A prerequisite for ensuring the correct operation of a system with many different sensors is the exact determination of the position and orientation of these sensors to the vehicle (i.e. their extrinsic calibration).

For each vehicle, a calibration process must be carried out once per sensor simply because of manufacturing tolerances.

However, environmental influences, ageing effects and accident damage change the alignment of the sensors, requiring continuous readjustment even with minor changes.

Depending on the calibration method, a "target" (i.e. an object known to the system) and therefore possibly also a visit to the workshop is required to perform the calibration.

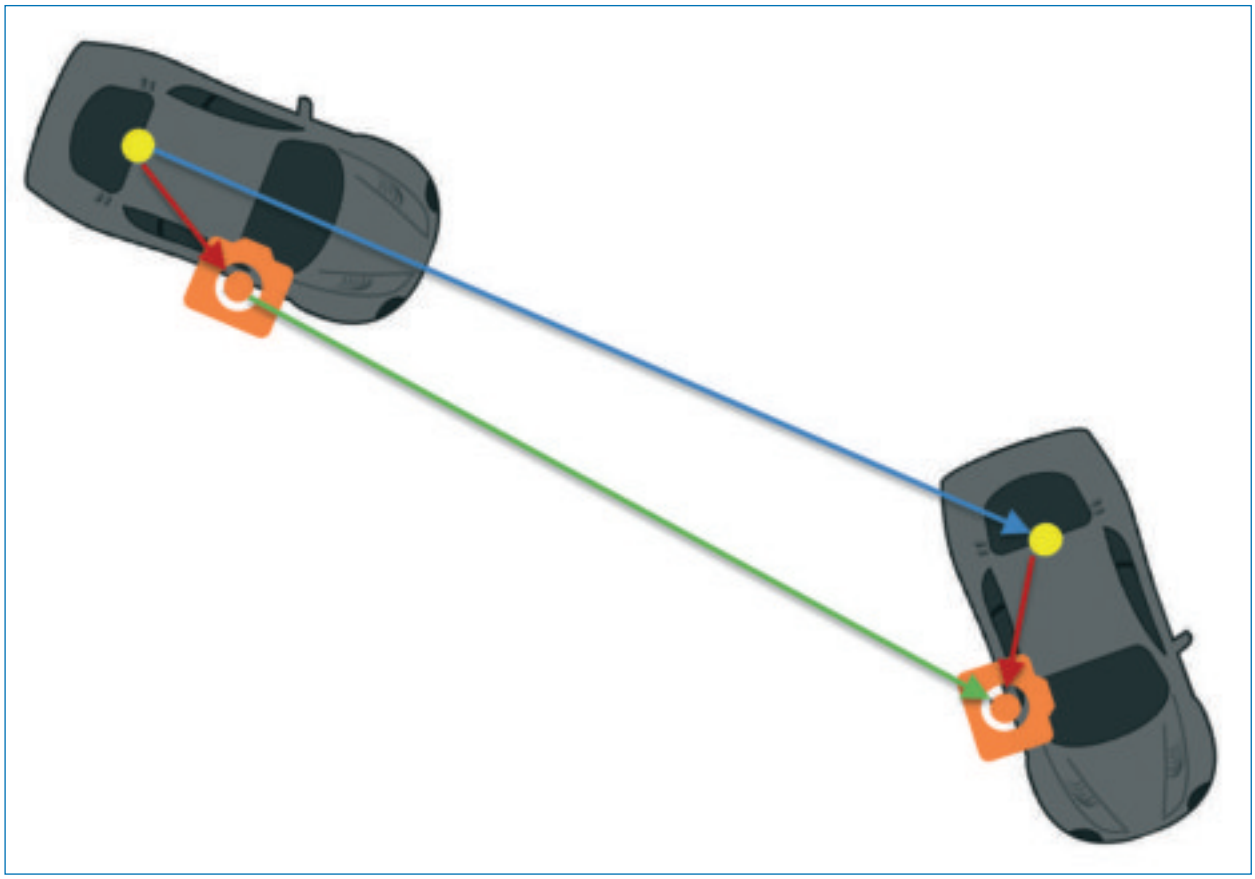
ESG has been working on calibration procedures that work without targets while the vehicle is on the road in normal driving situations since 2010.

A solution for purely camera-based systems is the Online

Calibration (OC), which uses the method of visual motion estimation (i.e. reconstruction of the camera movement based on the video stream). From the reconstructed camera trajectory and a simplified vehicle model, it is possible to determine the viewing direction of the camera. The calibration is performed per camera, the calibration results of the other sensors are not taken into account. This process was expanded to include additional sensor types for multi-sensor calibration, which determine the alignment and position of all sensors simultaneously during a calibration process by fusing and processing the sensor data of all sensors.

Sensor positions and orientations for the vehicle are determined based on the fact that sensors undergo different movements when cornering, depending on their positioning on an automobile. In this case, a movement is composed of a linear component and a rotational component. This is reflected in the following figure: When the car drives around a curve, it is clear that the relative movement of the displayed camera differs from that of the reference point in the car. Furthermore, it is assumed that the position and orientation of the sensor to the vehicle is rigid, or does not change much. Taking into account these assumptions and information about the movement of the car and sensor, it is possible to determine the position of the sensor to the car.

The method described above is based on the availability of information about the vehicle, as well as sensor movement. The former can be obtained from the automobile's odometry data, for example. The latter is determined, depending on the sensor used, with the aid of a variety of algorithms. Some examples of these are Visual Simultaneous



Localization and Mapping (VSLAM) for cameras or Iterative Closest Point (ICP) for LIDAR (Light Detection and Ranging). In order to increase the robustness of the system, the resulting equation is stretched for a variety of movements and the sensor positions that represent the best consensus across all measurement data are selected. Since, as mentioned above, a large number of sensors are used for automated driving, the system of equations can be extended not only in the time dimension, but the different sensors - multiple cameras, LIDARs, etc. - can also be linked to a get better result for the position of all sensors on the vehicle.

The approach described above and the motion estimation algorithms were implemented and then verified, taking into account additional practical problems. For verification purposes, a city trip including sensor data was generated in a virtual simulation environment and then processed by the system. The results obtained have shown that this method can be used to obtain precise values for the sensor orientation, but the specific position does not exceed the accuracy of values from a CAD model (production inaccuracies). However, accurately determining the rotation of the sensors is more important for a precise environmental model because small inaccuracies can cause very large errors.

One problem that the tests have shown is the use of odometry as a means for measuring the movement of the car, as this merely provides two-dimensional information and therefore cannot accurately determine all the degrees of freedom of the overall vehicle system. For this reason, the integration of an additional motion estimation sensor, such as an Intertial Measurement Unit (IMU), significantly improves results. This is currently the subject of internal further developments of the calibration procedure.

In summary, the multi-sensor calibration system is an exciting application from many different fields of research for addressing the problem of calibrating a large number of sensors on a vehicle. Such a solution promises many potential applications and benefits, such as recognizing the need for recalibration or cost savings in production and after-sales. ■

Author:

Thomas Scherübl
Senior Software Engineer, Development Advanced Driver Assistance / Embedded Software

ESG ELEKTRONIKSYSTEM- UND LOGISTIK-GMBH

Livry-Gargan-Straße 6
82256 Fürstenfeldbruck/Germany
Thomas.Scheruebl@esg.de

Highly flexible remote laser beam welding for the car body production of the future

Innovations in photonics as an enabler for highly adaptable production systems

The general trend towards individualized products is also evident in the automotive industry with a strong increase in vehicle derivatives. In this context, the steadily expanding use of electric drive concepts is exacerbating the situation, with the variety of variants and thus the complexity of production increasing significantly. In contrast, rigid production structures can only cover a limited number of variants. For this reason, the Institute for Machine Tools and Industrial Management (iwb) at the Technical University of Munich is researching together with partners from industry to make car body production more flexible. The RoKtoLas project consortium covers wide parts of the value chain - from sensor manufacturer to an automobile OEM. The aim of the research project is to achieve a technological breakthrough in automotive engineering which, on the one hand, makes the process chains in car body construction more flexible and, on the other hand, enables internal quality assurance in remote laser beam welding. Finally, the functional principle and the advantages of a highly flexible production cell are shown by means of a demonstrator *(see Figure 1 left)*. ■

Technology substitution in the field of joining technology

The desired flexibility of the process chains will be achieved by replacing conventional resistance spot welding with remote laser beam welding of individual body parts. The sensor unit based on optical coherence tomography (OCT sensor unit) forms the focus of the project, with work packages shown in *Figure 2*. This enables for the first time an integrated and continuous process monitoring.

The information obtained by the sensor unit concerning component positioning, measured in advance of the process zone, enables the use of a robot-based clamping technology. Compared to fixture-based systems, this system can significantly reduce the accessibility requirements. For the first time, a component design optimized for laser beam welding can be used, which offers new possibilities for efficient lightweight construction. This allows the full potential of remote laser beam welding to be exploited and the implementation of highly flexible production systems. ■

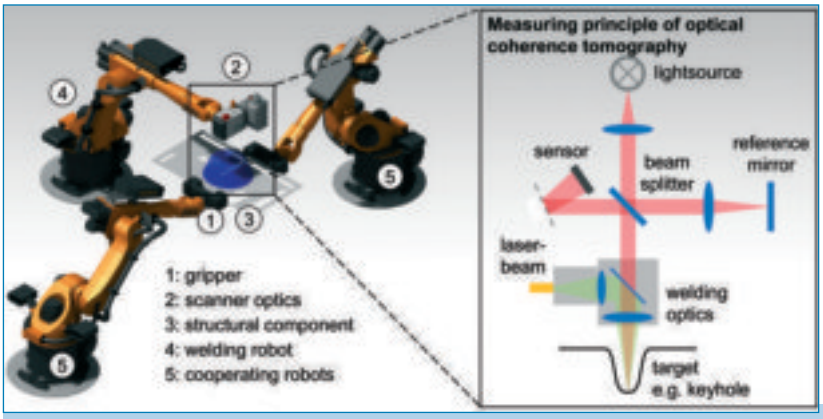


Fig. 1: *Planned functional demonstrator in the context of RoKtoLas and measuring principle of optical coherence tomography* ■

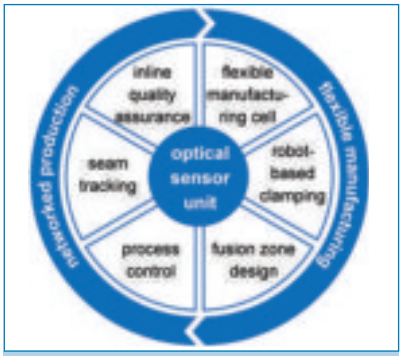


Fig. 2: *Concept for making process chains in body construction more flexible* ■

Photonic

Universal sensor concept for quality assurance

The use of laser beam welding processes in car body construction requires a reliable and reproduceable assessment of the weld seam quality. A comprehensive quality assurance is necessary to qualify laser beam welding for this application. In addition, process monitoring as a measure for maintaining and tracking the seam quality is increasingly becoming a basic requirement for the use of laser beam welding in the automotive industry.

However, direct process observation during laser beam welding is currently only feasible to a very limited extent. Optical images of the process zone are confined, for example, to the surface of the component. The characteristic processes during laser beam welding within the capillary are therefore not visible. Likewise, a reliable evaluation of the image data for quality assurance purposes cannot be reproduced. Statements on the quality of the welds are usually derived from a comparison with reference welds. In this way, larger deviations from the collected data of a stable process can be detected and categorized into high and low quality parts. However, since no absolute statements can be made about the seam quality, indirect observation technologies such as camera systems are susceptible to interpretation errors. This applies in particular to remote laser beam welding, since the dynamic mechanisms in the process zone and their influence on the seam quality are hardly detectable. This is due to the large working distance of the processing optics and to interferences, such as metal vapor escaping from the process zone. The high-speed image of a remote laser beam welding process shown in *Figure 3*, in which a clear spatter formation can be seen, illustrates the high process dynamics and the influence of the escaping metal vapor on the observability of process irregularities.

A direct measurement of the parameters within the process zone is a much more robust approach for evaluating the process result. So far, there are no suitable methods for direct observation of the interaction zone, with the exception of complex X-ray procedures. The use of optical coherence tomography, with the functional principle shown in *Fig. 1* on the right, enables the processes within the vapor capillary to be observed directly. The method is based on the interferometer principle and allows both high space- and time-resolved distance measurements. For example, it is possible to determine the welding depth during laser deep penetration welding in real time.

In the context of the RoKtoLas research project, an OCT measurement system for the use in 3D scanner optics is investigated. The measuring beam can be positioned in any position within the working area of the scanner system via an additional deflection unit. It is thus possible not only to measure the welding depth, but also to observe the front and rear area of the process zone. With the sensor, edges in the joining zone can be found and used for seam tracking or the surface of the weld seam in the trailing zone can be analyzed *(see Figure 4)*. The measuring method, which has been established for a considerable time in medical technology, is increasingly finding its way into industrial production. Until now, such sensors have been used only on fixed optics for one-dimensional measurements. The transition to remote laser material processing enables a comprehensive observation of the interaction zone as well as of the pre- and post-processing zone and thus an integrated quality assurance. ■

Fig. 3: *Process dynamics in remote laser beam welding* ■

Robot-based clamping technology

Today, mainly workpiece-specific clamping devices are used to accurately position and align the individual sheet metal parts with the desired tolerance for the production of car bodies. Due to their solid construction, these devices can reliably hold the components in position during the joining process. However, since they are usually individually adapted to a specific assembly, they allow hardly any changes to the component geometry, the component position or the process sequence without significant changes to the assembly. If, for example, the position of a component has to be changed due to design modifications, it is often necessary to transfer the component to a subsequent fixture or even to a new fixture. This is not only associated with high costs, but also with considerable restrictions in the planning of process steps. This means that any change, for example by adapting the joining sequence, integrating new vehicle derivatives or changing models, not only leads to remarkable adjustments of the devices, but also of the entire production process.

For this reason, robot-based, fixture-free concepts for component positioning are currently being researched. These aim to replace rigid joining devices with flexible grippers on industrial

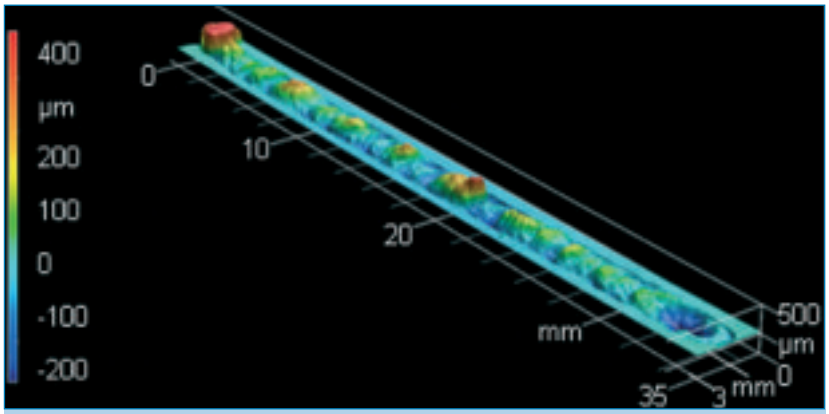


Fig. 4: *Measurement of the seam topology for quality assurance* ■

robots. In addition to cooperating robots, complex optical and mechanical sensor systems are usually used. The aim is always to ensure that changes in component geometry or in the process sequence do not require hardware changes, but only software adaptations to the robot and gripper system.

Previous research approaches have focused on the integration of external sensors and on evaluation methods for component positioning. However, all approaches lack an intelligent coupling of the gripper systems with the joining process data and their integration into a highly flexible overall system. The extensive data of the sensor system enable this intelligent coupling so that changes in the joining process can be flexibly handled at any time. For example, individual component deviations that influence the dimensional accuracy of the assembly can be corrected. Overall, a wider range of components can be reliably processed. ■

Highly flexible intelligent production systems

n summary, the joining processes commonly used in car body construction require the use of rigid clamping devices and thus lead to considerable restrictions in both component design and in production processes. Contrary to this, remote laser beam welding places significantly lower demands on component accessibility and thus improves the load-bearing design of components.

In addition, fixture-free joining can be made possible by adapting and optimizing the component design. For this purpose, a robot-based gripper system for the positioning of components is designed and developed. Based on the data of the optical measuring system, the clamping situation can be evaluated and adjusted with active grippers. The robot-based system offers a wide range of control variables. Machine learning processes are used to adapt the clamping situation or the welding process so that the newly created degrees of freedom can be used efficiently. An intelligent positioning facilitates the control of component tolerances and increases the process stability.

Finally, the new sensor concept enables a comprehensive and consistent process data generation on the basis of which integrated process monitoring in remote laser beam welding can take place for the first time. This enables a more demand-oriented design as well as an overall process-accompanying quality assurance and represents the prerequisite for the construction of highly flexible production plants in the sense of a networked production. ■

Acknowledgements

The project is supported with funds from the Federal Ministry for Education, Science, Research and Technology (BMBF) under the funding code 13N14555 and supervised by the VDI Technology Centre (VDI TZ). We thank the BMBF and the VDI TZ for their support and the good and trusting cooperation. ■

SPONSORED BY THE

Federal Ministry of Education and Research

Authors:

Christian Stadter

Research Associate
christian.stadter@iwb.mw.tum.de
+49 89 289 15560

Maximilian Schmöller

Research Associate
maximilian.schmoeller@iwb.mw.tum.de
+49 89 289 15492

Prof. Dr.-Ing. Michael F. Zäh

Head of Institute
michael.zaeh@iwb.mw.tum.de
+49 89 289 15502

Technical University of Munich
Department of Mechanical Engineering

Institute for Machine Tools and Industrial Management (iwb)

www.iwb.mw.tum.de/en

Special e-Car

Preface

Germany is undoubtedly an Automotive and Mobility Country and this should continue. Wie are currently confronted with enormous challenges to keep the air clean in our cities. The decision of the Bundesverwaltungsgericht concerning car-banning accelerated the dynamics in this topic and showed that all measures to reduce the nitrogen oxide have to be adequate.

So the question is: how do we manage to bring together more mobility with reduced emissions and do without car-banning and the so called „blue plaque".

The German federal government reacted very quickly and sustainably and offered one billion Euro with 11 support programs for the retrofitting of Diesel-busses, and for the electrification and digitalization of local traffic systems.

With the on demand program „Clean Air 2017 - 2020" and the implementation of a pilot point which assists the applicants with their access to the support programs, this process will be strongly promoted. Additionally the federal government committed the car manufacturers to refit 5,3 Mio. Diesel-cars of the emission category Euro 5 and Euro 6. Theses measures already work: several cities report about reducing emission rates.

It`s now necessary not to slacken. So the federal government has chosen 5 Lead cities, in which one will test innovative measures to reduce nitrogen oxide exceeding the measures of the on demand program.

This could be a temporarily free public transport a sophisticated traffic guiding and environmental zones for trucks.

This is our intelligent package of measures to improve the air and life quality in our cities and to combine more mobility with reduced emissions. I am convinced, that if all - the federal level, the Länder level and the cities, are pulling together the „Emissionswende" will be successful.

Siegfried Balleis

Sonderbeauftragter der Bundesregierung für das Sofortprogramm „Saubere Luft"

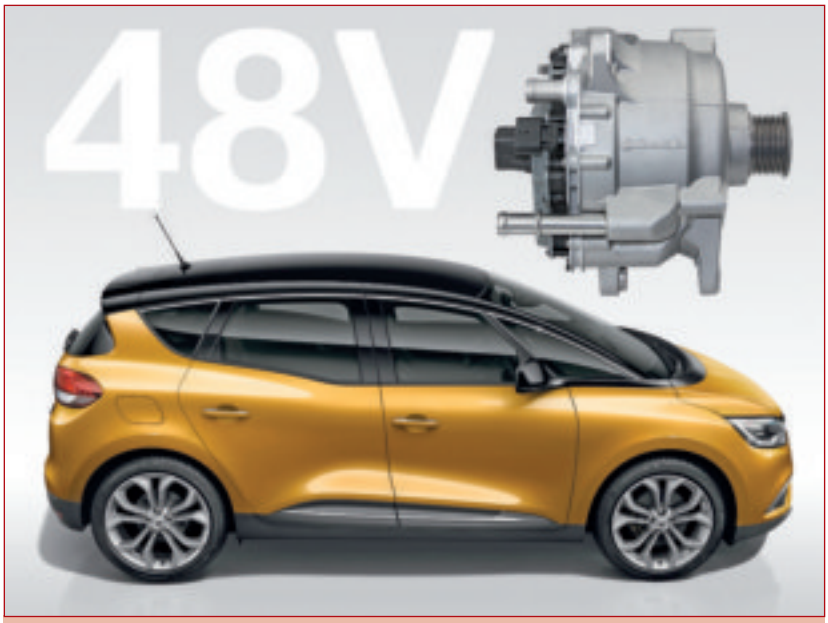
European Metropolitan Region of Nuremberg: strength in the automotive industry – e-mobility as a strategic driver of innovation

Automobile suppliers form the industrial backbone of the European metropolitan region of Nuremberg (EMN). With around 88,000 employees and job growth of over ten per cent within the last six years, they represent a key industry. The EMN's corporate landscape is shaped mostly by medium-sized businesses. However, it is also home to global market leaders from various sectors. Its particular strengths lie in electrical and mechanical drive technology and mechatronic system solutions.

It is therefore not without reason that the EMN's plans for development focus on the "automotive" technology-oriented field of expertise and the "intelligent mobility" action field. Key areas include: automated driving, environmental compatibility, intelligent networks, age-appropriate mobility and hybrid drive systems including e-mobility.

Efficient and electric mobility is gaining more and more importance and it seems only a question of time before it permanently replaces the classic combustion engine. With its mix of varied suppliers, the EMN is perfectly positioned to advance and decisively shape this and other issues.

One example is provided by Conti-Temic microelectronic GmbH in Nuremberg, where around 2,500 employees work on all aspects of electrification. The world's first 48-volt hybrid drive has been mass produced there since October 2016. The technology used is a particularly cost-efficient solution that significantly reduces fuel consumption and exhaust emissions. The 48-volt variant is an alternative to the considerably more complex 300 to 400 volt technology that has previously been the standard in hybrid vehicles. Since 2013, the engineers at Continental in Nuremberg have been developing this hybrid drive together with Renault and regional partners such as the Fraunhofer Institute for Integrated Systems and Device Technology (IISB) and the Bayerisches Laserzentrum (both based in Erlangen).



The world's first hybrid drive, which works with a voltage of 48V, was developed by Conti in Nuremberg and continues to be mass produced there. Image: Continental ■

Other companies and brands such as Siemens, Baumüller, Brose,

Semikron, Schaeffler, MAN and ABM Greiffenberger also stand for considerable global expertise in the field of electric and hybrid drive technology.

The region's other strengths include the provision of components and solutions for electronics, cables, wiring systems, and storage and charging systems. Examples of companies and brands in these sectors include Bosch, Leoni, Komax, FCI Connectors, ZF, Delphi, Diehl, Schlenk, Scherdel, E-T-A, ABL Sursum, TÜV Süd and TÜV Rheinland.

The "Ladeverbund Franken+" combines the services of around 50 local municipal utilities for a regionwide uniform and user-friendly charging infrastructure. There are currently around 200 charging stations available. Quelle: N-ERGIE ■

The Nuremberg metropolitan area is home to several research institutes and university departments specialising in electromobility. Examples include the above-mentioned Fraunhofer IISB (developing power electronics, designing and implementing storage systems and test centres for electric vehicles), the Fraunhofer Institute for Integrated Circuits IIS (e.g. information and communication technology for battery management, energy management, connection to smart grids, non-destructive material testing), Fraunhofer Institute for Silicate Research ISC (material development for fast, high-performance and secure energy storage) and the Fraunhofer UMSICHT Institute Branch Sulzbach-Rosenberg (centre for energy storage). Institutions such as the E|Drive Center at the Friedrich-Alexander Universität Erlangen-Nürnberg (production-related design, production technology and application development for electric drives), the Bayerische Polymer-Institut in three Universities based in Bayreuth, Fürth and Würzburg (development of fibre-reinforced composites such as CFRP) and the Technologie-Transfer-Zentrum-Elektromobilität (TTZ-EMO) at the University of Applied Sciences Würzburg-Schweinfurt (i.a. load management with electromobility and innovative charging technology) provide future-oriented solutions, as do the Institute for Power Electronic Systems (ELSYS) at the Technische Hochschule Nürnberg Georg Simon Ohm (network integration of electric vehicles i.a.), Automobiltechnikum Bayern in Hof (measurement and testing technology), the Ostbayerische Technische Hochschule Amberg-Weiden (integrated systems and real-time software for electromobility) and the Technologietransferzentrum Automotive of the Hochschule Coburg (TAC).

Since 2013, the Nuremberg Chamber of Commerce and Industry for Central Franconia has provided the CCI Innovation & User Club e-mobility (http://emo-

The electric engines from the Baumüller Group in Nuremberg are now also used in battery-powered FRAMO trucks. The 18-ton electric truck has a range of 250 - 270 km and can carry a cargo load of 9.5 tons. Quelle: Baumüller ■

Netherlands@Schaeffler: The Schaeffler bio-hybrid combines benefits such as stability and weather protection with the energy consumption and space utilisation of a pedelec. Photo: Schaeffler ■

bility-nordbayern.de) in cooperation with the chambers of commerce and industry based in Coburg, Bayreuth, Regensburg and Würzburg-Schweinfurt to create opportunities for regional providers, users and developers to cooperate and promote the exchange of knowledge. Examples of other regional clusters and networks advancing the issue of electronic mobility include Nuremberg-based Bayern Innovativ GmbH, and the competence initiatives EnergieRegion Nürnberg e.V. (project "CODIFeY"), Center for Transportation and Logistics Neuer Adler e.V. (CNA), European Center for Power Electronics e.V. (ECPE) and in Bayreuth the Automobilnetzwerk ofraCar-Automobilnetzwerk e.V. Fürth-based solid GmbH combines the electronic mobility activities of regional energy providers, for example in the "Ladeverbund Franken+" project, a charging network in and around Franconia. ■

metropolregion nürnberg

iawc
IHK-Innovations- & AnwenderClub Elektromobilität

IHK Industrie- und Handelskammern in der Metropolregion Nürnberg

Authors:

Dr.-Ing. Robert Schmidt

Dr. rer. nat. Ronald Künneth

Nuremberg Chamber of Commerce and Industry (CCI)
Innovation & Environmental Affairs Division

Ulmenstraße 52
90443 Nuremberg, Germany
e-mail: iu@nuernberg.ihk.de
www.ihk-nuernberg.de

Audi e-tron Sportback concept – Architecture of e-mobility

- *From 2019 on in series: a second e-Audi*
- *Emotional and strong: Audi Coupé style*
- *Enlightening: Seeing the e-tron lights communicating*

Design study and technology demonstrator, electric car and power pack in the guise of a coupé: The study of a four-door Gran Turismo contains a powerful 320 kW electric drive. The formal idiom of the coupé with Lux Silver paint finish combines classic Audi elements with an array of trendsetting details: an electrifying architecture, tailored consistently to the technology and the package of the electric drive.

Audi e-tron Sportback concept

The Audi e-tron Sportback represents an important milepost for Audi along the road to electric mobility. Rupert Stadler, Chairman of the Board of Management of AUDI AG, confirmed: "Our Audi e-tron will be starting out in 2018 – the first electric car in its competitive field that is fit for everyday use. With a range of over 500 kilometers (310.7 miles) and the special electric driving experience, we will make this sporty SUV the must-have product of the next decade. Following close on its heels, in 2019, comes the production version of the Audi e-tron Sportback – an emotional coupé version that is thrillingly identifiable as an electric car at the very first glance."

In its consciously light-colored interior the Audi e-tron Sportback concept offers a blend of functional clarity and reductive controls as a formal principle. Expansive touch-sensitive screens below the central display, on the center console and in the door trims supply information and interact with the on-board systems. Horizontal surfaces on the dashboard and the seemingly floating center console convey a sense of open perspectives for the occupants of the four individual seats.

Audi e-tron Sportback concept - Front view ■

The concept car's lighting technology is an innovation that is visible by both day and night. Digitally controlled Matrix LED units at the front and rear produce an excellent light yield. Minuscule Digital Matrix projectors literally make their mark on the road ahead, turning light into a versatile, dynamic channel of communication with the surroundings.

The brand with the four rings was the first in the world to adopt full LED headlights, and gave Matrix LED technology, laser lighting and OLED technology a significant push towards their breakthrough. The tech-

Audi e-tron Sportback concept - Cockpit ■

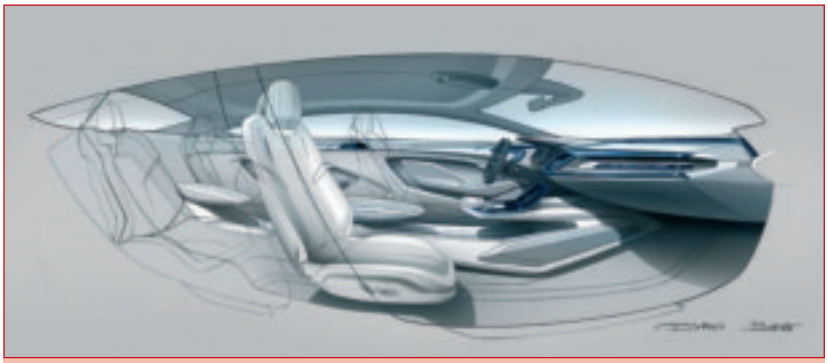
nology study now premieres a whole host of complex functions that steer vision and interaction with the surroundings in a new direction.

Narrow light strips on both sides below the front lid – the daytime running lights – become the eyes on the face of the study. Thanks to a combination of LEDs and a micromirror-studded surface plus complex control technology, a large number of animated movements and signatures are possible. When the e-tron Sportback starts and also when the doors are opened, the system uses switchable segments to generate dynamic visual welcome signals.

Below the daytime running lights, to the left and right of the Singleframe, there are two large-area light fields each comprising an arrangement of around 250 LEDs. They offer a vast array of possibilities for creating engaging graphics or specific communicative signs, even while on the move.

For its drive, the e-tron Sportback uses a configuration that will also be adopted in future production Audi models with all-electric drive: One electric motor on the front axle and two on the rear power all four wheels, transforming the high-performance coupé into a quattro in typical Audi style. 320 kilowatts of power – which can even reach 370 kW in the boost mode – provide a fitting level of propulsion, with the sprint from 0 to 100 km/h (62.1 mph) a done deal in just 4.5 seconds. With the battery's energy content of 95 kilowatt-hours, its range is in excess of 500 kilometers (310.7 miles) (NEDC).

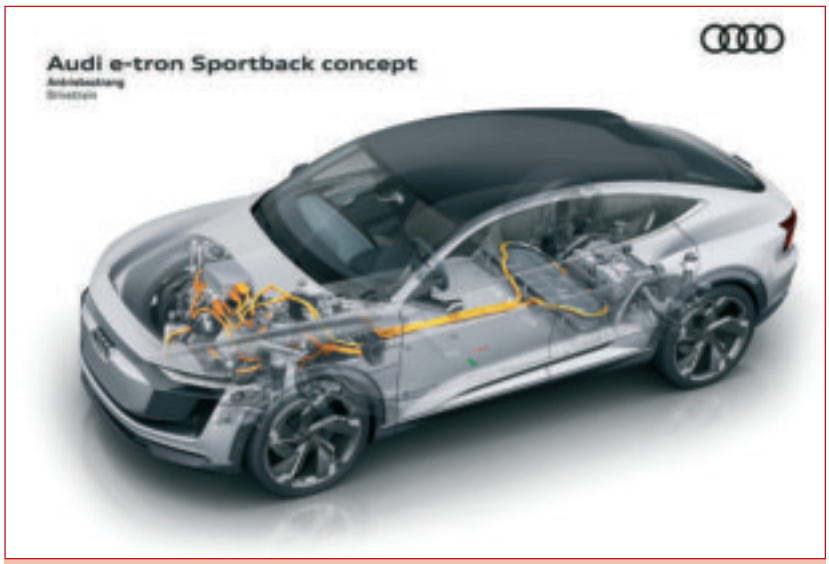
As previously on the e-tron quattro concept, the technology



Audi e-tron Sportback concept - Design sketch interior ■

study's liquid-cooled lithium-ion battery is positioned between the axles below the passenger compartment. This installation position provides for a low center of gravity and a balanced axle load distribution of 52:48 (front/rear). And that gives the sporty SUV outstanding driving dynamics and driving safety compared with other vehicles in the segment. The Combined Charging System with two connectors enables charging with alternating current (AC) and direct current (DC).

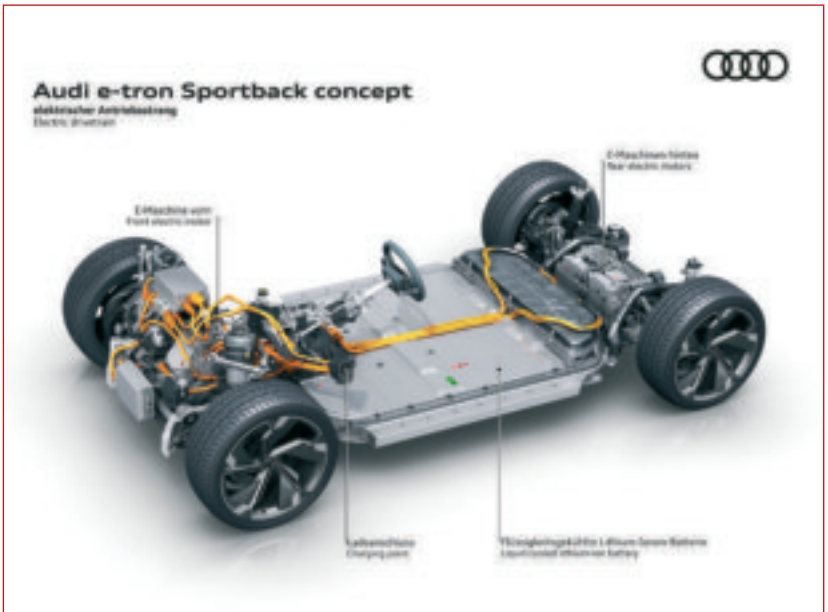
The study vehicle's front end displays the familiar octagonal Singleframe with an overtly wide, horizontal cut – the greatly reduced amount of air required by the electric motor means the large opening can be omitted here. The sculptural surface painted in the body color has a structured



Audi e-tron Sportback concept - Drivetrain ■

pattern emblazoned with the four-rings logo – just like the grille of the classic Singleframe.
The edges of the central surface are drawn back, allowing air to flow through at the top. The air inlet is bracketed again by an octagonal, black-painted frame that structures almost the entire width of the front end.
Between the front lid extending low down, the front apron and the wheel arches, it combines with the light units to give this Audi an unmistakable face.
The Audi designers also adopt a new tack for the air flow through the front lid. Above its front section, which dips deeply at the front, a bridge running parallel with the nose connects the two wheel arches and also doubles up as an air deflector. This gives the front end a much more dynamic character than the hefty forward structure of a car with a combustion engine installed at the front.
The four wheel arches with pointedly horizontal top edges extend well out from the cabin. They shape the conspicuous quattro architecture – not just by providing visual evidence of a wide track and dynamic potential, but also by binding the e-tron Sportback into the brand's DNA. Large 23-inch wheels in a technical 6-spoke design highlight the confident presence of the imposingly dimensioned coupé. An exterior length of 4.90 meters (16.1 ft), a width of 1.98 meters (6.5 ft) and a height of 1.53 meters (5.0 ft) with a wheelbase of 2.93 meters (9.6 ft) position the e-tron Sportback in the C segment, close to the Audi A7.
Small cameras replace the exterior mirrors. This technology offers other advantages besides improved air flow and reduced wind noise. The blind spot of the physical exterior mirror is virtually eliminated, as is the obstruction to the diagonal forward view. The camera images are shown on separate displays in the doors. Audi is showing this technology as a concrete foretaste of the production version.
At the 2015 Frankfurt Motor Show Audi unveiled the Audi e-tron quattro concept – the forerunner of the brand's first all-electric-drive production automobile. As a radically reconfigured SUV it offers a range of up to 500 kilometers (310.7 miles) with the spaciousness and comfort of a typical full-size automobile from Audi. It has the road performance of a high-performance sports car – the Audi e-tron quattro sprints from 0 to 100 km/h (62.1 mph) in only 4.6 seconds. The production version of this pioneering electric SUV will appear on the market in 2018. The Audi e-tron Sportback concept car will be followed by its production version in 2019. ■

Audi e-tron Sportback concept - Rear view ■



Audi e-tron Sportback concept - Electric Drivetrain ■

Contact::

Josef Schloßmacher

AUDI AG
I/GP-P
D-85045 Ingolstadt
Tel.: +49-841-89-33869
Fax: +49-841-89-90786
josef.schlossmacher@audi.de
www.audi.com

Electrical steel: Strong magnetic fields due to sharp tools

Researchers optimize cutting process for steel sheets used in electric motors

In an electric drive, magnetic fields have to be created in order to transform electric energy into kinetic energy. The magnetic properties of the motor's main components, referred to as electrical steel sheets, are the decisive factor in the efficiency of the electric motor. Scientists at the Technical University of Munich (TUM) have investigated the way these steel sheets are processed and have concluded that using blunt cutting tools deteriorates the magnetic properties of the steel sheets significantly.

Magnetic fields

Current criticism of electromobility usually focuses on long battery charging times and inadequate range. Researchers are working to increase the efficiency of electric drives in order to reduce the energy requirements of electric vehicles. This involves a large number of individual components, in particular electrical steel sheets: These sheets are important since the magnetic fields that move the motor using attractive and repulsive forces are generated within them.

Depending on the motor's design, a variety of different holes have to be cut in the steel sheets, for example to make room for copper coils built into the motor. Each steel sheet is "stamped" individually in a press, using the same principle as a hole punch. Special cutting tools are used to ensure that the specified geometries are created in the steel sheets. Finally, the steel sheets are put together in order to form the desired shape.■

Hannes Alois Weiss, research associate at the Chair of Metal Forming and Casting, at the punching machine. (Photo: Andreas Heddergott / TUM) ■

Power consumption rises by as much as 400 percent

Researchers from the TUM Chair of Metal Forming and Casting have investigated this process in detail in their workshop. "We wanted to examine how manufacturing the electrical steel sheets by blanking influences their magnetic properties," explained project director Hannes Weiss.

The scientists found out that the sharpness of the cutting tools used has a very significant impact on the magnetic properties of the steel sheets. The effect can be compared to a pair of scissors which dulls over time: More energy is needed to cut paper with the scissors. Regarding blanking, worn cutting edges result in higher tension in the

Individual electric sheets are assembled into a compact package. The picture shows a rotor laminated core. (Photo: Andreas Heddergott / TUM) ■

steel sheets themselves – the material is bent and thus subject to increased mechanical stress. The resulting stress has a major impact on magnetic properties. "In some cases as much as four times the amount of electricity is needed to achieve the same degree of magnetization," Weiss explains.

Another factor also has a major influence, the distance between the cutting edges, referred to as the cutting clearance. Once again, the process can be illustrated using the example of scissors: When the screw which holds the scissor blades together loosens, the distance between the blades becomes too large and the paper frays when cut. "Sharp cutting edges and a very small cutting clearance are optimum in achieving the best magnetic properties and thus a high level of efficiency."

Weiss and his team have formulated recommendations for the production process. However, economic factors also have to be taken into account, the engineer explains: “When the cutting tools and their maintenance incur additional costs, the final price of the electric drives produced rises as well.” ■

Major energy savings

Processing electrical steel sheets is not only an important issue in the context of electric motors. The sheets are also used in transformers, for example in mobile phone chargers and computer power supplies. The researchers also want to focus on the processing methods in this context as well. Weiss: "If we think of the enormous number of transformers in use, then even a small increase in efficiency can save a large amount of energy."

Hannes Alois Weiss, research associate at the Chair of Metal Forming and Casting, at the punching machine. Photo: Andreas Heddergott / TUM ■

Information on the project:

Project work was conducted under the first part of the research project FOR1897 on low-loss electrical steel sheets for energy-efficient drives, "Verlustarme Elektrobleche für energieeffiziente Antriebe". The project was supported by the German Research Foundation (Deutsche Forschungsgemeinschaft or DFG) - 218259799. ■

Publications:

Weiss, H. A. et al.: Loss reduction due to blanking parameter optimization for different non-grain oriented electrical steel grades. Electric Machines and Drives Conference (IEMDC), 2017 IEEE International, 2017

Weiss, H. A. et al.: Influence of shear cutting parameters on the electromagnetic properties of non-oriented electrical steel sheets. Journal of Magnetism and Magnetic Materials Volume 421, 2016, 250-259 ■

Contact:

Hannes Alois Weiss, M. Sc.
Technical University of Munich
Chair of Metal Forming and Casting

Telephone: +49 (0)89 / 289 - 13998
E-Mail: hannes.weiss@utg.de

Audi Aicon concept car – autonomous on course for the future

With the four-door design vision Audi Aicon, the brand with the four rings is presenting a autonomous Audi of the future – with no steering wheel or pedals. As a design concept, the four-door 2+2 boldly leaps ahead to show the exterior and interior design of the next decades. The technology demonstrator combines innovations relating to the drivetrain, suspension, digitalization and sustainability in a visionary manner. The Aicon, too, is designed for purely electric operation and should be able to cover distances between 700 and 800 kilometers (435.0 - 497.1 mi) on a single charge.

Concept Car Audi Aicon

Design study, technology demonstrator, mobility concept: The Audi Aicon exploits every possibility offered by an autonomous luxury sedan of the future with unprecedented consistency. As a design study, the four-door 2+2 boldly leaps ahead to show the exterior and interior design of the next decades. The technology demonstrator combines innovations relating to the drivetrain, suspension, digitalization and sustainability in a visionary manner.

And as a mobility concept, the Audi Aicon shows the world of tomorrow, in which the advantages of door-to-door individual transportation are combined with the luxurious ambiance of a first-class airline cabin. A cabin with no steering wheel or pedals that can thus offer all the comforts of modern communications electronics and perfect ergonomics – simply first-class.

One look is all it takes: In contrast to a robot taxi, which is reduced to pure functionality, the autonomous Audi Aicon concept vehicle pulls out all the stops. Its presence is impossible to ignore, and its exterior hints at the spacious comfort afforded the passengers and the upscale technical aspirations. The Audi Aicon is a sneak peek at a prestigious automobile of tomorrow that stirs the desires of demanding customers. ■

Audi Aicon - Front view ■

Pure presence – the exterior

The Audi Aicon looks spectacular from any angle. Its sheer size – an exterior length of 5,444 millimeters (17.9 ft), a width of 2,100 millimeters (6.9 ft) and a height of 1,506 millimeters (4.9 ft) – places it in the automotive top tier, the D segment. The wheelbase measures 3,470 millimeters (11.4 ft). That's 240 millimeters (9.4 in) more than with the long version of the new Audi A8.

The central element of the exterior is the cabin. Large glass surfaces at the front and rear as well as the significantly convex side windows create a bright expanse of space for the travelers. A distinct edge runs as a hard line along the side window surfaces of the Aicon back to the D-pillar – a first in automotive design. This line emphasizes the car's length and effectively reduces the apparent volume of the cabin relative to the overall body. The darkened side sills rise subtly toward the rear, making it seem like the car is ducking.

The designers reduced the front and rear ends to a minimum of lines and focused on large, uninterrupted surfaces. As with the Audi e-tron Sportback concept, the Aicon front features the inverted hex-

Audi Aicon - Design sketch lateral light fields ■

agonal Singleframe, a typical feature of the upcoming generation of electric cars from Audi. The sharply inclined silhouette of the entire front end evokes a sense of forging ahead – this, too, is a typical sports car body line. ■

Emotion and information – the LED lighting technology

Conventional headlights and lighting units are absent from both the front and rear of this car. Instead there are fully digital display surfaces comprising hundreds of triangular pixel segments. They are three-dimensional recreations of the Audi AI symbol.

Grouped around the Singleframe are large light fields, in which – as at the rear – more than 600 3D pixels are arranged in space. The large surfaces and high pixel count enable versatile graphics, animations and information visualizations in any color. The Audi Aicon is thus no longer bound to a daytime running lights look, but rather can adapt to the driving situation and even its passengers. The customization is boundless.

The Audi Aicon supports its surroundings intelligently and uses animations on its display surfaces to warn pedestrians or cyclists of dangerous situations. Driving modes such as platooning, urban driving or driving at a walking pace can be visualized. Horizontal stripes of light move from the bottom up when the car accelerates and in the opposite direction during braking. Their speed increases or decreases in sync with that of the car.

Future cars will expand their sphere of communication to the surroundings. The Audi Aicon uses projector modules to illuminate the road and surroundings in high resolution and project signals onto the ground. This enables it to communicate warnings and vehicle information to passers-by with no direct line of sight to the car. ■

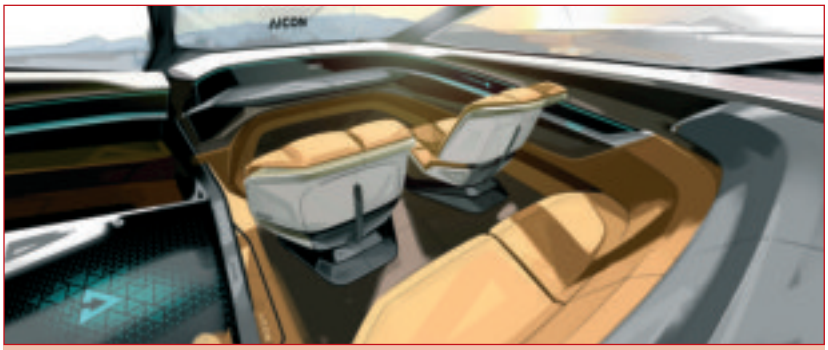
Space, form, function – the interior

The Audi Aicon features opposed doors that open to the front and rear. There is no B-pillar. The entire breadth of the interior is thus exposed to the passengers as they get in the car. In the interior, the lines of the decorative surfaces and functional elements are markedly horizontal. Becoming lighter from bottom to top, the interior reinforces the impression of unique spaciousness, and the lack of a steering wheel and a classic dashboard creates a sense of openness and expanse.

The interior appears to be particularly wide when the two individual front seats are slid all the way back. The Audi Aicon is a 2+2-seater. An upholstered, two-seat bench is integrated into the rear panel. The two front seats are designed for maximum comfort and optimal spaciousness. Passengers can slide them up to 500 millimeters (19.7 in) back and forth between the forward and rear positions. The seats don‘t slide on rails, but rather on a platform covered in high-pile carpet that can be moved longitudinally, and on which the passengers‘ feet also rest. The platform height is variable, so that it can also be used as an ottoman for your legs. The pitch of the seat cushions and backrests can be steplessly adjusted for a comfortable working or resting position.

The individual seats can also be swiveled by up to 15 degrees. Turning the seats outward makes it even easier for the passengers to get in. Turning them inward makes it easier for the passengers to talk and interact. If the passengers turn around, the head restraints fold back like a collar and become an arm rest.

The architecture of the seats is the automotive reinterpretation of a classic piece of furniture, the lounge chair. The seat cushion and backrest are visually separated from one another. Two outer shells support the light-colored, pillow-like

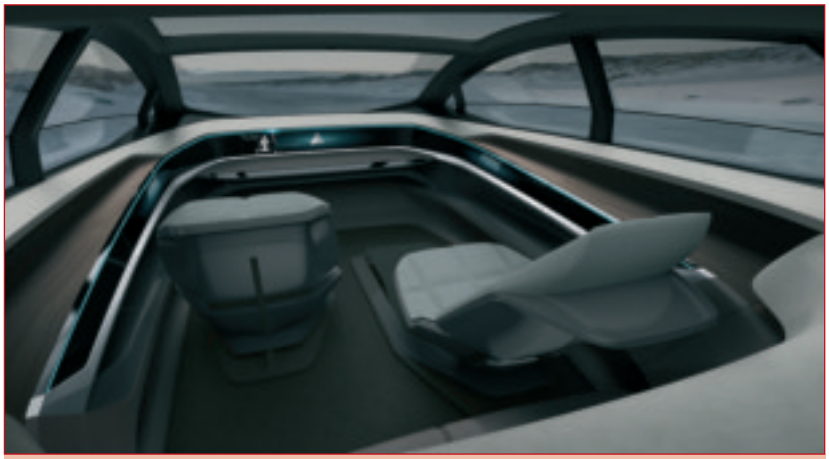


Audi Aicon - Design sketch interior ■

upholstery elements with a square-quilted surface. The side bolsters of the backrest are subtly angled to provide sufficient support in curves.
There is also plenty of space in the Audi Aicon long-distance vehicle for luggage, of course. Thanks to the space-saving design of the electric drive, there is a storage compartment at both the front and the rear of the vehicle with a combined capacity of roughly 660 liters (23.3 cu ft). The Aicon also offers numerous storage options in the passenger compartment. ■

Accommodating – operation and communication

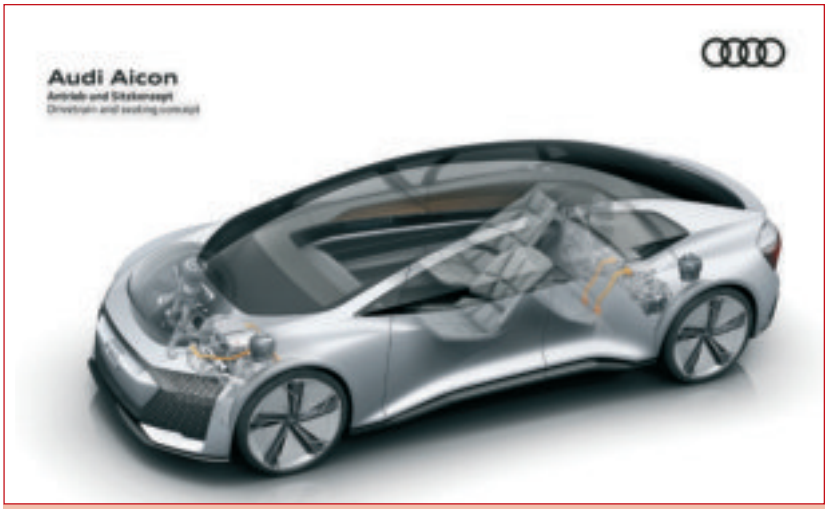
The oft-cited paradigm change in the automotive world – it shows in the Audi Aicon. One glance is all it takes to realize that all of the controls and displays are missing. Steering wheel, pedals, groups of buttons and instruments – nothing. Instead just wide, uninterrupted surfaces. The passengers are enveloped by the gently curved armrest along the doors, which rises slightly from back to front. Instead of a dashboard in front of them, there is a generous shelf and the central display below the windshield. The interior quickly comes to life once passengers enter. Illuminated lines of LEDs set colorful accents in the area of the doors. The front display lights up with a welcome message. PIA, the empathetic electronic vehicle assistant, recognizes the passenger by his phone and activates all of his personal settings. There are custom settings for the air conditioning and seating position, interior light color and the layout of the infotainment system. The navigation system awaits entry of a destination, and all accessible channels of communication are ready for use, connected via the fastest available standard.
New are the variably positionable control interfaces in the encircling door rail. Depending on the position of the seats, which can be shifted by up to 50 centimeters (19.7 in), ergonomically perfectly positioned touch and display elements are available in the digitized wrap-around. Your hand instinctively finds its way to the touch-sensitive control panels. Passengers can set the most important settings by tapping with their fingers without having to sit up in their seats or leaning forward. Operation is also interactive. The PIA system is often one step ahead of the passenger and offers services before they actively chose them.
There are multiple input modes available for engaging with the car. Besides the haptic-manual layer, there are also voice control and eye tracking, in which sensors in the front end of the interior track where the passenger is looking. The passenger locks his onto a control element in the area of the front main display to select it and performs fine adjustments using his hand or voice.
The full range of services offered by modern communications electronics are available at all times in the Audi Aicon. Travelers can relax and watch a film or surf the web. Video conferences are another option, as is interaction on social media. Depending on the seating position, the passengers can use the large front display as the output surface or a virtual head-up image displayed above it in the windshield.
The glass roof panels can block out the sunlight, if desired. Their transparency level changes upon application of an electric voltage. Integrated OLED lighting elements allow for precise mood lighting or the even illumination of the interior when getting in or out of the car, for instance.
The Audi Aicon opens up a new world of mobility to its passengers. Freed from the tasks of driving, they can choose how to spend their time in the car. Working, communicating or simply just relaxing and even napping: Anything is possible while the car autonomously and safely finds its way. ■



Audi Aicon - Interior ■

Optimized for the long haul – drivetrain and suspension

The very shape of the Audi Aicon reveals that it is a car from another world, an automobile of the future. The technology used in the concept vehicle has also been systematically designed for this world. It presumes a transportation infrastructure in which autonomously driving automobiles are a given on every street. Road users are connected to one another and their surroundings.
The drive and the total vehicle have also been optimally adapted to this new world of mobility. A highly efficient electric drive



Audi Aicon - Drivetrain and seating concept ■

provides for the dynamics of the Audi Aicon. A total of four electric motors are located in the area of the front and rear axles. The energy storage units are integrated into the area below the floor. These are solid body batteries with considerably more energy capacity than lithium-ion batteries.

The four electric motors produce a total of 260 kW and 550 Newtonmeters (405.7 lb-ft). Each drives one wheel, enabling electronically controlled, variable quattro all-wheel drive. Maximum acceleration played a less important role in the specification than maximum efficiency and thus also range. This operating strategy is also pursued by the powertrain and electric brake units, which use recuperation to recover energy. Targeted lightweight construction of the multimaterial body and optimized aerodynamics also help the Audi Aicon to achieve ranges between 700 and 800 kilometers (435.0 - 497.1 mi) on a single charge.

Even charging has been reduced to a minimum. Thanks to a high-voltage system with 800 volts, the Aicon's battery unit can be charged to 80 percent of capacity in less than 30 minutes. The car is also equipped with a unit of inductive, i.e. wireless, charging. The Aicon manages both without a driver. In an AI Zone, it can pull up to a charging station on its own and charge its battery without any human assistance.

As a true quattro, the Audi Aicon offers ample performance and even autonomously always reaches its destination safely regardless of the weather or road surface. The suspension is designed for maximum comfort. Pneumatic spring and damper units smooth out any road surface irregularities. And electric actuators at all four wheels actively counteract any body lean, whether when cornering, accelerating or braking. As a fully active suspension system, it also optimizes the qualities of the adaptive air suspension. The Audi Aicon literally glides over even large potholes.

The Aicon brakes primarily by way of recuperation and in so doing recharges the batteries. The development engineers have relocated the disk brakes from the wheels to a position close to the drivetrain. This improves the aerodynamics at the wheels as there is no longer any need for air cooling at the wheels, which is always associated with turbulence. Another secondary effect is the reduction of the unsprung masses, which the Aicon's passengers perceive as a particularly sensitive damping response to road surface irregularities.

The axle and drive units in the Audi Aicon are symmetrical, i.e. identical at the front and rear. Mechanical components, such as the steering shaft or steering hydraulics, have been eliminated. The car is therefore equipped with a complete all-wheel steering system without compromising the available space and thus the passenger compartment. A positive effect for the practical qualities of the Audi Aicon: Despite its long wheelbase of nearly 3.47 meters (11.4 ft), the car is extremely agile due to its two steerable axles – the turning radius of only 8.50 meters (27.9 ft) is below that of a small car thus making the Audi Aicon suitable for city center driving.

The Audi Aicon is an all-arounder well prepared for its primary task: to offer a maximum of comfort, communications technology and freedom for its occupants during a long journey. It combines the scopes for autonomous driving in an urban environment and on the highway with an unprecedented range for an electric drive. The Aicon will be followed by further multitalented Audi models, each with their own specialized discipline, ensuring that the vehicle range of the brand with the four rings remains as diverse as it is fascinating. ■

Contact:

Josef Schloßmacher

AUDI AG
I/GP-P
D-85045 Ingolstadt
Tel.: +49-841-89-33869
Fax: +49-841-89-90786
josef.schlossmacher@audi.de
www.audi.com

Industry 4.0 and Intellectual Property Law

The catchword "Industry 4.0" stands for the revolutionary digitalization and networking of working and production processes. The use of computer-controlled production units in the form of robots and the utilization of machine-generated data (artificial intelligence) requires fundamental innovations in the fields of automatization and production, which are particularly relevant for automotive technology. New developments, such as digital navigation and information systems, driverless cars, electromobility, and smart devices in automobiles call for suitable legal and organizational protection concepts.

New challenges for Patent Offices and Applicants

In the field of patent law, the primary focus lies on questions of patentability of new software-based inventions and developments through artificial intelligence. In many cases, interdisciplinary combinations of computer science and natural sciences will be involved, which make special demands on the expertise of examiners and patent attorneys regarding prior art search and formulation of patent claims.

An increasing number of patent applications relates to computer-implemented inventions. These are inventions involving a computer, a computer network or another programmable device, that are realized, completely or in part, using a computer program. Revelant for the grant of European patents in this field are the EPO's Guidelines for Examination, Part C II. In each individual case it must be determined whether the subject-matter claimed is a computer program "as such", which according to Section 1, Sub-section 3, No. 3 PatG (German Patent Act) and Art. 52 (2)(c) EPC is not regarded as patentable invention, or whether it fulfills the patentability requirement of technical character by technical effects that are present during implementation. If this is not the case, there only remains the copyright law which protects its owner against the copying of his/her work but not against third-party use of its content. If the first hurdle of the requirement of technical nature has been cleared, the decisive factor for patentability is that it relates to a technical problem that is solved by technical means. This will often be the case in the realm of industry 4. Here, however, both a careful formulation of the patent claims and an optimized application strategy already at the drafting stage of the application will play a key role.

It remains to be clarified who will be entitled to the ownership and right of use of computer-generated data. In this connection, the question arises whether the character of inventor provided for in patent law and his/her performance of mental acts are to be applied at all to automated development results. Largely resolved is the question of whether data sequences generated by a patented process are capable of being protected. In this regard, the Federal Court of Justice (BGH) clarified in its "Rezeptortyrosinkinase II" decision that patent protection for such process products is only possible if the process provides them with specific objective technical properties, so that, by their nature, they are suitable of being protected by a product patent. Mere information is thus not patentable.

Standard essential patents

The increasing digitalization of products and services requires the development of globally valid standard norms to facilitate the international exchange of goods and services as well as the cooperation in the scientific and technological sectors. This applies, in particular, to the field of networked products (smart devices, intelligent products for the home and automobiles) that are connected to the internet and other devices. Corresponding standards are defined by international standardization organizations. These standards often relate to technologies that are protected by patent, i.e. so-called standard

essential patents (SEPs). Manufacturers of intelligent products that utilize SEPs thus require licenses for the relevant standardized technologies. Under current legislation, SEP owners are obliged to grant licenses to potential users of the standard at fair, reasonable and non-discriminatory (FRAND) conditions for patented technologies covered by the standard. According to the decisive European Court of Justice judgment in Huawei v. ZTE, the holder of a standard essential patent may only seek an injunction against the infringement of an SEP if prior to bringing that action, the proprietor has, first, alerted the alleged infringer of the infringement complained about by designating that patent and specifying the way in which it has been infringed, and, secondly, after the alleged infringer has expressed its willingness to conclude a licensing agreement on FRAND terms, presented to that infringer a specific, written offer for a licence on such terms. For lack of uniform legal regulations and in view of divergent case law, there remains considerable uncertainty regarding the evaluation and enforcement of standard essential patents. Thus, the intention of the European Commission to establish a harmonised framework for the licensing and enforcement of standard essential patents is to be welcomed. In this regard, reference is made to the Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee of November 29, 2017 (https://ec.europa.eu/docsroom/documents/26583).

Transnational patent protection

The cooperation of networked production and processing units located in different countries requires crossborder patent protection which, under the current system of territorially limited IP rights, is difficult to guarantee. In particular, this applies to cross-border infringement where some process steps of a patented process are performed in Germany and some abroad. These processes may be production, working or controlling processes connected to computer-controlled transmitting and receiving units, such as autonomous motor vehicles, that are distributed over several countries. In such case constellations, a domestic patent infringement will only be ruled if the partial acts taken abroad can be attributed to the party acting in Germany. The implementation of the planned unitary patent system with a unitary patent valid in all participating member states of the EU and with the Unified Patent Court (UPC), expected in 2019, promises a solution for these cases. The UPC is an international court which will hear cases regarding infringement and revocation proceedings both of unitary patents and regular European patents. It is intended to set up local divisions in all participating member states so that, for example, it will be possible to bring an action before the local division in Munich or Düsseldorf against infringements throughout Europe. Thus, costly parallel actions in several countries will no longer be needed. In the case of a cross-border infringement, the question of attribution of liability for acts partially taken in Germany and partially abroad does not arise provided the individual process steps are taken in the territory of the participating EU member states.

European-wide protection of know-how

With respect to know-how, too, harmonized protection for the territory of the European Union on the basis of a new EU Directive has already been provided for (Directive (EU) 2016/943 of the European Parliament and of the Council of 8 June 2016 on the protection of undisclosed know-how and business information (trade secrets) against their unlawful acquisition, use and disclosure). The Directive is to be implemented into national law in 2018 and ensures a uniform protection of trade secrets that, compared to present national unfair competition legislation, sets higher standards regarding the measures to be taken to protect the confidentiality of trade secrets. Therefore, special caution must be taken, especially with respect to decentrally stored data that are processed across companies.

Conclusion

The application of current intellectual property law in the digital context presents a particular challenge and requires the further development of legal and organisational protection concepts. Therefore, the progressing harmonization of European law in this field is highly welcome.

VOSSIUS & PARTNER

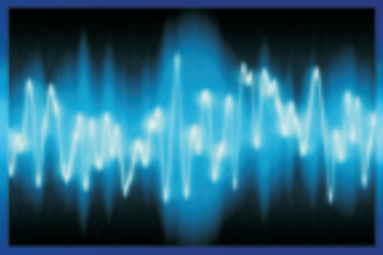
Author:

Dr. Johann Pitz

Rechtsanwalt Patentstreitigkeiten und Patentverletzungsprozesse

Vossius & Partner
Siebertstraße 3
81675 München
Phone +49 89 41304-0
Fax +49 89 41304-430
E-mail: pitz@vossiusandpartner.com
www.vossiusandpartner.com

Artificial sounds for traffic safety

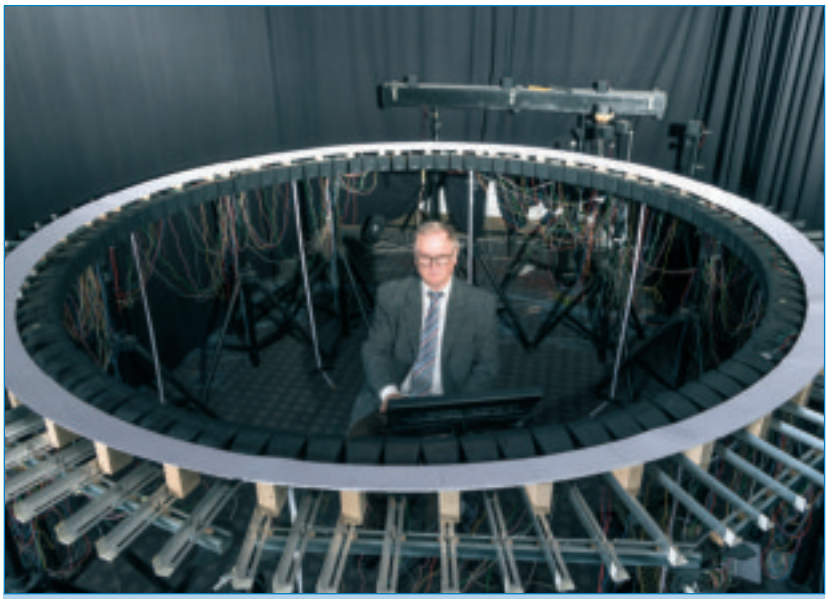


Acoustic Vehicle Alert System: TUM researchers design sounds for electric cars

The almost complete silence of the motors used in electric cars may pose a hazard to inattentive pedestrians. As a result, starting in summer 2019 all new electric and hybrid vehicles will have to be equipped with an acoustic warning system. Psychoacousticians at the Technical University of Munich (TUM) are developing the corresponding sounds.

It's supposed to sound similar to a vehicle – but not exactly the same as a diesel or gasoline-powered vehicle. The specifications for an Acoustic Vehicle Alert System warning sound that electric and hybrid vehicles will have to emit starting in the summer of 2019 are fairly general. Although playing a musical piece is not allowed, the nature of the sound with which individual approaching vehicles will warn pedestrians is being left up to manufacturers.

One example of how the signal should sound can be found on the Internet page of the United Nations Economic Commission for Europe (UNECE) http://www.unece.org/fileadmin/DAM/for_PR_Silent_car__AVAS_sound.mp3: The listener is immediately reminded of a spaceship taking off or an effect from a science fiction series. In Europe the warning sounds are required for e-vehicles travelling at speeds of 20 kilometers per hour or less. The sound created by the tires on the road surface is considered adequate for vehicles travelling at higher speeds.



Prof. Hugo Fastl in his Sound-Laboratory. (Photo: Uli Benz / TUM) ■

Hugo Fastl, Professor at the TUM Chair for Human-Machine Communication, researches the basics of sounds design for electric cars made by a variety of manufacturers. And although the sounds are still being kept secret, Fastl can reveal one thing: Each company wants its own branding, a sound which is characteristic of the car in question. "After all, right now a BMW also sounds different from a Mercedes or a Porsche – and that's supposed be the case with e-cars as well." ■

Frequency range, timbre and roughness

How exactly is a sound like that developed? "First we have a basic sound to which we assign a pitch," says Fastl. Here the researchers work with medium-range frequencies: "Very low frequencies are difficult to produce," says Fastl. "This would require very

large speakers on the car." On the other hand, elderly people can no longer perceive frequencies that are too high. Pitch can also indicate how fast the car is driving, for example with the sound rising in pitch as the automobile accelerates.

Another sound property is timbre. "It's like in music: You can play the first notes of a Mozart symphony on a smartphone in such a way that everyone recognizes the melody," says Fastl. "But it doesn't sound so great. When the same notes are played by a chamber orchestra with ten musicians, it sounds much better. And a full orchestra with 50 people can play the music to sound just the way the composer intended it to sound." Nevertheless, Fastl and his team don't work with an orchestra, they generate the timbre of the sounds on the computer.

Here they use a sound "construction kit" which they conceived and programmed themselves to develop target group-specific sounds. "It's a computer that can generate a wide range of sounds for use as ingredients, based on algorithms we developed ourselves." The sound machine resembles a mixing board in a sound studio. Its controls are used to create a synthetic sound which is then processed and adapted according to the results of listening tests conducted with human subjects.

In addition to frequency range and timbre there are several other particularly important properties when it comes to automotive sound design, for example roughness. Roughness is determined by the speed of changes in a sound's volume. Particular roughness is created when the volume changes something like 50 to 70 times per second. "Roughness in a sound is perceived as especially sporty," Fastl explains. "A Ferrari without roughness would be very hard to sell." ■

Loud, but not too loud

Special interior sounds are being designed for e-vehicles as well, even though there are no applicable regulations. The actual sound created by an electric motor could remind the driver of a tram; the interior sounds are tailored to the right target group just as the external sounds are. "Anyone who drives a 7 Series BMW will want to have peace and quiet," Fastl points out. "On the other hand Porsche drivers will want to be able to hear their investment at work."

And presumably pedestrians and those living and working close to streets don't want to be overwhelmed by traffic noise. "For 20 years the objective has always been to make cars quieter," says Fastl. "Now things are in part too quiet and we have to get louder again." Nevertheless, Fastl advises against doing away with all the advantages of the low-noise electric vehicle: "More and more cars with automatic pedestrian detection will be coming onto the market. We recommend that the e-vehicle only transmit sounds when a pedestrian is in the vicinity." ■

Contact:
Prof. Dr.-Ing. Hugo Fastl
Chair for
Human-Machine Communication

Phone: +49 (0)89 289 28541
mmk@ei.tum.de

aCar – The electric „all-rounder“

An electric car for Africa, custom-designed for the needs of the population there, that strengthens rural structures and helps drive the economy: Scientists at the Technical University of Munich (TUM) and partners have been working intensively towards this goal for four years. The aCar is designed for passenger and cargo transportation and is also interesting for the European automotive market.

Mobility is a part of our everyday lives: We transport large loads, commute to work, fly to a faraway country on vacation. However, access to a vehicle of any kind is hardly a given for many people in Africa. For farmers who live far from urban centers, this means that they have no direct access to medical care, education or to political processes. They are dependent on transport contractors who bring their products to the next city for sale in order to make a living. As a result many people are leaving rural areas in search of better living conditions in the city.

The new aCar prototype. (Photo: Florian Lehmann / TUM) ■

"With the aCar we have developed a mobility concept that can solve these problems," explains Prof. Markus Lienkamp, head of the TUM Chair of Automotive Technology. "The aCar is an off-road capable vehicle that is affordable for people there and is capable of transporting heavy loads. The modular structure also allows other uses for example for water treatment." Together with the "Bayern Innovativ" campaign, the TUM launched the project "aCar mobility - Rural mobility in developing countries" in 2013. The objective was to conceive a vehicle that precisely meets the requirements of the rural population in sub-Saharan countries. The project is supported by the Bavarian Research Foundation. ■

The concept: One vehicle, a variety of demands

Four-wheel drive is a must for the roads of Africa, the majority of which are not paved. The team also decided on an electric power train. "An electric drive is not only greener, but is also the better solution in technical terms, since it is low-maintenance and can apply its full torque directly to accelerating from a stop," says Martin äoltés, who shares leadership of the project with Sascha Koberstaedt at the Chair of Automotive Technology.

The vehicle is primarily intended for transporting passengers and cargo, with a total load capacity of

The new aCar prototype. (Photo: Florian Lehmann / TUM) ■

one ton. The battery offers a variety of other possible applications, either as an energy source or as a drive for high-consumption applications, for example as a winch. A number of various superstructures have been designed for the cargo bed which can be used on a modular basis. Additional modules can turn the vehicle for example into a mobile physician's office or a water treatment station.

The 20 kWh battery capacity gives the vehicle an electric range of 80 kilometers. The battery can be loaded from an ordinary 220 volt household wall socket within 7 hours. Solar modules mounted on the roof of the aCar gather energy throughout the day. Optional solar collector sheets can be unrolled to significantly increase the amount of solar energy produced for self-contained battery charging.

“Of course we'll have to import high-tech components such as the battery and the electric motors in the beginning," says Martin Šoltés. In future, as many of the aCar's components as possible are to be manufactured on location, in order to strengthen local economies. In order to make the automobile affordable for people on location, the price for the basic vehicle in Africa is to be kept under 10,000 Euros on a long-term basis. "Cast nodes and simple bolted construction enable simple manufacturing processes with very low investment costs," says Prof. Wolfram Volk, head of the Chair of Metal Forming and Casting. ■

First prototype: Technology testing and user studies

The scientists produced the first prototype in May 2016 and conducted initial tests in Germany. However, to make sure the aCar also meets all the demands placed on it on location, they shipped the vehicle to Ghana, where they tested the technology and concept under local conditions in July 2017.

The aCar passed all the tests with flying colors. "It spent six weeks in a container on its way there, we unloaded it, switched it on and it functioned perfectly all the way to the last day of testing," says Sascha Koberstaedt. The team also asked locals to drive the car; they were thrilled by the "Solar car". Another important point was testing the impact of the higher temperatures and air humidity on the electric systems. "We gathered a lot of data which we now have to evaluate," says Koberstaedt. "But we can already say that the aCar fulfills all the necessary requirements and has even exceeded our expectations."

New prototype: Modern design, optimized technology

In September, the new prototype of the aCar was presented at the International Motor Show in Frankfurt. The car is characterized by an unembellished, clear

aCar, assembly of the prototype at R & R Fahrzeugtechnik. Photo: Andreas Heddergott / TUM ■

The aCar team, the aCar and guests at the IAA in Frankfurt. Photo: Andreas Heddergott / TUM ■

and modern design. "The challenge was to develop an appealing, functional and high-quality vehicle, while at the same time maintaining simple production methods and low manufacturing costs," explains Prof. Fritz Frenkler, head of the TUM Chair of Industrial Design. "Reducing everything to the essentials resulted in a modern and thus long-lasting design."

The aCar has also undergone considerable further technical developments. The team was working among other things on optimizing weight, on electrical systems and software, acoustics and ergonomic seating and visibility. ■

Model factory in Germany for the first vehicles

To make sure the idea of the aCar becomes more than just an idea and actually makes it to series production, Sascha Koberstaedt and Martin äoltés have founded the company "Evum Motors GmbH". The first vehicles are to be manufactured in a model factory in Europe. "We'll have to master all the technical procedures before the car can be made in Africa. Then we can train people from Africa who can in turn pass on their knowledge there."

The aCar is an electric four-wheel drive utility vehicle. These specifications make it not only excellently suited for use in Africa, but also for anyone looking for a no-emission transport solution. Thus for example it could be used in urban operation for transport purposes, in maintaining urban parks and gardens and in agricultural settings such as alpine meadows and vineyards. Compared to its competition, the purely electric aCar is significantly more cost-efficient and uses the most modern battery and power train technology. ■

Solar modules are installed on the roof of the vehicle.
Credit: Florian Lehmann / TUM ■

aCar Technical Data:

Power output: 2 x 8 kilowatts; Electric drive range: 80 kilometers; EU vehicle classification: L7e; Voltage level: 48 volts; Battery capacity: 20 kWh; Top speed: 60 km/h; Tare weight: 800 kg; Load capacity: 1000 kg; Length: 3.7 m; Width: 1.5 m; Height: 2.1 m; Seating capacity: 2 ■

About the project:

The project "aCar mobility - Rural mobility in developing countries", supported by the Bavarian Research Foundation, involves the TUM Chairs of Automotive Technology, Metal Forming and Casting, Industrial Design as well as Strategy and Organization. The Rosenheim University of Applied Sciences (Hochschule Rosenheim) and the University of Bayreuth are scientific partners in the project. In addition, seven industry partners are participating in the project: African Health & Agricultural Foundation, DRÄXLMAIER Group, Hirschvogel Automotive Group, McKinsey & Company Inc., Otto SPANNER GmbH and Schnupp GmbH & Co. Hydraulik KG. The concept of the vehicle was developed together with scientific partners in Nigeria, Ghana, Kenya and Tanzania, the Federal University of Technology, Owerri (FUTO) Nigeria, the Kwame Nkrumah University of Science and Technology (KNUST) Ghana, the Dedan Kimathi University of Technology (DeKUT) Kenya and the St. Augustine University of Tanzania (SAUT) Tanzania.■

Contact:
Dipl.-Ing. Sascha Koberstaedt
Technical University Munich
Chair of Automotive Technology
info@acar.tum.de
Phone: +49 (89) 289 - 15875

VOSSIUS & PARTNER

Special ideas require special protection.

For over 50 years, VOSSIUS & PARTNER has been providing high-end consultancy for innovative companies in all fields of patent, trademark, design and copyright law. VOSSIUS & PARTNER works in your interest: competently, reliably, precisely and creatively.

Legal areas. Patents, trademarks and brands, design rights, copyrights, know-how protection, domains, competition law, anticounterfeiting, software and IT, law on employees' inventions, licensing, food law, distribution agreements, franchise agreements, R & D agreements, media law, right of publicity, antitrust aspects in licensing, supplementary protection certificates, pharmaceutical law.

Technical areas. Mechanical & electrical engineering, IT, physics, chemistry, biotechnology, pharmacology, life sciences.

Services. IP prosecution, IP litigation, IP searches, freedom to operate, contracts, annuities, arbitration, mediation, IP portfolio management, due diligence, strategic IP consulting, IP landscaping, IP valuation services.

It is not without reason that VOSSIUS & PARTNER is among Europe's most renowned law firms in the field of intellectual property.

VOSSIUS & PARTNER · Patentanwälte Rechtsanwälte mbB · MÜNCHEN · DÜSSELDORF · BERLIN · BASEL
Main Office: Siebertstr. 3 · 81675 Munich, Germany · Tel.: +49 89 413 04-0 · info@vossiusandpartner.com · www.vossiusandpartner.com