ENCOUNTER 01/2018

The Audi Technology Magazine

Quality
Digital

Electronics Lab
Microchips tough it out
→ Page 16

Innovation
Freedom

Knowledge
Speed

Revolution
Ducati four-cylinder
→ Page 82

Moonshot
Thinking

Alpha Bull
The new Lamborghini Urus
→ Page 88

Ampere Meter
Audi in Formula E
→ Page 74

Shared
Mobility
Flexibility
Efficiency

Autonomous
Driving

Machine
Learning

AI

Seven Up
The new Audi A7
→ Page 28

Data
Augmented
Reality

Jam Session
Testing traffic jam pilot
→ Page 52

ENCOUNTER 01/2018

The Audi Technology Magazine

Encounter online – The magazine on the web

Experience the topics and videos from this edition of Encounter online, the Audi Communications website. There are also plenty of other stories from the fields of technology, brand and environment. Thanks to responsive web design, Encounter online runs on all devices, regardless of the technology platform.

audi-encounter.com

Encounter – The magazine subscription

Serveral times a year, Encounter presents fascinating stories from Audi's world of technology. You can subscribe to Encounter Magazine – completely free-of-charge and with no obligation.

Register at audi-encounter.com

EDITORIAL

Dear reader,

We'll be driving autonomously in future – facilitated by digitalization. In the space of just a few decades, massive increases in computing capacity have been turning our lives inside out – growing data storage, powerful smartphones, high-speed internet, artificial intelligence, virtual reality. Changing mobility is part of this trend.

Data streams and the way in which we use them are changing processes within many companies, including Audi. Just in October, we inaugurated the new Audi Design Center, where virtual design is part of everyday life, with other parts of the process going on in parallel in the creative co-working space. The connection of human and artificial intelligence defines each and every subsequent production step until the customer finally takes possession of his car. Premium products of today and tomorrow are being created digitally.

Looking inside the automobile at the micro level, there are currently around 8,000 active semiconductor devices in an Audi. Nothing would work these days without this armada of microelectronics. And that's without even touching on autonomous driving. The constant in this highly dynamic environment is our high standard of quality. Our customers can rely on their Audis – even in the age of digitalization. And particularly when the car takes control. That's why we have established a semiconductor lab – the only automaker in Europe to do so.

Digitalization and quality contribute to progress. We want to get quickly to where Apple co-founder Steve Wozniak would already like to be – in the driverless car. To that end, we have already incorporated laser scanners into the sensor systems in the Audi A8 and Audi A7 – a key technical element and, looking forward, a prerequisite for safe, autonomous driving.

Mobility defines our freedom. In future, the car will offer even more space for living. That's why we are shaping mobile life for our customers to be as safe and as pleasant as possible – today and tomorrow. Digitalization runs through our lives like a red thread – as does this issue of Audi's *Encounter* technology magazine.

I wish you an enjoyable read.
Yours,

The constant in this highly dynamic environment is our high standard of quality. Our customers can rely on their Audis – even in the age of digitalization.

Peter Mertens
Member of the Board of AUDI AG, Technical Development

CONTENTS

ENCOUNTER 01/2018

Imprint

AUDI AG
85045 Ingolstadt

Responsible for Content:
Toni Melfi,
Head of Communication, I/GP

Editorial Coordination:
Jürgen Pippig

Project Leader:
Tom Volpe

Concept und Realization:
reilmedia
Hermann Reil

Copy Editing:
Winfried Stürzl

Translation from German:
Elaine Catton

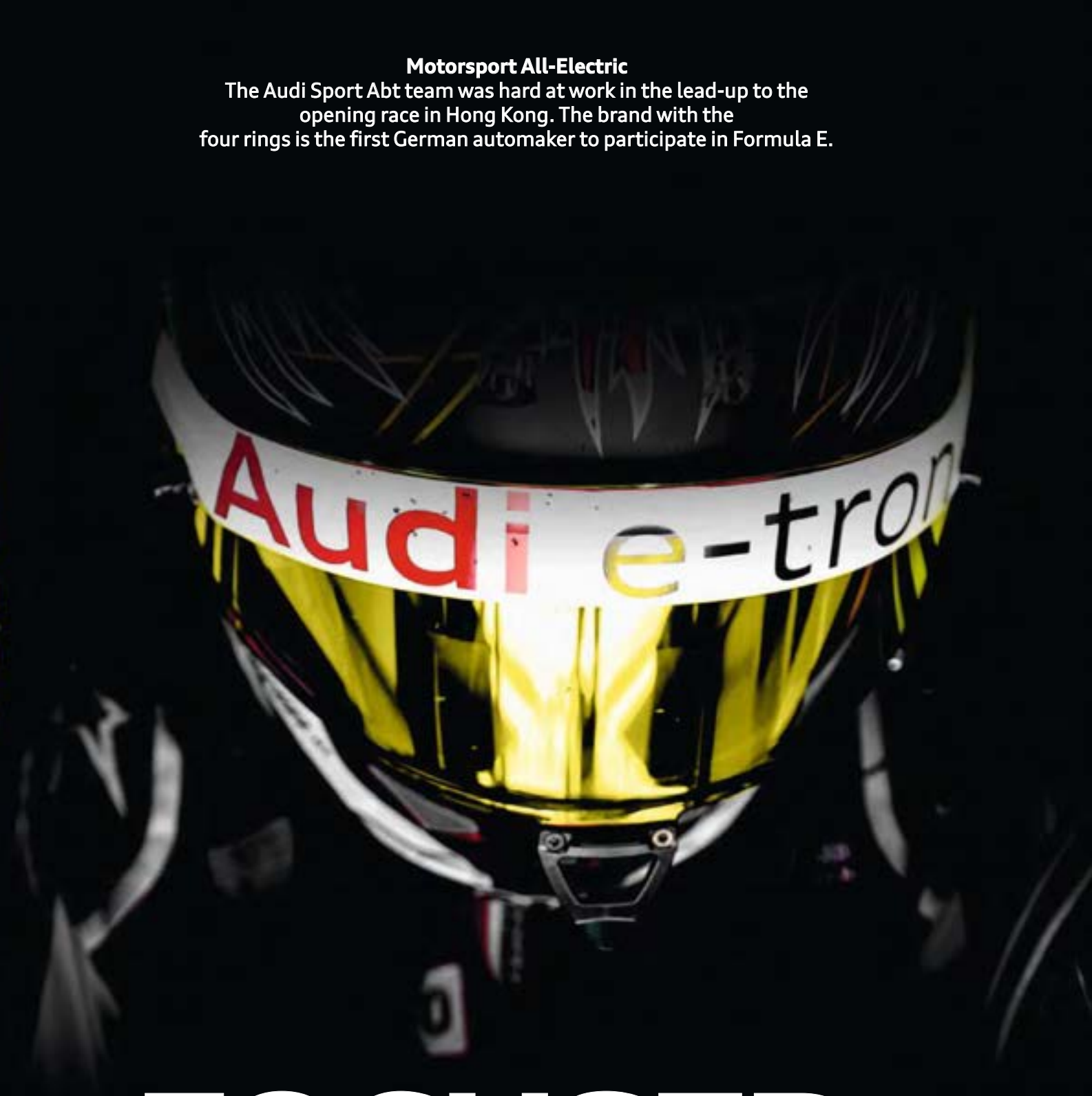
Graphic Concept and Layout:
stapelberg&fritz
Daniel Fritz
Roman Heinrich
Marcel Mendler
Maik Stapelberg

Post Production:
Wagnerchic – Digital Artwork

Printing:
Druck Pruskil

MQ! Summit

Motorsport All-Electric
The Audi Sport Abt team was hard at work in the lead-up to the opening race in Hong Kong. The brand with the four rings is the first German automaker to participate in Formula E.



FOCUSED.

Current drivers –
Daniel Abt and champion, Lucas di Grassi drive the Audi e-tron FE04 for the works team.

→ Page 74

Audi A7 Sportback
The new sport coupe is beautifully flowing and extremely progressive.
The headlamps have an even more determined gaze.
And they're not the only elements evocative of the highly acclaimed
Audi prologue concept car.

BRIGHTNESS.

LED eyes –
The daytime running lights give strong
character to the A7's face.
And dazzle with innovative technology.

→ Page 28

Optimum Design Process
A bright, airy look-and-feel characterizes the new Audi Design Center, as does the perfect symbiosis of digital technologies and traditional craftsmanship. 600 people work here on the Audi design of the future.

VISIONARY.

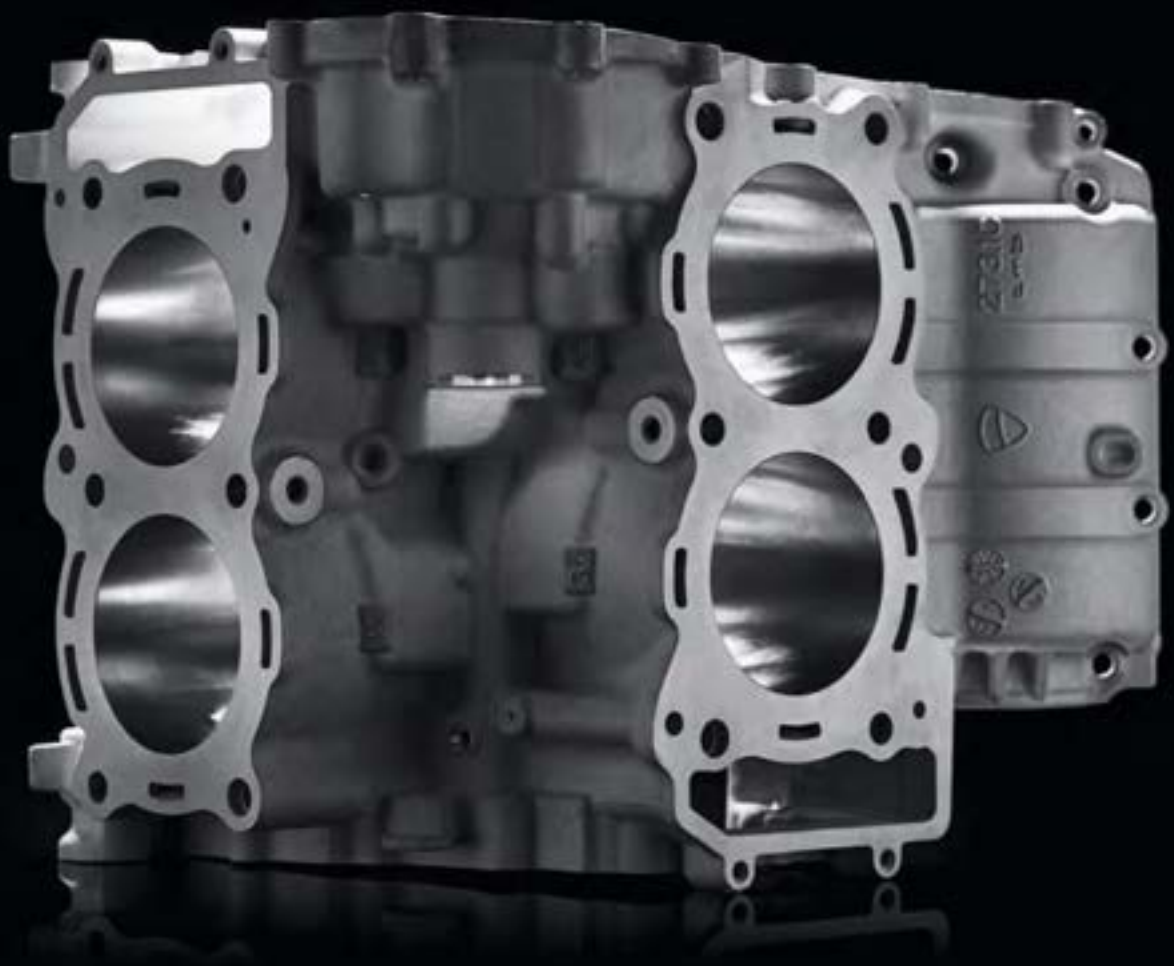
Clear view –
Designers and model makers are in constant sight of one another – and create design icons.

→ Page 38

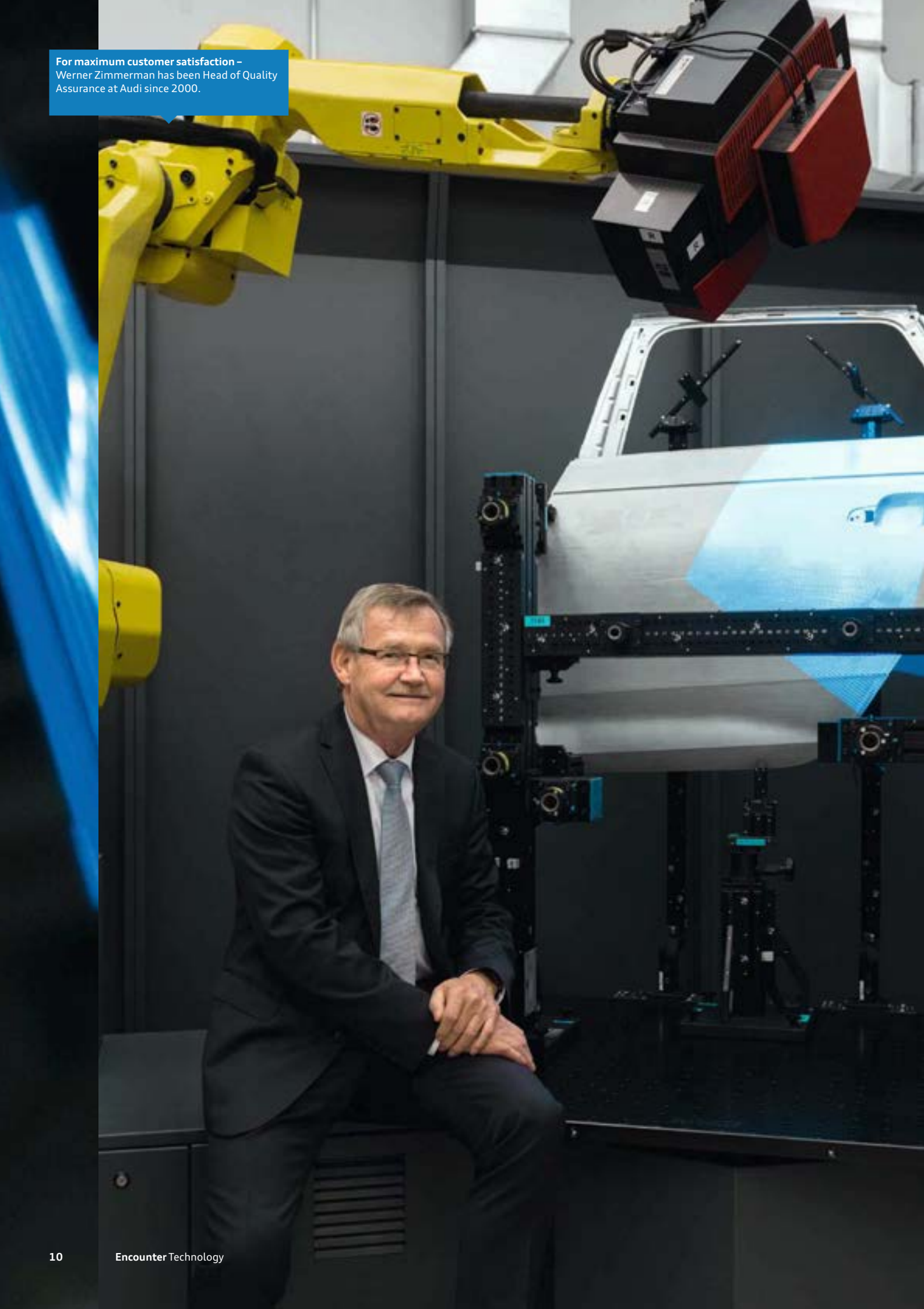
POWER.

Forza Ducati –
The Italian motorcycle magicians are
now also bringing to the road
a production bike with four cylinders –
the engine is sensational.

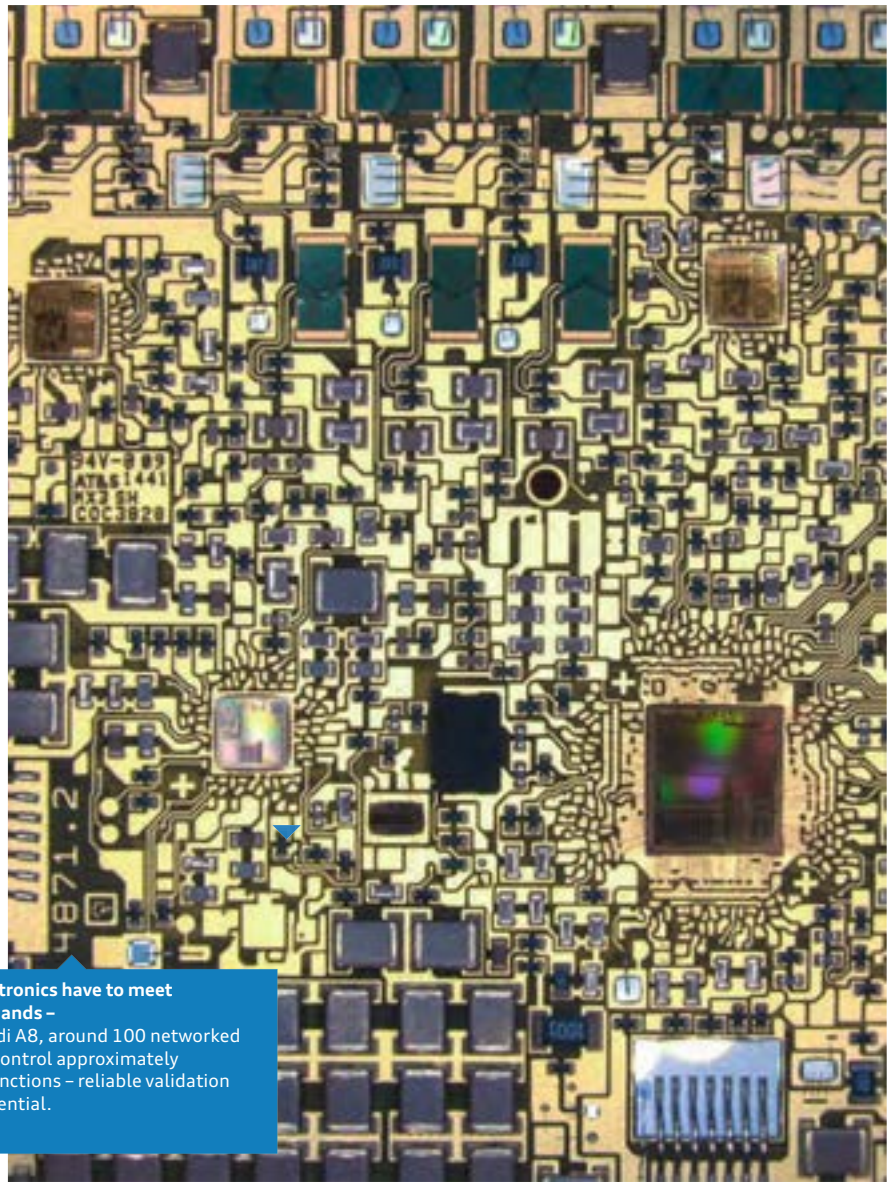
→ Page 82



Unfettered Power
Ducati is using the successful V4 engine from the
MotoGP racing machine almost unchanged
in the production bike – something of a revolution in Bologna.



For maximum customer satisfaction – Werner Zimmerman has been Head of Quality Assurance at Audi since 2000.



The microelectronics have to meet very high demands –
In the new Audi A8, around 100 networked control units control approximately 500 vehicle functions – reliable validation of these is essential.

A MEASURED APPROACH

Text
Maximilian Kranl

Photos
Manfred Jarisch
Heinrich Hülser

Audi customers are demanding. Werner Zimmerman ensures first-class quality, precision dimensionality and the best possible craftsmanship. He has been running Audi's Quality Assurance function for the last 17 years. And he and his team have been working with the digital transformation for some time as the brand is increasingly attracting customers with connectivity and digital services.

Time for a conversation – with the main question being: **How does quality go digital?**

Werner Zimmermann's office is graced by a paternoster – basically, an elevator otherwise found only in antiquated buildings. However, Zimmermann's paternoster is a special one – it doesn't carry people up and down, but models of all the cars that have accompanied him during his 40 years with the Volkswagen Group. Attention to detail is not just a part of every Audi, but also of Werner Zimmermann himself. We talk to a man who lives and breathes Audi quality with every fiber of his being.

Mr. Zimmermann, are Audi customers still interested in shutlines, or are things like a perfectly integrated smartphone interface far more important these days?

Zimmermann: The two are not mutually exclusive. We know from customer feedback that they value and expect Audi's outstanding quality. Shutlines are just one aspect of it. What matters is the overall experience with the car – with all the senses: seeing, hearing, feeling, smelling. But yes, connectivity within the vehicle and with the outside world is becoming increasingly important. And quality isn't a static concept. It moves with the times.

The contact points between driver and car have quite literally shifted. What is the significance of the touch displays in the new Audi A8?

Zimmermann: The new Audi A8 is a particularly good example not only of classic quality, but also of the shift into the automotive future – with maximum connectivity, touch control and highly automated driving. The touch screen has to be rational and already embedded – i.e. part of the whole. And it has to be easy to reach. Safe, relaxed driving is a key aspect for us. That brings us to the operating logic. It has to match with what customers know from their smartphones. That's what they expect and how we can satisfy them. And if you enhance it, as we have with haptic feedback, then satisfaction turns into delight.

With what digital services will you be able to delight customers going forward?

Zimmermann: The Audi connect services already make the new Audi A8 a symbol of digitalization. Looking forward, we will develop more and more to become an expert resource for digital services. Function-on-demand is one example. Those are functions in the car that the customer can activate later using a software update, such as a lighting function like Matrix LED for a longer night drive. Or intelligent assistance functions that save the customer effort and time before, during and after the journey. The PIA Personal Intelligent Assistant is already demonstrating in show cars how that might work. The focus will be on the seamless networking of the car with the customer's individual communication needs, with the security of customer data right at the top of the priority list.

What else can Audi drivers look forward to?

Zimmermann: To new technology in familiar Audi quality and to new service opportunities. In future, every Audi will be online and always up-to-date with the latest software. That means we will be able to read error patterns over the air and, in some case, even resolve them – without the customer having to visit a workshop. For the customer, this is a benefit in terms of time and convenience. And for us, it's a cost saving – so a win-win situation.

Where do customers get a sense of high digital quality? What's the interface between man and machine?

Zimmermann: Customers want to be able to use their smartphones to their full extent in the car, to be connected and fully networked. With all the benefits offered by the car – such as larger monitors, top voice quality and speakers for a musical experience. This networking will be the basis for everything else. So, we have to think: Where can we set accents? Where can we delight the customer even more? ⟶

The digital operating concept in the new Audi A8 – Testing the touch screen's haptic feedback.

Optical metrology for even more efficient component calibration – Specialists bring the traditional instrumentation of Audi perfection into the digital age.

Quality has always been and remains a core competence of the Audi brand. Quality leadership in the premium segment is our aim. This applies especially to the sustainable, automated and connected driving experience in the digital age.

Werner Zimmermann
Head of Quality Assurance AUDI AG

Werner Zimmermann
was born 1953 in Bad Tölz and studied vehicle technology at Fachhochschule München (Munich Technical College). He has been the Head of Quality Assurance at Audi since 2000. He came to the company in 1976 and, in the years that followed, held several management jobs in Quality Assurance. In his capacity as head of Quality Assurance, Zimmerman was appointed a fully authorized representative of AUDI AG in 2010 and Deputy Head of Quality Assurance for the Volkswagen Group.

Compact datalogger and special apps – Digitalization in the field of service technology delivers personal freedom for the customer.

Dataloggers in the Audi A7 during the testing phase – Fast and efficient data management is increasingly important to the quality control of the overall vehicle.

What kind of accent might that be?

Zimmermann: One example is voice control. It has to be as simple as possible to use. When I say to the car, I want to go to Munich Airport, then it should navigate me to my destination via the fastest route without the need for additional questions and confirmation. In future, the car will know its owner and what they want. Machine learning will help us with this.

How do you ensure that "analogue" quality features like shutlines and surface finishes are not neglected as digitalization increases?

Zimmermann: That's a very important point. Quality – in its totality – has always been and remains a core competence of the Audi brand. We must apply the same commitment to our current strengths, while at the same time facing the challenges of the digital world. This is the only way to become quality leader in the premium segment. Our customers expect that of us. Quality is also an important, decisive purchasing reason.

This Audi quality has been hard fought for. You've been doing it for 40 years now.

Zimmermann: Quality doesn't happen on its own. It's hard work every single day. Quality has long been one of the fundamental principles of our brand. We can be proud of that.

Competitors like Tesla are setting a fast pace with their development. How can Audi keep up without cutting corners in quality?

Zimmermann: I believe we're doing the right thing to concentrate on what we do best. The key here is to be fast and thorough. Our response to the Tesla question will come next year. The all-electric Audi e-tron will be a true Audi. In all respects.

What kind of priority is given to quality assurance with regards to a topic as complex as automated driving?

Zimmermann: We have seen with the new Audi A8 the complexity of the tasks that lie ahead – 500 vehicle functions, around 100 networked control units, more than 12,000 bus signals. Validating these new functions reliably is essential. We began that in Quality Assurance a long time ago and are working extremely well with our colleagues from Technical Development. When it comes to the reliability of driving functions, we don't allow a single millimeter of wiggle room.

An Audi has to offer a very special overall experience in future, too – and for all customers, in all markets around the world.

Werner Zimmermann
Head of Quality Assurance AUDI AG

How do you envisage a high-quality Audi of the future?

Zimmermann: An Audi has to offer a very special overall experience in future, too – and for all customers, in all markets around the world. We have to pull together the best digital functions for the customer into a coherent package. The customer has to be able to make better use of time spent in the car. For instance, to work, to relax or to interact with friends and family. We're building up this knowledge of customer desires and feeding it increasingly and specifically into the concept phase.

Customer curiosity for this new world continues to grow. What further digital business models can the customer expect in future?

Zimmermann: We talked earlier about over-the-air flashes. In future, we'll be able to offer the customer completely new warranty concepts – i.e. intelligent "no-worry packages". This is another point where we can make the customer's life easier and better. We also envisage incorporating so-called third-party apps into the car, i.e. giving outside entities the opportunity to program apps specifically for the car – as has been the case with smartphones for years now.

What developments of the last few years make you especially proud?

Zimmermann: To cite a current example, we were recently listed for the sixth time in succession as the best European brand for reliability in the rankings published by Consumer Reports in the USA. All Audi models were given the all-important "recommended" classification. That shows we've done our homework. It's not just a success for Quality Assurance, but for the whole company.

How has your understanding of quality changed in recent years?

Zimmermann: Let me be absolutely clear, we're facing a paradigm shift. We have to approach things with an open mind and consider where the big strategic issues are for us. Be it in software, be it in the vehicle functions. We're working intensely on these things. But I'm convinced the fundamental values of a high-quality premium vehicle will remain the same. And these are qualities that we at Audi will continue to make the most of in future, too.

To finish off – what do you wish for Audi?

Zimmermann: That we get even more customer orientation into our company and our cars. That has to guide the way we think and act. That we understand even better what the customer wants from us. That's what I truly wish for. ←

Essential for autonomous driving –
The semiconductor lab in Audi Quality Assurance is a center of competence in the development of new technologies – such as the laser scanner in the new Audi A8.

New brilliance –
The innovative OLED technology (Organic Light Emitting Diodes) for the rear lights on the Audi A8 were developed in the semiconductor lab.

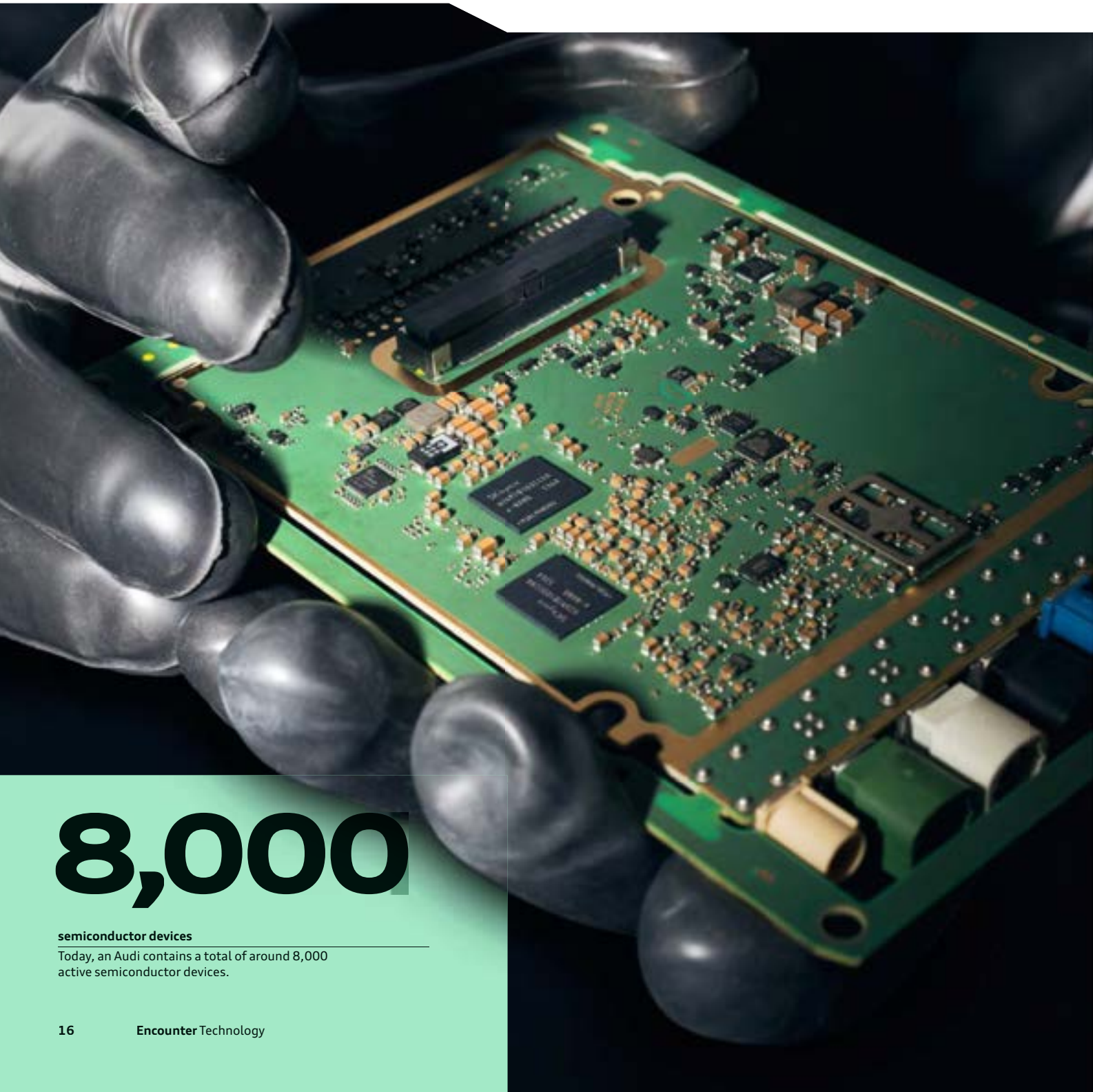
Hi-tech analysis technology for high-end materials –
An Audi g-tron tank made from carbon-fiber and glass-fiber reinforced plastic in the computer tomograph.

CONDUCTING MATTERS

Vorsprung begins in the chip on just a few nanometers. Automated driving, infotainment and electric mobility pose enormous challenges for in-car microelectronics. Our visit to the semiconductor lab in Audi Quality Assurance.

Text
Jana Schröpfer
Stefanie Lackner

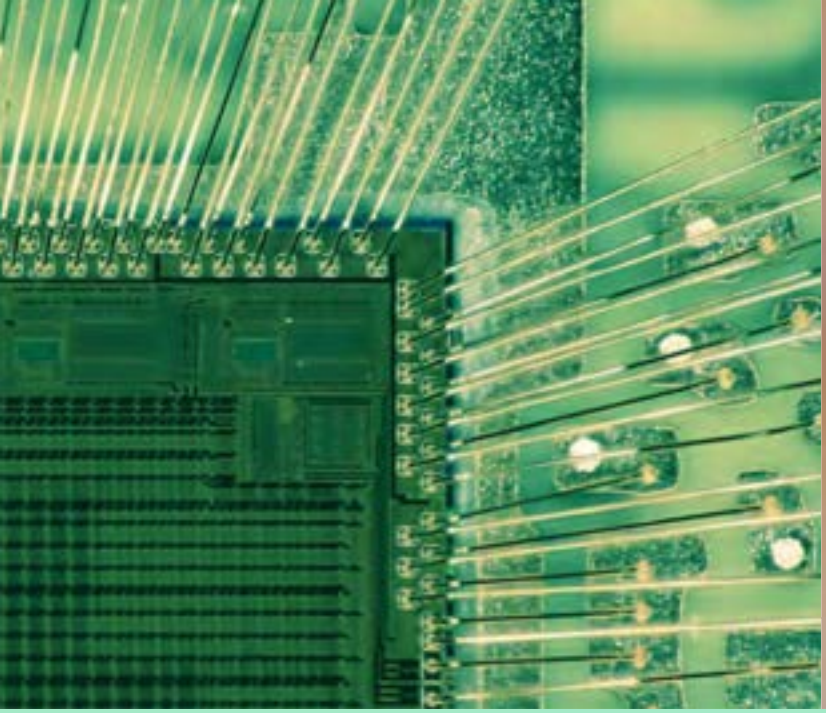
Photos
Manfred Jarisch



8,000

semiconductor devices

Today, an Audi contains a total of around 8,000 active semiconductor devices.



20

micrometers

Wire bonds connect the chip's contact surfaces with the contacts on the casing or chip carrier. The wires are about half the thickness of a human hair.

<1

micrometer

The combined layers of an OLED have a total thickness of just 1/100 or 1/200 that of a human hair (less than 1 µm).

X-ray on! The machine's lights are flashing red. Work can commence. Stefan Simon, dressed in a white protective suit, operates the joystick with a practiced hand. His watchful eye scans a component – in search of irregularities like particles, bubbles or specks of dust. He is well aware that technical cleanliness is the number one priority. Even the tiniest foreign body can have fatal consequences. "Examining microelectronics is like detective work," explains Simon. "A hair is an absolute killer because it becomes conductive if it gets damp."

More than 80 percent of all innovations in a modern automobile are facilitated by microelectronics. Automated driving, powertrain electrification and the ever-increasing connectivity among cars and with their environment – all these innovations are based on powerful semiconductors. Altogether, there are around 8,000 active semiconductor devices in a vehicle in approx. 100 networked control units. "Every single one of them has more computing power than the first moon rocket," stresses Simon. He is one of the experts in the semiconductor lab in Audi Quality Assurance, which was set up in 2006 as an independent electrics and electronics lab. The lab combines high-end analysis equipment with the specialist knowledge of the semiconductor experts. This facilitates eye-level discussion with suppliers and semiconductor manufacturers. Audi is the only automaker in Europe to operate such a lab.

A great deal of responsibility rests on the shoulders of the four physicists and electrical engineers. "We are the customers' attorneys," →

Lab team – Stefan Simon, Robert Kraus and Helmut Lochner (l. to r.) are the specialists of the semiconductor lab. They share the same passion – microelectronics.

Quality means reliability and durability down to the tiniest detail, and it always has to be assured. That's the only way Audi can continue to maintain its high quality ethos going forward.

Stefan Simon

explains Robert Kraus, whose work includes evaluating suppliers' component quality and production processes. The team applies expertise and experience to conducting lab analysis on electronics and semiconductor devices and examining them for suitability, reliability and production quality.

In in-depth specialist analyses, the experts often cooperate closely with their colleagues in the materials lab, which can help them identify production defects early on. But also proven semiconductor chips are closely examined and optimized. "We're not just the firefighters for vehicle electronics," explains Kraus. "The lab is more of an interdisciplinary and cross-project competence center for semiconductor quality at Audi." And that applies to the entire product lifecycle – from its definition and creation, to its manufacture and validation. "Quality means reliability and durability down to the tiniest detail, and it always has to be assured. That's the only way Audi can continue to maintain its high quality ethos going forward," says Simon.

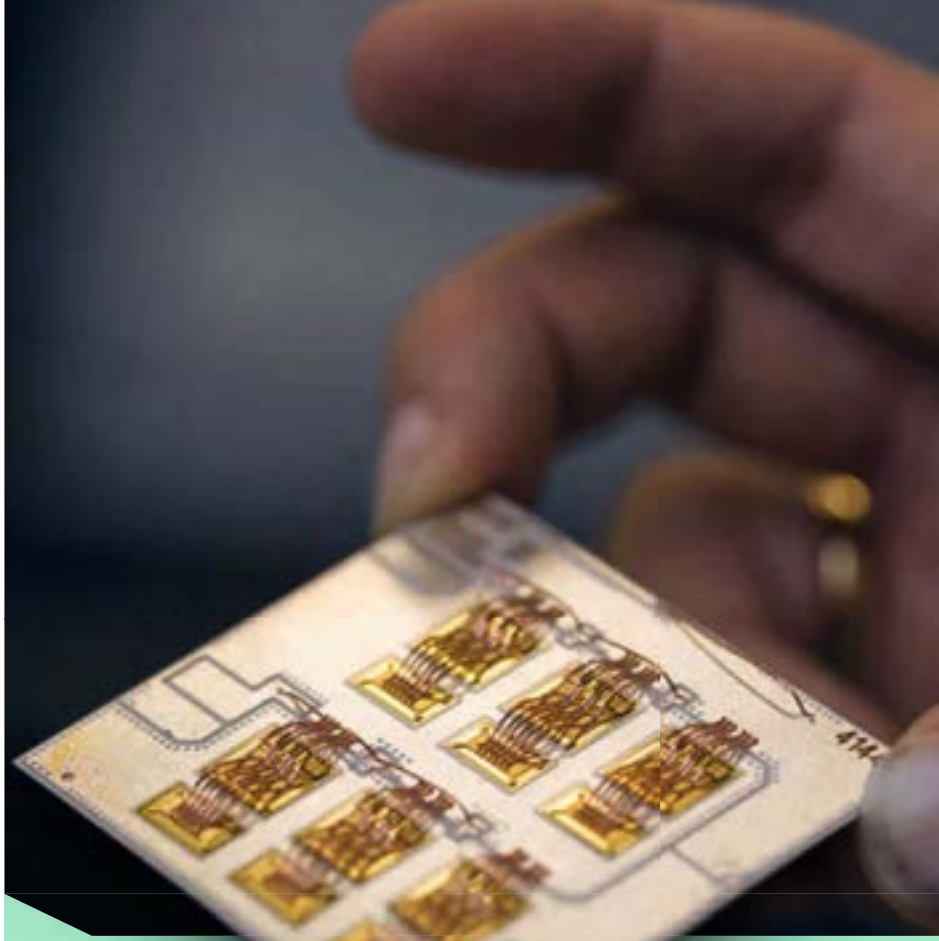
Anyone who thinks the semiconductor detectives work purely in the lab is mistaken. As quality managers, they spent a great deal of their working time in contact with the other specialist departments and coordinating collaborations with suppliers and semiconductor manufacturers.

The lab has long been a melting pot of innovation at Audi. Previously, the automotive industry worked on the basis of proven technology from consumer electronics. However, the demands on in-car microelectronics have changed massively since then: "The customer steps into his car and expects the infotainment system to be just as powerful as his tablet or cell phone," expands Simon. The semiconductor team makes sure the latest technologies from the consumer electronics sector are adapted in parallel for automotive applications – e.g. in terms of lifespan. While a cell phone might be replaced every few years, an Audi has to function perfectly for at least fifteen years – under extremely tough conditions. "When an Audi customer gets into his car in Siberia at minus 40 degrees Celsius, the electronics still have to work; a smartphone would have long given up," says Simon.

In future, electric powertrains and automated driving will demand even more from microelectronics. Semiconductors will have to deliver even greater performance, despite minimal packaging space, will be operating for even longer due to additional battery charging times and will be subjected to even heavier loads as the usage time of piloted cars increases. The performance of new technologies has to be continuously optimized. This is something that has already been achieved with the OLEDs in the rear lights of the new A8. They are considerably more hard-wearing than conventional components from the consumer electronics sector.

Unusual solutions are likewise part of everyday business. A central device in the new A8 laser scanner, which enables highly automated driving on Level 3, is a laser diode which is used in a similar form in recreational sports. The lab team accompanied the diode's transformation process from the initial drafts to series production. "Our work covers a very broad spectrum," sums up Helmut Lochner, whose responsibilities include semiconductors in infotainment as well as change and bottleneck management.

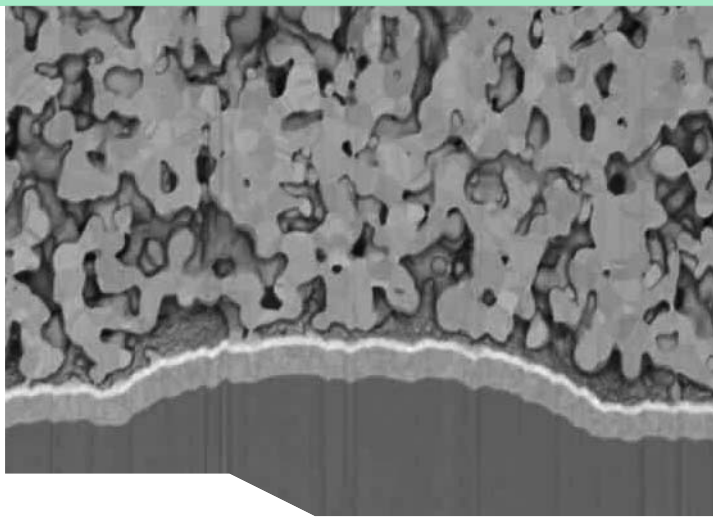
Lochner and the lab team often also have to act as "interpreters" and go-betweens for the semiconductor manufacturers, electronics suppliers and their colleagues from the internal specialist departments: "We can understand them all, from semiconductor



100

control units

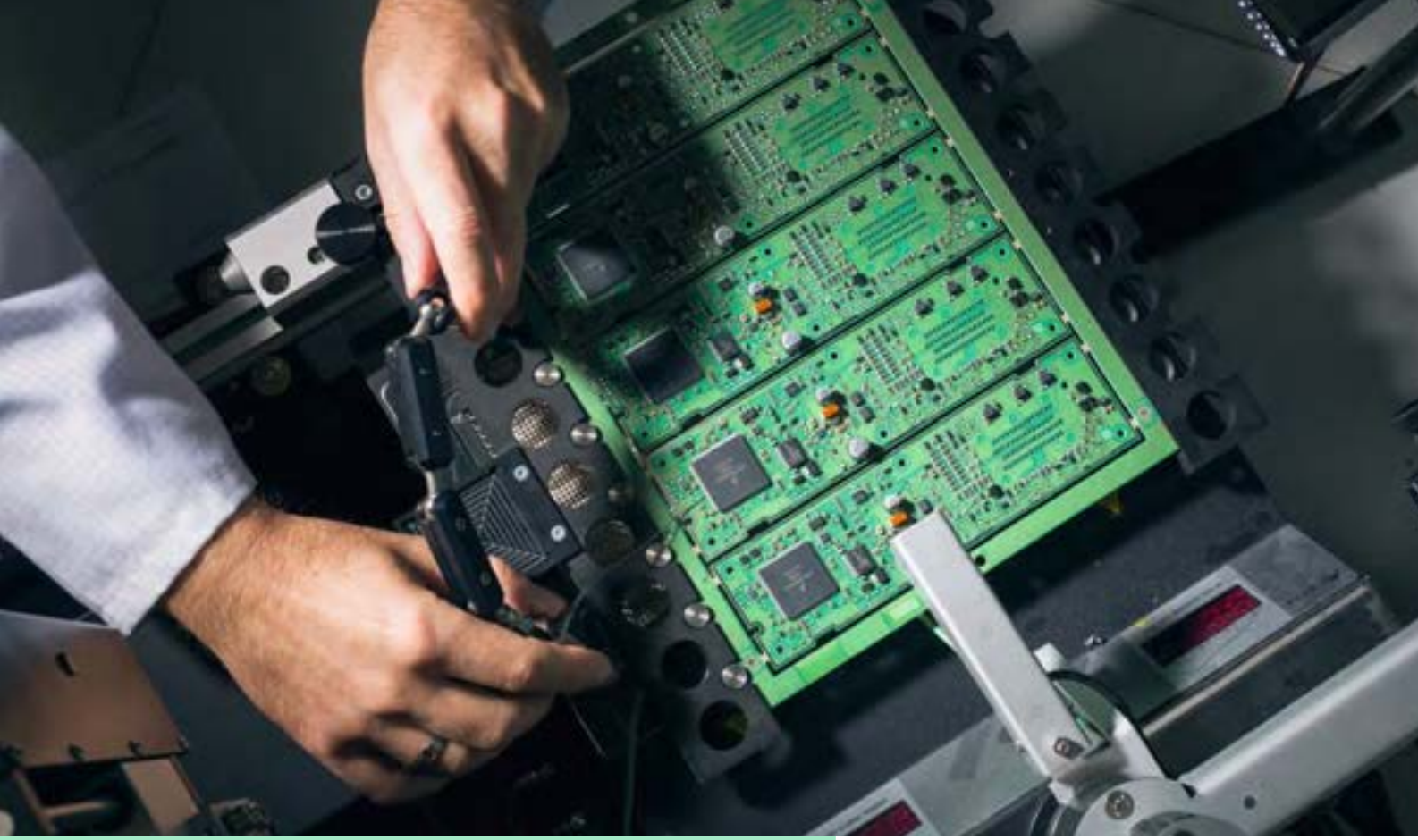
Around 100 networked control units are installed in an Audi these days. Every single one of them has more computing power than the first moon rocket.



Coating – Beneath the chips are sintered layers that connect the power semiconductor devices.

Our lab is more of an interdisciplinary and cross-project competence center for semiconductor quality at Audi.

Robert Kraus



15

years

The microelectronics in an Audi have to work perfectly for at least fifteen years – under the harshest conditions.

The increasing level of microelectronics in the car has also seen the semiconductor lab grow steadily in importance as a competence center. “It makes us really happy to be able to provide a deeper insight into the fascinating world of semiconductors,” maintains Simon. “Nanometer for nanometer, we’re accompanying Audi in the process of digitalization – and it’s incredibly exciting!” ←

manufacturer to automaker,” explains Lochner. The influence on the development and production processes at Audi and its suppliers is substantial. “If we see potential for optimization in the supplier’s product or production process, we include it in the standards and specifications documents for future projects,” adds Kraus. The latest achievement in the semiconductor lab is the database compiled by Helmut Lochner known as HAMON (Semiconductor Management Online). “It records all semiconductor devices built and, in the event of quality issues, delivers greater transparency in the increasingly complex semiconductor industry,” elaborates Lochner.

However, many results from the work done by the semiconductor lab are significant on more than just an internal level. Some also benefit the entire automotive industry. Thanks to its many years of experience in the field, the lab team has established standards for assessing wire bonds – the miniscule connections used on semiconductor chips. It was through the team’s initiative that the “wire bond standard” was created within the Volkswagen Group to provide suppliers with detailed specifications on the supply quality for these tiny conductive elements, and has now been adopted as the national standard in Germany.

Detailed examination – Under the scanning electron microscope, it’s possible to identify even the tiniest structures such as the attachments of the minute wire bonds in a transmission control unit.

Our HAMON database records all semiconductor devices built and, in the event of quality issues, delivers greater transparency in the increasingly complex semiconductor industry.

Helmut Lochner

400

times magnification

The high-performance microscope, which is based on endoscopy and has a maximum magnification of 400 times, facilitates crystal-clear cross-sectional images of things like hidden solder joints in electronic devices.

WHAT ARE SEMI-CONDUCTORS?

Complex –
Several chips with a variety of functions are mounted on a control unit PCB.

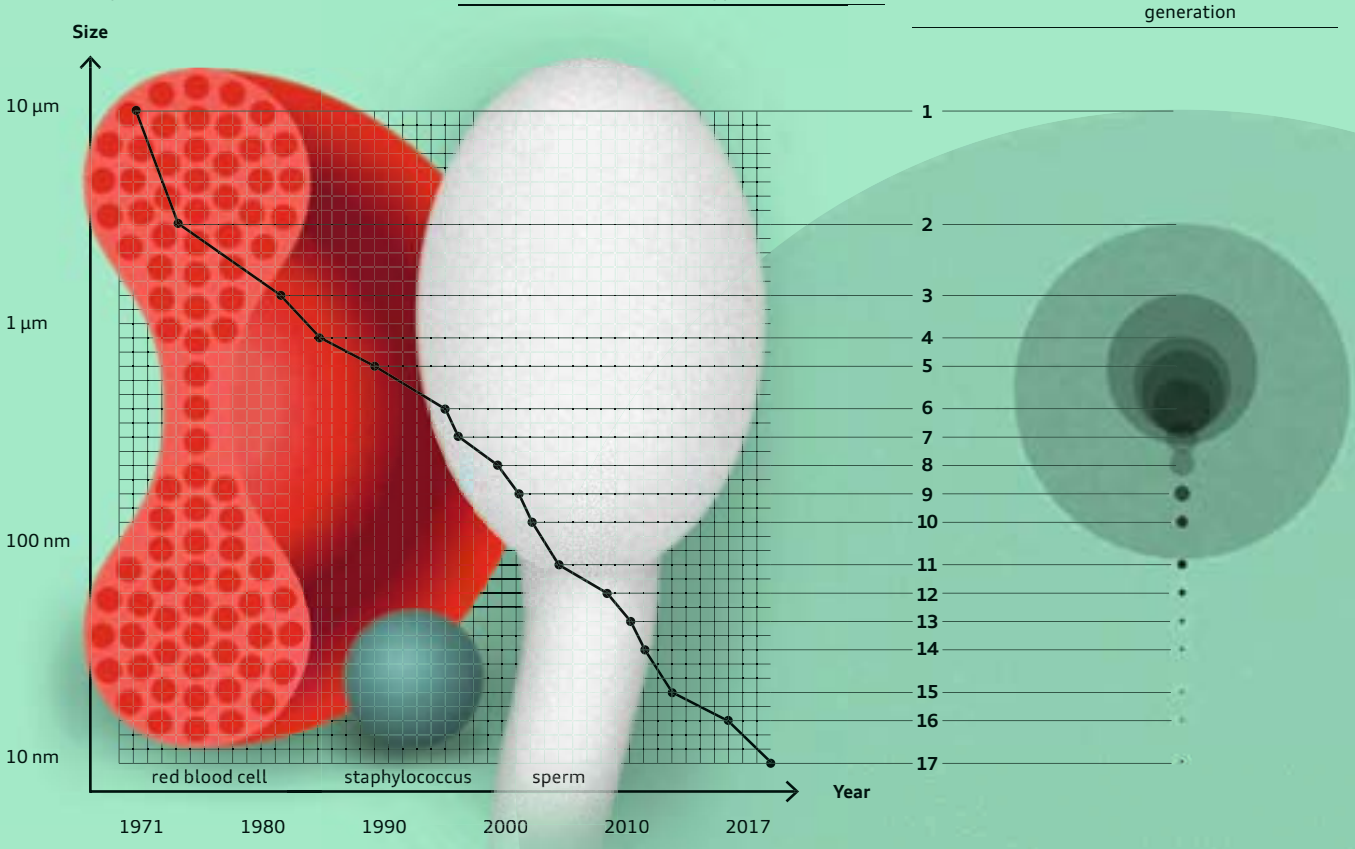
Processors, LEDs, sensors and displays – semiconductor devices are hidden in almost every piece of automotive technology. Semiconductors are solids that possess the characteristics of insulators and conductors. They only conduct under certain conditions and form the basis of every microchip (the size of a current graphics chip is approx. 18 x 25 millimeters). Silicon chips are their best-known representative in microelectronics, as standardized manufacturing processes enable mass production and thus cost-efficient application. Silicon is a natural semiconductor and exists in abundance in the Earth's crust, e.g. in the form of sand. Nevertheless, it takes four to six weeks and around 600 process steps to manufacture the coveted chips. In optoelectronics applications, such as the manufacture of LEDs, most of the semiconductor combinations used have other optical and electrical features (e.g. gallium nitride, gallium arsenide and indium gallium nitride).

A silicon chip consists of several billion transistors. These incredibly important electronic components function mainly as on/off switches in integrated circuits and are configured in extremely fine structures – not unlike a detailed city plan. Audi currently uses 14-nanometer transistors for logic switching and memory applications. Future transistors will measure less than 10 nanometers, which is 700 times smaller than a red blood cell.

Development of transistor size

Between 1971 and today, transistors have been getting steadily smaller. The graph shows their change in size as a curve (left) as well as their size (right) relative to blood cells, staphylococcus and sperm.

	Size	Year	Processor (example)
1	10 µm	1971	Intel 8008
2	3 µm	1975	Intel 8088
4	1 µm	1982	Intel 80286
5	1.5 µm	1985	Intel 80386
6	800 nm	1989	Pentium 60 MHz
7	600 nm	1994	Pentium II Klamath
8	250 nm	1998	AMD K6–2
9	180 nm	1999	Coppermine E
10	130 nm	2000	PowerPC 7447
11	90 nm	2002	VIA C7
12	65 nm	2006	Core Duo
13	45 nm	2008	Core 2 (Wolfdale)
14	32 nm	2010	Core i3 (Clarkdale)
15	22 nm	2012	Core i7 (Ivy Bridge)
16	14 nm	2014	Core M (Broadwell)
17	10 nm	2017	Next transistor-generation



Perfectionists and full of passion for the tiniest detail
The silent heroes of Quality Assurance often accompany a part through the entire creative process all the way to final sign-off, during which, their focus is always on the perfect end product – and therefore the best possible benefits for the customer.

QUALITY TO THE POWER OF 3

Jens Schaufler
Audi Quality Assurance: Materials Technology, Engines / Transmissions

Lots of cable, lots of functions –
As a materials specialist, Schaufler works with the high-end Auriga microscope, which unites analogue and digital methods.

Daniel Reitzig
Audi Quality Assurance: Automated Driving

Everything under control –
Reitzig holding the laser scanner, without which automated driving would not be possible.

Audi QR-Code

Scan the QR code and see a video on Audi Quality at work.

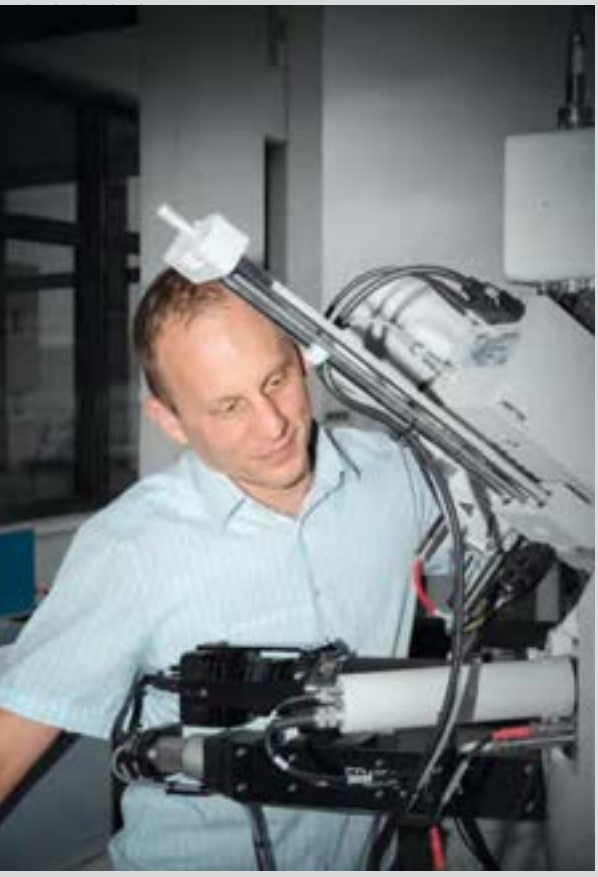
Gerald Funk
Audi Quality Assurance: Exterior Master Buck

So fast these days –
Gerald Funk in front of a CNC measuring machine with optical sensors and reference bodyshell on the exterior master buck.

Text
Lisa Niermann
Charlotte Seybold

Photos
Manfred Jarisch

Lord of Auriga
Jens Schaufler



Detailed search –
Jens Schaufler can use the Auriga to watch live how an ion beam makes cuts on a sub-micrometer level beneath the surface of a component.

Jens Schaufler is responsible for a very special microscope in Audi Quality Assurance. His job is to solve tricky cases. For about four years now, the materials technology function in Audi Quality Assurance has been working with Auriga, a scanning electron microscope (SEM) with a focused ion beam (FIB) – a brand-new combination. This high-end microscope has put Audi at the forefront of materials technology among the original equipment manufacturers.

With an engineering doctorate in the field of materials technology, Schaufler worked intensively with ion-beam technology during his PhD. He and three other materials experts make up the Auriga team in Audi Quality Assurance. Using the ion beam, the microscope is able to create cuts beneath the surface of a component that are invisible to the human eye, and then generate a high-resolution cross-sectional image of the material with the SEM technology. What makes this so special, however, is the ability to monitor the cutting process live, enabling Auriga to dig through the material on a sub-micrometer level in a more targeted way.

This detailed search beneath the surface means the experts can find a disruptive factor faster than before and can, for instance, analyze displays better. However, the perspective of one individual is often insufficient to interpret the discovery: “A team of people with a variety of different experiences can achieve far more when it comes to damage analysis,” stresses Schaufler. The state-of-the-art microscope also takes the digitalization of materials technology one step further, but doesn’t change it completely. “It was always good, but now it’s better at the very top end because you get a different view,” sums up Schaufler. Scanning electron microscopy (SEM) is and remains the standard. Digitalization raises new questions – but also delivers more precisely defined defect analyses.

Although Schaufler’s component responsibility is for the base engine, what he finds fascinating in his work with Auriga is that the full bandwidth of vehicle parts can be examined. Be it interior, exterior, running gear or engine – the objective remains the car as a complete product. And Schaufler and his team play an important role in ensuring that every single component ends up perfect and with zero defects. →

With Auriga, we’ve laid the foundation for digitalization.

Jens Schaufler
Audi Quality Assurance:
Materials Technology, Engines/Transmissions

Auriga –
The high-end microscope improves component defect analysis.

Sensory talent
Daniel Reitzig

Faster response –
Errors are recorded on an interdepartmental database and thus not repeated in other components.

The work I'm doing now can play a part in making driving less stressful again.

Daniel Reitzig
Audi Quality Assurance: Automated Driving

As someone who has spent many years as a commuter, what I always dream of is a car that can pick me up in front of the factory and drive me into the weekend!" His work on the Audi A8 has brought Daniel Reitzig a good deal closer to his goal. For more than a year now, the 29-year-old mechanical engineer has been working within the Quality Assurance Total Vehicle function with responsibility for the laser scanner and radar sensor installed in the first production car capable of Level 3 autonomous driving. With this car, Audi is laying the groundwork for the future of autonomous driving.

Daniel Reitzig began his career in 2011, working in Quality Assurance at VW in Brunswick. Almost two years ago, he moved to Audi Quality Assurance, which has established a new department staffed by experts in automated driving. Reitzig's job is to take care of the laser scanner and the front radar sensor – from the start of the project right through to sign-off for the customer.

The laser scanner plays an important role in the way the sensors work together. Its large included angle means it is able to identify objects, such as vehicles moving out of line, very early on, and sends the information to the central driver assistance control system (zFAS), which is the interface for the piloted driving functions. Technical innovations like the traffic jam pilot and the turning assist in the Audi A8 would not be conceivable without the laser scanner.

Reitzig's job is well illustrated by the example of this particular instrument. Prior to production, he worked with his colleagues in Technical Development and Production to write specification documents in which requirements were set out and errors precluded. The contracted supplier used these specifications to develop an initial product, which was examined by Reitzig and specialists from Quality Assurance and Technical Development for possible errors or defects. The scanner was also subjected to a wide array of tests in the lab and in the car in order to guarantee flawless operation throughout the life of the vehicle. At the end of all this, he undertook a final evaluation of the product and issued the customer sign-off. Any errors or problems arising during the process were fed into a cross-functional database to ensure they are eliminated in future components.

"It's my job to identify problems and defects, find a solution and eliminate them across the board," sums up Reitzig. People come to him when changes and difficulties arise in ongoing processes. Reitzig then contacts the corresponding supplier and travels with his experts to their plants in order to address the challenges.

"As a mechanical engineer, I have a certain professional ethic – I give my all to ensure that the customer gets the best possible product," explains Reitzig. Despite having always had a firm grip on everything during the development of the front sensors, he nevertheless found it strange to hand over control to the car during the initial test drive in the new Audi A8 with AI traffic jam pilot. "At least I know everything was done 100-percent correctly," he says with a smile.

Laser scanner –
In the new Audi A8, it makes an important contribution to Level 3 automated driving.

In the photometry measurement cell –
Robots use optical sensors to capture component geometry and surface.

Master of measurement
Gerald Funk

A wealth of experience –
Gerald Funk used to measure individual components himself. Now, he coordinates all the work on the exterior master buck.

Bright light, concentrated silence and the highest precision. In a large hall at the Audi plant in Ingolstadt, the critical eyes of Quality Assurance gather at the exterior master buck to examine all visible vehicle components prior to start-of-production. One of them is Gerald Funk. The foreman began working 33 years ago as a measurement technician and is the number one go-to man for all questions in his field of specialty. As the old hand and coordinator at the exterior master buck, he provides the benefits of his experience to his younger co-workers on a daily basis.

In the near future, we'll have reached the point of being able to virtually merge and examine components under the influence of simulated forces.

Gerald Funk
Audi Quality Assurance: Exterior Master Buck

Funk's eyes light up when he talks about the changes that have taken place over the last few decades. He started off measuring individual parts and bodies manually with feeler gauges and sliding cylinders, before tactile metrology was introduced a short time later. The associated offline programming marked a mini-revolution in Funk's daily work: "Suddenly, it was possible to write programs on the computer, while the machine carried out other measurements. It saved a huge amount of time." This didn't make the work any easier, but it did make it significantly faster, more precise and less costly. In tactile metrology, CNC measuring machines record the data with measuring heads that come into contact with the sample. The data is then graphically interpreted in CAD models.

Gerald Funk is one of those men who get in about things and embrace change. His aim is to establish optical processes and so-called reference bodyshells at all plants and thereby take another step into the future. "The work we do with the exterior master buck on a current reference bodyshell already brings us a whole lot closer to the product delivered to our customers. And optical metrology can help us analyze and optimize components down to the tiniest detail," explains Funk. To achieve this objective, Funk has also spent the last twelve years training international colleagues at several plants such as those in China and Mexico.

In optical metrology, CNC measuring machines use optical measuring heads to capture data without touching the sample. This means so-called photometry measurement cells can automatically digitize individual components and subassemblies, as well as bodyshells and even complete vehicles. Even data sets positioned and digitized separately can then be merged virtually afterward. "In the near future, we'll have reached the point of being able to virtually merge and examine components under the influence of simulated forces," continues Funk. This significantly shortens the time spent measuring and manually setting up the components compared with taking tactile measurements on the exterior master buck.

But doesn't he find all these changes unnerving? "No," says Funk emphatically. "I look forward to them," he laughs, and hurries off to a young co-worker who has asked for his assistance. ←

Head turner –
The new A7 Sportback exudes dynamism and progressiveness. This is thanks to its expansive surfaces, sharp edges and taut lines.

Text Tom Volpe
Photos Robin Wink

How do you top a success?
See for yourself. The design of the new Audi A7 Sportback is even more progressive – and very close indeed to the hugely well received Audi prologue concept. We chat to the A7-makers about courage, muscularity, monitors and modules.


seven
Up
IN A 7102

Deep down below –
The Singleframe grille is extremely wide and positioned low down to emphasize the sporting character.

The strong, muscular wheel arches are our visual expression of quattro, our superlative technology.

Marc Lichte
Head of Design AUDI AG

Light-fest –
The rear light consists of 13 vertical segments. A narrow band of light (see below) connects the taillights with one another.

Beautiful flow –
The steep drop of the roofline defines the silhouette, with the light show at the rear.

The four men walk slowly around the car, gesticulating, tracing lines with their hands, standing for a moment, kneeling down, pointing to details – and laughing a lot. Spirits are high among the designers of the new Audi A7 Sportback*. On this day in September, they are seeing the final version of their creation for the very first time. In a few weeks, the new sports coupe will celebrate its premiere.

Anyone who observes design boss, Marc Lichte, for a while – with his alert eyes and hallmark expansive gestures – can immediately tell that this giant of a man is bristling with vibrancy. And he has channeled it into the A7: "We were courageous," says the chief designer with a degree of pride. "We've taken a huge step forward with the new A7." And that's quite a statement, given how beautiful the first generation was. Following its launch in 2011, the coupe was bestowed with countless design awards, with many experts citing it as the most beautiful model in the full-size class. The bar was set pretty high for its successor.

Sketches and ideas were submitted by Audi Design's various studios – in Los Angeles, Beijing and Ingolstadt. The designers were ultimately presented with five full-size clay models. And it quickly became evident – the new A7 would have to be completely rethought. Sportier, more progressive – with even more character.

We were courageous. We've taken a huge step forward with the new A7.

Marc Lichte
Head of Design AUDI AG

The car needs to stand out, "especially through its face," says Lichte, kneeling down in front of the car. The Singleframe grille is now wider and sits lower down, which emphasizes the sporty look – and is evocative of the highly praised prologue study. With a gesture, the chief designer demonstrates how a few surfaces and lines run directly from the radiator grille, such as the contours on the hood and the slender headlamps. They now have a more intense, aggressive gaze, with a form very close to those of the groundbreaking concept car. ⟶

*** Audi A7:**
Combined fuel consumption in l/100 km: 7.2 – 6.8
Combined CO_2 emissions in g/km: 163 – 154

Even more beautiful –
The twelve LED segments are illuminated by day, and the low beam module by night. They look like pupils.

Our lighting design brings technology to life. We're putting the soul of our car on show.

Cesar Muntada
Head of Lighting Design AUDI AG

Eye-catcher –
The A7 has a powerful stance.
The slender headlamps
have a fiercely determined gaze.

We've made the A7 even more extreme
than our prologue concept study.

Marc Lichte
Head of Design AUDI AG

Airs and graces –
The three air intakes in the front skirt make the face even more dynamic.

A beautiful engine –
The distinctive rear end is evocative of the bow of a yacht. The spoiler deploys at 120 km/h.

However, as determined as the new luxury Audi may look, it remains true to its predecessor and is clearly and immediately identifiable as an A7. Distinctive features have been intentionally retained and developed – such as the powerful rear end with its spoiler edge and the third side window, which draws upward to a point at the back. The relationship is apparent in the side profile, too. The shoulder line now sits lower and runs only between the B- and D-pillars, giving the main part of the car a stronger waistline. This also makes the wheels and wheel arches more exposed, explains Lichte. "This is our visual expression of quattro, our superlative technology."

Lichte has thus given the A7 compelling muscularity. It's a well-known fact that the wheels are what makes the car. And fast rooflines are the coupe trademark. The new A7 is undeniably evocative of the 1970s, of the very first coupe to bear the four rings, the chic Audi 100 Coupe S. Its creator, Hartmut Warkuß, longstanding design boss at Audi and Volkswagen, later became a mentor to Marc Lichte who, with the A7, is himself now presenting his first Audi coupe.

For me, the Audi 90 quattro IMSA GTO is the essence of Audi.

Andreas Mindt
Head of Exterior Design AUDI AG

Andreas Mindt, Head of Exterior Design, joins the conversation. He assesses the A7's muscular wheel arches, which are mainly his work. Mindt is a motorsport fan. And when he came to Ingolstadt, he went to the museum six or seven times in rapid succession. "I just couldn't see enough of our race cars," he recalls. Then his eyes light up – he was particularly taken by the Audi 90 quattro IMSA GTO: "For me, it's the essence of Audi." Is a hardcore racer really a role model for a luxury coupe? Mindt is in no doubt and reckons this is clearly apparent in the A7 – IMSA influences are evident in its face, in the accentuated waistline, in the muscular wheel arches and in the light strip along the rear end.

→

Audi QR-Code

Scan the QR code and see a video on the Audi A7 design.

“And in the interior design,” adds interior designer Ulrich Beierlein, who is now sitting in the driver’s seat. Inside the new Audi coupe, the driver focus is almost on par with that of a race car. “The seating position here is like a direct extension of the road,” explains Beierlein. “That makes for the perfect driving experience. And all the instruments have to serve that purpose.” The minimalist dashboard is just as much part of that as the slender-looking virtual cockpit, the cleverly integrated head-up display and the black monitors in the center console. Keys, switches, buttons? Nope. The tone is set by large-format touch displays. The operating concept is entirely new: “The human being is center stage.”

Everything looks elegant, nothing is extravagant – aside from the feeling of space. Minimalism is the main design element. “The A7 represents our digital transformation,” says Beierlein, tapping his forefinger on a monitor. Its surface gives him tactile feedback, complete with the hallmark Audi “click”. The key here is that digital instruments such as touchscreens are closer to the driver than analogue features like the cupholder. There is, however, a charming link between the former level (digital) and the latter (analogue) – via a graphite grey, elaborately interwoven trim insert. Not only does it look good, Beierlein also finds it “a haptic sensation” stroking his right hand appreciatively over the surface. This is where hi-tech meets craftsmanship.

Our light is design in motion. Tempo and rhythm are adapted specifically to the model.

Cesar Muntada
Head of Lighting Design AUDI AG

For design boss, Lichte, the A7 also provides a visual sensation. “I love the daytime running lights!” The new “eyes” with their “pupils” are a key feature of the car’s face. “They give it a self-confident, expressive character.” Cesar Muntada is pleased to hear this. He is the lead designer for light, and when the native of Barcelona talks, you often hear terms like “digital eyes”, “phy-gital” or “light in bodies”.

Precision lighting design –
In the new A7, contour lights create a subtle setting for the interior volumes and materials, with a choice of 30 colors. The quattro badge in the dashboard is also illuminated.

Digital focus –
In place of buttons and knobs are two high-resolution touch displays: one for infotainment, the second for air conditioning and comfort functions. There is a physical feedback when the finger types an entry.

Airy feeling –
The horizontal lines and slender dashboard create a look-and-feel of elegant simplicity. The center console is oriented toward the driver.

With his left hand, he points to the slender headlamp, which is divided in two – above are the daytime running light and low beam; below are functions like the cornering and turning lights. Muntada's pride lies in the upper section. The twelve light segments of the daytime running light stand upright side-by-side, interrupted in the middle by low-beam modules that look like a pupil. By day, only the twelve segments are illuminated, while the "pupil" remains black. In the dark, the lighting setup reverses – the segments stay switched off, while the pupil (alias: low beam) shines all the more clearly.

Even the way the A7 greets you is spectacular. As soon as the driver unlocks the doors, the dynamic indicators run twice from side to side. Then a point of light moves to-and-fro, opening up the signature pattern of the daytime running lights – as the curtain does a stage. When the car is locked, the little light show runs in reverse order. Muntada calls it "design in motion" – fast and progressive on the A7; calm and elegant on the A8. The tempo and rhythm of the light motion are adapted to the character of the model. What fascinates the Spaniard most is the "aesthetic of the movement". And that applies to the rear end, too. The taillight on the luxury coupe is a band of light made up of 26 LED segments and is in homage to the Ur-quattro. The rear foglamp is positioned in the center – as on a race car.

The new operating concept is the stage. The focus is on the driver.

Ulrich Beierlein
Deputy Head of Interior Design AUDI AG

But Muntada's lighting design is a lot more than merely sporty and beautiful. He also places enormous emphasis on safety. The moving indicator lights are one example, as "our eyes are better at recognizing segmented light". Over many months, Muntada sat down, sometimes three times a day, with the lighting development experts to execute this function. He spent countless hours driving the A7 in the dark to test his light, and its effect, on the open road. And he admits that there's even more to it than that – passion. "Our lighting design brings technology to life," says Muntada, who enjoys expressing himself in more poetic terms: "We're putting the soul of our cars on show."

His boss sees it more fundamentally. Marc Lichte reckons that people like to say that show cars are all smoke-and-mirrors, and will never be produced in this form. The new A7 proves this is not the case: "We've made it even more extreme than our highly acclaimed prologue." ←

CREATIVE FORCE

Text
Tom Volpe

Photos
Manfred Jarisch

Digital Craftsmanship
Relationships at Audi? They are very much encouraged – in the new Design Center, for instance. This is where designers and model makers work side by side in a constant “visual relationship”. It's also how they create the perfect combination of digital technologies and traditional craftsmanship.

1
Visual relationship – Designers Andreas Koglin and Sebastiano Russo (l. to r.) compare their A7 sketches with the clay model. Florian Kröpfl (right) builds the digital model at the monitor.

24 CUBES

Anyone passing by the northern edge of the Audi plant in Ingolstadt is sure to do a double-take – the new Design Center is a real eye-catcher. It sets a veritable architectural accent with its classically calm glass façade. The new building extends over six floors and has a footprint of 107 by 71 meters – the size of a soccer field. It took three years to build. Around 600 people who were previously spread across seven different locations now work together under one roof. Most of them are designers; added to that are the folks who work in concept development and the "Strak", an interface to Technical Development.

Andrea Staebner is project leader for the new building. She has been working on the concept and execution since 2012. So, what was her biggest challenge? "My co-workers are all about creativity and aesthetics. Planning a building for them is extremely demanding." The entrance hall, for instance, has been structured as an exhibition area for art and design with changing themes and accessible to all Audi employees. In the bistro, there's a small library, large-format pictures grace its walls, and it features only authentic materials like oak, exposed concrete and cotton.

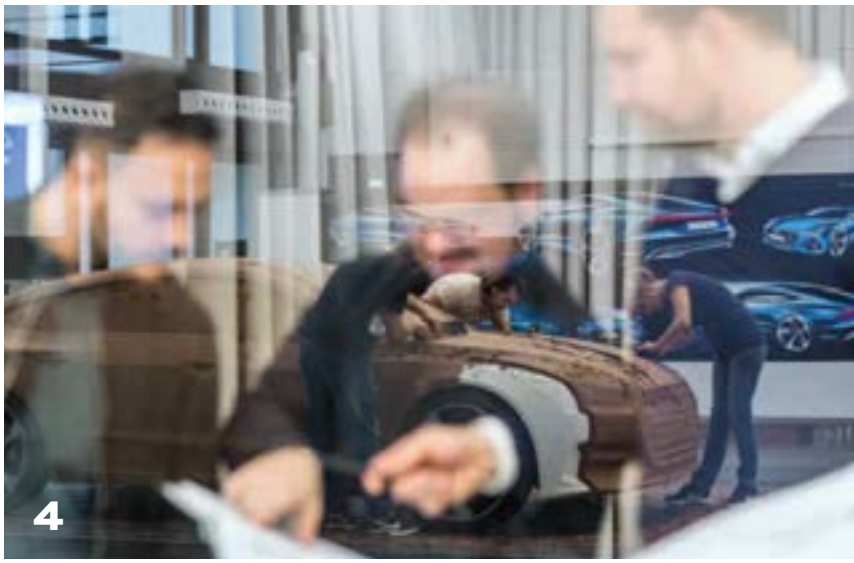
A light, bright look-and-feel are core aspects of the spacious, open Design Center – as are the expansive views of the outside world. "It's inspiring and promotes creativity," asserts Staebner, who came to Audi after completing her studies in interior architecture and wrote her masters' thesis on "open office-space planning". "The building has been conceived to optimize the design process." LED screens and modelling workspace with cutting machines are now located side by side, enabling the designers to draw continuous comparisons between the 3D model and the reference clay model. The designers have a direct sightline not only to the CAD specialists, who work up the vehicle's design from sketches to create a 3D model, but also to the model makers – and thus to both the digital and physical models. "The co-workers are in a constant visual relationship."

This eye contact is facilitated by glass walls between the offices, the creative spaces and the studios with the clay models. Meeting islands provide inviting areas for discussions, while the modelling studios become a gathering point – ideal conditions for close dialogue among designers, CAD experts and model makers. Their intense networking is becoming increasingly important as Audi prepares itself to bring a true product offensive to the roads over the next few years. The designers are having to bring even more concepts to production maturity, within an even shorter timeframe. →

> The building has been conceived to optimize the design process. The co-workers are in a constant visual relationship.
>
> **Andrea Staebner**
> Design Management

2

2
Transparency –
A light, bright look-and-feel are core aspects of the spacious, open Design Center.



3
In the thick of it instead of on the sidelines –
The designers' sketching table is directly in the modelling studio.

4
View of the studio –
Shop-talk about the progressive design language of the new A7.

OPEN SPACE

5
Masterpiece – Andrea Staebner created the office-space concept for the new Design Center.

6
First row – Designers and model makers work hand-in-hand on the new full-size coupe.

6

With employees numbering more than 400, Audi Design has more than doubled its workforce since 2000, while the team is already handling five times more projects and facing substantially greater technical demands. The process of matching design ideas with technical specifications is intensifying all the time.

It is for these reasons that the design team has developed the new C3 process, combining the digital with the traditional. Computer-aided design (CAD) and 3D visualization on huge LED walls are just as important to the process as classic model making. The new Design Center functions as a digital design workshop. It makes it possible to present the vehicle realistically in all phases of its development – three-dimensionally, in any setting and in all weathers. How might the light fall on the car on a grey February morning in London? All optical effects are accurately calculated and incorporated on the LED walls. "It means I can make a very precise assessment of a design idea even when it's still in the digital phase," says design boss, Marc Lichte, "and we can cut the first clay model with a significantly greater degree of design maturity." The outcome is a high level of process certainty, a more coherent outline design and a higher level of flexibility for creative ideas.

Thanks to 3D visualization, I can make a very precise assessment of a design idea even when it's still in the digital phase, and we can cut the first clay model with a significantly greater degree of design maturity.

Marc Lichte
Head of Design AUDI AG

This creativity is aided by extraordinary space-in-space situations known as cubes. The 24 large, open boxes made from wood and metal are a little like industrial containers, and function as islands in the everyday working environment. They, too, play an important role in the design process, as Andrea Staebner knows: "They act as a retreat and give the team the space they need to generate creative ideas." It starts with a strong idea than then develops positively – and ultimately becomes a coherent, fascinating product. ⟵

Data
Augmented Reality
Innovation
Freedom
Internet of Things
Smart City

MQ!

We like to move it, move it

When you think about mobility, it's usually about cars, bicycles and trains. But there's a lot more to the term than the straightforward movement from A to B. What our future mobility will look like has far more to do with the question of how we envisage our future lives. At Audi's MQ! Innovation Summit, advance thinkers from commerce and science came together to share their thoughts on the mobility of tomorrow. We take a look at the foremost future scenarios.

Text
Maj-Britt Peters
Maximilian Kranl

Illustrations
Bernd Schifferdecker

Autonomous
Shared Mobility
Driving
Machine Learning
Efficiency
Flexibility
Speed

AI

Knowledge
Science Fiction

Flexibili

What do Apple co-founder Steve Wozniak, 17-year-old robotics expert Anna Nixon and women's rights campaigner Fatima Bhutto have in common? They are all actively involved in the topic of mobility. Together with other visionaries from around the world, they all came to the "MQ! The Mobility Quotient" innovation summit to seek a formula for defining mobility. And it has not only a spatial and a temporal component, but also, to a very large degree, a social and a sustainability element. For two days, AI experts, city planners, vehicle developers and entrepreneurs discussed questions like: In what reality will we be moving in future? Or: How much is data actually worth? Answers became theses – and they all provide an impressive outline of how technology is going to turn our whole lives upside down.

MQ!

#1

Flexibility is the new intelligence.

After intelligence and emotions, flexibility is now one of the most important characteristics of a human being, and of a company, too. Even now, we are already facing on a daily basis the question of how we move ourselves efficiently through space, time and society. We have to adapt increasingly quickly to change and use it to our benefit. It's therefore hardly surprising that the pace at which new technologies are becoming part of our lives is also increasing. At the end of the 19th century, it took decades for the telephone to reach 25 percent of American households, while the smartphone achieved that in less than five years. In today's world, the capability to adapt quickly to new things has evolved to become a core competence. That applies to people as well as to companies. A high degree of flexibility is important for companies to participate in defining the speed at which new technologies are developed, and thus stay a step ahead of the competition.

When discussing flexibility in the development process, it's hard not to talk about X. Against the backdrop that nothing is impossible, the research department of Google parent company, Alphabet, pursues what it calls Moonshot Thinking. This is based on the notion that it's not enough simply to improve existing technologies. An idea only becomes an innovation if it is at least ten times better than anything that has existed before. By way of example: Reducing a car's fuel consumption to three liters per 100 kilometers would require the optimization of existing technologies. It would count as an innovation if a car could drive 1,000 kilometers on the same amount of fuel. And to do that, everything would have to be completely rethought. So, innovation means radical chance of an entire market, where the development focus lies not on the technology or the product or the underlying conditions. The focus is entirely on the problem. To achieve a solution often requires rethinking or lateral thinking.

Moonshot Thinking is a means to an end. However, the same principle always applies: To be able to anticipate and use change, companies have to create structures in which they can act flexibly. This is the only way they will be able to keep pace with the speed of innovation development, because everything we can imagine will become reality. And as Mo Gawdat from X says: "Either you build it or someone else will."

Moonshot Thinking

"Take nothing for granted."

Mo Gawdat
Chief Business Officer X

Mo Gawdat
is CBO at X, the research department of Google parent company, Alphabet. He has already co-founded more than 15 companies in various sectors and looks back on a career with IBM Egypt, NCR Abu Dhabi and Microsoft. Beyond that, he is active as a board member in a number of start-ups in technology, health and consumer goods. Gawdat is the author of the highly acclaimed book, *Solve for Happy.*

ity AI traffic jam pilot Level 3 and 4

“Children born today will no longer drive cars themselves.”

Sacha Vrazic
Head of Development Autonomous Driving, Rimac Automobili

Sacha Vrazic
heads up the development of autonomous driving for Croatian supplier Rimac Automobili. He is the author of many publications and is an expert in machine learning and artificial intelligence. As such, he works tirelessly for social change.

MQ!

#2

We’re overestimating autonomous driving in the short term and underestimating it in the long term.

“Children born today will no longer drive cars themselves,” says Sacha Vrazic, Director of Autonomous Driving at supplier, Rimac Automobili. This technology is the future of our mobility and it will change our lives massively. However, the road there is lined with open questions and obstacles that have to be overcome. It starts with integration into today’s traffic – who adapts to whom? The city to the car or the car to the city? Another question to be addressed is how autonomous vehicles will interact with supposedly “normal” cars. Will some cars have right of way? That would be one possibility.

At the same time, adaptation of the technology to different markets is a challenge that would be hard to overstate. Traffic does not flow and stop around the world in quite such an orderly manner as it does in central Europe. Preparing even Level 3 functions like the Audi AI traffic jam pilot in the new A8 for traffic in Beijing or New Delhi is a huge task. And even Apple guru, Steve Wozniak, asks what the benefit of Level 3 and Level 4 actually is if you as the driver have to be prepared to take back control of the wheel. The technical challenges are also quickly evident, as a requirement to resume control generally comes in a complex and not in a straightforward driving situation. So, what’s to stop a reaction time of one second turning into a reaction time of one minute? Augmented reality in windows could be the solution. The driver would receive a direct indication of where the danger is coming from and what must be done about it.

What’s missing most from the vision of the fully autonomous car is concrete data – spanning from map material to the way road users behave in specific situations. Virtual reality and machine learning could provide assistance in technical development. With their help, it would be possible to simulate an infinite number of driving situations from which the car could learn. One important objective of autonomous driving is also the significant reduction of traffic fatalities. Experts are talking of up to one million fewer victims per year worldwide. Similarly positive changes can be expected in the areas of efficiency and sustainability. Shared mobility is one example, with autonomous cars potentially providing the right incentive. In city environments, in particularly, they are tailormade for intelligent traffic solutions. One possible side effect could be less regulation. If traffic flows better on its own, it needs fewer interventions from lights and signs. So how does each one of us benefit from autonomous driving? We have more time, less stress and greater safety. In the long term, therefore, we shouldn’t underestimate autonomous driving. It will change our whole life.

MQ!

#3

The "naked passenger" is the future of mobility.

A smooth transition from one transport system to the next – with no wallet, no cell phone, no ticket. This vision of seamless transport is what Dirk Ahlborn, CEO of Hyperloop Transportation Technologies, describes as the "naked passenger". The idea is not to use data for maximum transparency, but to make organizing the transition from one transport system to the next as smooth as possible. Right now, switching from one means of transport to another can sometimes take more time than the actual traveling itself. What's called for is more efficient mobility concepts for society as a whole. Ahlborn proposes the Hyperloop, a magnetic monorail that moves through tubes with the help of a vacuum, connecting rural areas with the city in double-quick time. For individual mobility, one solution could be autonomous vehicles that park on their own or are ready and waiting when you leave the house – such as the Audi Aicon concept vehicle.

The absence of a ticket is an important aspect of this, as tickets have a negative effect on human mobility. Furthermore, many means of public transport financed via ticket sales are not profitable. Consequently, new monetarization strategies are also part of more efficient mobility concepts. What would it be like, for example, if it were possible to market passenger experiences? Data-based services are also an option – like a dating app that knows who you're sitting next to. You see, once you know who is where and when, you can develop completely new business models and establish whole new industries. A study carried out by Strategy Analytics on behalf of Intel valued the global market potential of this passenger economy at seven billion U.S. dollars per year. However, there is still a problem with trading in data – it has no measurable exchange value, meaning that customers' willingness to pay varies considerably.

Passeng
Econom
Seamless Transport
Data

"Mobility is working when you no longer notice it."

Dirk Ahlborn
CEO Hyperloop Transportation Technologies

Dirk Ahlborn
is CEO of Hyperloop Transportation Technologies. He is known for his outside-the-box approach, a strategy designed to breathe new life into companies with the aid of a paradigm shift. To do this, he relies on the full power of crowd collaboration, the internet and exponentially growing technologies.

ger
ny
a

Shared Mobility

Smart City

MQ!

#4

2–50–75–80

Four numbers, one major global challenge: 50 percent of humanity lives on just two percent of the earth's surface, consumes 75 percent of the world's energy and is responsible for 80 percent of its emissions. Conversely, that means if our cities were just a little more efficient, the global impact would be substantial. Shared mobility, autonomous vehicles and the Internet of Things can turn a city into a smart city.

Shared mobility, for example, could noticeably reduce traffic and air pollution in cities. Carlo Ratti from Massachusetts Institute of Technology (MIT) has the perfect example: Just 30 percent of the vehicles in Singapore would be necessary to meet the mobility needs of its population. In theory, a further 40 percent could be removed if passengers were prepared to cover similar routes together. Autonomous cars could make a further contribution by optimizing traffic flow. With automated intersection management, for instance, vehicles organize themselves in accordance with the first come, first served principle, without the need for lights hindering traffic flow. Everything runs via car-to-x communication. In another example, large quantities of energy are wasted right now in heating and cooling empty buildings. The Internet of Things could help synchronize climate control in offices and apartments with the presence of human beings.

However, the success of smart city concepts is heavily dependent upon social acceptance. It is therefore important to involve society in the discourse by allowing people to experiment with these concepts.

"50 percent of humanity lives on just two percent of the earth's surface, but consumes 75 percent of the world's energy and is responsible for 80 percent of its emissions."

Carlo Ratti
Head of MIT Senseable City Lab

Carlo Ratti
is an architect, engineer, inventor and professor at Massachusetts Institute of Technology (MIT), where he heads up the Senseable City Lab, a research group that examines how new technologies change the way we understand, design and live in cities. He was included by *Wired Magazine* in the "Smart List: 50 People Who Will Change the World".

7.5 billion

Social Mobility Knowledge & Education

“Platforms like the internet are founded on weak bonds, because they demand little from those who participate in them.”

Fatima Bhutto
Afghan journalist and writer

Fatima Bhutto
is an Afghan writer and journalist. Born the daughter of the Pakistani dynasty, she lost her parents at an early age and grew up in exile. She wrote her first book at the age of 15 and since then has been campaigning on behalf of minorities, especially in the Middle East.

MQ!

#5

The internet is the biggest nation on earth.

Access to technology means access to knowledge and education. Technology thus fuels our social mobility, enabling us to further ourselves and participate. For Steve Wozniak, the best Apple invention of all was not the iPhone, but the third-party App Store. It gave millions of people the opportunity to create something from nothing and make it available to others. Extrapolating this, you could also say that the one thing that connects the majority of the 7.5 billion people in the world across borders and religions is the internet.

However, Afghan journalist Fatima Bhutto sees these technologies not only as a positive thing. The reason is that, while they may be creating change in third-world countries, they are not necessarily resulting in upward mobility: “Platforms like the internet are founded on weak bonds, because they demand little from those who participate in them. “A phenomenon recognized by most people active on social networks is that many users have contacts or even friends all over the world and learn a great deal in the process. And that’s a good thing. The images they see have an impact, they generate awareness. But very few of them ever act on that. And if you think that 6.4 billion people in the world have access to a smartphone, but only four billion have access to a toilet, it becomes clear that there is still a great deal to do. It will take quite some time and demand considerable commitment for a similar level of social dynamism fired by technology to take root in developing countries.

So, is mobility measurable? Certainly, distances, journey times, social factors and environmental influences can be expressed in numbers. However, if we want to understand mobility in its entirety and draw conclusions from that for our future, this is not enough. That alone shows that the understanding of mobility must be fundamentally rethought. Mobility is not only something that can be created, but also something that can happen on its own – every day and all over the world.

←

Future
New from Nothing

Steve Wozniak,
also known as "The Woz", is an American computer engineer and entrepreneur. He founded Apple in 1976 together with Steve Jobs and Ronald Wayne, leaving the company in 1985. Since then, he has become famous worldwide as a hi-tech guru.

"The best Apple invention of all was neither the iPhone nor the Apple I, but the third-party App Store. It gave millions of people the opportunity to create something from nothing."

Steve Wozniak
Co-founder of Apple Computers

MQ! Summit

Jam Session

Audi AI traffic jam pilot
If you want it to, the new Audi A8* can take over the wheel in heavy highway traffic. As if by magic, the brand's flagship moves smoothly through slow-moving traffic. Meanwhile, the driver can sit back and relax until prompted to take back control as of 60 km/h. This is all made possible by the Audi AI traffic jam pilot, the first system worldwide to master highly automated driving on Level 3. For drivers who feel passionate about always being in full control of their car, doubt is simply par for the course. We invited two dyed-in-the-wool self-drivers to test the traffic jam pilot in the new A8 – with surprising results.

→ Page 54

In Tech We Trust
Jürgen Pippig examines the Audi AI traffic jam pilot in the new A8 – and tries it for himself.

→ Page 58

Pilot Project
Jochen Wagner reflects on autonomy and automobility during a drive in the new A8 with the Audi AI traffic jam pilot.

→ Page 61

Net-Work
The new Audi A8 uses up to 23 sensors and cameras to recognize and identify its surroundings. We take a look at the innovative technologies of the AI traffic jam pilot.

*** Audi A8:**
Combined fuel consumption in l/100 km: 7.8 – 5.6
Combined CO_2 emissions in g/km: 178 – 145


Audi
QR-Code
Scan the QR code and see a video on
the Audi AI traffic jam pilot.

In Tech We Trust

An essay by Jürgen Pippig

The joy of driving is one of his great passions – professionally and personally. But so is openness to innovations. Jürgen Pippig is a committed car guy. He conducts an investigation in the new Audi A8 with AI traffic jam pilot – and talks about curiosity, trust and experience.

Photos
Tobias Sagmeister

1 Up to 60 km/h – In congestion or in slow-moving highway traffic, the Audi A8 will take over highly automated control if you want it to.

The Control

I realize that, when it comes to driving, I'm a pretty tough case – certainly in some respects. Since passing my test in 1972, I've covered around 6,000,000 kilometers. Six million! And had just one, solitary, no-fault accident. This astonishing kilometer tally is the result of my job – I was, and still am, a long-distance commuter. I've been covering many miles every single day for years, plus business travel the length and breadth of Europe. And I love nothing more than to do it all by car.

The draw for me has always been the sheer love of driving. It's all about the journey, not the destination, and the expression of a very specific approach to life. I don't just want to drive individual cars, I also want to move them the way they deserve to be moved – i.e. very quickly – and to master them within the scope of own personal skill set. And my expectations are always the same – the car has to do what I want the way I want it to. So, I keep it clean, rounded and smooth – straightforward even. I don't bring any agitation into the flow. It means the suspension, brakes and steering can all work to their technical limits. But I'm in control at all times!

I've found it hard to accept the various driving aids and assistance systems that have been introduced over the years. To this day, I still distrust radar-based distance control and lane warning systems. Nevertheless, one single element has gradually found my approval – the increasingly precise fuel consumption displays opened up a whole new perspective for me, that of frugal, efficient driving. Achieving low fuel consumption figures became an important target for me – paired with the fastest possible driving style, of course. The latest iteration is gliding, which is a breeze with the current models. Go lightly on the brakes and sail along on idle – it really encourages active, predictive driving. I also see it as a very special kind of motorsport.

The Curiosity

So, I approach a topic such as piloted driving with caution and a healthy helping of skepticism – but also with interest.

Jürgen Pippig

These days, folks like me are often referred to as "old school". And for many, that's associated with a certain aversion to progress. However, I see it more as a reference to characteristics such as commitment and attention to detail. So, I approach a topic such as piloted driving with caution and a healthy helping of skepticism – but also with interest, because I clearly can't ignore the sheer traffic density we now face. Michael Schreckenberg, one of the most renowned researchers of traffic jams, has worked it out. If you take the average figures for Germany, the kind of mileage I cover means I spend around 120 hours per year standing in traffic jams. A whole five days and nights. That's a lot of wasted time I'll not get back! Possibly, piloted driving actually does open up a new dimension of mobility. Maybe even for me? I think I should at least give it a try.

The Trust

2 Driving on the Düsseldorf city autobahn – The AI traffic jam pilot in the new A8 is still waiting to start work.

3 Passionate driver – Jürgen Pippig, now being driven by the new Audi A8.

I'm meeting Peter Bergmiller, one of the development engineers responsible for the Audi AI traffic jam pilot. I simply can't disguise my doubts. The way I see it, absolute control of the vehicle and the situation is the very core of driving, and it's something I'm reluctant to relinquish. Extremely reluctant indeed. A technical system that doesn't want merely to assist me but to take over control entirely demands trust – a whole lot of trust. And that's something it first has to earn.

Bergmiller agrees with me: "Trust is indeed the key," he says. "It's something we've been working on in an enormous amount of depth and detail. The new A8 is the world's first production vehicle developed for Level 3 highly automated driving. On autobahns and multi-lane highways with a solid median, the ⟶

Audi AI traffic jam pilot takes over driving – and thus control – in solid and slow-moving traffic at up to 60 km/h. That can only work if people trust the technology."

But how do you establish this trust? "It's crucial that everything is simple, clear and easy to understand," says the engineer. "That starts with the controls! If something is perceived as complicated, there's an immediate and significant increase in rejection." Bergmiller is pleased with the results of the development work: "Our experience has been that most people begin to trust the system after just around ten minutes, because they see how well it works. And that trust is consolidated through sustained reliability. You see, unlike previous systems, which leave responsibility in the hands of the driver, traffic jam pilot manages moving off, acceleration, steering and braking on its own – without the need to monitor it continuously." For Bergmiller, getting used to that, the growth of trust in the technology, is not a matter of age. "It's easier for open-minded and inquisitive people," he explains, "regardless of how long they've been driving."

The Experience

Blinking around me are the lights of the city; in front of me, the lights of slow-moving traffic on the urban autobahn. I'm on my way to an evening appointment in Düsseldorf's harbor district, and thanks to the Audi AI traffic jam pilot, I am legally entitled to use the mobile infotainment toolkit to read emails, answer a text or simply allow the flickering billboard lights to wash over me. The congestion may still be time wasted, but at least I kind of get some of that back again.

The traffic jam pilot is indeed simple to use. When the traffic situation becomes really irritating and slows down to less than 60 km/h, "traffic jam pilot available" appears in the active info display. Now all you have to do is press the silver AI button. The speedometer shrinks and a stylized rear view of an A8 appears in the display. Two green bars light up to the left and right of it – as a clear signal that I no longer have to pay heed to the traffic.

I initially feel quite irritated. Incredulity creeps into the back of my mind. Is this situation for real? I watch closely what the car is doing, how it stays in lane and keeps its distance to the vehicle in front as it accelerates and decelerates. It's amazing! But I'm still happy that I have Peter Bergmiller with me. "We've built in redundancy everywhere, like a multi-layer safety net," he reassures me. But what if, just by way of example, another driver was suddenly to step out of his car in the right lane in front of us? "The traffic jam pilot obviously identifies pedestrians on the road and stops the car." And what about letting emergency vehicles through? "Because we're in the left lane, the vehicle moves to the left side of the road. If we were driving in the right or middle lane, the car would move to the right – thus immediately making way." Okay, I admit you can't get better than that.

4 Communication with the driver – When the traffic jam pilot is active, a stylized image of the rear end of an A8 appears in the Active Info Display.

5 Magic eye – The laser scanner in the front bumper is an important sensor for the AI traffic jam pilot.

6 Let's go – As soon at the notice "traffic jam pilot available" appears in the Active Info Display, all it takes is a touch of the silver AI button to activate the traffic jam pilot.

> Our experience has been that most people begin to trust the system after just around ten minutes, because they see how well it works.
>
> **Peter Bergmiller**

The Chauffeur

7 Future meets past – While the A8 masters the jam in highly automatic mode, U.S. cult series *Columbo* is playing on the screen.

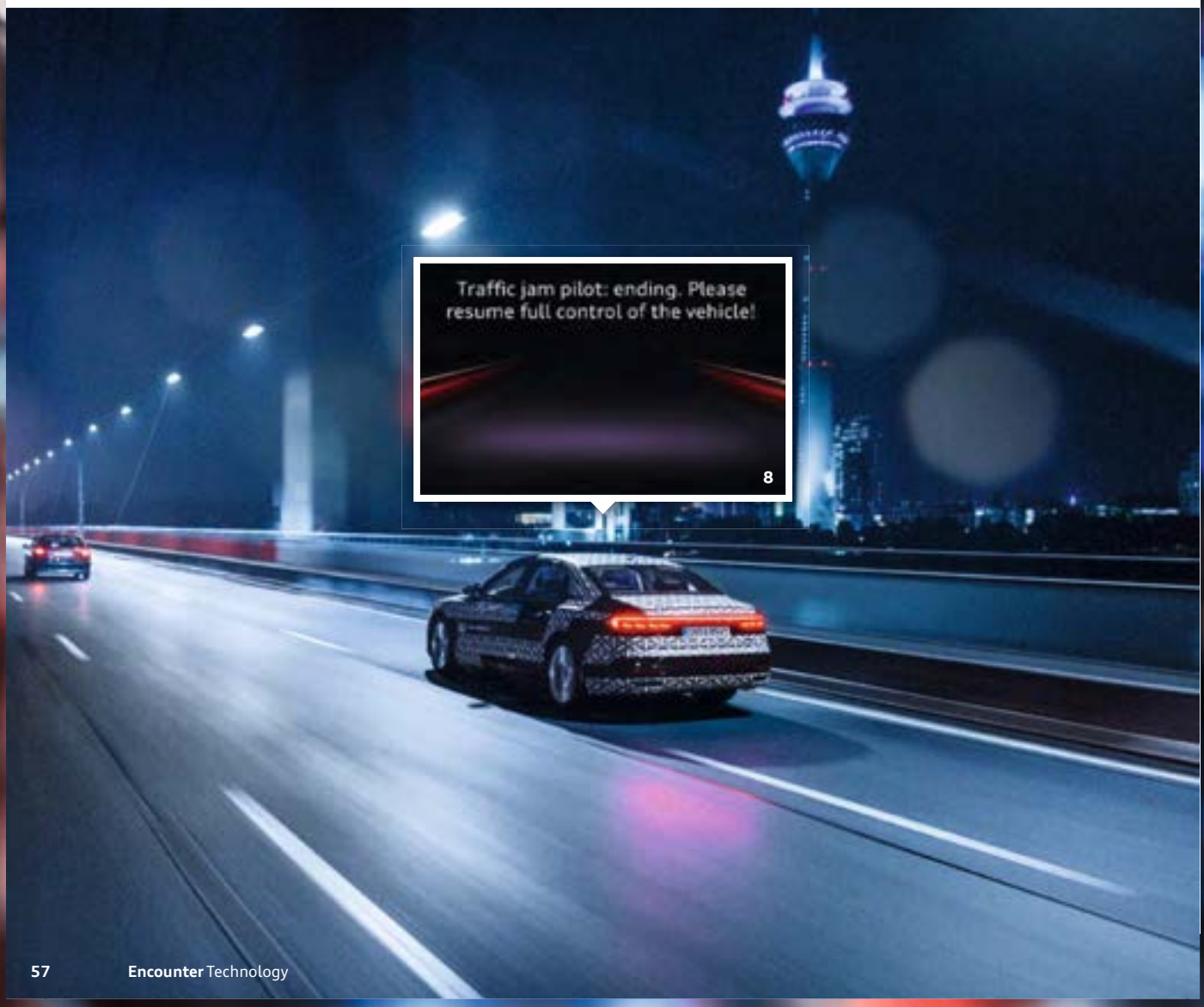
8 Over 60 km/h – When the congestion is over, the system prompts the driver to take back control of the wheel.

The Audi A8 with AI traffic jam pilot also drives as if an experienced British chauffeur were sitting at the wheel. It accelerates gently, smoothly and with nary a jolt to 60 km/h. If you would prefer a more direct style, you can change the mode in drive select. There's only one thing that the Audi AI does differently to many human drivers – it doesn't change lane. Traffic jam researcher Michael Schreckenberg already told me why: "Our findings simply tell us that changing lane in a traffic jam achieves nothing – apart from increased danger."

Peter Bergmiller laughs: "Text-book case. We're a good ten minutes in, and I can see you getting more relaxed." The engineer is right. Now I, too, notice how I'm slowly gaining trust. Bergmiller roots around in the A8's entertainment system for an interesting TV show. As soon as Professor Doctor zFAS – the central driver assistance control unit – has taken over control, distraction is permitted and even desirable. We end up stuck on old U.S. cult series *Columbo,* starring Peter Falk. The contrast couldn't be more extreme: We're currently experiencing a real glimpse of the future – while watching a series from a time when Bergmiller was a child and I was a young adult. We're both delighted by the old Peugeot convertible, with its roof even more ragged than the detective's old trench coat … great entertainment!

Maybe I should hand over control every now and then and simply place my trust in the reliable technology. Especially when – as is the case in a traffic jam – the pleasure of mastering a car is next to nothing anyway. It's a new perspective that – next to sporty driving and efficiency – could well take up a fixed place in my own personal driving philosophy. ←

> Maybe I should hand over control every now and then and simply place my trust in the reliable technology.
>
> **Jürgen Pippig**



Pilot Project

An essay by Jochen Wagner

The Director of Studies at the Evangelische Akademie in Tutzing loves fast cars just as much as he loves philosophy. While testing the new A8 with Audi AI traffic jam pilot, Jochen Wagner reflects on autonomy, ecstasy and automobility in the struggle between contemplation and distraction.

Photos
Bernhard Huber

1

To be honest, I'm pretty dumbfounded. It actually works! The car drives, steers, accelerates and brakes entirely by itself. And it all happens so smoothly and unobtrusively, as if controlled by an invisible hand. In fact, I was just a little bit irritated that the Audi AI traffic jam pilot got me hooked so quickly. I had felt so well armed, brimming with resistance, scathing in my skepticism: Who on earth needs something like this? The highly motivated young engineer from the development center demonstrated the technology for me. Interesting, I thought, still resisting the notion of assisted driving. What kind of treachery would that be, to betray my own "Golf GTI generation" – that thorn in the flesh of the fully controlled, cookie-cutter life? Had I not been successfully raised according to the automotive 101 of collector cards, tricycle, scooter, bicycle, go-cart, moped, dad's motor scooter – all the way through to the triumphant achievement of the license of all licenses in the space of just a few lessons?

At that very moment, I was conjuring in my mind's eye the horror that the tempters from the digital cosmos were using this antibody to the analogue alphabet of free mobility for free citizens in an attempt to snatch the zealously captured steering wheel from my fervent grasp. But the effortlessness with which the A8 was running at a standstill – virtually imperceptible to the senses – should have warned me. A short time later, the AI traffic jam pilot was no less convincing in its demonstration of all that it can do – and with such consummate ease. The sheer scale of the expertise – both analogue and digital – that goes into this is nothing short of humbling.

Just like our own body – our own physical autopilot – the A8's artificial sensors use radar, laser and ultrasound to see, hear and feel what's going on around it. How exactly it does that in its logarithmic or algorithmic logic is beyond me – but somehow, onboard infotainment agents use millions of stimuli, impulses, constellations and objects (both mobile and immobile) to construct a reality that reflects the actual road traffic in a way that is apparently coherent and similar to or compatible with our own reality. Umpteen assistants and modules translate all this into actions that mimic 1:1 all the skills that we, as a rule, enjoy executing so much ourselves.

It's pretty breathtaking what human beings come up with – the technology with which we manage to emancipate ourselves from nature's lethargy is now at least enabling us to escape the affliction of the infernal automotive gridlock. The ancient Greeks theorized that philosophy was the fruit of wonder *(thaumazein).* And indeed, I did have cause to wonder when we headed off in search of congestion to try out the autopilot's performance – right into the heart of Munich's snaking glaciers of metal. And again, I continued to wonder at all this miraculous mix of analogue and digital potential can do. Once you have activated the traffic jam pilot using the AI button on the center console, you can lay your hands on your lap and take your feet from the pedals. As the journey continues, a camera automatically monitors, through head and eye movements, whether the human driver is still capable of resuming control – because when the needle hits 60 km/h, the traffic jam pilot bids the driver to take over. And if you happen to have nodded off in the meantime, you'll be jerked out of your reverie by red lights, warning sounds, a triple tug on the seatbelt, brake judder, by the car coming to a standstill or even an emergency call to resume driving pronto. Still, in heavy stop-and-go traffic, the deputy driver releases us from the mind-numbing drudgery of the shiny metal conga line.

And again, I continued to wonder at all this miraculous mix of analogue and digital potential can do. Once you have activated the traffic jam pilot using the AI button on the center console, you can lay your hands on your lap and take your feet from the pedals.

Jochen Wagner

1 Fascinated – Jochen Wagner with the traffic jam pilot activated in the new Audi A8.

However, even if a gargantuan package of hi-tech noticeably frees us from undesirable everyday hardship with an ever-expanding array of comforts, the archaic and instinctive love of freedom that has flourished keenly within us since hunter/gatherer times does not suddenly transform into an automotive cage mentality. Us asphalt junkies are still firmly wedded to the Futurism ethos "A racing car is more beautiful than the Victory of Samothrace". We simply love the *Born to be Wild,* the *Vita Spericolata,* the reckless *Like a Rolling Stone* attitude to life far too much. The animalistic instincts were thus still astir beneath the thin veil of the surprisingly beguiling initial experience with the AI traffic jam pilot in the deliciously refined A8 flagship. This – the lust for speed, grip and drive – is to blame for us not wanting to molder away on our sofas but to break out into the open. Okay, I admit it! That also means a lot of time stuck in traffic. But are we not running the risk of heading straight into a jam of our own making with such finely crafted inventions of imperative support? ⟶

2

2 All seeing – Jochen Wagner enjoys considering driving from a philosophical perspective from time to time.

Admittedly, after spending a few deeply fascinating hours on autopilot, I'm a bit like a sober alcoholic – one touch of the steering wheel, a stroke of the pedal and I suffer a relapse. I delight in the haptic rendezvous with squeezing the gas pedal, nudging the brake, and the cha-cha-cha with the gear ratios, the foxtrot with the acceleration and the waltz with the centripetal or centrifugal forces, never mind the flirtation with corners and inclines, liturgically accompanied by that most ecstatic of accomplices – the glorious sound. This is not a boy-racer or speed-junkie thing; this is about the feeling – about the sheer sense of being that arises from escape. About the consensus of speed, rhythm, coordination, balance, grace and charm; this cacophonous loss of oneself in focused intensity – where the fairground carousel, your home track and the Nürburgring Nordschleife merge into one. It smells like dancing! Yes, perhaps dancing incarnate is the reference model for the automobile, the self-moving state of being. Perhaps it is our true nature – created in the image of God, but to move like a beast?

We at least have both of those inside us, authentically split – the yearning for peace, silence, contemplation. And the flipside of meditative collection – galloping diffusion. As pedestrians, we are terrorized by car drivers, motorbike riders. As motorized contemporaries, we are irritated by pedestrians – this resistance, these obstacles between dream and deed. Whatever we do, dash or dawdle, the one quotes, provokes, nourishes its counter-finality. The Audi AI traffic jam pilot certainly helps, when on a journey and stuck in traffic, to use the enforced standstill as a breather. A technical accomplice should rather soften the self-contradiction of highly mobile modernity. However, for now, no artefact will mitigate our duality completely. Slumbering within our body – nature's control unit – is sufficient latent energy for a simple spark plug to fire pipe-and-slippers man into a wannabe champion. When we're at home, we yearn to travel. When we travel, we get homesick. And our vehicle always doubles as our companion. *De corpore, de motu* – of body, of motion: Thomas Hobbes summed up our being succinctly and to the point. We are still human beings, made of flesh and blood, not post-factual or even post-human biomechanoids or trans-human PC sculptures. Much like our bodies, automotive artefacts are the beloved motion amplifiers of our creature *élan vital.*

Can we slow down, decelerate the unfettered global hi-tech capitalism in any sustainable way? Perhaps what we are dealing with is the myth of Icarus. The technical (r)evolutions will incessantly seek to steer Icarus' soaring antics towards a happy ending rather than a calamitous crash. But he also has to reach the lower altitude of his father, Daedalus. The compromise between the technically possible and the humanly sensible has been rewritten. Anyone who has ever driven a Lamborghini and experienced the tumultuous standstill of any ecological or social sustainability thinks initially that a Tesla is absolutely and utterly out of the question – ugh! But a test drive with a silent, battery-powered rocket delivers an emphatic lesson. The same applies to the first taste of autopilot – because you certainly can't deny that the A8 with AI traffic jam pilot has style. And style, *fare bella figura,* is the power to endow heavy necessity with the appearance of utmost grace. If appearances do not deceive, the mechanical, steering-wheel fixated orthodoxy will certainly be led into temptation by some kind of automotive heresy. Frenzied standstill, *les extrèmes se touchent,* in mobile life, too. It is always the light touch of change that sets the existing in motion. Asphalt organ meets whisperer.

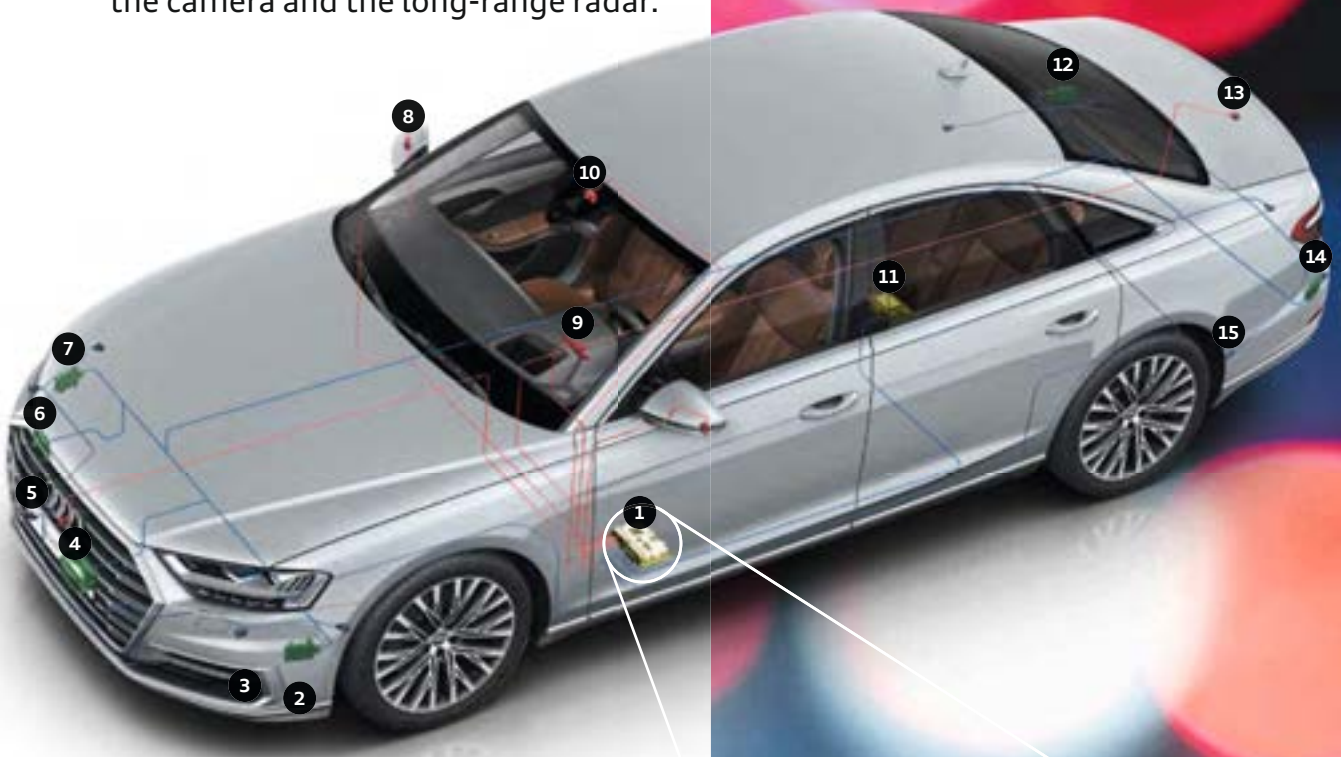
> Whatever we do, dash or dawdle, the one quotes, provokes, nourishes its counter-finality. The Audi AI traffic jam pilot certainly helps, when on a journey and stuck in traffic, to use the enforced standstill as a breather.
>
> **Jochen Wagner**

Audi promotes itself with "Vorsprung durch Technik". Even more appropriate, however, is *nomen est omen.* Translated literally, Audi means "listen!". A command, an imperative to new alertness, to prick up your ears, listen closely, sharpen all your senses to detect the scent of what's coming. What is now merely whispered behind upheld hands will come screaming onto the market in full production maturity. What has a future? ←

Net–Work

The sensor set in the new A8

The new Audi flagship uses up to 23 sensors and cameras to recognize and identify its surroundings. The AI traffic jam pilot uses primarily the laser scanner, the camera and the long-range radar.



Networking of sensors and cameras

1 **Central driver assistance controller (zFAS)**
Uses the fusion of sensor data to calculate an image of the vehicle's surroundings

2 **Mid-range radar, front left**
Captures the area to the front left of the car

3 **Ultrasonic sensors, front (x 6)**
Deliver signals from the immediate vicinity

4 **Laser scanner**
Measures objects in front of the car with great precision, wide included angle

5 **360° camera, front**
Delivers image signals from the direct vicinity of the vehicle

6 **Long-range radar**
Identifies objects in front of the car at a distance of up to 250 meters, measures proximity highly accurately

7 **Mid-range radar, front right**
Captures the area to the front right of the car

8 **360° cameras, exterior mirror (x 2)**
Deliver image signals from the direct vicinity of the vehicle

9 **Sensor for driver availability**
Monitors the driver's head

10 **Front camera**
Delivers image signals from the area in front of the car, classifies objects

11 **Gateway**
Establishes the connection to other onboard systems

12 **Mid-range radar, rear right**
Captures the area to the rear right of the car

13 **360° camera, rear**
Delivers image signals from the direct vicinity of the vehicle

14 **Mid-range radar, rear left**
Captures the area to the rear left of the car

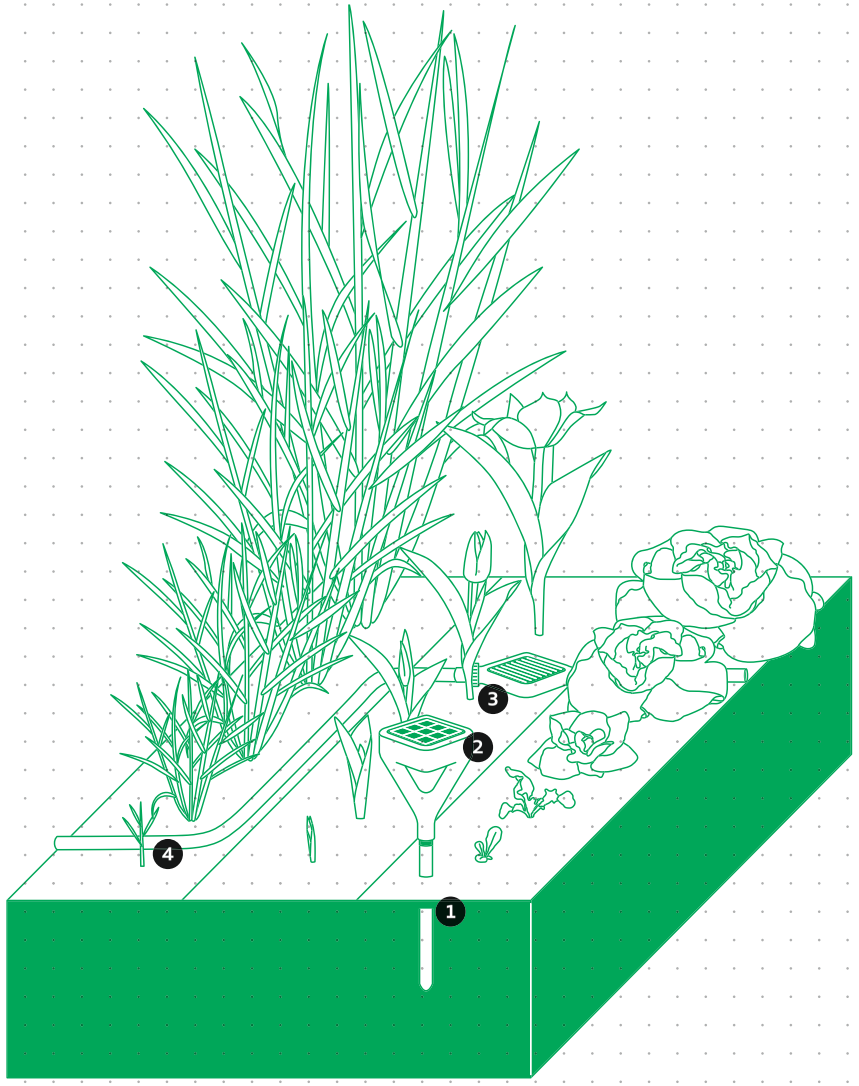
15 **Ultrasonic sensors, rear (x 6)**
Delivers signals from the immediate vicinity

Central driver assistance controller (zFAS) – The zFAS, which celebrates its premiere in the new Audi A8, is about the size of a tablet. It continuously fuses signals from all the sensors using extremely powerful processors to create a differentiated model of the surroundings.

TECH NEWS 1/2018

Text
Stefanie Lackner
Lisa Niermann
Jana Schröpfer

Illustrations
Marcel Mendler

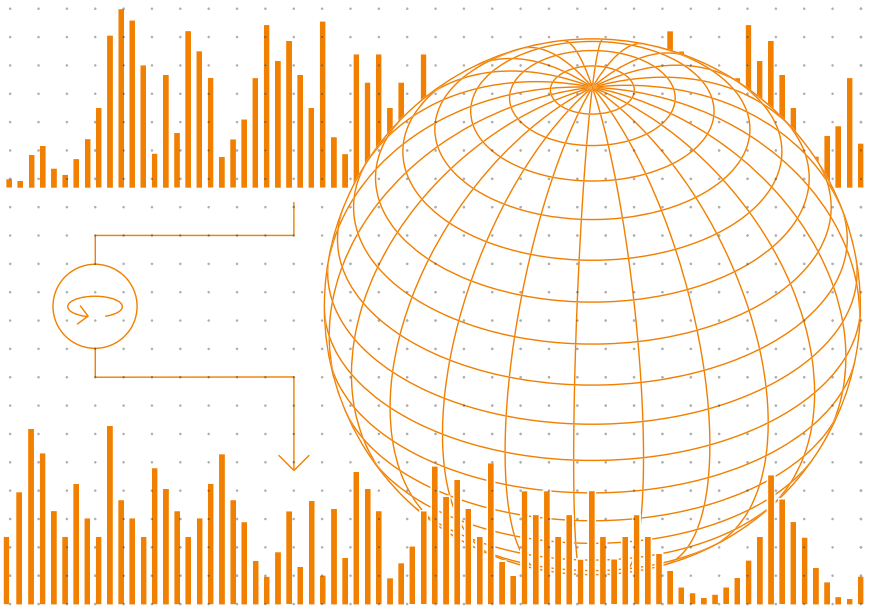


1 Anchored in the earth, the square sensor monitors garden health.

2 The status quo is immediately transmitted to the Edyn app.

3 If required, the small sprinkler systems switch on and off automatically.

4 The intelligent sprinkler system adapts to the weather forecast and thus reduces water and energy costs.



6,500

languages are spoken around the world. BabelOn could enable people from different countries to talk fluently with one another – without the need to learn vocabulary.

Your own voice in any language

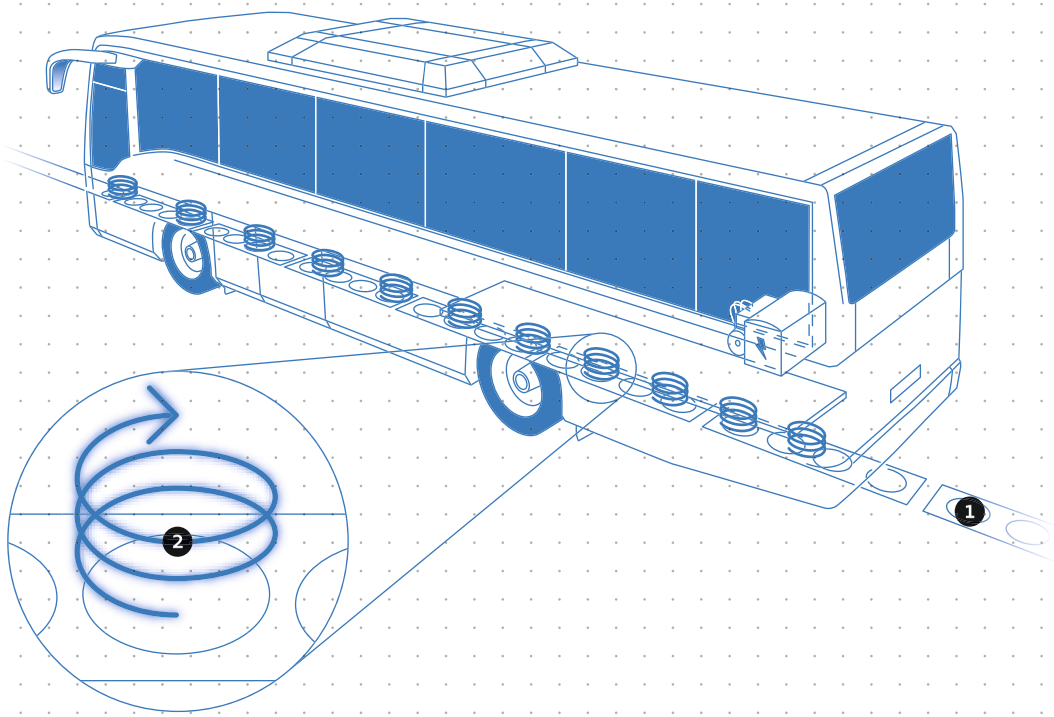
Could you hold a speech in German, Hindi or Mandarin? Would you like to know how your voice would sound in French? Start-up BabelOn has held the patent for a new type of voice synthesis since 2004. Originally developed for voice synchronization in the film industry, BabelOn can transfer the unique characteristics of your voice into other languages and use the results in video games, the music industry or in a business context. In future, it will also be possible translate directly via Skype telephony. A combination of hardware and software records the voice characteristics of individuals (such as tonality, lip movements, breathing) and uses them to create a digital profile. Supported by the Lawrence Livermore National Laboratory and NASA's Ames Research Center, BabelOn wants to bring out initial demo versions. Successful implementation could lead to BabelOn replacing Siri and Alexa, Apple and Amazon's voice assistants, in realistic human voice synthesis, aiding cultural networking and taking us one step closer to artificial intelligence. But first, all aspects of data protection and individual rights must be closely examined.

Further Information:
www.babelon.net

Connected Garden

There are plenty of intelligent homes around these days, but what about gardens? A company in the U.S. has now developed the Edyn intelligent garden system. A square sensor is set into the ground and collects information on light, moisture, temperature and soil nutrients, and compares this with databases on plants, soil science and weather. The Edyn app is connected to the system and shows snapshots of the garden in real time, issues warning if changes occur and makes suggestions for optimizing plant health. Besides the current moisture content, users can also find personalized tips on fertilizer and sunlight. There is also the option of installing an intelligent sprinkler system that automatically adapts to the weather forecast. Not only does this lower water and energy costs – it also makes the neighbors green with envy ...

Further information:
www.edyn.com
Image source: Edyn



1 Copper wires in the asphalt supply electricity to the electric road.

2 Energy is transferred inductively when driving along the electric road.

800

meters is the length of the electric road. If the project is a success, there are plans to build a 17-kilometer bus shuttle route.

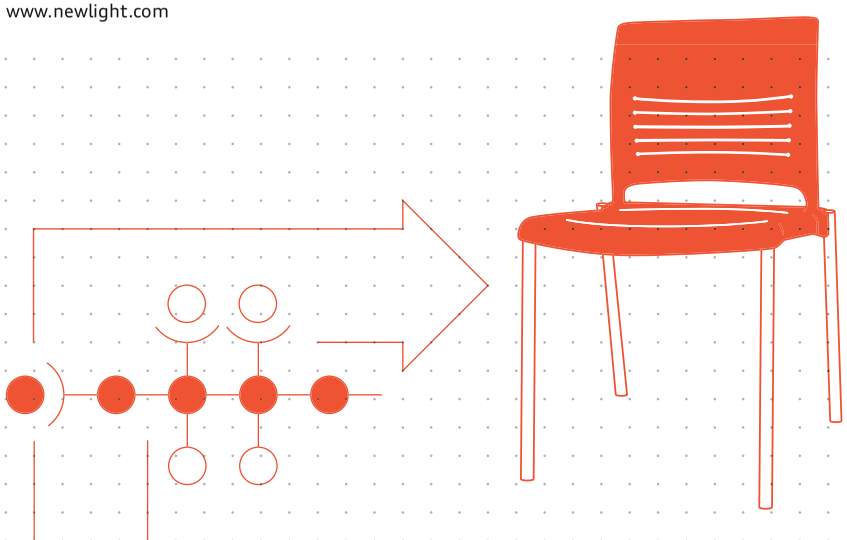
Highway to Electricity
The ability to charge the battery of an electric car while driving. The execution of this idea is drawing ever closer. Israeli start-up ElectRoad is currently testing the world's first electric road in Tel Aviv. Copper wire laid into the asphalt is able to charge cars while they drive. The principle is a highly promising one. The underside of the car is fitted with a receiver for wireless electricity supply. When it then drives along the electric road, energy can be transmitted via induction. This kind of road would be particularly beneficial for public transport, as it would dispense with the need for heavy batteries. And the idea could be applied to more than just electric vehicles – smartphones, too, could be charged in a matter of minutes with the help of the electric road, as scientists from Rice University in Texas have established.

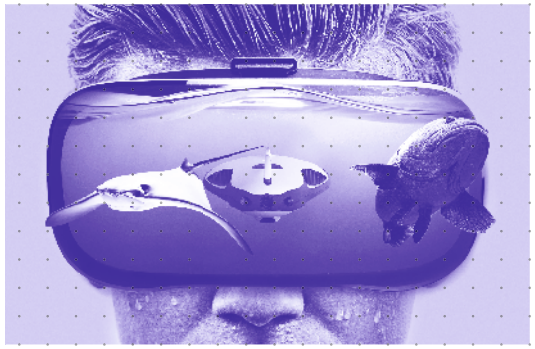
Further Information:
www.electroad.me

Chairs made from greenhouse gases

Making chairs from greenhouse gases is made possible by Californian company Newlight Technologies. The Americans have developed a technology that combines air with methane emissions. The mission is to lower the greenhouse gases in the atmosphere, while at the same time creating new resources to replace oil-based materials – such as plastics and other substances made from crude oil. In its simplest form, AirCarbon is comprised of 40 percent airborne oxygen and 60 percent carbon and hydrogen from atmospheric greenhouse gases. In cooperation with furniture company KI, Newlight is building the first chairs from materials recycled from greenhouse gases. Smartphone cases and beauty products can now also be produced from AirCarbon. In future, this technology could help reduce the amount of carbon in the air.

Further Information:
www.newlight.com





30

meters is the depth to which the drone can dive and transmit photos and video from the underwater world.

1 The PowerRay is connected to its base station via 50 meters of cable because wi-fi doesn't work underwater (yet).

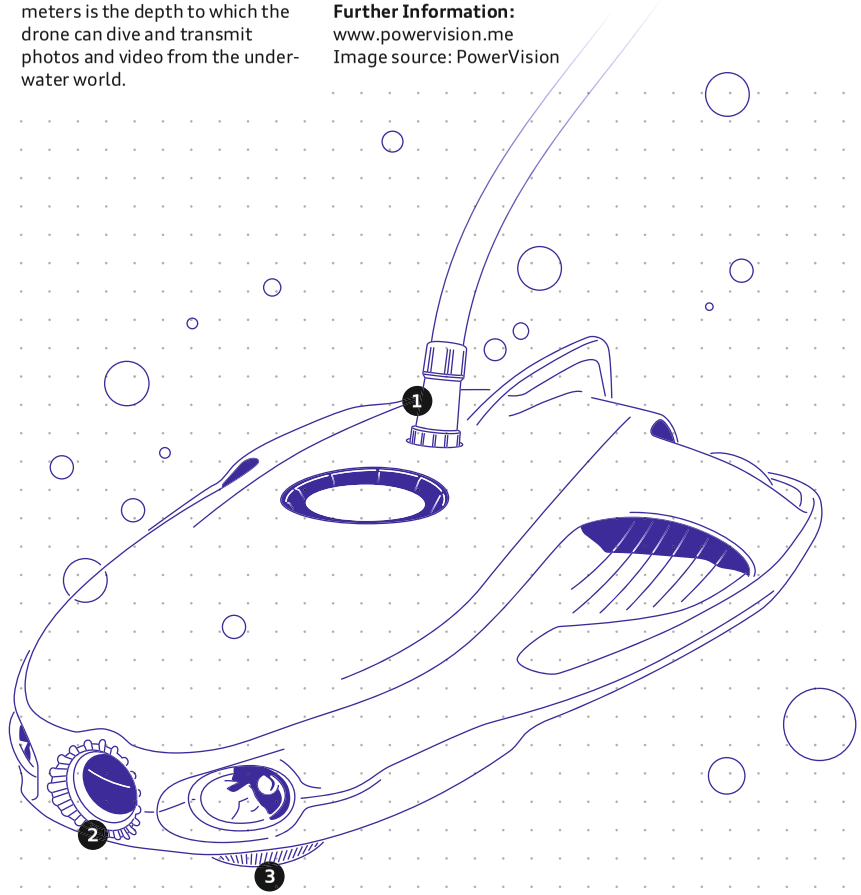
2 The 4K UHD camera shoots live images from the undersea world and transmits them via cable to a smartphone or VR goggles.

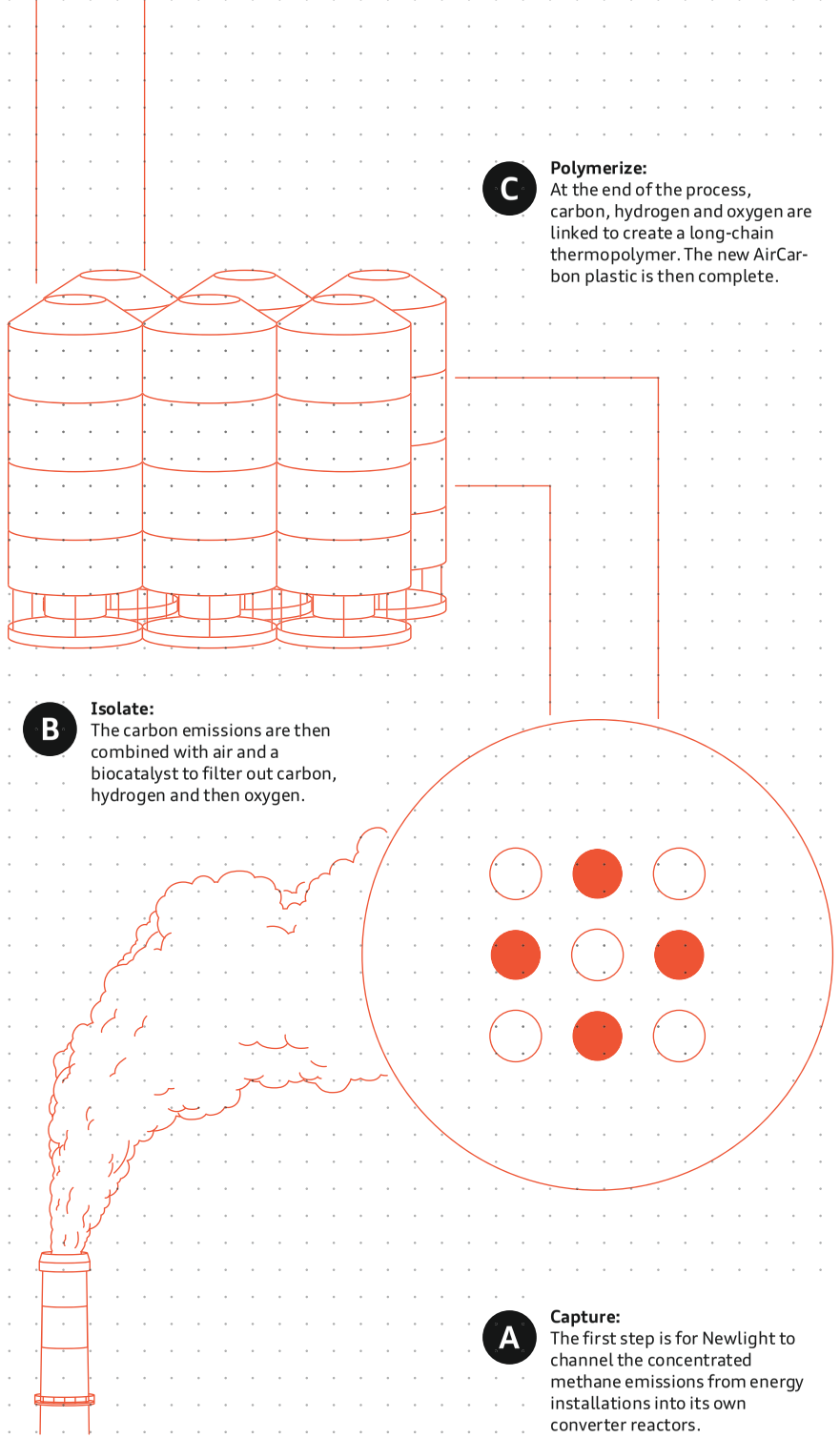
3 The sonar on the underside of the drone provides keen anglers with real-time information from the water. It can also be used without the drone.

"Good catch!" with ray drone

For passionate anglers seeking modern-day fun with drones, Chinese company PowerVision Group has developed an underwater drone with smart additional functionality. The PowerRay has been available in Germany since summer 2017 and permits not only anglers but also other enthusiasts to immerse themselves in underwater worlds. The drone uses its 4K UHD camera to shoot photos and videos to a maximum depth of 30 meters and then transmits them to a smartphone. Users searching for the perfect catch can switch to "fish finding mode" and a ball-shaped sonar in the base of the drone will detect shoals of fish – complete with information on the depth and temperature of the water. Remote control under water can be made even more realistic by using VR goggles. This allows the user to look at coral reefs and shoals of fish from the perspective of sea creature.

Further Information:
www.powervision.me
Image source: PowerVision





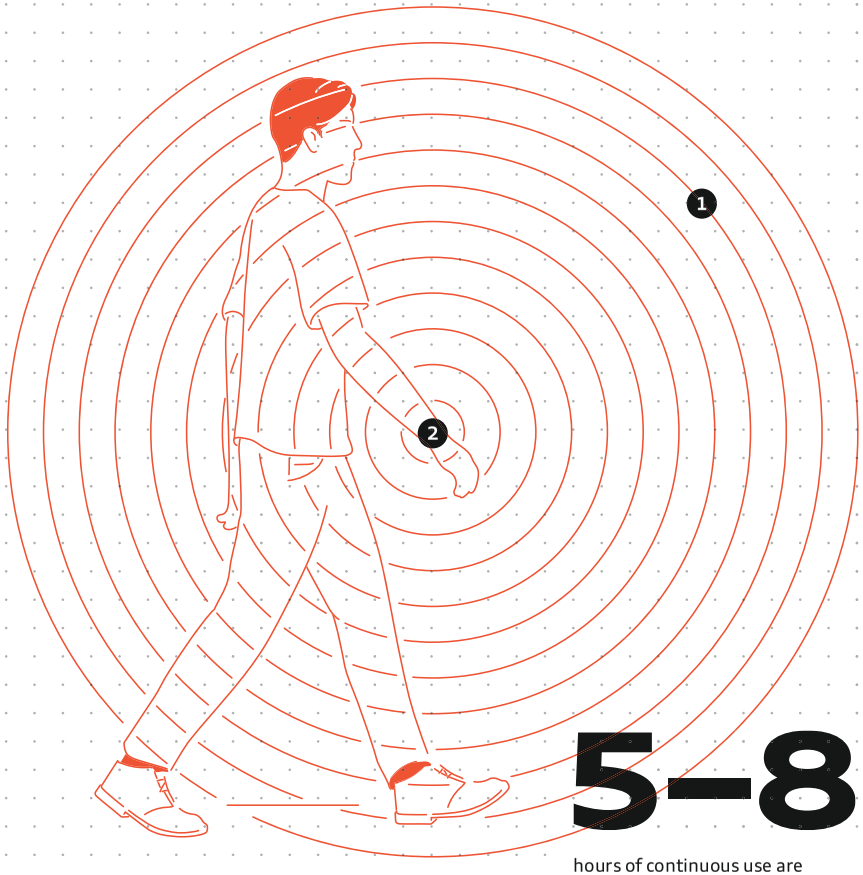
C **Polymerize:**
At the end of the process, carbon, hydrogen and oxygen are linked to create a long-chain thermopolymer. The new AirCarbon plastic is then complete.

B **Isolate:**
The carbon emissions are then combined with air and a biocatalyst to filter out carbon, hydrogen and then oxygen.

A **Capture:**
The first step is for Newlight to channel the concentrated methane emissions from energy installations into its own converter reactors.

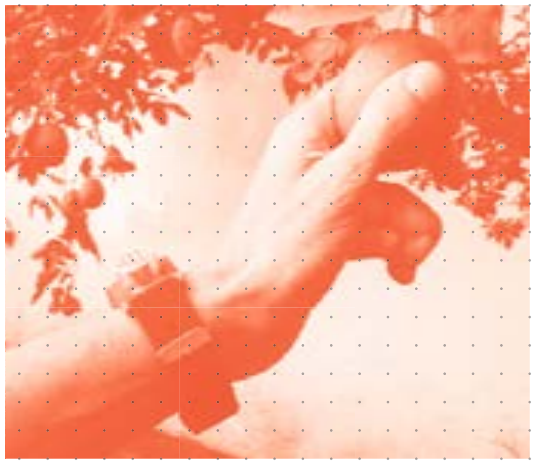
1 High-frequency ultrasound waves analyze the surroundings.

2 Vibrations warn the wearer of obstacles.



5–8

hours of continuous use are possible before the wristband needs to recharged via a USB connection.



Feel the Way

U.S. start-up Sunu has come up with the idea of using vibrations to improve everyday mobility. It is developing smart wristbands specially for blind and partially sighted individuals. High-frequency ultrasound waves identify objects in the vicinity and inform the wearer of obstacles via gentle vibrations on their wrist. The closer they are, the stronger the vibration. The wearable has a rechargeable battery with a USB connection and can be used for five to eight hours between charges. As well as identifying building entrances, the Sunu band also facilitates lengthy walks. It's a pioneering development that points the way forward – quite literally!

Further Information:
www.sunu.io
Image source: Sunu

High Power

Audi Sport is presenting a new high-performance engine in the new Audi RS 4 Avant*. The 2.9 TFSI V6 biturbo is bristling with immense power, emotional sound and impressively low fuel consumption.

Text
Johannes Köbler

Illustrations
Steven Pope

BT TURBO V6

Compact and lightweight –
The V6 biturbo weighs just 182 kilograms, 31 kilograms less than its predecessor with eight cylinders.

Technical Data

2.9 TFSI engine in Audi RS 4 Avant
FSI gasoline direct injection
Two turbochargers, one per cylinder bank
Continuous camshaft adjustment, Audi valvelift system
Camshafts driven by chain
2,894 cm^3
331 kW (450 hp) from 5,700-6,700 rpm
600 Nm from 1,900-5,000 rpm

*** Audi RS 4 Avant:**
Combined fuel consumption in l/100 km: 8.8
Combined CO_2 emissions in g/km: 200 – 199

600 NM

Biturbo concept –
Both turbochargers are mounted inside the engine V – a solution that delivers extremely responsive power build-up.

With the newly developed 2.9 TFSI, Audi is creating a direct link to the legendary 2.7-liter V6 from the first RS 4 Avant. Produced from 1999 until 2001, it generated 280 kW (380 hp). Like the 2.7-liter engine, the new high-performance engine has been conceived as a biturbo. Compared with its direct predecessor, a naturally aspirated, high-revving V8, it enters a whole new dimension in terms of power, torque and efficiency. From 1,900 to 5,000 rpm, the 2.9 TFSI sends a mighty 600 Nm of torque through the crankshaft, marking an increase of 170 Nm. With its 331 kW (450 hp) – 155.5 hp per liter of displacement – it catapults the new RS 4 Avant from zero to 100 km/h in just 4.1 seconds. In the RS Dynamics package, Audi lifts the electronic top speed from 250 to 280 km/h.

Concentrated power in an elegant package –
The 2.9 TFSI in the new Audi RS 4 Avant.

The 2.9 TFSI is derived from the likewise new 3.0 TFSI. Due to the higher internal forces, its stroke has been shortened by 3.0 millimeters to 86.0 millimeters. With the bore remaining unchanged, the displacement is now 2,894 cm^3. The crankcase incorporates thin-wall cylinder liners made from grey cast iron, while the diameter of the crankshaft main bearings has been enlarged by two millimeters. The crankcase is made from an aluminum-silicon alloy using a sophisticated sand-casting process and weighs just 34 kilograms. Its walls are of the so-called deep-skirt design – another weight-saving solution. The whole engine weighs in at just 182 kilograms, 31 kilograms less than its V8 predecessor. This benefits the overall weight and the axle load distribution of the new Audi RS 4 Avant.

The two turbochargers on the 2.9 TFSI are dedicated to one cylinder bank each, with each one generating up to 1.5 bar of charge pressure. Just like all of Audi's new V6 and V8 power units, the chargers are mounted in the 90-degree angle between the cylinder banks, meaning the exhaust is on the inside of the V and the intake is on the outside. This layout facilitates a compact design and short gas paths with minimal flow losses – the 2.9 TFSI reacts extremely spontaneously to the right pedal.

The high-performance V6 boasts compelling efficiency. It consumes just 8.8 liters of fuel per 100 kilometers in the NEDC (199 grams of CO_2 per kilometer) – 17 percent less than in the preceding model. A key factor in this is Audi's new TFSI combustion process, known as the B-cycle. Without restricting performance, it displays its strengths primarily under partial load, which is by far the most prevalent operating mode. In the area around the intake valves, it enables a geometry that, paired with the intake ports, generates targeted swirl of the gas charge. The common-rail system injects the fuel at up to 250 bar, whereby the high pressure ensures a homogenous spray pattern and even propagation of the flame front.

A further aspect in the efficiency of the 2.9 TFSI is the thermal management. Crankcase and cylinder head have separate cooling circuits. Following cold start, the adjustable water pump regulates the flow of coolant through the engine so that the oil warms up extremely quickly. The exhaust manifolds are integrated into the cylinder heads and are bathed in coolant, which aids the rapid warm-up. Once the engine is warm, this technology reduces the exhaust temperature and consumption decreases significantly as a result, especially during sporty driving.

The high efficiency of the V6 biturbo is also due in part to the low friction. Regulation of the oil pump, for instance, is fully variable, meaning it develops only as much pressure as is necessary. A new chain-drive concept reduces the power required – the balancer shaft is located deep inside the cylinder V and is driven by the crankshaft via a gear set. Chains run from here to the four camshaft gears, which have a slightly triangular shape to smooth out force spikes. The balancer shaft runs on extremely low-friction roller bearings.

Dynamic performance for everyday and leisure use –
The sprint from zero to 100 km/h in the new Audi RS 4 Avant takes 4.1 seconds.

The new 2.9 TFSI is also a highly emotional engine from an acoustic standpoint, with its distinctive sound evident from the moment it fires up. The flaps in the exhaust line open up under higher loads, generating an even richer, throatier sound. The Audi drive select handling system is fitted as standard and enables the driver to control the flaps – on both the standard RS exhaust system and the optional RS sports exhaust system with black end pipes. The induction system for the V6 biturbo has also been extensively optimized – pipes made from polished stainless steel allow the air to flow almost completely unobstructed.

←

FROM HERE → TO THERE

Super navigation vs. super brain
Franz is a committed taxi driver. He knows the **streets of Munich like the back of his hand. The same goes for the new HERE navigation in the** Audi A8. But who gets there faster? We examine this question en route from Ismaning to the Residenztheater in downtown Munich.

Text
Alexander Stiehle

Photos
Bernhard Huber

It's 3 pm at an Aral gas station on Leopoldstraße in Munich. It's a cloudy Tuesday afternoon, and Franz Daumer is sipping a cup of coffee. He has a long night behind him and is facing another tonight, so this probably won't be his last coffee. Franz is a taxi driver and works permanent nightshift. The Munich man has been sitting at the wheel of his car, pulling all-nighters for the past 14 years.

Committed taxi driver

But he's not looking for sympathy. He's one of the few people who have truly found their calling. "If this job didn't exist, I would have had to invent it," says Franz, laughing. "I love my job. I can choose my own hours and I really like being on the road at night because the party people are so colorful and far more relaxed."

Franz has covered more than 140,000 kilometers with his taxi in the space of just one-and-a-half years. Anyone who spends that much time in a vehicle develops a special relationship with it. Which is why his taxi also has a name: "Schickeria-Schleuder". And Franz has already been through a lot with her: "One night, I was waiting in front of the Hofbräuhaus when suddenly this drunk guy came staggering up to my taxi. He climbs in, and it wasn't until I took a second look that I realized it was Bruce Willis. I drove him to his hotel, which was only 500 meters down the street. But he was probably too disoriented, or too drunk."

In his job, Franz can't allow himself to be disoriented. To earn his taxi license, he learnt the vast majority of Munich's streets by heart. He knows every square, every park and every promenade. He's a master at dodging traffic jams. His gut feel and his experience are his best navigation system. When asked how he fancies his chances in a race against the world's most state-of-the-art navigation system, he nods confidently and says: "I know what I know. Challenge accepted."

The new HERE navigation in the Audi A8

Around 24 hours later at Audi's Technical Development complex in Ingolstadt: Guido Müller is filled with anticipation. Today, he's going to drive against taxi legend Franz Daumer in a race from the Schlossmuseum in Ismaning to the Residenztheater in downtown Munich. Guido is Project Leader for the new HERE navigation system in the Audi A8. There's only one question on his mind today: Who is faster? Taxi driver Franz with his experience or the navigation system Guido and his colleagues have been working on for the past four years.

Even on our way to the vehicle, we can already see what the new system can do. Guido enters the address into the myAudi app on his smartphone. The app begins navigating and first guides us to the vehicle. As soon as Guido steps inside, the Audi A8 automatically begins route guidance to the previously entered destination. "We want this end-to-end navigation to offer the customer a holistic solution that guides him from his door to his vehicle and then to his final destination," explains Guido then starts the engine.

As we travel on the A9 heading for Munich, Guido explains the navigation system's other highlights. He's completely relaxed as he drives along the middle lane, guiding the car with gentle steering movements. Suddenly a tighter corner emerges in front of us and the Audi A8 automatically lowers the speed. "This function is called predictive ACC (Editor: Adaptive Cruise Control). The navigation delivers data to the system based on the route currently being driven. It knows in advance what bends lie ahead and at which ⟶

↑ **The challenger –** The Audi A8 with the new HERE navigation in front of the Bavarian Parliament building.

The opponents

The expert – Franz Daumer has been driving a taxi in Munich for 14 years. Experience and gut feel are his navigation systems.

The technology geek – Guido Müller is Project Leader for the new HERE navigation system in the Audi A8. The electronics specialist puts his faith in technology in road traffic.

speed I can take them," says Guido. "This function is also an important element of autonomous driving."

The further development of autonomous driving is one of the reasons for Audi acquiring HERE in 2015 from Nokia, together with other German automakers. "What we see in HERE is far more than purely a guidance experience to get from A to B," he says. "HERE's maps are extremely accurate down to the last ten centimeters. We'll need this kind of precision later when Audi wants to put autonomous driving into series production."

The accurate map material is one of HERE's great strengths. Furthermore, the new system offers precise traffic information from geodata service, TomTom, and comprehensive search functionality from Google. "Each service has its own strengths. We're bringing them together in a single system to offer the customer the best outcome," says Guido as he exits the A9.

↑ **Crash course –** Franz is curious and wants to know how the HERE navigation works. Guido is happy to give him a short introduction.

First meeting

Shortly before our arrival at the Schlossmuseum in Ismaning, a notice appears on the navigation screen asking if we need a parking space. "This notice appears as soon as you approach your destination. If the drivers confirms, the software searches for a parking space and directs the driver there," explains Guido. But we're not looking for a parking space, just Guido's opponent for today – Franz, the taxi driver.

He's already waiting at the side of the road, leaning casually on his Schickeria-Schleuder. Guido steps out and the two men greet each other warmly. Obviously, Franz is keen to meet his opponent first. He settles himself into the passenger seat of the new Audi A8 and takes an inquisitive look around the interior, while Guido gives him a short crash course in HERE navigation. The two men appear to get along well – but there's still a race to run. Franz gets back into his taxi, and they're off. Both men accelerate sharply and head into the beginnings of the evening rush hour.

The duel

Guido's chattiness evident on the way here evaporates. Deep in concentration, he steers the Audi A8 through the heavy traffic. The HERE navigation guides him deftly through the busy roads.

Franz is driving right in front of us. He had a better start, and we drive behind him for a while along Oberföhringerstraße. As we leave Oberföhring, Franz suddenly take a right turn.

The HERE navigation tells us to drive on. Is Franz perhaps aware of a traffic jam unknown to the navigation system? Guido doesn't let it bother him and sticks to his course.

But the succession of red lights keeps slowing us down. Seconds become eternities. Maybe Franz is intentionally avoiding this flood of stoplights and is slinking along back roads. Is the Schickeria-Schleuder going to beat us?

Guido picks up the tempo after every red light. But the traffic is getting heavier and sometimes we come to a complete standstill. Guido's gas foot is getting nervous. The finish line is still around 1.5 kilometers away.

As we head along Maximilianstraße towards our destination, Guido uses a gap in the traffic to make up some time. We arrive at the finish line after around 15 kilometers.

Guido turns right onto Max-Joseph-Platz. We've been driving for just 32 minutes, but the red lights have distorted our perception of time. It feels like a wholelot longer.

We stop in front of the Residenztheater and look around. Where's Franz? Schickeria-Schleuder is nowhere to be seen. It looks likewe actually won.

Seconds later, Franz drives around the corner and pulls up next to us

↑ **Post-race debrief –** It was a close finish. Franz and Guido talk shop for a while about their respective strategies as they stand in front of the Bavarian National Theater.

Franz and Guido review the race results. Guido asks why he turned off. "The traffic on the Oberföhringer is usually heavy at that time and I wanted to avoid the congestion. But unfortunately, I drove into construction site and lost time," responds Franz. In Munich, roadworks can pop up from nowhere overnight. Nevertheless, it was a very close race, just that the HERE navigation was able to score a narrow victory this time. Franz takes it like a sportsman and gives Guido a high five before climbing back into his Schickeria-Schleuder. It's the start of his shift. ←

What is HERE?

HERE is an online geo-service that offers a navigation program orginally developed by Nokia for smartphones. In 2015, Audi, BMW and Daimler each bought a one-third share in HERE. The service's extremely accurate map data provides the automakers with the basis for autonomous driving. The Audi A8 marks the first use of the new HERE navigation system. It offers customers features such as end-to-end navigation from the front door to their destination, with optimized routes based on precise traffic information and the predictive ACC (Adaptive Cruise Control) function. This gives the vehicle advance knowledge of the bends and corners on the route ahead and the speed at which they can be driven. The vehicle automatically adapts the speed without any input from the driver.

AMPERE METER

The start of the Formula E season in Hong Kong marked the dawning of a new era for Audi – this is the first time the brand has participated in all-electric motorsport. Following on from successful programs in the DTM and Le Mans, this means entirely new challenges for the racing drivers, but also for the people not necessarily on the front line. **We take a look from five different angles.**

Text
Mark Schneider

Photos
Michael Kunkel

Three, two, one – Following one third and one second place overall, Lucas di Grassi was able to celebrate winning the title in the electric race series in summer 2017.

1 Lucas di Grassi

Formula E champion

In the course of his career, Lucas di Grassi has driven pretty much every kind of race car – formula cars all the way through to Formula 1, GT cars and Le Mans sports prototypes capable of up to 340 km/h. However, the 33-year-old Brazilian has found his great passion in Formula E – and not just because the electric championship is where di Grassi picked up the first big title of his career. "A driver's strengths count far more in Formula E than they do in many other racing series, where there are so many technical assistance features," he says. ABS, traction control and even automated energy management of the type used in the FIA World Endurance Championship (WEC) are not allowed in Formula E.

Added to that, all the drivers face the challenge of the tight city tracks: "After the start of a race on a permanent track like Hockenheim, half the drivers miss the first corner and take a wide arc over the surfaced run-off zone – get it wrong in Hong Kong, even by just two meters, and you end up in the wall and your race is over. Even the tiniest mistake is brutally punished." That makes for truly thrilling races and hard-fought duels, not to mention the occasional minor drama.

"I've never been involved in a racing series that's as unpredictable as Formula E," says di Grassi. And he knows what he's talking about – more than once, the reigning champion has managed to start from the very back of the pack and still end up on the podium, or even in first place, thanks to perfect energy management. "Anybody watching Formula E who leaves the stands or switches channels before the last lap is making a big mistake."

> A driver's strengths count far more in Formula E than they do in many other racing series, where there are so many technical assistance features.
>
> **Lucas di Grassi**

2 Daniel Grunwald

Vehicle Manager with Daniel Abt

Eager anticipation. The thoughts of Daniel Grunwald as soon as he was nominated Vehicle Manager for Formula E can be summed up by these two words. Not because he didn't enjoy his work in the same role in the DTM alongside young driver Nico Müller. "But Formula E is an amazing challenge with lots of aspects and ways of doing things that I'd not yet experienced in conventional motorsport." For the engineer with Daniel Abt, it begins with preparations for a race weekend. "In the DTM, the number one priorities were the perfect lines and getting the car's setup right. But I noticed pretty quickly that it's far more complex and time-intensive in Formula E because there's a lot more data – from the simulator, for example."

Another new aspect that's unique in motorsport, but already a given for fans of Formula E, is that the vehicle manager has to deal with not just one car, but two. The process of digitalization in motorsport, the growing importance of software, rethinking the pursuit of performance – for Daniel Grunwald, these are the most prominent observations from his still young Formula E career, which only began summer 2017. "In the conventional race series, we engineers often find the decisive tenths of a second in the race car's setup. In Formula E, on the other hand, they're in the energy management, i.e. in the most efficient interaction of driver, car and software."

Formula E is an amazing challenge with lots of aspects and ways of doing things that I'd not yet experienced in conventional motorsport.

Daniel Grunwald

3 Timo Breuer

Chief Mechanic with Daniel Abt

Hong Kong, New York, Paris – when Timo Breuer tells friends or colleagues from other motorsport series all the places he goes to with the Formula E circus, he is often met with looks of astonishment. "Manhattan obviously has a very different ring to it than Lausitzring. But wherever we are, our remit is to do a perfect job for the team, not to go sightseeing in the city," says Timo Breuer with a smile. This job often involves 15-hour days – including climatic challenges like 35 degrees in the shade or 92 percent humidity.

Qualified in vehicle mechatronics, Timo has been onboard since the very start and is Chief Mechanic for both Daniel Abt cars. He previously spent two years in the Abt Sportsline workshop in Kempten. "Formula E is a whole new challenge for mechanics like us," says Breuer. By that, he means things like the compressed racing format that squeezes practice laps, qualifying and the race itself into the space of just a few hours. "We all obviously have our specific jobs, but when push comes to shove after, say, an accident during practice, then we all work together and help one another. Every minute counts and can make the difference between victory and defeat."

The second aspect is in the nature of the beast – Formula E is the only all-electric race series and is therefore new territory for all involved. Timo Breuer: "The nasty bit is that you can neither see nor smell electricity." While fear may not enter into the equation when, for instance, the charging cable for the high-voltage battery has to be connected, "there is certainly respect," says Breuer. "And it's never a matter of routine."

We all obviously have our specific jobs, but when push comes to shove after an accident during practice, we all work together and help one another.

Timo Breuer

Perfectly prepared – Drivers and teams readied themselves for the new season with test drives in Valencia, Spain.

We all have to work with absolute precision, we can't make any mistakes and we have to react to all eventualities extremely quickly and, above all, correctly.

Tristan Summerscale

4 Tristan Summerscale

Project Leader Formula E

Tristan Summerscale can't help smiling when he hears for the umpteenth time that Formula E is simple when it comes to development and not particularly demanding from a technical standpoint. "It's exactly the opposite," says the engineer who has been part of the Formula E family since the start of 2017, when he took over as Project Leader for Audi. "The regulations may well be more tightly specified than in other championships, but that makes Formula E all the more about meticulous detail work."

Summerscale came to Audi with experience in Formula 3, LMP2 and Formula 1, taking over responsibility for the brand in the successful LMP program. "In the FIA WEC, one of the main focal points was always on development of the aerodynamics," he recalls. With Formula E using a standardized chassis, this is one area that is specifically excluded. "This places tremendous focus on the powertrain, software development and, above all, simulation work in order to be fully equipped for the initial races." Once the season is up and running, the emphasis shifts to hardware.

Which makes ongoing fine tuning of the software all the more important, with efficiency being the keyword that makes the difference between victory and defeat. It's a word that Tristan Summerscales also believes is vital to the work done on the race track: "In contrast to all the other series, we have very little manpower trackside. And on top of that, the program is compressed into one solitary race day. So, we all have to work with absolute precision, we can't make any mistakes and we have to react to all eventualities extremely quickly and, above all, correctly." It's that simple.


KUKA

Formula race car by Audi –
The FE04 e-tron is fully electric and is the new generation of Lucas di Grassi's championship-winning car.

5

Luis José Rodríguez García

Motorsport fan from Mexico City

Motorsport is sacred – that applies in Mexico probably more than in any other place on earth. It's with good reason that the enthusiastic fans have made the Formula 1 weekends at the Autódromo Hermanos Rodríguez in the heart of the capital one of the high points of the calendar for many years.

One of them is 36-year-old Luis – and he had a hard time in 2016 when Formula E came to his home city for the first time. "I was immediately fired up because I'd already seen a lot of the series on YouTube," he says. "That's why I absolutely had to see it live. But my friends were really skeptical to start with and sent me on my own." One year on, Luis' group has grown to 13, including four women. "We're having an absolutely fantastic time here. The races are exciting and action packed, including the occasional collision. The absence of sound doesn't bother me – I hear enough engines on my way through the city."

The group, sporting sombreros and cheerful spirits, have already spent all day Friday in the paddock: "Everyone is friendly and open and always happy to oblige with a quick photo." Luis is particularly proud of his shirt, signed by the racing drivers. "I have lots of pictures of me with the drivers and managed to collect 17 autographs in the space of an hour, just walking along the pit lane," he recounts. "In Formula 1, I'd have been lucky to have gotten one or two signatures by the end of the whole weekend."

We're having an absolutely fantastic time here. The races are exciting and action packed, including the occasional collision.

Luis José Rodríguez García

New look –
The Audi e-tron FE04 has a completely new design for season four, dominated by clean lines and dynamic forms.

Teamwork –
Plenty of test driving on the track and simulator work takes place at Audi in Neuburg. The cars are run and prepared by partner ABT Sportsline.

Audi in Formula E

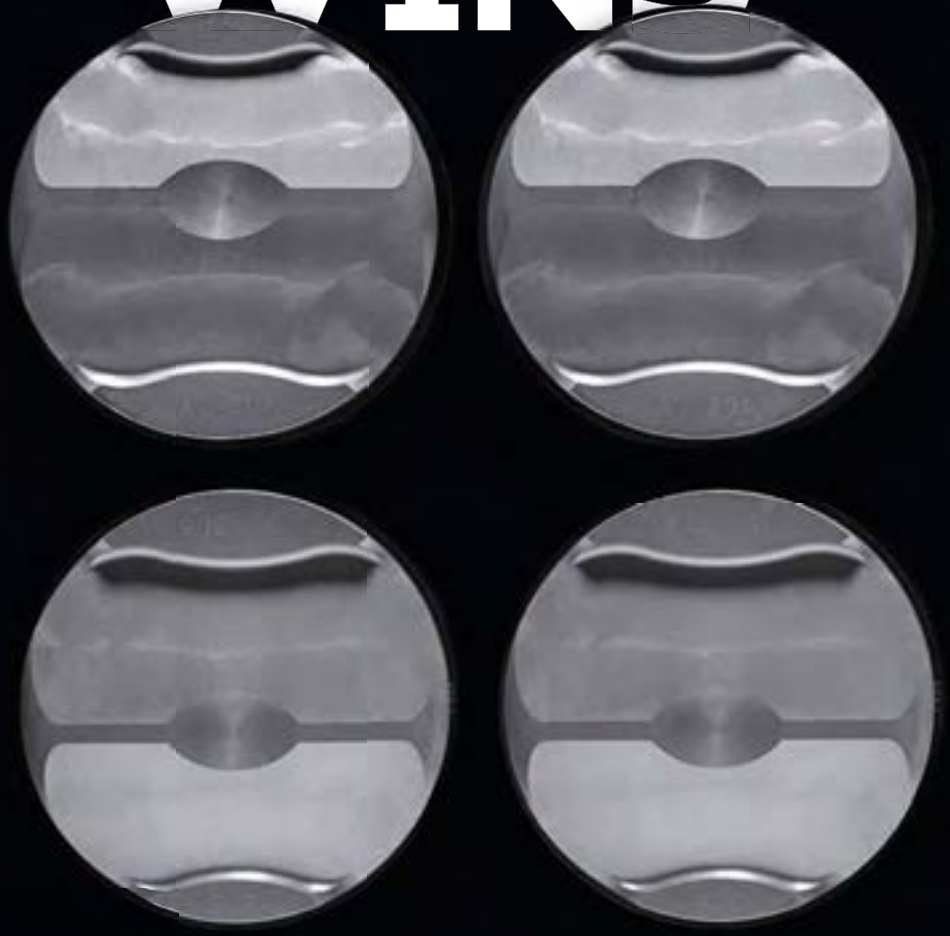
Formula E is establishing a whole new generation of motorsport – all-electric, bang-smack in the middle of the world's major cities and with a totally unique race format. This concept has fired up manufacturers, teams, fans, media and drivers alike. The series celebrated its debut September 2014 in Beijing and is currently in its fourth season. Audi is the first German automaker to participate in Formula E, with BMW joining next season, followed by Porsche and Mercedes the year after.

The Audi e-tron FE04 is a thoroughbred formula race car and the new generation of Luca di Grassi's (and Daniel Abt's) championship-winning car. While the first Formula E season in 2014/2015 featured identical electric race cars, the teams and manufacturers have been permitted since the 2015/2106 season to develop the complete powertrain themselves – comprising motor, transmission, parts of the running gear and the associated software. Behind the wheel, Audi is relying on reigning champion, Lucas di Grassi (Brazil), and youngster, Daniel Abt (Germany). Since Formula E was founded, both men have been driving for the only German team on the international grid, made up of ten teams and 20 drivers.

Audi e-tron FE04

Technical data	
Vehicle type	Monoposto (FIA Formel E)
Motor/generator unit (MGU)	Audi Schaeffler MGU02
Power practice and qualifying	200 kW (272 hp)
Power race	180 kW (245 hp) plus FanBoost
Drive	Rear-wheel
Transmission	High-efficiency 1-speed racing gearbox
Length	5,000 mm
Width	1,790 mm
Height	1,070 mm
Wheelbase	3,100 mm
Minimum weight	880 kg (incl. driver)
0–100 km/h	ca. 3.5 seconds
Top speed	225 km/h

FOUR WINS



Four cylinders for a Ducati production motorcycle –
The sporty motorcycle company from Bologna writes a new chapter in its glorious history.

Revolution in Bologna

Ducati presents its first four-cylinder engine for production motorcycles. The V4, derived directly from motorsport, is called the Ducati Desmosedici Stradale and generates sensational 157.5 kW (214 hp) from a displacement of 1,103 cm³.

Text
Johannes Köbler

Ducati has been using a V4 engine since the beginning of the MotoGP, the top-rung racing series on two wheels. And major technical elements from it have been carried over into the new production engine. The most important parallel between the racing and production engines is the heart of the engine – the 81 mm pistons and the combustion chambers with the straight-sided racing-derived intake ducts. The engine's fluid dynamics were developed in close collaboration with the racing technicians.

214 HP

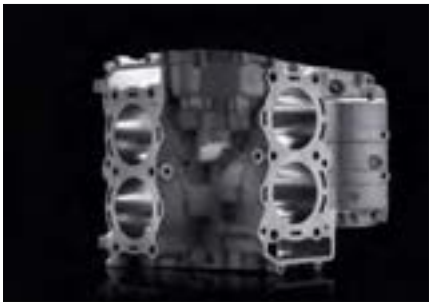
The road engine –
1,103 cm³ displacement, 157.5 kW (214 hp).

The race engine –
1,000 cm³ displacement, more than 184 kW (250 hp).

ENGINE BLOCK

The Ducati Desmosedici Stradale works with a displacement of 1,103 cm³ thanks to a stroke extended to 53.5 millimeters. Just like the racing version, the engine has a cylinder angle of 90 degrees, which equalizes the first-order inertial forces and means the V4 does not need a balancer shaft, thus saving weight and raising the revving characteristics. The V layout has considerable benefits compared with an inline four-cylinder – the engine is narrower and the shorter crankshaft lowers the gyroscopic effect, i.e. the stabilizing rotational forces emitted by the rolling wheels. This makes directional changes faster and easier.

The horizontally split, aluminum alloy engine block is made using the gravity die casting process and its upper section houses four aluminum cylinder liners coated with Nikasil to minimize friction and wear. Each of the cast aluminum pistons is fitted with two low-friction compression rings and an oil scraper ring, and is mounted on a forged steel con rod.



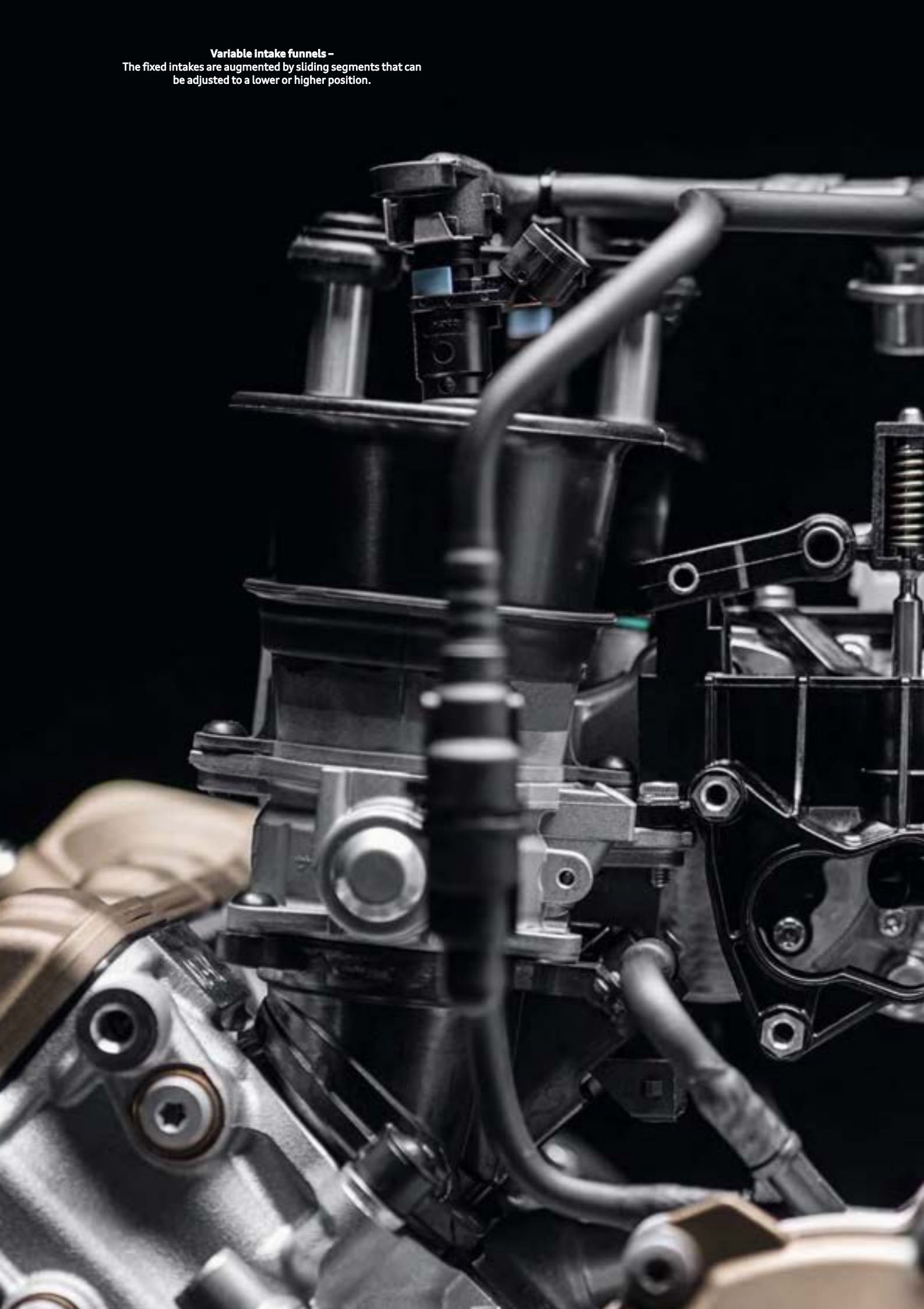
CRANKSHAFT

Inside the crankcase, the nitrided steel crankshaft spins on three main bearings with brass bearing shells and, due to a reversing shaft, rotates contrary to the wheels. This is another solution that has a positive influence on the gyroscopic effect as well as the inertial forces, in both the engine and throughout the bike as whole. Under acceleration, the reverse spin of the crankshaft generates a counteracting force that pushes the front of the motorbike downward. Under heavy braking, it has the opposite effect and counteracts lift at the rear wheel.

Just like the racing engine from the MotoGP, the crankshaft has a crank pin offset of 70 degrees. Together with the V configuration, this offset delivers the same twin-pulse ignition sequence as a twin two-cylinder – meaning the ignition intervals between the cylinders on the left and right are extremely short. The twin-pulse sequence not only delivers a unique and thrilling sound, it also lays the foundation for the outstanding performance and excellent power control. The maximum output of 157.5 kW (214 hp) is available at 13,000 rpm, with the revs peaking at 14,000. The V4 has a compression ratio of 14.0:1 and generates more than 120 Nm of torque between 8,750 and 12,250 rpm. ⟶

“It clearly states how close the cooperation is between Ducati Corse and the development group working on production motorbikes. And it shows how much motorsport can contribute to the development of a technology that is then used in series production.”

Claudio Domenicali
CEO of Ducati Motor Holding



Variable intake funnels –
The fixed intakes are augmented by sliding segments that can be adjusted to a lower or higher position.

DESMODROMIC SYSTEM

Another key performance element is Ducati's classic desmodromic control system, which uses rocker arms to open and close the valves with the very highest degree of mechanical precision. This process facilitates the steep cam lifting curves and exceptionally fast timing, which pairs with the cylinder flow to generate the high power output. The Desmosedici Stradale uses a completely new desmodromic system with weight-optimized components. Together with the ultra-compact spark plugs, it forms the basis for the configuration of the extremely narrow cylinder head.

“The new Desmosedici Stradale is the first four-cylinder ever developed by Ducati for volume production. And it, too, features desmodromic valve control for high revving and exceptional performance.”

Marco Sairu
Head of Ducati Engine Project Management

VALVES

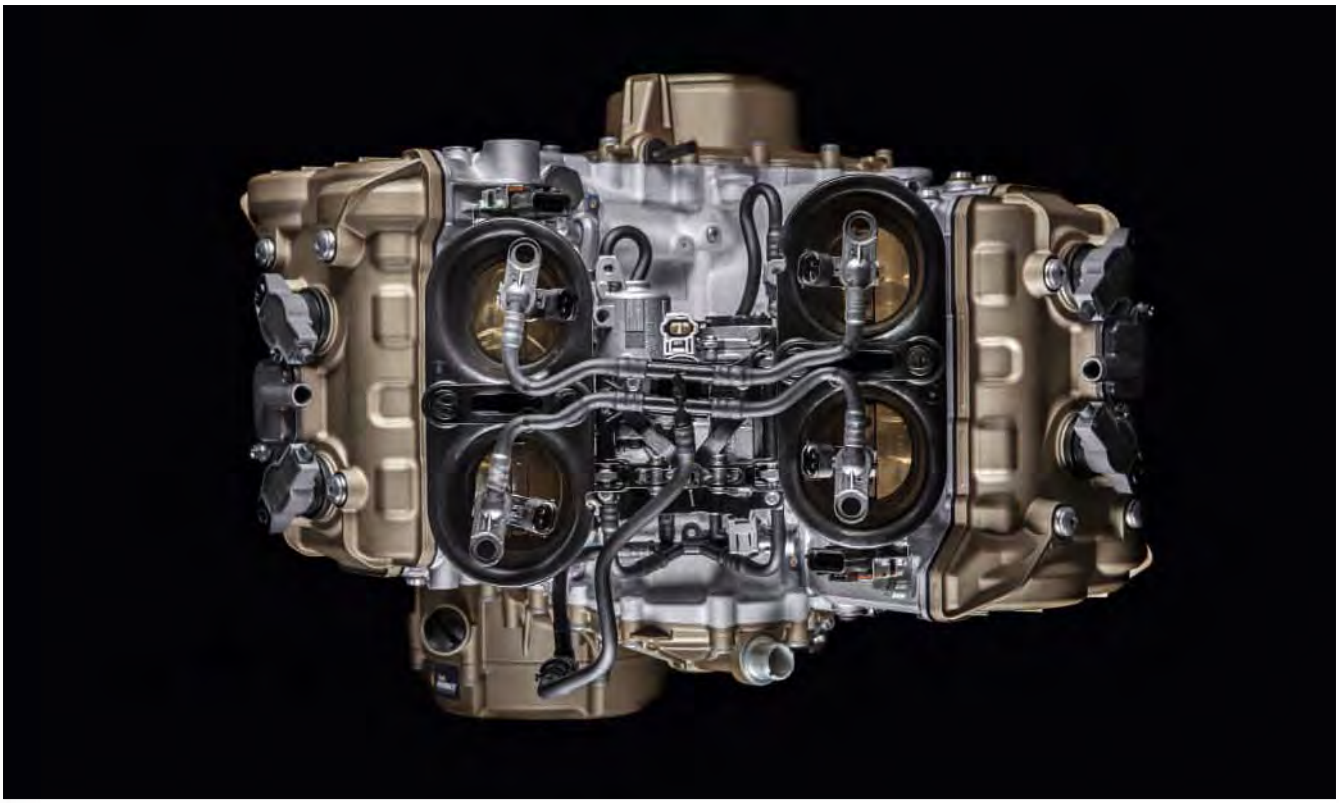
Four camshafts driven by chains and gearwheels are responsible for actuating the 16 valves in the Desmosedici Stradale from which the engine derives its name (sedici = sixteen). The timing chain for the front cylinder bank runs on the right side of the engine, while the one for the rear bank runs on the left – a solution that narrows the overall width. While the intake valves have a diameter of 34 mm, the exhaust valves measure 27.5 mm. Both are made from steel, while the valve seats and guides are made from sintered metal.

The semi-dry-sump lubrication is yet another technology from the MotoGP engine. A pressure pump forces oil into the areas under load, while three recirculating pumps collect it and send it back again. They ensure that there is a constant vacuum beneath the pistons, which reduces resistance during the downstroke. The oil sump, which contains the oil filter, is located beneath the engine casing, while the oil cooler is underneath the radiator. The water pump is mounted in the inner V of the cylinder banks, together with a large 12.8-liter airbox that allows the engine to breathe deeply.

INTAKE SYSTEM

The Desmosedici Stradale draws in the fuel/air mixture through four oval throttle bodies, which, in a first for Ducati, are equipped with variable induction funnels – whereby the fixed trumpet can be augmented with an electrically adjustable section that can move between an upper and lower stage. This means the length of the intake path can now be adapted across the entire rev range for optimum power delivery. Each of the throttle bodies is equipped with two injection nozzles. The first sits beneath the throttle valve and is active at low and medium loads; the second nozzle is above the throttle valve and activated under high load. Ducati's ride-by-wire control means the engine characteristics can be precisely adapted to the selected operating mode.

*** Duacti Panigale V4:**
Combined fuel consumption in l/100 km: 6.9
Combined CO_2 emissions in g/km: 165



LIGHTWEIGHT DESIGN

At just 64.9 kilograms, the new Desmosedici Stradale weighs just 2.2 kilograms more than the top-of-the-range V2, the 1,285 cm³ Superquadro Twin. In order to reduce weight, all the covers on the engine casing are made from magnesium alloy. This also applies to the cylinder head covers and oil sump. The new V4 has been engineered as a load-bearing element of the frame and, as is the case on the racing bikes, is mounted at an angle of 42 degrees to the rear. This positioning optimizes weight distribution, enables the installation of a large radiator and brings the pivot point of the swinging arm as far forward as possible.

The hydraulically actuated wet clutch has a progressive self-servo mechanism that actively pushes the friction plates together under positive torque. During heavy braking, on the other hand, the system opens, in order to prevent the rear wheel from blocking. This lowers the operating forces and delivers a light, extremely exact feel. The six-speed transmission was developed specifically for the Desmosedici Stradale and is equipped with a gear sensor that ensures optimum control with the Ducati Quick Shift up & down system. It detects the position of the gear selector drum with a high degree of precision, in order to enable ignition/injection only once the correct gear is fully engaged. The outcome is smooth, precise and fast shifting.

While performance levels surpass even those of the Superquadro, the valve clearance inspection and adjustment (Desmo Service) interval for the new V4 engine remains the same at 24,000 km (15,000 miles). General service intervals remain unchanged at 12 months/12,000 km (7,500 miles). ←

Ducati is entering a new era with the Panigale V4*, the brand's first four-cylinder road bike to enter series production. The top model was created in close collaboration with Ducati Corse and is based to a large extent on the MotoGP racing bike. The newly conceived frame, which incorporates the engine as a load-bearing component, delivers a slender cross section and low weight. The Panigale V4 weighs just 198 kilograms with a full tank of fuel and 175 kilograms dry. The Panigale V4 S (photo) and the limited-edition V4 Speciale are a further three kilograms lighter. The V4 S is equipped with Öhlins suspensions, forged aluminum wheels and a lithium-ion battery. The V4 Speciale, with Ducati Corse paintwork, has all that plus a titanium exhaust and carbon-fiber components. All models feature three newly developed riding modes (Race, Sport and Road) for the control system setup.

DUCATI PANIGALE V4

Technical Data	
Displacement	1,103 cm³
Power	157.5 kW (214 hp) at 13,000 1/min
Torque	124 Nm at 10,000 1/min
Weight with fuel	198 kg

Text
Susanne Mellinghoff

Photos
Manfred Jarisch

ALPHA BULL

SUV with bull genes – the new Urus is a true Lamborghini. For the iconic brand, the world's first Super Sport Utility Vehicle means far more than a third model range – this is a whole company reinventing itself.

[↑]
Bull genes –
With its angular design, the Urus is unmistakably a Lamborghini.

[↓]
Super sports car and Super SUV –
There are now two lines running in the brand-new final sign-off hall.

[→]
Doubling up –
The Urus aims to raise the company's turnover from 3,500 to a total of 7,000 vehicles per year.

Anyone who has paid a visit to the Automobili Lamborghini factory in Sant'Agata Bolognese in the last year would hardly believe their eyes today. In the space of 18 months, the Italian sports car manufacturer has doubled its production area and readied itself for the production of the Super SUV. In the brand-new final sign-off hall, a white Lamborghini Urus waits in line between Huracán and Aventador.

As of now, there are two final sign-off lines running here. The super sports cars are checked on the left, the brand-new model on the right. To the left, almost 1.5 metric tons, to the right, 600 kilograms more. On the left, only two seats, on the right, five. Left, is a small trunk at the front end, right is a spacious trunk at the rear. Just one look is all it takes to know – this vehicle will change the Lamborghini brand.

The introduction of a new model is an upheaval for any automaker. For Lamborghini, however, the Urus means a fundamental shift – a new vehicle concept, a larger production site and new markets. Ultimately, the Lamborghini defines a new class of vehicle – the Super Sport Utility Vehicle (SSUV).

The manufacturer launched an off-road vehicle back in 1986 – the LM002. By 1992, 300 of the 450 hp all-terrain vehicle had been built, and it stands as the pioneer of today's luxury SUVs. 25 years on, the Urus, with its 650 hp, will achieve a whole new dimension in terms of performance, comfort and versatility. Named for the historic forebear of Spanish fighting bulls, the Super SUV remains true to the Lamborghini in more than name alone.

The extreme proportions of the silhouette leave no doubt that this is a Lamborghini. The Urus bears the sharp-edged design philosophy of the super sports cars from Sant'Agata Bolognese into the SUV segment. Clearly visible are the typical hexagonal and Y-shaped design elements, as is the extreme ratio of metal surface to window size. Anyone who has ever seen a Lamborghini will also immediately recognize the Urus as such. ⟶

[↑]
Hallmark Lamborghini –
The extreme ratio between metal surface area and window size.

[↓]
Versatile –
The ANIMA (Adaptive Network Intelligent Management) handling system is operated via the Tamburo control unit in the center console.

[→]
Five modes –
Strada (road), Sport, Corsa (track), Sabbia (sand), Terra (gravel) and Neve (snow).

The Urus displays its bull genes in the interior, too. The cockpit, infotainment and classic Lamborghini switches are derived from those in the Huracán and Aventador. And the Urus also remains faithful to the fighter-jet ambience of the other models. Its pilot can only fire the SSUV to life after he has flipped open the enticing red cap covering the start button. And as with its siblings, the sports car magicians have committed themselves 100-percent to lightweight design. The majority of the bodyshell is made from lightweight aluminum, while carbon fiber can be found throughout the interior.

When it comes to market at the start of 2018, the Urus will be powered by a four-liter V8 biturbo engine – the very first forced-induction power unit in a production model bearing the sign of the bull. The eight-cylinder generates 850 newton meters and accelerates the Super SUV from zero to 100 km/h in less than 3.7 seconds – even faster than the first Gallardo. A short time later, and in another first, Lamborghini will also launch a plug-in hybrid version of the Urus.

But the new crossroad flagship can do a lot more than merely drive fast in a straight line. Thanks to all-wheel drive with torque vectoring and all-wheel steering, it shoots precisely and under full control through bends and corners of all radii. The carbon-ceramic brake system has been sized to give the Urus the same short braking distances as the Aventador and Huracán, even when fully loaded.

Just like the two super sports cars, the Urus is also equipped with the ANIMA (Adaptive Network Intelligent Management) handling system, which is operated via a switch unit called the Tamburo (drum) in the center console. As well as the classic modes, Strada (road) Sport and Corsa (track), the Urus also displays true off-road qualities with Sabbia (sand), Terra (gravel) and Neve (snow). The Ego mode allows the driver to individualize handling characteristics to suit his personal preferences.

ANIMA controls all driving systems and alters the dynamic performance as required. In Sport mode, for instance, the Urus' handling is noticeably more agile, responsive and emotional. If you select Corsa, the Super SUV hunkers down for the hunt on the race track. And the Strada mode simply makes it a comfortable and pleasant everyday ride. A wheelbase of more than three meters and comfortable suspension mean it is ideal for relaxed long-distance journeys, too.

Changing the driving mode also alters the virtual display and information shown to the driver. In addition to this, driver assistance systems like adaptive cruise control and park assist feature for the first time. "The Urus offers a unique level of comfort, yet remains a true super sports car," says Maurizio Reggiani, responsible for research and development at Automobili Lamborghini. ⟶

SUV with Lamborghini DNA

Lamborghini is building a Super SUV suitable for everyday life. The brand's chief engineer Maurizio Reggiani reveals how this works and why the Urus is still a true super sports car.

You define your new model Urus as a Super Sports Utility Vehicle. How do you distinguish it from what we know as a SUV?

Reggiani: Our main mission was to guarantee the DNA of a super sports car inside an SUV. With the Urus you can easily reach over 300 km/h, you can comfortably cruise along through city traffic with your whole family, you can experience off-road driving in the Sahara and you can lap the famous Nürburgring Nordschleife in under eight minutes. The car adapts to the driver's ambitions; it changes dramatically depending on what you need. This is possible thanks to our ANIMA system, which provides six different driving modes for different needs.

How does ANIMA work?

Reggiani: The ANIMA selector is the key command center for controlling the vehicle. The customer can use it via the Tamburo (drum) switch unit in the center console. ANIMA changes the entire setup of the car. For road and track driving you can choose between Strada (road), Sport and Corsa (track). In Strada, the car provides the highest level of comfort. By activating Corsa mode you can dial the car up to maximum performance. The powertrain is in its sharpest setting. Torque vectoring and four-wheel steering allow high cornering speeds and you get the typical Lamborghini sound. In this setup, you forget you're sitting in a SUV. New for Lamborghini are three modes suitable for off-road driving: Terra (gravel), Sabbia (sand) and Neve (snow). With these modes the car can go literally anywhere.

Of course, building the world's fastest series-production SUV is our target.

Maurizio Reggiani
Director Research and Development
Automobili Lamborghini S.p.A.

Does this make the Urus a genuine Lamborghini?

Reggiani: Absolutely. It was very important for us to transport the Lamborghini DNA into our first SSUV. It's immediately apparent that this is a Lamborghini. The feeling you get when you sit inside is the same as in our other models. I'll give you an example: To start the car, you open the classic red cap and engage the start button. What you hear is the bark of a Lamborghini engine ready to deliver outstanding performance.

You cracked quite a few records with your other models. What can we expect from the Urus?

Reggiani: When you're developing a Lamborghini, you're goal cannot be similarity to others. You must aim to be better. So of course, building the world's fastest series-production SUV is our target. In fact, the Urus is faster than our first Gallardo. We managed to put the same performance inside this SUV that, just a few years ago, was state-of-the-art for a super sports car. ←

[↓]
Enticing –
Just like its siblings, the Urus' engine can't be started until the hallmark red cap is opened.

[→]
Cockpit –
The Urus displays its bull genes on the inside, too.

In that respect, it addresses not only existing customers, but also completely new target groups. Plus, the company would like to appeal to more women with the Super SUV. In order to meet the anticipated high demand, Lamborghini expanded its production site in the space of just 18 months from 80,000 to 160,000 square meters. Besides building a new assembly line for the Urus, there is also a new final sign-off facility for all Lamborghini models and a new office complex. The Prototype and Preproduction Center has been expanded and a new Paint Shop will be completed by the end of 2018. Every Urus has to prove its mettle on a brand-new test track – 13 different surfaces cover all imaginable situations.

Despite extensive expansion activity, the plant in Sant'Agata Bolognese remains a certified CO_2-neutral production facility. The site has been expanded by a new logistics store, a second combined cooling, heat and power plant and a new production center for energy carriers.

With the third model range, the company is also introducing a smart factory concept and innovative production technologies. It all makes the manufacturing process more flexible, employees gain access to information more easily and production is networked. Collaborative robots assist technicians in their assembly work on the new line. "The Urus production system marks a new production model that we call Manifattura Lamborghini. It sets new benchmarks in the manufacturing of luxury automobiles," says Ranieri Niccoli, who is responsible for production at Lamborghini.

The Urus aims to increase the company's output from around 3,500 to a total of 7,000 vehicles per year. "The Urus marks an important step for our brand and our company," says development boss, Maurizio Reggiani. "We are having to adapt ourselves in all areas of the company, from Development, to Purchasing and Production to Quality and Sales. When I came to Lamborghini more than 20 years ago, we had 200 employees. Now, we have more than 1,500. We're still a small company, but there's a whole lot happening here for the future," adds Reggiani.

The white Urus now stands at the end of the line. It's time to fire its engine to life with a loud roar. Not long now, and it will be allowed to drive out of the final sign-off hall – out onto the road, the race track, snow, rough terrain or over the sand dunes.

←

The Urus production system marks a new production model that we call Manifattura Lamborghini. It sets new benchmarks in the manufacturing of luxury automobiles.

Ranieri Niccoli
Responsible for production at Lamborghini

The cockpit, the Infotainment and the classic Lamborghini switches are related to those in the Huracán and Aventador.

Das Cockpit, das Infotainment und die klassischen Lamborghini-Schalter sind denen in Huracán und Aventador verwandt.

Neues Fahrzeugkonzept, verdoppeltes Produktionsgelände und neue Märkte. Der Urus wird die Marke Lamborghini grundlegend verändern.

New vehicle concept, twice the factory space and new markets. The Urus will fundamentally alter the Lamborghini brand.