Porsche Engineering

Magazine
Issue
2/2019

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DIGITAL SOLUTIONS

Engineering in the data space


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Wherever the soul resides,
it isn't in the gas tank.
The first all-electric Porsche.
Soul, electrified. The new Taycan.
Electricity consumption (in kWh/100km) combined: 26.9; CO_2 emissions combined: 0g/km

PORSCHE

Dirk Lappe,
Managing Director Porsche Engineering

Dear Reader,

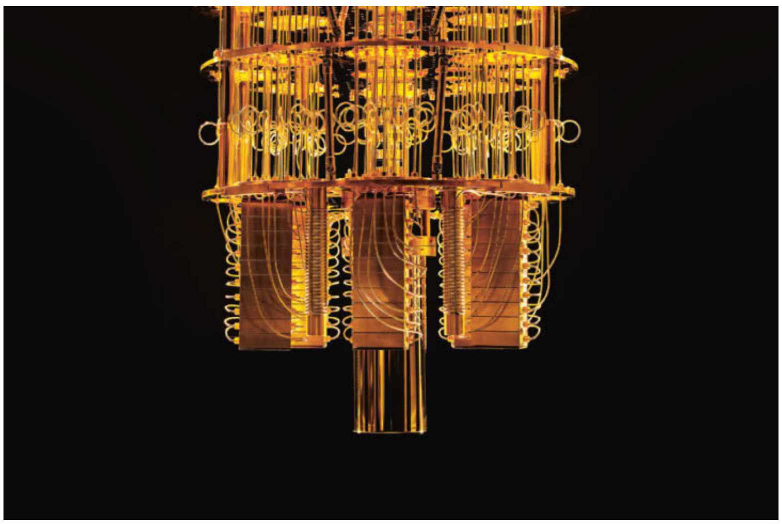
We have the privilege today to experience first-hand what Claude Shannon expresses in abstract form in his information theory: the more unlikely an event is, the greater the volume of information it supplies. Things that repeat are boring—it's what's rare that's exciting. As such, we're living in exciting times: there's more change going on than ever, and never before have there been so many things for us to learn. In Shannon's jargon: our environment currently holds extraordinarily high levels of information.

This issue of Porsche Engineering Magazine investigates one of today's disruptive trends: digitalization. We look at how to back up driver assistance systems and autonomous driving functions using computer-generated sensor data. Another article provides insights into how using Docker containers makes moving apps into vehicles reliable. Our Cluj item presents the team from our Romanian site and reports on their work on AI. My own interview with Lutz Meschke, member of the Executive Board of Porsche, sheds light on how digitalization will impact the sports car company and the industry as a whole.

But we shouldn't consider the subject purely from a technical angle. Instead, there are social issues, too: how is digitalization affecting us, and how far are we prepared to take it? Self-driving cars, for example, certainly make sense in urban environments or on the freeway, but when taking a trip out to the countryside, most people will likely prefer to drive themselves. What do we want to do with the free time an autonomous car affords us?

In our guest article, Christoph Keese asks who's actually in charge: is technology at our beck and call? Or we at its? His interesting retrospective, with its outlook on our future, offers advice on mastering our fate in the digital age.

Dirk Lappe



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Authors

40 **Axel Novak** is a freelance journalist who has written with great enthusiasm about new forms of mobility for over 20 years.

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52 **Monika Weiner** is a freelance journalist based in Munich and writes about technology and science.

News

New Chairman of the Board of Porsche Engineering

Dr. Peter Schäfer succeeds Malte Radmann

Dr. Peter Schäfer took over as Chairman of the Management Board of Porsche Engineering in July 2019. He succeeds Malte Radmann, who entered retirement at the end of July 2019. Radmann was a member of the board at Porsche Engineering since 2008, and took on the position of Chairman in 2009. Under his management, Porsche Engineering substantially grew its sales and workforce. New subsidiaries were founded in Shanghai and Cluj, the Czech subsidiary was expanded, and the Nardò Technical Center was integrated. Dr. Schäfer joined the Porsche group in 2003, and was already a member of Porsche Engineering's executive management from 2004 to 2009. Dr. Schäfer then took over Porsche AG's chassis division, followed by his latest post as Vice President Complete Vehicle Development/Quality. In June 2018, Dr. Schäfer returned to Porsche Engineering, becoming a member of the Management Board. Dirk Lappe will also remain technical Managing Director, a position he has held since 2009.

Extreme testing

Porsche Taycan covers 3,425 kilometers in 24 hours

Just ahead of its world premiere on September 4, six Porsche test drivers took a Taycan that was almost identical to the series model to the high-speed test track in Nardò, Italy. They pushed the vehicle through 24 hours of driving, covering precisely 3,425 kilometers—roughly equivalent to the distance from Nardò to the Norwegian town of Trondheim. Speeds during the trials, conducted in the blistering heat in Italy's south, lay between 195 and 215 kilometers per hour. At ambient temperatures reaching 42° Celsius, with the asphalt as hot as 54° Celsius, the Taycan prototype and Porsche Engineering charging infrastructure proved their mettle before series production on the model began. Driving was interrupted only for brief driver swaps and rapid charging. The quality assurance test was part of a hot-country endurance trial.

The Taycan models

Electricity consumption (in kWh/100 km) combined: 26.9-24.6
CO_2 emissions combined: 0 g/km

Top speed

215 km/h (134 mph)

Top asphalt temperature

54 °C

“I’m really looking forward to tackling Formula E together with Porsche. The electric racing series has grown a lot in recent years, it’s a fully fledged part of motorsports now.”

André Lotterer

Electric racing

Porsche to join Formula E

Porsche is set to return to Formula motorsports, joining the ABB FIA Formula E championships: beginning this season, the two drivers Neel Jani and André Lotterer take the wheel in the Porsche 99X Electric for the TAG Heuer Porsche Formula E team. The electric motorsports series has a number of features that differ from Formula 1: all the races take place on city circuits (including Hong Kong, Berlin, New York, and Mexico City, to name a few). Also, all teams use a standardized chassis, standardized battery, and standardized tires. By contrast, the drive components—among them the electric motor, frequency converter, brake-by-wire system, and transmission—are each designed by the respective manufacturers. The Porsche 99X Electric uses the Porsche E-Performance Powertrain to deliver maximum performance. The powertrain operates at 800 volts—just like in the Porsche Taycan sports car. Energy management and efficiency are key factors in Formula E as much as they are in the series vehicles, which is why motorsports and series-production experts are working in close-knit teams in the research and development center in Weissach. This way, the experience gained in motorsports finds its way back to series development.

“Starting from scratch in a new series is naturally a huge challenge for everyone involved. We’re all really focused and highly motivated.”

Neel Jani

Junior sponsorship program in Nardò

Turbo for Talents

Together with its partners, Porsche has started its initiative Turbo for Talents to actively support junior talent in a variety of sports.

As of this year, the Nardò Technical Center (NTC) officially sponsors the junior teams of the A.C. Nardò soccer club, and maintains a local junior sponsorship program. The sponsorship program began with a school break summer camp for kids and teenagers. More than 150 boys and girls from the region, aged 3 to 13, took part.

"Italian Summer" was the nine-week-long program's motto. The teenagers were offered a wide variety of different activities, all of which taught them something about the customs and traditions of Italy's various regions. The camp's activities focused on sports—soccer and volleyball—workshops to promote skills and arts, crafts courses, and cognitive training. There were also a treasure hunt, team games, and a range of sports competitions.

Beyond supporting sports training, the NTC's sponsorship aims to promote social and personal growth of children and teenagers from the region. Collaboration with the A.C. Nardò soccer club is being expanded to ensure that the scope of activities can be maintained in the future.

Student competitions

Become a part of the automotive future!

Students took on a particularly interesting challenge in Ostrava and Prague on November 13 and 21, respectively. Porsche Engineering and its partner, the Czech Technical University, had invited them to become part of the automotive future. Over the course of two competitions, their task was to design software for a self-driving car. Their instructions were to make optimal use of a vehicle-mounted camera to navigate a competitive track under various conditions. The junior engineers were assisted by experienced Porsche mentors, and the hardware was supplied. A unique opportunity—to gain experience in teamwork, improve debating and presentation skills, and grow personally.

ELIV congress

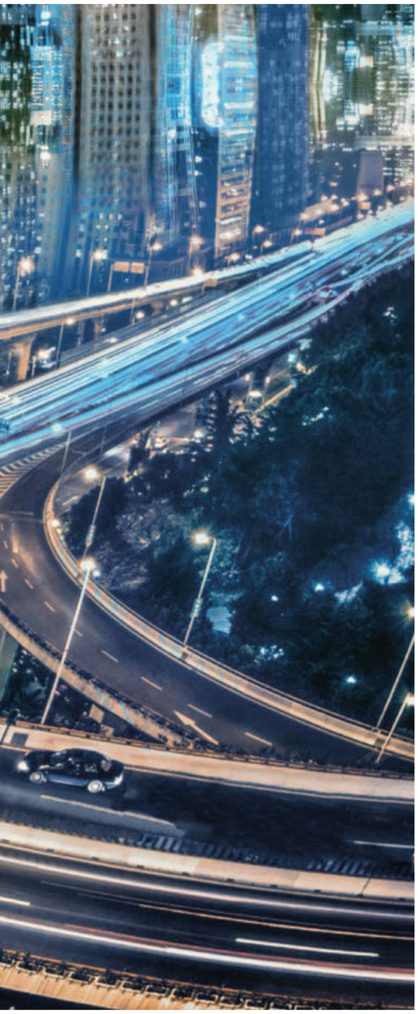
Industry meeting for vehicle electronics engineers

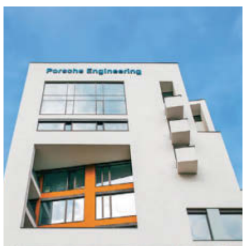
Porsche Engineering presented its expertise in the field of pioneering mobility at the international automotive electronics congress. Trade visitors were given the opportunity to investigate connectivity, driver assistance systems, and artificial intelligence, and to see for themselves the Charging Solutions devised by Porsche Engineering.

October 16 to 17, 2019
www.vdi-wissensforum.de/en/eliv

The great transformation

Upheaval in automotive development: digitalization and artificial intelligence are changing an entire industry. They enable new driving functions and applications, but they're also changing development. And they offer enormous added value.





Test drives on the computer

Text: Andreas Burkert Contributors: Dr. Clara Martina Martinez, Frank Sayer

Photos: Mihail Onaca

Developers are creating a virtual world in which to test, train, and validate driver assistance systems and autonomous driving functions. At the Porsche Engineering Virtual ADAS Testing Center (PEVATeC), computer-generated environments with physically realistic effects are being created that cannot be distinguished from tests in real traffic.

1 Darkness, oncoming headlights, and reflections

2 Daylight and wet road

3

Fog, rain, and wet road

Weather changes at the push of a button: the computer creates snow, fog, wetness, and darkness. This allows the sensors to be tested under various ambient conditions.

Deceptively real: dynamic objects such as virtual vehicles **(1)** and pedestrians **(2)** can be integrated into the PEVATeC simulations. Thanks to physically based rendering, the synthetic input for the sensors is indistinguishable from reality. This can be seen, among other things, in light reflections on wet roads **(3)** and on reflecting surfaces such as windows **(4)**. It is crucial for the distribution patterns of natural light, artificial sources of light, and active laser and radar outputs to be represented in a physically correct way.

No person is more attentive in traffic situations than a driver assistance system. Nonetheless, both optical and radar-based sensor systems are required to capture the environment for this purpose much more accurately than an experienced driver would ever be able to do. Using the data from the numerous camera, radar, lidar, and ultrasonic systems installed and networked in the car, algorithms determine control strategies in a fraction of a second in order to optimally control the vehicle in a risky situation. And they do so with exceptional precision. So it is not surprising that driver assistance systems—also known as ADAS (Advanced Driver Assistance Systems) in the jargon—demonstrably reduce the risk of accidents on roads. With each additional ADAS system, automotive developers come one step closer to the vision of accident-free driving. But the journey there is indeed as difficult as one might imagine.

This is especially true for autonomous driving. With the help of agile development methods, engineers have made great strides in development, but are still far from mastering all technical requirements. Nonetheless, in pilot projects on public roads under known and circumscribed conditions, self-driving vehicles demonstrate an economical and safe driving style at low speeds. In contrast to driver assistance systems with their precisely defined tasks, however, an autonomous vehicle must be able to master all driving situations and completely replace the driver. Moreover, the critical conditions for ADAS and autonomous driving are not necessarily the same as for human drivers and are not yet fully understood.

Autonomous driving still requires extensive testing. For example, scientists at the US think tank RAND Corporation assume that fully autonomous vehicles would have to drive hundreds of millions and in some cases hundreds of billions of miles in order to test the individual systems and their interactions in a robust and meaningful way. They claim, for example, that some eleven billion miles would be needed to reduce the risk of a fatal accident caused by an autonomous vehicle by 20 percent over a human driver. If 100 test vehicles were in use 24 hours a day, seven days a week, the test drives would take around 500 years at an average speed of 40 kilometers per hour and roughly 250 years at an average speed of 80 kilometers per hour—timeframes and costs that are manifestly incompatible with product development.

11 billion
miles of test drives would be needed to reduce the risk of a fatal accident caused by an autonomous vehicle by 20 percent over a human driver.

500
years is how long 100 test vehicles would have to be on the road around the clock at 40 kilometers per hour.

PEVATeC
replaces many test drives with tests in virtual worlds.

Even in the case of semi-autonomous driving functions, a host of engineers would have to test the ADAS systems over a period of several years in order to validate every conceivable scenario. Frank Sayer is well aware that this would be neither economically justifiable nor feasible, not to mention the fact that it would also be extremely dangerous for other road users. “It would be impossible to do this on the road,” explains the Senior Manager Virtual Vehicle Development at Porsche Engineering. The idea, therefore, is to transfer many of those kilometers to the lab through digitalization and extensive computer simulations—namely to the Porsche Engineering Virtual ADAS Testing Center (PEVATeC). In the years to come, PEVATeC will create virtual worlds that will encompass all relevant situations on the road and thus serve as test cases for algorithms and sensors used in driver assistance systems.

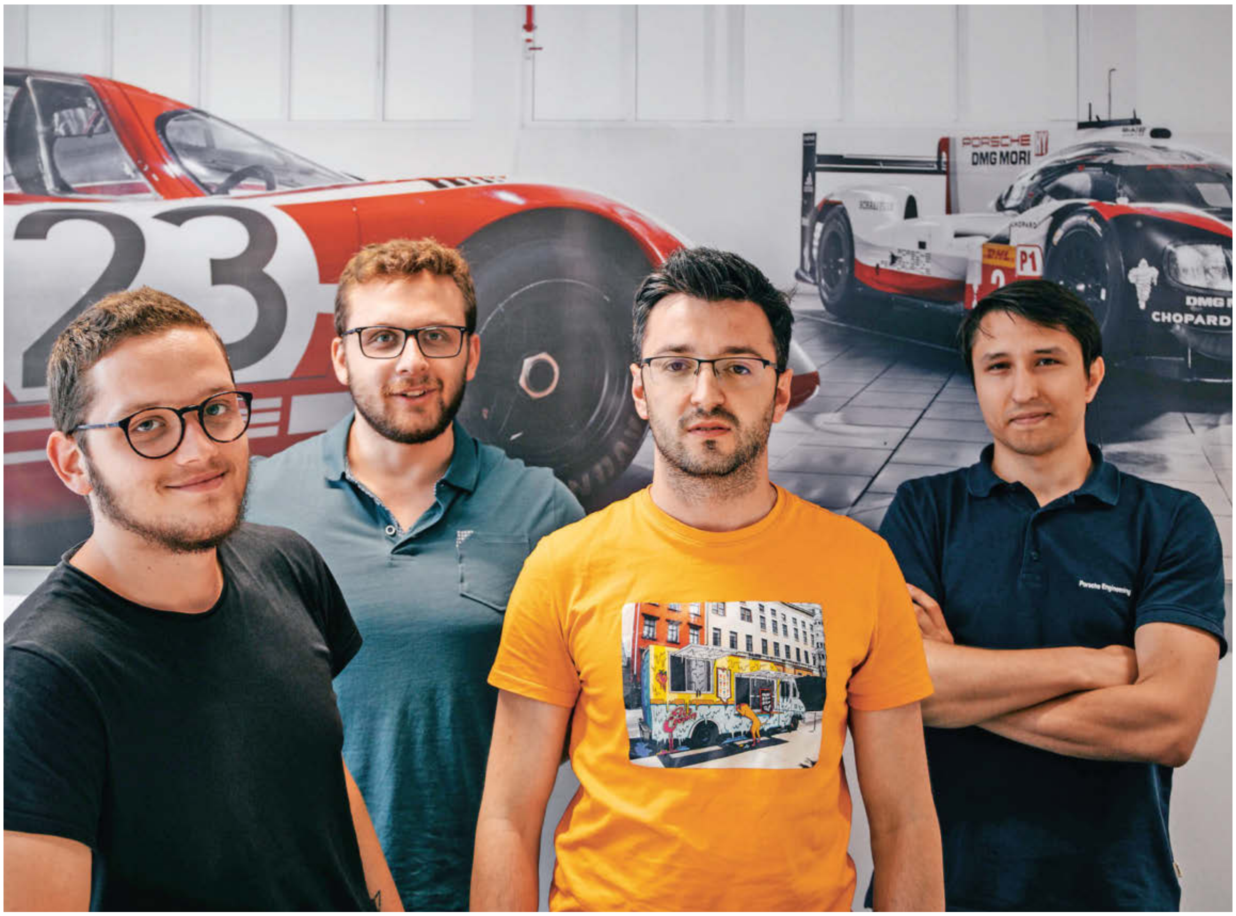
Reproducing critical situations

Test drives in a simulated environment are not only cheaper, time-saving, and possible with less organizational effort—they can also reproduce and modify critical situations from real road traffic. Furthermore, simulation can help to discover new critical scenarios that have not yet been understood by the human driver, but are crucial for ensuring safety under any possible use case of sensor-based autonomous driving.

Beyond real-time capability, the virtual realities created must also be able to produce physically realistic effects. Digitally reproduced objects such as roads, sidewalks, house walls, and vehicles must have exactly the same properties as those found in actual road traffic—only then can they provide the camera, lidar, radar, and ultrasound systems with realistic input. The magic words are “physically based rendering”: existing object

"It would be impossible to perform the necessary tests for ADAS on the road. That's why we developed PEVATeC."

Frank Sayer,
Senior Manager
Virtual Vehicle Development



Experts for computer-generated worlds:
employees at the Cluj site (pictured top and bottom) play a decisive role in developing software for PEVATeC.

rendering methods mean that properties such as surface structure, color gradation, and light sources are simulated in a simplifying way that also saves resources. Physically based rendering, by contrast, is a proven method for realistic imaging of light reflection and refraction on three-dimensional objects. The main task here is to represent physically correct distribution patterns of light.

In order to minimize the differences between real and virtual driving tests, the engineers at PEVATeC are working intensively on a physical material definition that is as accurate as possible, as well as algorithms that reproduce the light close to real life. This is important to prevent driver assistance systems from making situational miscalculations due to factors such as dirty camera lenses or multiple reflections of the radar waves. For this reason, the effect of weather conditions and lighting on the camera-based sensors in a vehicle, for example, can be displayed at the touch of a button. "This also includes the effects of a low sun, a wet and reflecting road surface, and a snow-covered road surface," explains Sayer.

Including dynamic objects

In the future, even the road surface, with all its unevenness, will be capable of being calculated just as realistically as the consequences of a dirty camera lens. Even conducting tests under different environmental conditions on real roads is difficult to achieve in practice. Moreover, developers also have numerous virtual objects such as trees and everyday objects at their disposal in order to make the street environment as realistic as possible. After all, autonomous vehicles have to recognize potential risks even where the course of the road is confusing. This includes the ability to integrate dynamic objects into the simulation, meaning people, cyclists, and other road users, who should move naturally in the digital 3D world.

If the individual scenarios are now compared with each other in real and virtual driving tests, conclusions can be drawn about the accuracy of the overall simulation. This also leads to the emergence of an ever more precise basis for optimizing the sensor systems in the vehicle through simulation—for example by virtually testing different installation locations for an ultrasonic sensor in the vehicle. This enables rapid validation and calibration of optical and radar-based sensors. Data interfaces to Simulink, ROS, or OpenDRIVE, for example, are available to all departments involved in the development process so that the results can later be integrated into the simulation of the entire vehicle.

Simulink, ROS, and OpenDRIVE

can be connected to PEVATeC via data interfaces.

Another important task performed by PEVATeC is the classification of objects. The sensor intelligence must be programmed to recognize traffic signs, people, and situations even under the most difficult conditions. This requires training image recognition software, which is done using artificial intelligence and a combination of real and simulated image data. The system is shown countless variations of images or video sequences so that it can be trained with the aid of machine learning to correctly classify objects and situations. High-performance computers carry out this labeling process automatically. In the simulated scenario only, all objects are known and positioned in the game engine. In this way, the objects in the image can be automatically identified, dimensioned, and characterized.

ADAS test center: infrastructure of a high-performance computing center

Because the virtual testing, training, and validation of new vehicle functions require an immense amount of data to be processed in real time, the future infrastructure of the ADAS test center will be similar to that of a high-performance computing center, where a significant number of graphics chips (GPUs) will be required to process the enormous amount of information. GPUs are particularly suitable for applications involving automated driving because mathematical operations run in parallel in them. They are therefore also an essential part of the PEVATeC concept. In addition, there is also storage capacity for a pool of scenarios required for testing and validating different ADAS systems. The determination of valid data is an essential prerequisite for the development of algorithms that bring autonomous driving to the road efficiently and safely. That's exactly what PEVATeC is supposed to do: the findings from the simulations help the engineers optimally train the control algorithms of the driver assistance systems—in a way that enables the installed ADAS systems independently master the most difficult maneuvers and situations.

IN BRIEF

Testing advanced driver assistance systems and autonomous driving functions requires billions of test kilometers. Road tests alone are not enough to get it done. That's why Porsche Engineering has developed PEVATeC. A computer system specialized in 3D simulations generates synthetic data that serves as input for the vehicle sensors. The data is so realistic that it cannot be distinguished from reality. This makes it possible to shift many tests from the real to the virtual world.

"We need to use all our options now"

Interview: Michael Gneuss Photos: Sebastian Berger

Lutz Meschke, Deputy Chairman of the Executive Board and Member of the Executive Board—Finance and IT of Porsche AG, and Dirk Lappe, Managing Director Porsche Engineering, met to talk about how digitalization and new technologies such as artificial intelligence (AI) affect Porsche and the automotive industry.

Mr. Meschke, in an earlier interview you quoted from a movie by Italian director Luchino Visconti: "If we want things to stay as they are, things will have to change." Can you explain this contradiction to us: how will technologies classed as disruptive—digitalization and artificial intelligence—make it possible to keep everything the way it is?

— **LUTZ MESCHKE:** What I meant was this: the Porsche brand produces remarkable inertia, and we are highly successful in terms of revenue. But if we want to make sure that both of these are still that way in five years' time, we need to use all the options we have now to position Porsche for the future. Especially with respect to digitalization and AI. We'll only reach our goals if we use these technologies to devise new products and services. On top of that, we need to completely re-orient all of our corporate processes and manage a shift in mentality. Which, by the way, not only Porsche needs to do but all of the automotive industry.

How far has Porsche been able to shift its mentality so far?

— **MESCHKE:** In some ways, we're quite far already. But the point is that we need to get everyone at Porsche on board. Sure, some people are worried about the changes digitalization brings with it and see their jobs in jeopardy. But we need to understand that the new technologies are opportunities, not risks. We have to be prepared to learn and develop. It's the only way for everybody to actively engage in taking the company forward.

Mr. Lappe, what is Porsche Engineering's role in digitalization?

— **DIRK LAPPE:** We want to be part of the front line in the digitalization of our customers. It's really important to me that we don't simply deliver run-of-the-mill solutions but that our designs actually add value. Which is why we love working with artificial intelligence and digitalization, because these technologies massively add value for our customers.

But digitalization and AI are still new fields for a service provider who comes from classic vehicle design. How are you feeling the changes?

— **LAPPE:** The rate of change has increased dramatically and we're experiencing more and more sudden events that require matching solutions for our customers. For example, software development has now become a major item with us, because it's turning more and more into a USP. It's already leading to increased customer inquiries today.

— **MESCHKE:** It's really important to us that Porsche Engineering be successful in the market. Porsche Engineering is where the entire group began. Porsche

Looking ahead: Dirk Lappe (left) and Lutz Meschke met at Porsche in Stuttgart-Weilimdorf to speak about new technologies in the automotive industry.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"Investing in IT doesn't only improve your competitiveness, it also cuts costs, for example by using virtual prototyping."

Dirk Lappe

"We need to completely re-orient all of our corporate processes and manage a shift in mentality."

Lutz Meschke

started off by offering development services for customers before designing and producing any sports cars of our own. So, Porsche Engineering is obviously really important to us. They have lots of customers from all over the automotive trade, everywhere in the world, and I think that their position will only become more pivotal as digitalization progresses, not only for us, but throughout the whole market.

What role does an engineering services company like Porsche Engineering play in this phase of digitalization?

— **MESCHKE:** An engineering services provider always needs to know where events are leading—at a global scale, even. Especially in terms of internationalization, Porsche Engineering has made excellent progress over the last few years, for example by setting up sites in Prague, and in Cluj in Romania. We've been able to take on lots of great new people who really want to work with us long-term. Porsche Engineering at the innovation site Cluj: to me, that's a real story of success.

— **LAPPE:** Our activities in Shanghai also play a key role. We've become a sort of gateway into China. You know, these days nobody believes in the world car anymore. For China, an automobile manufacturer needs different software from that in the same model supplied in the US or Europe. Which makes maintaining a permanent site in China really important for a vehicle developer.

Mr. Meschke, you're not only in charge of IT and digitalization at Porsche AG, you're head of finance, too. Doesn't it vex you that digitalization is pretty expensive?

— **MESCHKE:** In the past, IT was a cost issue. Everyone knew you needed IT, but everyone wanted it at budget price. It's not like that anymore: today, we view IT and digitalization as competitive strengths. If I don't make the cut with the big players, I'm losing out to my competitors. We'll never be selling the same number of cars if we don't offer the full connectivity package. In China, our customers are very young. They want to be able to use all the features their smartphones offer in their cars, too. And they expect additional digital services in the car on top of that. So we have no choice but to invest heavily.

800 million

euros is Porsche's annual budget for investing in digitalization.

150 million

euros are available every year for investing in start-ups and venture capital enterprises.

— **LAPPE:** And investing in IT doesn't only improve your competitiveness, it also cuts costs. Take a look at prototype construction in vehicle development, for example. We used to build a whole lot of vehicles. Today, we use digital tools to build a virtual vehicle. We save on building a large number of prototypes; that's a lot of money saved. The digital world offers lots of options for improving efficiency like that.

How much are you investing in digitalization?

— **MESCHKE:** For all of the corporate processes, smart factory, interfaces with customers, products and services, all that, we're investing more than 800 million euros a year. We're also budgeting more than 150 million a year for investing in start-ups and venture capital businesses. So we're looking at almost one billion euros all together. We have a budget of over two billion euros for conventional vehicle development. So you can see how significant digitalization has become. And it'll only get more important in future.

What role does Porsche play in Volkswagen Group's digitalization process?

— **MESCHKE:** As a premium brand manufacturer, we're naturally looking at different challenges from those of mass-market manufacturers. We need to engage with the relevant tech players to offer our customers the solutions they're looking for. The partners themselves are different depending on the region we're talking about. But in terms of an electronics platform, standardizing across the entire group makes sense to enable us to benefit from economies of scale. Digitalization also makes it necessary for us to focus the capacities within the group because we need to meet a vast scope of development requirements in the new fields.

— **LAPPE:** Porsche will be using more and more modules and platforms supplied by the group. But we still need to make sure that a Porsche stays a Porsche—and digitalization can help us do so. This is where Porsche Engineering will act as a driver to push brand-specific developments. The experience we gain in software development for sports cars will benefit our other customers, too—the same as with all of our other engineering activities.

Lutz Meschke graduated in business administration. He left Hugo Boss to join Porsche AG in 2001. He has been a member of the Executive Board since 2009, where he is in charge of Finance and IT. In 2015, Lutz Meschke took on the post of Deputy Chairman of the Executive Board with the sports car company.

Dirk Lappe graduated in electrical engineering. He joined Porsche Engineering in 2002, where he started off as head of the electrics/electronics division. He has been Managing Director at Porsche Engineering since 2009. Dirk Lappe previously worked for Bosch and Harman Becker.

The Taycan models

Electricity consumption (in kWh/100 km) combined: 26.9-24.6
CO_2 emissions combined: 0 g/km

Out of the box

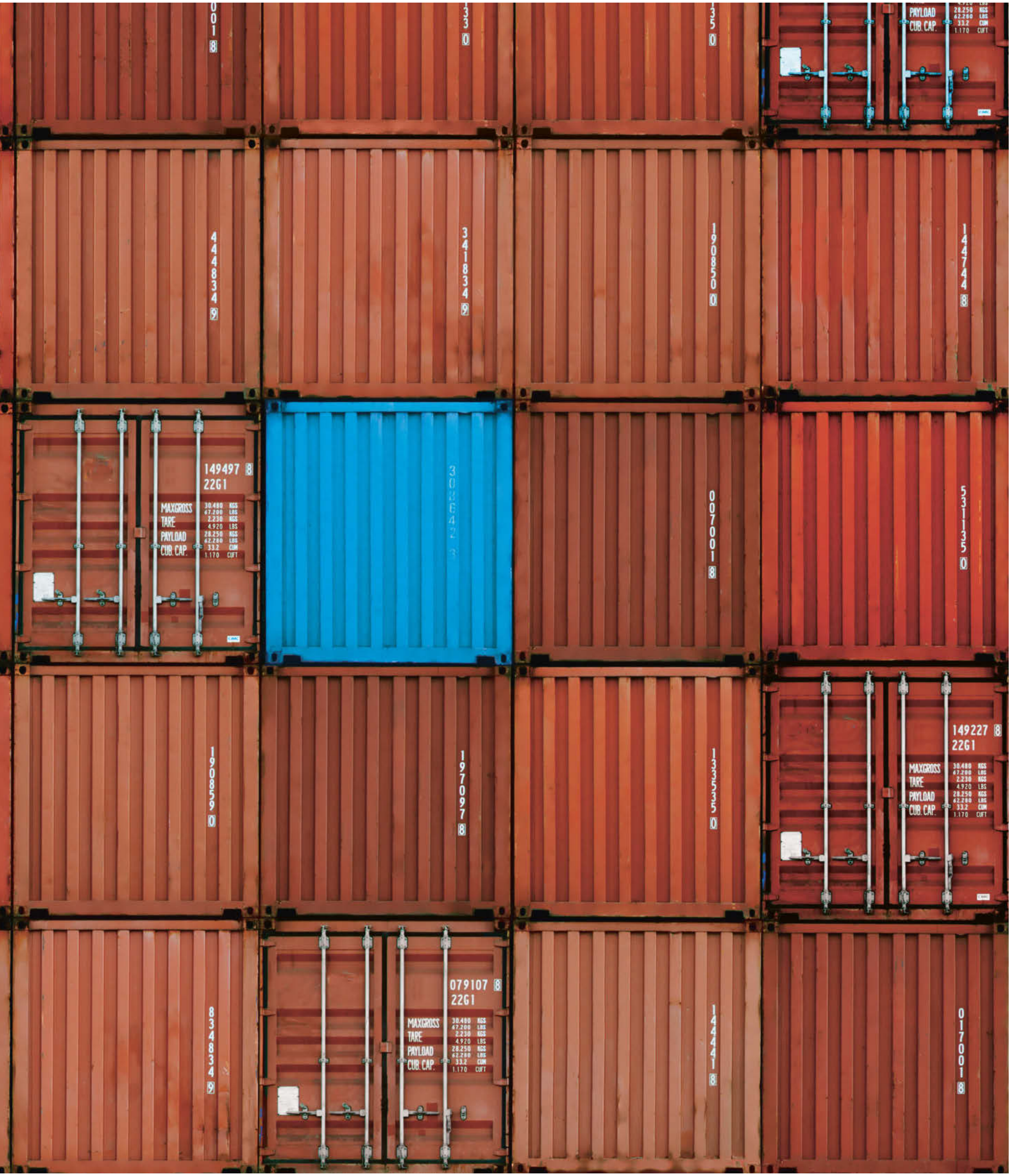
Text: Christian Buck Contributors: Fabian Breisig, Thomas Pretsch

It has never been so easy to develop apps for the Modular Infotainment System (MIB) and bring them to the customers. As the development of the MIB continues, Porsche Engineering is creating innovative applications for the Taycan using the containerization solution Docker. On this basis, a Software Development Kit (SDK) has been created with which third parties can bring new applications for the MIB to the market.

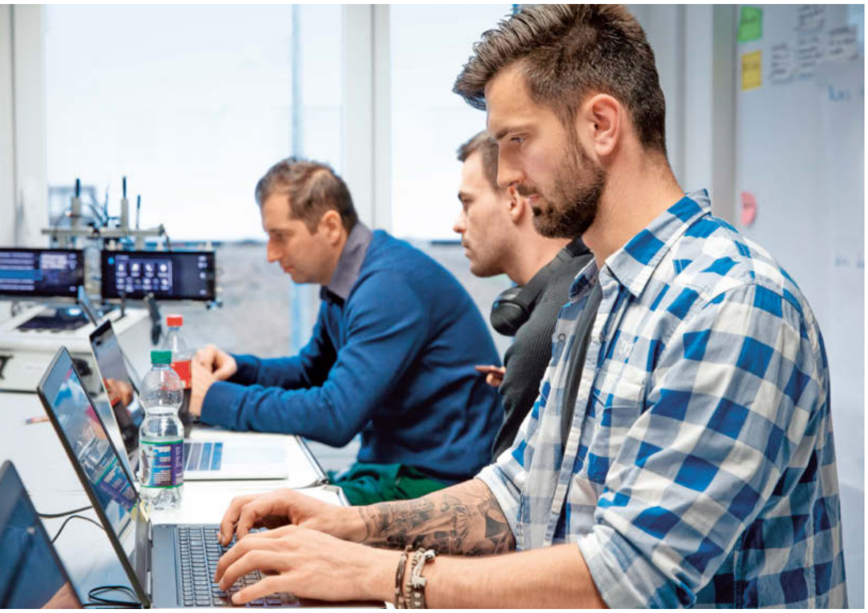
When the Porsche Taycan was launched in September 2019, it was not just the first all-electric Porsche coming to the market. It is also the first vehicle from the sports car manufacturer to feature the third version of the Modular Infotainment System (MIB3). The MIB3 offers not only state-of-the-art hardware and a larger display—it's also easy to add new apps to it. It's made possible by the Docker containerization solution integrated in the system: it enables app developers to bundle apps and their dependencies in containers and push them to the system at any time. This makes the development and distribution of new apps considerably easier than in previous versions of the MIB.

The name deliberately adopts the language of logistics: for decades, goods have been packed in standardized containers, enabling them to be transported much more efficiently along complex supply chains. In a similar fashion, the idea here is to enable apps to transfer as simply as possible from the provider to its customers. The difficulty is that one never knows exactly how the respective target system—the MIB3 in a vehicle, for instance—is configured. That can quickly pose problems, because programs often require a specifically defined environment in order to even be operable. This includes elements such as system libraries, which provide certain functions, such as access to networks. Moreover, interpreted languages such as JavaScript require a runtime engine for execution—and generally a particular version at that.

"Due to these dependencies, in the past all apps for the infotainment system came from the provider of the MIB," notes Fabian Breisig of Porsche Engineering. "In the past it was practically impossible for us to write our own apps. We would have had to send our code to the provider in order to have them integrate it into the overall system in a massive undertaking." Thanks to the Docker containers, this problem is now a thing of the past: in principle, third parties can now develop apps, pack them in a container with the



Proven solution: containers have long been indispensable in logistics—now they are conquering software development.



Independent: the Docker technology separates the update cycles for apps and MIB3.

required libraries, help programs and statistical data, and then, after being approved by Porsche, make them available to customers via convenient download.

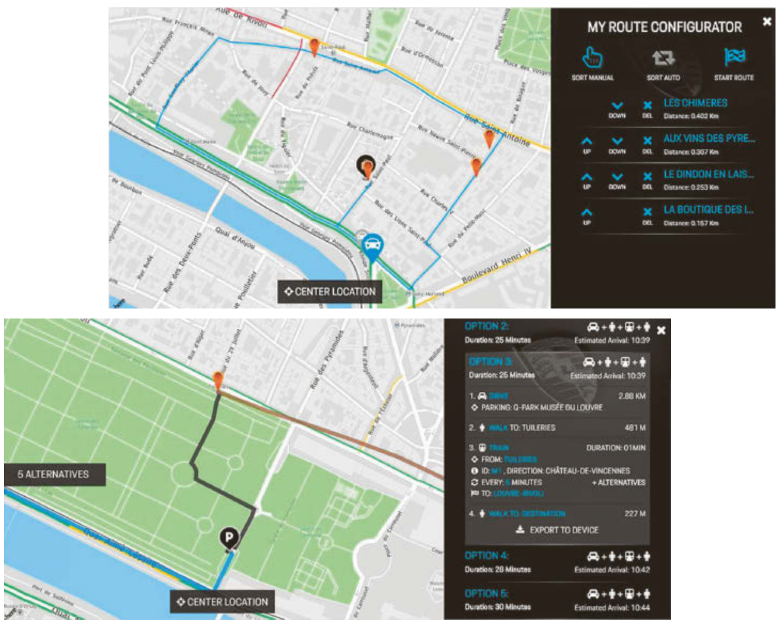
Between the operating system of the target system and the containers sits the Docker Engine. It is responsible for the administration and execution of the containers and taps the resources of the host system for the programs running in the containers. This allows containers to run on different target systems without host-specific adaptations. In contrast to the more widespread use of virtualization with hypervisor and virtual machines (VM), a container provides the application with a complete runtime environment with all requisite dependencies virtually without containing an entire guest operating system. Containers therefore consume fewer resources, are easier to port, and start faster. “The Docker containers are a lightweight form of virtualization on the application level,” says Breisig.

Development of innovative web applications

Using the Docker technology, Porsche Engineering has been developing web applications according to the client-server principle for the past two-and-a-half years. Over this period, multiple applications for the MIB3 were created: the Calendar app, for example, makes it possible to combine multiple calendars—say, from Office 365, Google, or your smartphone—and display the results on the infotainment display. It was already on board when the Porsche Taycan launched. The Stocks app shows the current market results, and the Data Plan app keeps users abreast of the data usage of the SIM card in the MIB3 over a given period of time.

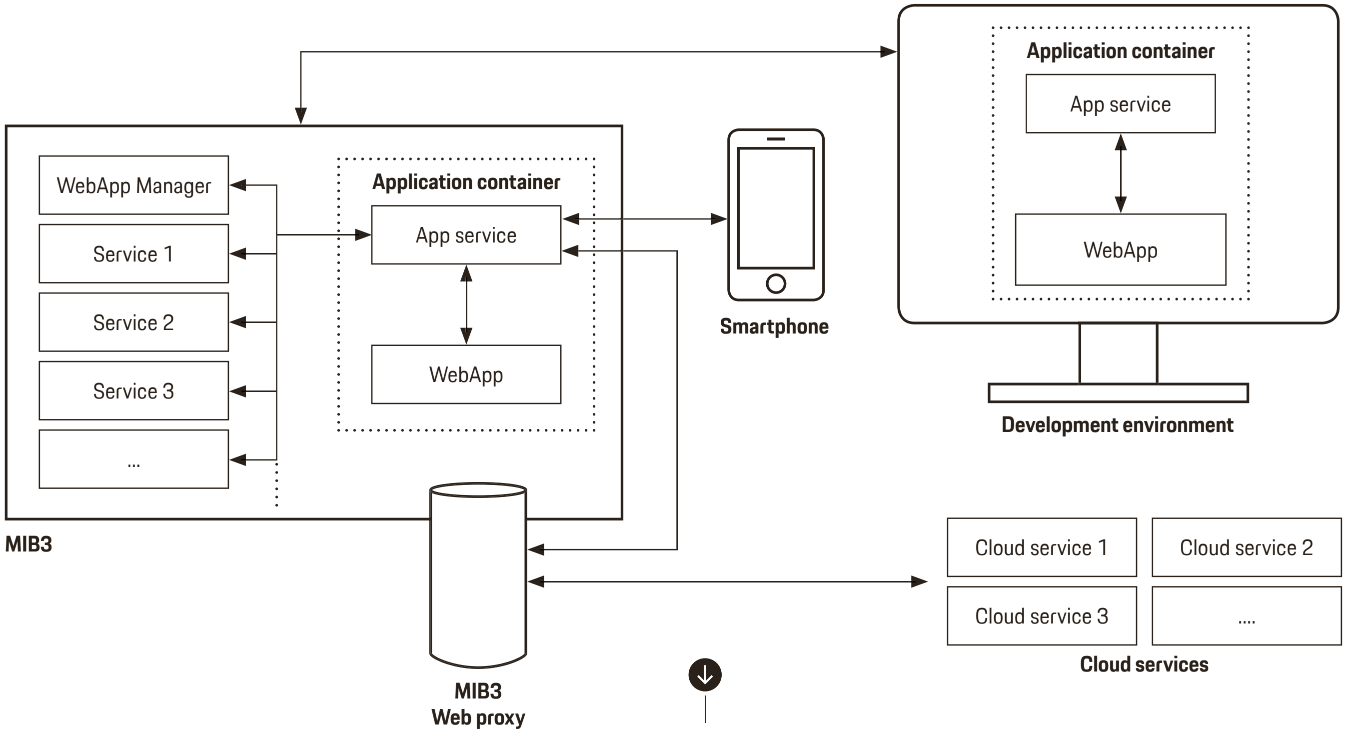
Beyond such series projects, the software developers at Porsche Engineering are also working on innovative ideas for the future. We’re always on the lookout for innovative and useful new use cases, for which we then realise as proof-of-concept in a first step,” says Breisig. “In that context, we want to find out which features yield tangible added value for the customer, what is capable of being implemented under the given conditions, and what limitations there are in terms of the system or external interfaces.” One of the innovation projects currently in the works is the City Tour Guide: sights, restaurants, and other points of interest (POIs) in the vicinity are displayed, enriched with information and images from a variety of content providers. It’s also possible to plan and run a turn-by-turn navigation route. The proof of concept is complemented by an augmented-reality smartphone app. As soon as the smartphone is targeted on a POI, additional information about the location is displayed on the Taycan’s passenger display. After a proof of concept has reached a functionally viable state, it is presented to a committee, which decides whether it should be developed to the level of series production maturity.

Customers can download such apps “over the air” at any time. They no longer have to wait for a software update of the MIB3, which de-couples the update cycles of the applications from those of the infotainment system—just like in a PC or smartphone, in which users can install new programs independently of new versions of the operating systems. The software developers, in turn,



Applications for the MIB3: the City Tour Guide app can be used to plan routes between POIs (top). It also makes intermodal route suggestions (bottom).

Architecture overview



Apps are executed in the MIB3 within Docker containers. They consist of app service and WebApp: the app service is a Node.js® application that contains the application logic. It can interact and exchange data with other services of the MIB3 (e.g. the navigation) or with cloud services via the web proxy. When the app is opened, the WebApp provides the user interface based on Angular and HTML5.

During development, the development environment can be connected to the MIB3. This makes it possible to use its interfaces directly without having to install the app on the MIB3 within each development step.

benefit from the separation of the target system and the application: "Thanks to the Docker containers, we can develop applications much more quickly because we no longer have to take a detailed look at the target system," explains Breisig. "That enabled us to tap into a completely new field of business."

Toolbox for app development

To simplify app development for the MIB3 for other companies as well, since mid-2018 Porsche Engineering has offered a Software Development Kit (SDK). The SDK is a collection of tools and libraries developed for the MIB3 that simplify and accelerate the development process of an application, from the initiation of the process to the programming and ultimate release. For example, all new apps have to register with MIB3—a rather cumbersome process whose execution is largely handled by the SDK rather than the programmer. The SDK also provides simple interfaces that allow the use of the functions of other apps such as the navigation system. Rather than having to transfer a plethora of parameters, simple commands suffice to input the destination and start the navigation process.

The 36 participants in the first one-week MIB3 hackathon in Weissach at the beginning of the year were among the first users of the SDK. The goal was to implement innovative ideas as executable prototypes. The participants made good use of the tools and libraries of the SDK and scored some quick successes. Tobias Schug was on hand for the event: "I got a very good impression of the SDK," reports the software developer, who works on the Gravity cloud platform for Porsche AG. "You get the job done more quickly because you don't have to write the code for everything yourself—for example frontend components that display images or text." He is also a fan of the container technology: "It is unquestionably a very good way to package and deliver apps," says Schug.

In the future, the SDK will have new features added in parallel with the ongoing development of the MIB3, for instance to enable data exchange between the MIB and external devices using the integrated WiFi hotspot. "Through the in-house-developed SDK as well as the expertise with regard to Docker, web architectures, and web frameworks like Angular, we are a port of call for progressive web development," concludes Breisig.

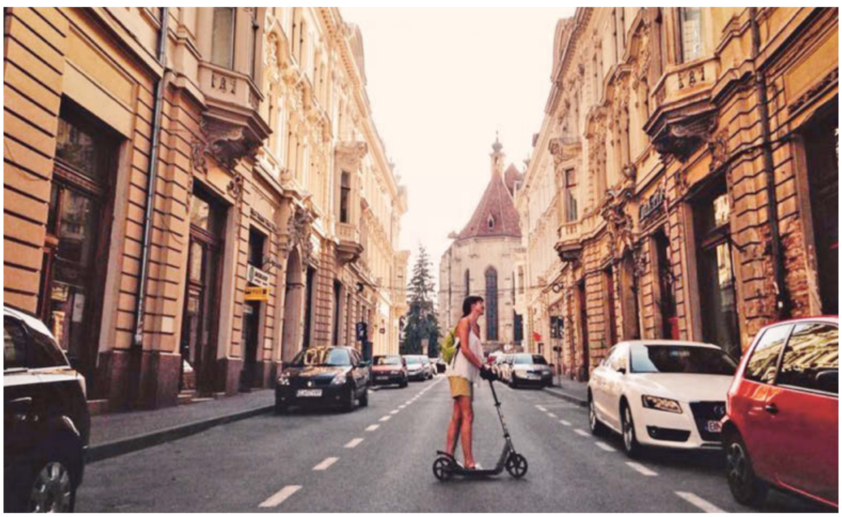
IT city with AI tradition

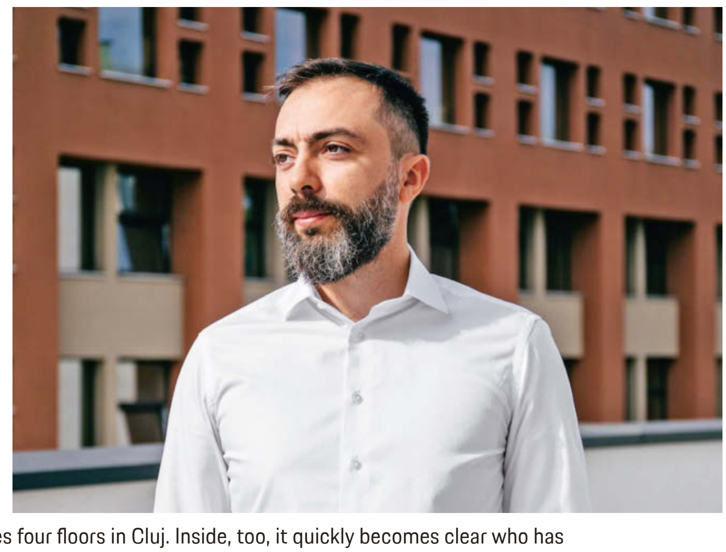
Text: Christian Buck

Contributors: Rares Barbantan, Andrei Saupe, Joachim Schaper, Tudor Ziman

Photos: Mihail Onaca, Lavinia Cernau

Since July 2016, Porsche Engineering has built up a team of software and function developers in Cluj-Napoca, Romania, who are responsible for new functions based on artificial intelligence (AI). The location benefits from an excellent academic environment and is working on solutions that will go into series production in the near future.





On course for growth: Porsche Engineering already occupies four floors in Cluj. Inside, too, it quickly becomes clear who has their offices here: a Porsche towers over the conference room. The environment is ideal: the city is young and has a historic center well worth seeing. Advanced Development Lead Andrei Saupe (right) is, among other duties, responsible for all AI activities in Cluj.

CLUJ

With its roughly 400,000 inhabitants, Cluj-Napoca is the second-largest city in Romania. Formerly known as Klausenburg, Cluj-Napoca lies in the historic region of Transylvania. The addition of "Napoca" comes from a Roman settlement in the same place. Today, the city is shaped by its numerous universities and the many IT companies that have settled there. Porsche Engineering has been in Cluj-Napoca since 2016.

It's a situation that every driver has experienced dozens of times. You're in the left lane on the highway and instinctively foresee that a car in front is intending to move into the left lane for a passing maneuver and will shortly pull in front of your vehicle. People have a kind of sixth sense for such situations: based on the context and their years of experience in traffic, they conclude that the other driver could be about to cut them off.

Machines still struggle to draw such conclusions. That's why Adaptive Cruise Control (ACC) currently only reacts when a car actually moves in front of the vehicle from the right or left. "Based on our experience in series development, we came up with an innovative idea: it would be much more convenient if the technology could anticipate the cut-in maneuver and create some space beforehand – just as any experienced human driver does. That's the idea behind 'cut-in-detection,' which should make driving even more practical in the future," explains Philipp Wustmann, Project Manager for Driver Assistance Systems.

Without artificial intelligence (AI), this idea is difficult to implement because the indications of cutting in can only be described to a limited extent by rules and traditional programming. That's why Porsche Engineering's location in Cluj-Napoca, Romania, comes into play when it comes to cut-in detection: the software and function developers there work on new vehicle functions, but also innovative development tools. "An important factor in our future success will be the development and use of AI methods and corresponding tools," says Dirk Lappe, Managing Director of Porsche Engineering. "The innovative environment and data science expertise at the Cluj location will enable us to break new ground in vehicle development." Some 160 employees are spread over four floors in a new building blessed with copious natural light—and numerous AI experts. New colleagues are added every month, and the location is set to grow to 210 staff by the middle of 2020.

New solutions soon in series prodution

The experts in Cluj-Napoca use the latest AI methods such as neural networks or reinforcement learning to develop new driver assistance systems, the autonomous vehicles of the future, or virtual tests of new vehicle functions. "Here we are developing new solutions and features that can go into series production in the near future," says Marius Mihailovici, Managing Director of Porsche Engineering in Romania (see also the interview on page 30). "By working on exciting development projects and cooperating closely with universities, we are continuously expanding our portfolio and our capabilities."

The cut-in detection function uses a neural network: people look at pictures of cars traveling on a highway and press a button as soon as they predict that a car in front will shortly cut in. "In the training phase, the neural network links this human input with the signals provided by the vehicle sensors," explains Rares Barbantan, a software architect at Porsche Engineering in Cluj-Napoca. "So it learns to predict the cut-in from the sensor data." With this knowledge, the ACC can react at an early stage to maintain the necessary distance from the vehicle cutting in. The developers in Cluj-Napoca have been working on the new system since late 2018. In many cases, cut-in detection does not require additional sensors—the main information used is the list of objects in the two nearest lanes that is already available for other assistance systems.

The AI experts in Romania also want to further improve adaptive cruise control itself. More precisely: they want to make it more practical and, in the future, able to adapt to the driving style of the vehicle owner. "In the first step, the development colleagues in Prague implemented the core function of adaptive cruise control using conventional methods. In the next step, it is now learning to optimize its behavior with AI in order to adapt in accordance with the preferences of the driver,"

"The innovative environment and data science expertise in Cluj will enable us to break new ground in vehicle development."

Dirk Lappe, Managing Director

Inspiring atmosphere: the Cluj location is situated in a new building that offers employees plenty of space and light—ideal conditions for creative colleagues such as Rares Barbantan—Software Architect (bottom left), Tudor Ziman—Functional Development Lead (to his right). As Porsche Engineering's AI head, Dr. Joachim Schaper (bottom right) is also often on site.

"Our developers love challenging projects"

Marius Mihailovici has been CEO of Porsche Engineering in Cluj-Napoca since 2016. In this interview, he talks about the opportunities and challenges of artificial intelligence and the strengths of the location in Romania.

Trailblazer: Marius Mihailovici considers AI in the vehicle indispensable.

1

What role does artificial intelligence play in the future of the automotive industry?

In the future, there will be no such thing as a vehicle without AI. It assists the driver and makes traffic safer and more efficient. That is why it will be a game-changer in our industry in the coming decade. Vehicles on SAE level 3 already exist, we will see levels 4 and 5 in the next ten years. On the way there, however, we have to grapple not only with the software, but with the entire ecosystem: the legal framework, the ethical questions, and the limits of AI. There are some things that machines—at least today—can't learn. After all, every person has gone through a learning curve of decades since childhood. The brain automatically recognizes that a child on the sidewalk could run into the street at any moment—and prepares for that eventuality. One challenge will be to transfer this knowledge to the software.

2

Why is Cluj-Napoca an attractive location for the AI activities of Porsche Engineering?

A few factors come together here. Through the Technical University, there are many well-trained software experts here. They are not only skilled, but also strongly focused on results and open to new technologies such as artificial intelligence. Our developers love challenging projects, always want to learn new things, and enjoy working in international teams. Moreover, many of them speak German, and there is also a cultural proximity to Germany here in Transylvania. So in 2014, the idea emerged that we could use all of these factors to our advantage. And that is also the exciting thing about my job: here in Cluj, we can use the potential of software developers to develop new features—and thus be part of automotive future.

3

How hard is it to attract top talent here?

It's very difficult because there are many other software companies besides us looking for good employees. We are also experiencing particularly exciting times in the automotive industry because the industry is undergoing fundamental change, not least as a result of AI. Those who work for us can play a direct role in shaping this development. We offer our developers an almost family-like environment that is characterized by trust and transparency. For many employees, that's an appealing prospect.

"Here in Cluj, we can use the potential of software developers to develop new features—and thus be part of automotive future."

> **"Cluj is an IT city. Many large companies and start-ups that have settled here have recognized that."**
>
> Andrei Saupe, Advanced Development Lead

explains Tudor Ziman, who directs software development for new functions in Cluj-Napoca. This process involves the use of reinforcement learning: in the simulator and on the road, people evaluate how practical they find adaptive cruise control. From this feedback, the system learns to respond more like a human.

There's a good reason that Porsche Engineering has concentrated such AI activities in Cluj-Napoca: the city of 400,000 inhabitants counts roughly 100,000 students at six universities. More than 20,000 students study at the Technical University alone, which every year produces around 800 graduates in computer science and automation. And the topic of AI has a long tradition here. "We have been working on it since 1978," says Professor Sergiu Nedevschi, Vice Rector for Research at the TU Cluj-Napoca and an expert in computer-aided image recognition. "And we have been cooperating with Volkswagen in this area since 2001, with the focus currently on autonomous driving and environment recognition." He is also talking to Porsche Engineering about a collaboration that will include not only the development of new solutions but also the training of students. Nedevschi has no difficulty finding new recruits for his working group of 25 employees and about 30 students: "The subject is so exciting that the interest is very great."

Many new solutions unthinkable without AI

Andrei Saupe was bitten by the "AI bug" in 2007. "At the time, I was working on a dialog system based on artificial intelligence," recalls the Advanced Development Lead at Porsche Engineering, who has been responsible for all AI activities, among other things, in Cluj-Napoca since 2017. "I've been fascinated by artificial intelligence ever since because it enables us to find solutions that would be unthinkable without AI—for new driver assistance systems, autonomous driving and the personalization of ACC, for example."

Saupe emphasizes the advantages of the location in Transylvania as well. "Cluj is an IT city," he says. "Many large companies and start-ups that have settled here have recognized that." What speaks for Porsche Engineering as an employer, he says, aside from the good atmosphere within the team, is primarily the type of projects done here: "There are many IT outsourcing companies in Cluj, but the developers would rather work on an automotive product—this makes Porsche Engineering an appealing prospect for graduates and experts with professional experience." Here they can use a whole range of current AI methods, including neuronal networks, recurrent neural networks, convolutional neural networks, reinforcement learning, decision trees, and support vector machines. "But we don't simply use the tools that are currently in fashion," stresses Saupe. "Rather, we use what fits the task at hand and can be integrated into the vehicle. That is exactly our challenge: We need to make AI usable for the car—and always keep an eye on the safety of all functions."

100,000
students attend six universities in Cluj-Napoca.

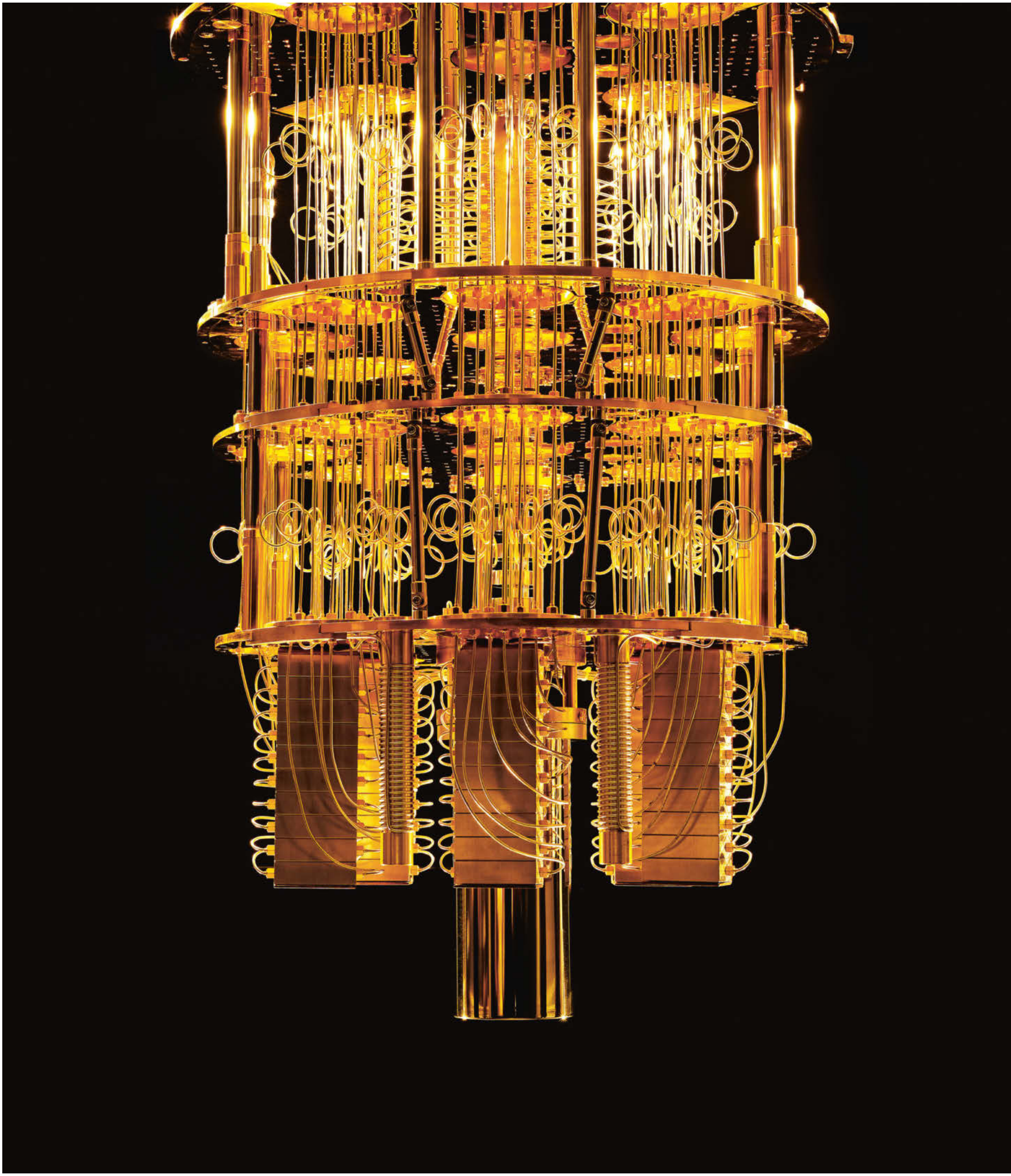
800
graduates leave the TU Cluj-Napoca every year with a degree in computer science or automation.

210
staff will be employed by Porsche Engineering in Cluj by the middle of 2020.

Because the topic of AI will become even more important in the future, Dr. Joachim Schaper has been coordinating Porsche Engineering's activities in this area since July 2019—as well as the collaboration with the company's other locations. "There are also some AI activities in Prague, but our colleagues there are mainly concerned with electronics hardware," says the experienced research manager. "In Mönsheim, a lot of data is generated that we can use in AI-based functions, for example for battery management." In his view, this is another attractive field of application for the use of artificial intelligence: algorithms could not only predict problems in the battery cells, but also determine the remaining energy in the energy storage device based on its utilization. It's an interesting idea that may soon be taken up by the AI experts in Cluj-Napoca.

IN BRIEF

In Cluj-Napoca, the experts from Porsche Engineering use state-of-the-art AI methods for new driver assistance systems, autonomous driving, and innovative development tools. The location benefits from the high local IT expertise and a long tradition of AI development.



Smart sculpture: this is what the interior life of the IBM quantum computer Q System One looks like.

Booster for AI calculations

Text: Christian Buck Contributors: Ralf Bauer, Dr. Christian Koelen

Automated and autonomous driving functions are impossible to implement without AI. The required computing capacity is provided by special chips specialized in parallel computing. But researchers are also working on new, biologically inspired solutions as well as on quantum computers that promise even more computing capacity.

For decades, electronics have become increasingly prevalent in vehicles. Today, dozens of networked control devices control the engine, transmission, infotainment system and many other functions. Cars have long since become rolling computing centers—but now a new leap in computer power awaits them, because automated driving functions and autonomous driving require ever more powerful computers. And because the required performance cannot be achieved with conventional chips, the hour has come for graphics processors, tensor processing units (TPUs), and other hardware specially designed for the calculations of neural networks.

While conventional CPUs (central processing units) can be used universally, they lack the optimal architecture for AI. That is due to the typical calculations that occur during the training of and inference process with neural networks. “The matrix multiplications in neural networks are very elaborate,” explains Dr. Markus Götz of the Steinbuch Centre for Computing at the Karlsruhe Institute of Technology (KIT). “But these calculations are very amenable to parallelization—particularly with graphics cards. Whereas a high-end CPU with 24 cores and vector commands can perform 24 times 4 calculations per cycle; with a modern graphics card it's over 5,000.”

5,000
calculations per cycle can be done by a modern graphics card. With a high-end CPU with 24 cores, the figure is 96.

Graphics processors (GPUs, graphics processing units) are specialized for parallel work from the outset and have an internal architecture tailored for that purpose: GPUs contain hundreds or thousands of simple computation modules for integer and floating-point operations, which can simultaneously apply the same operation to different data (single instruction multiple data). They are therefore able to execute thousands of computing operations per clock cycle—for instance to compute the pixels of a virtual landscape or the matrix multiplications for neural networks. So it's no wonder that chips from the GPU manufacturer NVIDIA are currently ideally positioned as the workhorses for artificial intelligence in general and autonomous driving in particular. Volkswagen uses the US company's hardware, among others. “You need special hardware for autonomous driving," says Ralf Bauer, Senior Manager Software Development at Porsche Engineering. "GPUs are the starting point; later, application-specific chips will presumably follow."

NVIDIA currently offers the Xavier processes for autonomous driving specifically. A silicon chip is outfitted with eight conventional CPUs and one GPU specifically optimized for machine learning. For automated driving on level 2+ (limited longitudinal and lateral control with enhanced functionality based on standard sensors compared to level 2), the Drive AGX Xavier platform is available, which can execute a maximum of 30 trillion computing operations per second (30 TOPS, Tera Operations Per Second). For highly automated and autonomous driving, NVIDIA has the Drive AGX Pegasus (320 TOPS), under the control of which a test vehicle has driven as far as 80 kilometers without human intervention through Silicon Valley. As the successor to Xavier, NVIDIA is now developing the Orin GPU, though little is currently known about its performance data.

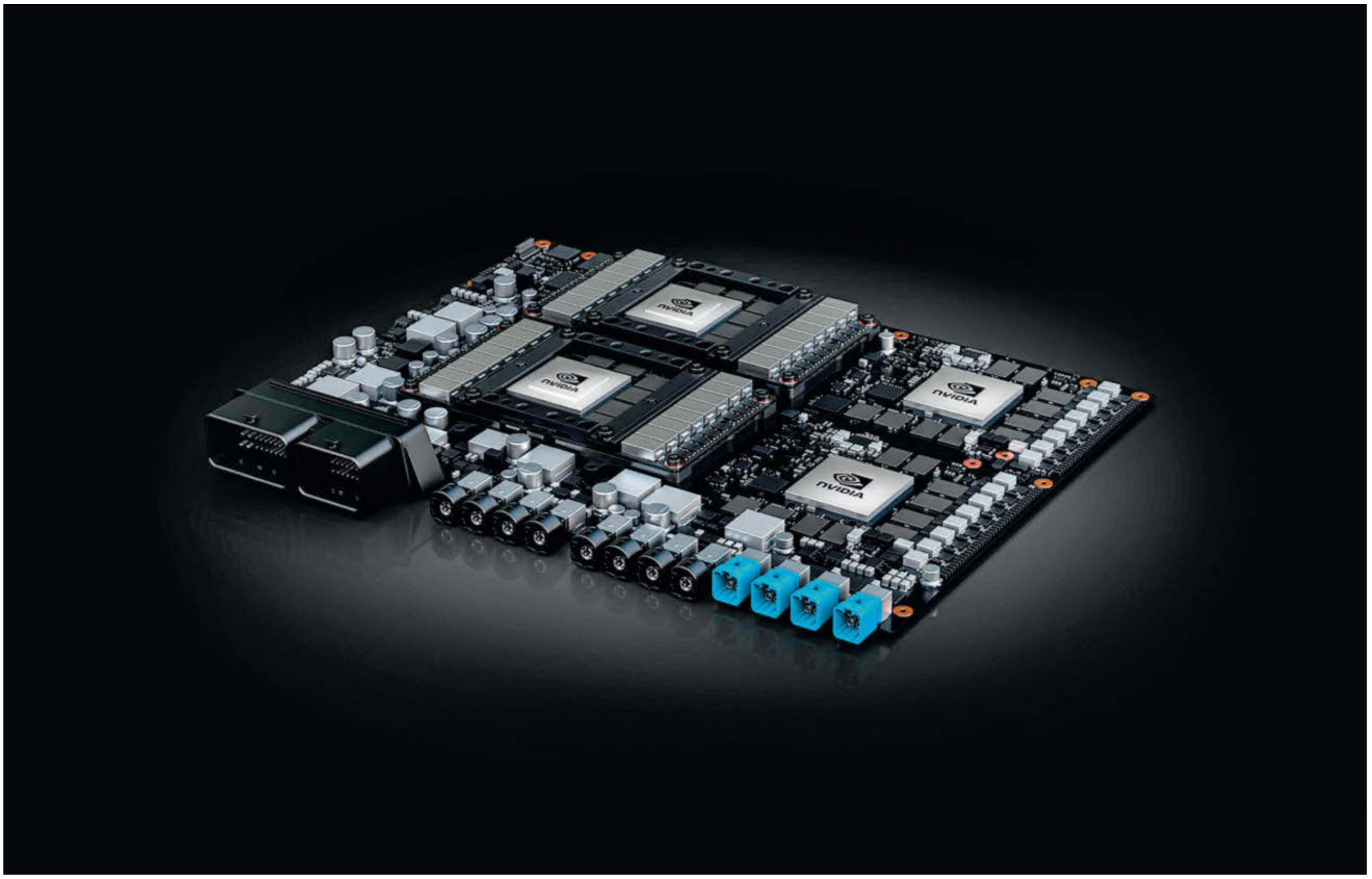
Not all automobile manufacturers utilize GPUs. In 2016, Tesla began developing its own processors for neural networks. Instead of graphics processors from NVIDIA, the US-based company has been installing its FSD (Full Self-Driving) chip in its vehicles since early 2019. In addition to two neural processing units (NPUs) with 72 TOPS apiece, it also contains twelve conventional CPU cores for general calculations and a GPU for post-processing of image and video data. The NPUs, like GPUs, are specialized in parallel and thereby fast execution of addition and multiplication operations.

Google chip for AI applications

Google is a further newcomer in the chip business: since 2015, the technology company has been using self-developed TPUs in its data centers. The name

"You need special hardware for autonomous driving. GPUs are the starting point; later, application-specific chips will presumably follow."

Ralf Bauer, Senior Manager Software Development



Platform for autonomous driving: the high-performance AI computer NVIDIA Drive AGX Pegasus is specialized in deep neural networks.

comes from the mathematical term "tensor," which encompasses vectors and matrices, among other elements. This is why Google's widely used software library for artificial intelligence is called TensorFlow—and the chips are optimized for them. In 2018, Google presented the third generation of its TPUs, which contain four "matrix multiplication units" and are said to be capable of 90 TFLOPS (Tera Floating Point Operations Per Second). The Google subsidiary Waymo uses TPUs to train neural networks for autonomous driving.

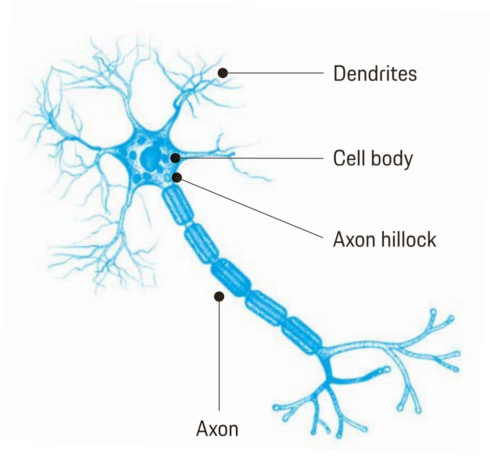
Application-specific chips like Tesla's FSD or the TPUs from Google only become economical at large unit numbers. One alternative is FPGAs (field-programmable gate arrays). These universally usable digital chips contain countless computing and memory blocks that can be combined with each other through programming and with which it is possible to essentially pour algorithms into hardware—like with an application-specific chip, but much more cheaply. FPGAs can be easily adapted to the specific requirements of an AI application (for instance specified data types), which yields benefits in terms of performance and energy consumption. The Munich-based start-up Kortiq has developed its AIScale architecture for FPGAs, which simplifies the neural networks for image recognition and so optimizes the calculations that the requirements on the hardware diminish significantly and results are available up to ten times faster.

Some researchers are pursuing an even closer relationship to the functioning of nerve cells for AI-specific chips. Researchers at Heidelberg University have developed the neuromorphic system BrainScaleS, whose artificial neurons are implemented as analog switches on silicon chips: the cell body consists of some 1,000 transistors and two capacitors, with the synapses requiring roughly 150 transistors. Individual cell bodies can be combined as modules to form various types of artificial neurons. These synapses can, as in nature, form strong connections, and there are also excitatory and inhibitory types. The output of the neurons consists of "spikes," short voltage pulses lasting a few microseconds that function as inputs for the other artificial neurons.

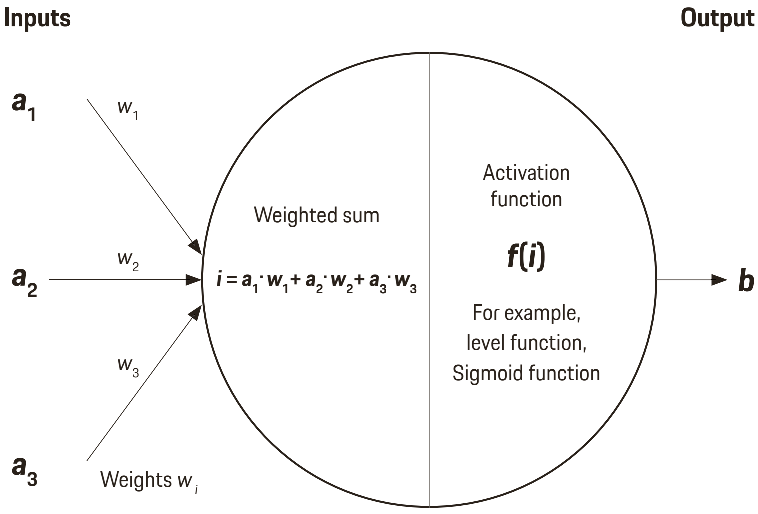
Energy-efficient neuro-chips

But BrainScaleS is not just used to research the human brain. The technical neurons can also be used to solve technical problems—such as object detection for autonomous driving. On the one hand, they offer high computing capacity of approximately a quadrillion computing operations (1,000 TOPS) per module with 200,000 neurons. On the other hand, the analog solution also uses very little energy. "In digital circuits, for example, there are some 10,000 transistors used for each operation," explains Johannes Schemmel of Heidelberg University. "We get by with substantially fewer,

Nerve cells and artificial neurons



Nerve cells receive their signals from other neurons via synapses that are located either on the dendrites or directly on the cell body. Synapses can have either an excitatory or inhibitory effect. All inputs are totaled at the axon hillock and if a threshold is exceeded in the process, the nerve cell fires off a roughly millisecond-long signal that propagates along the axon and reaches other neurons.

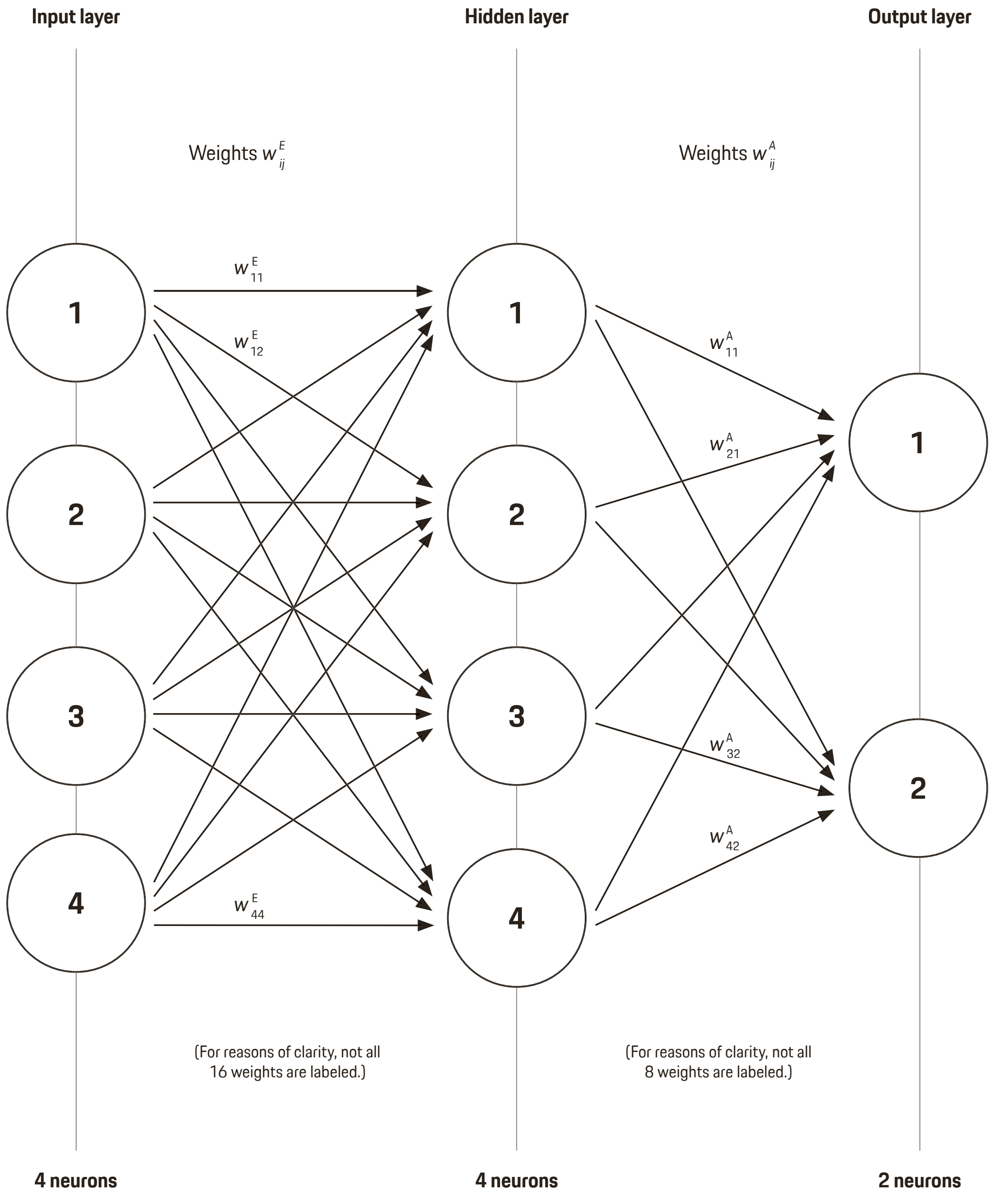


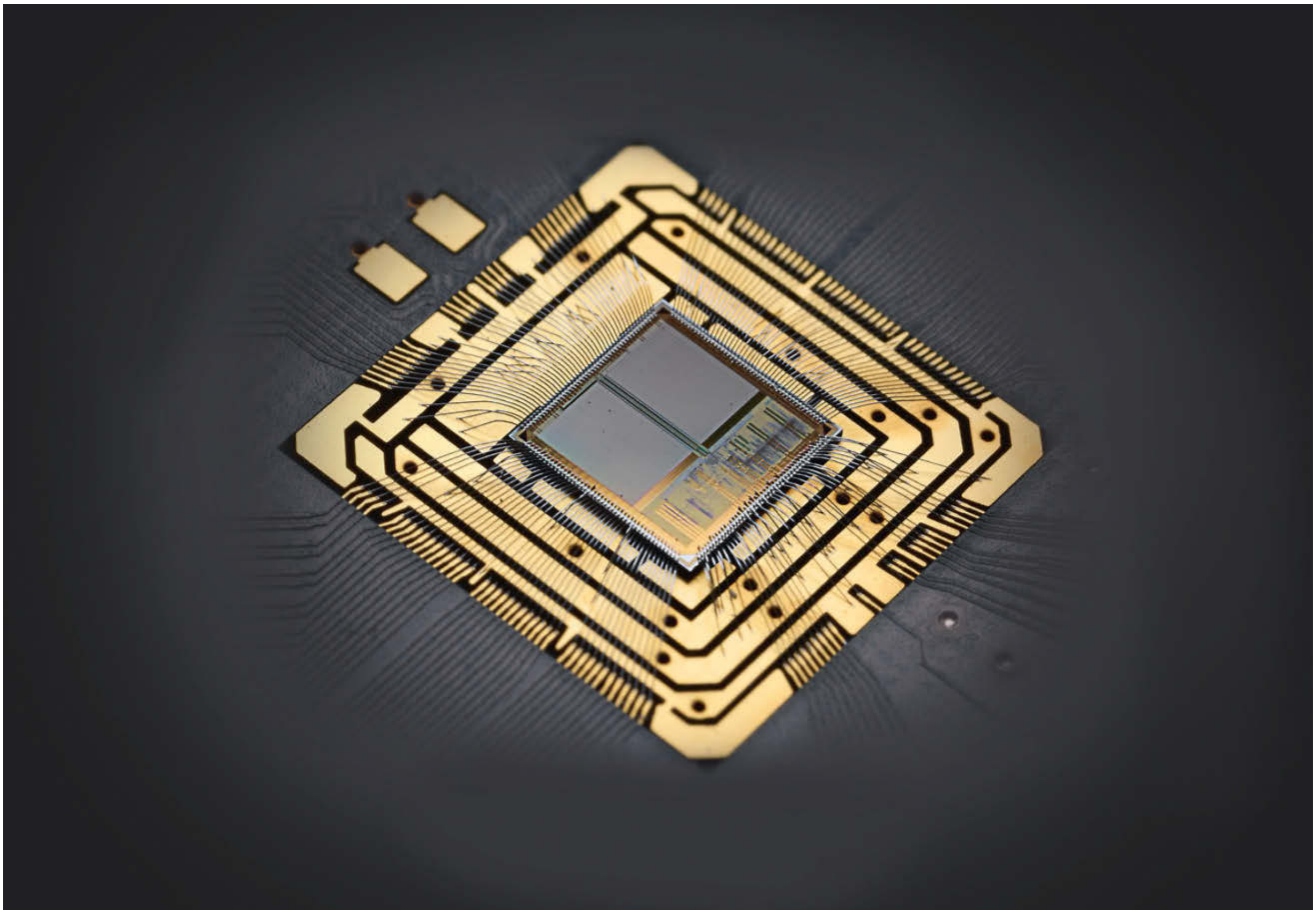
Artificial neurons mimic this behavior more or less exactly. In conventional neural networks with multiple layers, each "nerve cell" receives a weighted sum as an input. It consists of the outputs of the neurons of the preceding layer and the weighting factor w_i, in which the learning experience of the neural network is stored. These weighting factors correspond to the synapses and can also be excitatory or inhibitory. A configurable threshold value determines, like in a nerve cell, when the artificial neuron fires.

Learning from and inference with neural networks

Natural and artificial neural networks learn from changes in the strength of synaptic connections and the weighting factors. In deep neural networks, during training, data is fed to the inputs and the output compared with a desired result. Using mathematical methods, the weighting factor w_{ij} is continually readjusted until the neural network can reliably place images, for example, in specified categories. With inference, data is fed to the input and the output is used to make decisions, for example.

In both training and inference in deep neural networks (networks with multiple layers of artificial neurons), the same mathematical operations occur repeatedly. If one sums both the outputs of the neurons of layer 1 and the inputs of the neurons of layer 2 as column vectors, all calculations can be represented as matrix multiplications. In the process, numerous mutually independent multiplications and additions occur that can be executed in parallel. Conventional CPUs are not designed for that—and that is why graphics processors, TPUs, and other AI accelerators are vastly superior to them.





Neuromorphic hardware from Heidelberg: this chip contains 384 artificial neurons and 100,000 synapses.

which enables us to achieve roughly 100 TOPS per watt." The researchers have just developed the second generation of their circuits and are talking to industry partners about possible collaborations.

Quantum power from the cloud

In the future, even quantum computers could be used in the field of AI. Their fundamental unit is not the binary bit, but the qubit, with an infinite number of possible values. Thanks to the laws of quantum mechanics, calculations can be highly parallelized and thereby accelerated. At the same time, quantum computers are difficult to implement because qubits are represented by sensitive physical systems like electrons, photons, and ions. This was demonstrated, for example, with the IBM Q System One, which the company introduced at the CES 2019 electronics trade show in Las Vegas. The interior of the quantum computer must be fastidiously shielded against vibrations, electrical fields, and temperature fluctuations.

It is not possible to buy the IBM computer, but it can be used via a cloud. Other manufacturers, such as Canada-based D-Wave, also offer quantum computing power. Volkswagen has used a quantum computer from the company, for example, to implement a traffic management system designed to enhance the efficiency of taxi companies and other transport providers in urban areas. "Neural networks are also a type of optimization task—as a rule, one is attempting to achieve optimal prediction accuracy," says KIT expert Götz. "For that reason, among others, research is being conducted into how AI algorithms would have to be changed."

IN BRIEF

Conventional computer chips reach their limits when it comes to calculations for neural networks. Graphics processors and special hardware for AI developed by companies such as NVIDIA and Google are much more powerful. Neuromorphic chips are substantially similar to real neurons and work very efficiently. Quantum computers could also boost computing capacity enormously.

The fires of progress

Is technology at our beck and call? Or we at its? On human free will in the digital age. A guest article by journalist, manager, and author Christoph Keese.

My great-grandmother's name was Leni. I was fortunate enough for her to still be around when I was a kid. She had been born in the 80s of the 19th century. I can still picture her at work in her small open kitchen in Germany's Bergisches Land. When she cooked, she stood there in the smoke and fumes of her wood-fire stove. She'd send us kids out the back yard to ditch the glimmering ashes in the metal trash can and, fists firmly on her hips, she'd survey her handiwork after stirring the many pots on the hotplate with her seven wooden cooking spoons. Once all her hard work was done, a feast would spread across her creaking wooden table, its beams sagging under the weight of bowls, gravy boats, platters, and baskets.

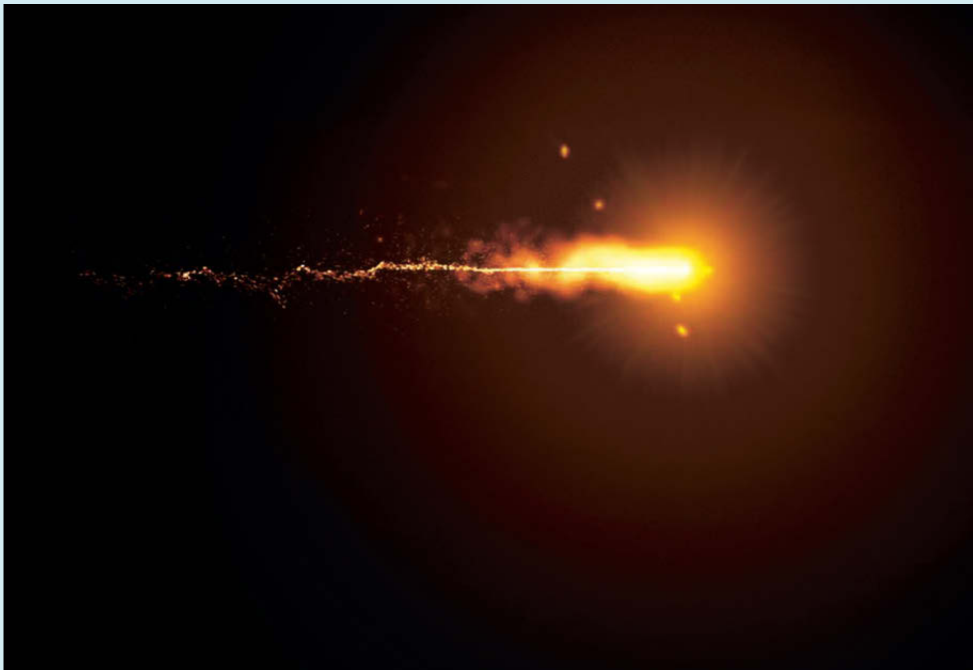
Today, in the digital age, cooking is something we do on the side, a casual activity that takes up less time than it took Leni just to stack her stove's oven with wood. Microwaves heat ready-cooked meals in a couple minutes. Convenience foods let us cook a Rhineland *Sauerbraten* in a *bain-marie*. Fridges exist that scan what's left inside and read out recipes for what you could make using these ingredients. "Alexa, get milk and potatoes," is still the new hotness today, but will likely be relegated to relic status one or two years from now. Because you won't even have to ask Alexa to do her job, she'll have ordered new supplies all by herself—second-guessing our desires from the data repositories and ingenious AI algorithms before these desires had any time to arise within us. That land of milk and honey, with its fried pigeons flying straight into our mouths, was a long time in coming. The digital age is making it a reality, now. The price of progress in convenience is a loss of sensuality. We are the children of our times, it is said. But are we still masters of our lives?

Not upgrades, but sidegrades

We believe ourselves to be, more or less, fully skilled in using modern digital assets, but we're slow to realize how we're losing other skills. We believe that skills grow one on the other, layer by layer, and without a second thought are convinced that we possess far more skills than any generation that came before. But we're wrong.

We never for a moment stop to consider that it might be otherwise: that skills supplant each other rather than complement. Kids edit smartphone videos at a moment's notice, uploading them to their YouTube channels. What they cannot do is use only a single match to light, without fanning the embers, a fire in a narrow oven shaft.

To meet our desire of staying abreast of our times, to be involved in the digital age, we pay a price—the slow, barely noticeable, yet inescapable sacrifice of other, previous skills. We're not upgrading, we're merely sidegrading. We're massively superior to any ancient Roman in terms of communications



technology. Caesar would turn green with envy if he could see how we transfer information from Gaul and Germania to Rome. Had he had access to today's capacities and skills, he would have saved himself a world of trouble on both sides of the Alps. All the same, Caesar would have taken us out with a short sword before we'd managed to whip out a smartphone and call for help.

There's a fair balance between the generations. Skills and the mastery over our fate are narrowly intertwined. I can make my own fate only if I have the capacities to act accordingly. In this, digitalization is now giving rise to a serious concern. Unlike earlier revolutions, such as early mechanization or the Industrial Revolution, digitalization does not seek to use steam and gears to enhance our physical strength ad infinitum. Instead, it exponentially increases the power of our minds, inexorably progressing from simple cognitive abilities to complex, sometimes unconscious and deeply hidden processes. Every time our digital aides and familiars delve further into the murky regions of our consciousness and the subconscious, they'll take more onerous daily routines off our hands, make us even more cozy and accepting of the fact that we're being taken care of, and supplant more of the old skills with new ones.

We cannot be indifferent to this. Because, what does it actually entail? If algorithms intervene in our nurturing of desires and fulfill desires even before they arise in us, then our capacity to develop desires will atrophy the same way a poorly trained and rarely used biceps does. Losing the capacity to grow desires for ourselves also robs us of our capacity to master our fate.

Let's look at future automobiles as an example. While most people will think of electrifying drive systems in this context, it's the field of control that is by far the more significant revolution. The true revolution of the relationship between machine and human will not begin until we actually have cars that drive themselves. We'll be able to take our hands off the wheel—so far, so good. But as soon as an algorithm starts handling largely accident-free driving, it will begin feeding us suggestions for destinations in a similar way to the thousands upon thousands of suggestions the Internet already throws at us every day: "Customers who bought this book also bought this one," Amazon lets us know. An autonomous car will speak to us kindly: "Absolutely right, the *Rheinauen* are a beautiful spot for a day out with the kids on a spring day like this. But perhaps you'd also like to check out the Phantasialand amusement park? Daytrippers there today save on sales tax."

Artificial intelligence, smartly integrated into tomorrow's car, will be able to eliminate tedious chores and, like our own private version of Fantasia, keep its ear to the door of our innermost, recognizing and fulfilling forthwith our most fledgling desires. All the data this kind of predictive planning requires is available in the information systems that already surround us today. All that remains is to link them up, evaluate them, and put them to use in our name. We will readily hand over management of our day-to-day lives to those assistants able to do so. The car will transition so smoothly to a locus of benign digital custodianship because it is capable of changing our destination and route. It will act as an agent of our subconscious desires by taking us to our place of yearning before we even recognize any yearning at all.

Cooking over a fire is a feast for the senses

Lost skills are not recognized as a loss. We're not aware of the majority of things we can't do. We don't miss being able to light a cast-iron stove with a single match, not least because we don't have those kinds of stoves in our kitchens anymore. We never really miss a lack of skill these days, surrounded as we are by others who possess these skills no more than we do. In the same way, once hyper-precise predictive algorithms become prevalent, our losing that great feeling of making a plan or harboring a desire will not leave us feeling bereft of something.

A terrible notion, many might say. We'll consider it far less terrible then than we do now. "Life is lived gazing forward and comprehended gazing backward," the philosopher Rüdiger Safranski writes. A loss of mastery over our lives appears awful gazing forward and insignificant with hindsight.

I'm gradually beginning to understand why my great-grandmother wanted no part of gas and electric cookers. Leni swept all such notions aside, I firmly believe today, because she liked the smell of the fire. Because she enjoyed hearing the wood popping as it burned, liked feeling the smoke tickle her nostrils. She enjoyed feeling her mastery over the elements when she struck the match to set ablaze a whole stack of wood. She wouldn't—couldn't—have it too easy. That would have robbed her of the well-earned reward for her tough, frugal life. In short: cooking over the archaic fire seemed an anachronism only to our eyes. For my great-grandmother, it was a feast for the senses, a celebration of life. Her standing stalwart against any who would rob her of this pleasure was her mastering her fate.

We can only guess today at what moved Leni's thoughts. Likewise, our own great-grandchildren will be at a loss to understand why we chose to suffer the agonies of deciding for ourselves in so many trivial situations, where all the while we could have been putting all that squandered time to far better use. Will our great-grandchildren, who will so monstrously fail to understand us, be more ignorant than us? No, they will not. They will simply possess different skills, a fact that we must accept.

GUEST AUTHOR CHRISTOPH KEESE, born 1964, is a successful author (*The Silicon Valley Challenge: A Wake-Up Call for Europe*) and has recently taken on the position of CEO at Axel Springer hy GmbH. Previous positions include manager at the media company Axel Springer, where he oversaw the business's transition to an Internet company as Executive Vice President.


MOIA
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Energy for ridesharing

Text: Axel Novak Contributors: Tim Munstermann, Andreas Rau

Photos: Martin Kess, MOIA

Since April 2019, the Volkswagen offshoot MOIA has offered ridesharing with electric vehicles in Hamburg. The concept relies heavily on the High-Power Charging Solution developed by Porsche Engineering.

High-Power Charging: it takes 20 to 30 minutes for the people carriers to charge for 300 kilometers of driving.

It's raining slightly in Hamburg. The MOIA vehicle will be at Heidi-Kabel-Platz in front of Hamburg Central Station in three minutes, the app says. "Almost there!" the app suddenly announces—and there's MOIA 181 turning onto the plaza already. The driver keys the door and greets us, introducing himself as the door glides smoothly open. Inside, a pleasant ambiance awaits us: everything is spacious and smartly lit. Cheerful colors, off-white, golden side paneling, the seats are a light shade. A car that's not just functional, but that's also out to offer its passengers an enjoyable ride.

There's another passenger in the car already, gazing intently at their phone. They hop off a couple minutes later. We drive on. Outside, Hamburg drifts past; we catch a glimpse of the Alster river. Inside, there's not so much as a hint of the city's traffic noise, and no engine noise either. MOIA moves through Hamburg strictly on electric power.

But that's not the only thing that's special about this Volkswagen subsidiary. Compared with the city's public transport on the one hand and taxi companies on the other, MOIA takes a different approach to business, too: MOIA serves the needs of different kinds of passengers, positioning itself midway between the scheduled departures of buses and trains and personal travel as offered by a taxi. When we use MOIA, we feed our transport wishes to an app and get picked up at the desired time from one of the many virtual stops scattered in close proximity to one another.

Efficient urban transport

While traveling from our starting point to our destination, other passengers can get on or off, which reduces the number of vehicles needed. These stops on the way can make the trip take longer, of course. The idea is called *ridesharing*. Smart software keeps the MOIA fleet operating at optimum capacity. MOIA primarily targets the daily commutes, aiming to merge traffic flows for greater efficiency. In Hanover, MOIA already took to the roads in 2018. We can catch them in Hamburg since spring 2019.

A trip with MOIA costs more than public transport but less than a taxi fare. We pay cashless, through the app. We can tip the driver and leave a rating, too. The vehicles themselves were designed specially for MOIA by Volkswagen under the project name Pluto. They are people carriers based on the Crafter, six meters long and two-and-half meters wide. They offer a ride for up to six passengers. By the end of 2019, 500 of them will be on Hamburg's roads.

500
MOIA MPVs will be on Hamburg's roads by the end of 2019.

18
fast-charger stations from Porsche Engineering make sure that MOIA's vehicles are always ready to run.

2,000
fast-charge operations at MOIA every week.

"We charge each vehicle we're actually running three or four times a day."

Dr. Christian Matt,
Management Consultant
with MOIA Operations

By now, MOIA 181 has turned the corner onto Grindelallee, moving with the traffic. Every now and again, we pass another MOIA transport. The new concept is gaining in popularity. No surprise, as the city's roads are congested with cars, buses, and taxis, all packed into tightly flowing traffic. Estimates predict that personal motor traffic hasn't even peaked yet. Apparently, despite Germany's declining population, the number of personal motor vehicles is expected to rise by about ten percent over the next few years. Especially because the older demographic is becoming more "automotively mobile."

Urban infrastructures are already beginning to struggle today. While action is being taken to divert or reduce traffic—investments in public transport, experiments in using carsharing or other mobility concepts, a rise in new modes of transport like e-scooters and e-bikes—none of this will be able to stem the tide of growing mobility. Cities and regions need to explore new ideas to cope with the predicted boom.

Hamburg, too, is investigating new types of mobility. In Germany, Hamburg takes top spot when it comes to the proliferation of electric car chargers. Together with Hanover, Hamburg has also wasted no time in testing—and proving—MOIA's ridesharing approach. Many other towns and cities today offer comparable services. But MOIA intends to become the market leader, with plans to expand to more places already being made.

The company and its vehicles have covered the city's entire area with a tightly woven web of many thousands of virtual stops. MOIA wants to push further outwards beyond the city bounds. The idea is to guarantee that

Powerhouse: the High-Power Chargers from Porsche Engineering supply 150 kilowatts.

Specially designed: Volkswagen developed MOIA's vehicles based on the Crafter.

we never have more than 250 meters to walk before we reach a pick-up point anywhere in the company's 200-square-kilometer business range. "We're still setting up," says Jens-Michael May, CEO of MOIA Operations. "But once we start operating all over the greater Hamburg area, the economies of scale of a major transit system begin kicking in."

Hoheluft, Eppendorf, Niendorf: MOIA 181 has reached the depot at Niendorfer Weg 11. The unadorned hangar is bustling. Vehicles are driving in, drivers getting out and hooking up the MPVs to the chargers. At the time of writing, there are 200 vehicles operating round the clock; every week sees new ones arriving to expand the web. Business only shuts down Tuesdays and Wednesdays, from one a.m. to seven a.m., when passenger numbers are very low—an opportunity to run checks on the vehicles.

Loves ridesharing: Jens-Michael May wants to do good by Hamburg.

"We're considering a grander scale"

Jens-Michael May is MOIA Operations' CEO. He tells us what the company does differently from other mobility services.

1

Mr. May, new mobility concepts are a hot topic. What's special about ridesharing and MOIA?

Tomorrow's mobility will comprise a whole range of elements. MOIA's ridesharing is a sound supplementation of the existing modes of transport. We merge traffic and motivate commuters to travel together. This reduces urban traffic and its environmental impact. What sets us apart is that we're considering a grander scale, planning a major transit system: we want to have around one thousand vehicles operating in Hamburg in the next three years, to handle roughly one percent of the total traffic volume. As a reference: the Hamburg metro alone moves two-and-a-half million people every day. So one percent of that isn't bad.

2

Will your idea also fly in megacities in Asia, Africa, or Latin America? And how long until MOIA's MPVs drive themselves?

Large cities are where ridesharing really comes into its own. The larger the city, the more fully the vehicles' capacities are utilized. Megacities benefit from major economies of scale. Ridesharing is only one element in a town's or region's mobility mix. But it's a highly efficient one because it supplements the other modes of transport. It's likely to be years yet before we have self-driving vehicles. For now, we need to demonstrate that MOIA, that ridesharing actually works. And driverless cars aren't only a technology issue, they're a social one, too.

3

How important is Porsche Engineering's charger technology for MOIA?

We naturally depend heavily on our ability to reliably charge our vehicles whenever we need to. That's why we chose the technology supplied by Porsche Engineering. On the one hand, it's definitely an advantage to have cutting-edge tech, because it's highly economical. On the other, the technology is excellently suited for our depots because it's really simple to expand in time with MOIA's growth and only takes up very little space. These are crucial aspects for the urban locations of our depots.

For everyday operations, it's essential that the vehicles can be charged whenever required. To charge them, MOIA uses 120 conventional AC chargers on the outdoor area of their depot. These take seven hours to fully charge the vehicles' batteries. Additionally, there are eighteen High-Power Chargers in the hangars for use during round-the-clock operation. These cutting-edge power plants run 400 volts into an MPV's 87-kilowatt-hour battery to fully charge it in twenty to thirty minutes. Enough to cover 300 kilometers.

The fast-charging infrastructure was devised by Porsche Engineering. "Our charger solutions offer MOIA three key benefits," Tim Munstermann tells us. He's in charge of project management and high-voltage systems with Porsche Engineering. "They take up little space, which makes them good for depots where space is an issue. They're also really easy to expand. And finally, they're more efficient compared to what competitors offer."

Important findings from practical application

Porsche Engineering is getting something out of MOIA using the chargers, too: the use of the charging solution is a valuable validation of the overall system's performance under continuous, high-load operation. The chargers are kept running 24/7, rain or shine. An important source of data, as the weather affects energy consumption and charge cycles: rain alone increases the vehicles' electricity consumption by fifteen percent; extreme temperatures of below minus ten or above thirty degrees Celsius affect operation even more severely. For Porsche Engineering, such data provides valuable information for improvement as well as further developing the Charging Solutions.

The power supply as a whole is also under pressure to adjust to the requirements of electric mobility. A high volume of electricity needs to be generated, renewably, and supplied to the vehicles. MOIA keeps this in mind, choosing locations for their depots not only based on where the city still offers space. The proximity to one of the medium-voltage circuits that supply all of Hamburg is also important. Porsche Engineering assisted MOIA in finding the right location, as getting the technical systems officially approved by the medium-voltage grid's operator is especially complicated.

MOIA currently purchases eight megawatt-hours of renewable energy a day from the Hamburg supplier Stadtenergie. "We charge each vehicle we're actually running three or four times a day, that's two thousand rapid-charge ops a week," says Dr. Christian Matt, management consultant and responsible for charging technology at MOIA Operations. "We maintain fine-tuned load management and control current consumption to prevent our charging the vehicles from causing hazardous grid voltages."

Sustainable: MOIA currently purchases eight megawatt-hours of renewable energy a day from a Hamburg supplier.

To ensure that the chargers remain constantly in use, MOIA also sets up shift schedules one month in advance and offsets the workforce's three shifts by a couple minutes. This way, there's always a vehicle ready to leave the depot, merge into the passing traffic, and pick up the next lot of passengers for their shared ride.

IN BRIEF

MOIA intends its ridesharing concept to revolutionize urban traffic. They run a fleet of electric MPVs. Frequent recharging is indispensable to putting the vehicles to optimum use. Porsche Engineering's charger technology ensures that "refueling" takes up as little time as possible.

Precision is the watchword: the driving surface is extremely smooth, because even irregularities in the millimeter range would be clearly perceptible in the car at high speeds.

Nardò 2.0

Text: Mirko Heinemann

Contributors: Antonio Leuzzi, Matthias Köstner, Jaroslav Jirásek

Photos: Danilo Dom Calogiuri

New asphalt, an innovative guardrail system, and a modern IT infrastructure: Porsche Engineering has renovated the Car Circular Track and the Car Dynamic Platform of the legendary automotive proving ground near Nardò in southern Italy. Among other things, the improvements enable high-stress endurance tests under extreme conditions as well as the testing of new vehicle functions.

Porsche 911 R

CO_2 emissions (combined): 308 g/km
Fuel consumption:
Urban: 20.1 l/100 km
Highway: 9.3 l/100 km
Combined: 13.3 l/100 km
Efficiency class:
Germany: G
Switzerland: G

The big ring is decidedly conspicuous on satellite images—it encircles the Pista di Nardò with a diameter of four kilometers. Originally slated for the construction of a particle accelerator, the site was instead turned into an automotive test track by Fiat in 1975. In 2012 the grounds were acquired by Porsche, and since then the Nardò Technical Center (NTC) north of the Apulian coastal city of Nardò has been operated by Porsche Engineering.

After a year of preparation, the construction work stretched from January to July. Over the seven-month period, a total of 420,000 square meters were renovated with 100,000 metric tons of asphalt delivered in 3,125 truckloads. The work also involved the installation of a specially designed, patented guardrail system on the Car Circular Track and established a basis for a digital infrastructure.

The asphalting of the Car Circular Track was a major challenge. "A test track is subject to completely different standards from those that apply in public road construction," explains Matthias Köstner of Porsche Engineering, who is the project manager for the modernization of the NTC. "On the test tracks at Nardò, vehicles are driven to their very limits, which means that irregularities in the surfaces and friction variations have to be avoided as much as possible." And then there is the special shape of the circuit. The Car Circular Track in Nardò has four lanes and a parabolic profile. Its incline becomes increasingly steep as it rises—at the top edge, the highest lane has a roughly 25% tilt compared to the ground. This means that drivers can drive at a speed of 240 kilometers per hour without lateral forces. On the lower lanes, the speeds at which the lateral forces do not occur are accordingly lower.

Before the new track surface could be applied, the road building team had to mill the existing surfaces of the track and test various mixtures and compacting programs—the test area alone was over 1,000 square meters in size. To demonstrate the high quality standards of Porsche Engineering, Köstner invited every worker to take a ride in a Porsche 911 R driving at the limit. "Many of them went pale and changed their opinions on the requirements for a perfect track surface," he recalls.

Around
25%
is the tilt of the highest lane at its top edge in relation to the ground.

This was followed by a particularly tricky task: the objective was to apply a homogeneous driving surface to a parabolic banked curve almost 13 kilometers in length—without critical longitudinal and lateral grooves and with a uniform rounding profile all the way up to the top. Meeting this challenge required the utilization of a type of full-width paver of which there are only two in the world. The roughly 100-metric-ton machine spans multiple lanes and moves on caterpillar tracks. The driving surface geometry is configured and fixed using a hydraulically adjustable mounted implement. Per day, the machine requires roughly 1,000 metric tons of material, comprised primarily of crushed rock, sand, and bitumen—the asphalt.

Seamless asphalt mat

The material was produced according to a defined recipe in an asphalt mixing plant and transported to the construction site in heavy trucks. The full-width paver distributed the asphalt over the track surface with a conveyor chain and compacted it with vibrating tamper bars. To enhance the quality and durability of the new surface, the hot asphalt was then further compacted with road rollers. The rollers were turned down in line with the planned track profile, and on the higher lanes they were held in place by anchor rollers on the external patrol lane. The new asphalt layers were applied in succession across a width of twelve meters in just a single pass—in good weather for up to 48 hours non-stop. The advantage: using this procedure eliminates joints.

The expansion continues

Between 2012 and today, Porsche Engineering has invested over 60 million euros in NTC. But the continued development is by no means complete: in the future, the Nardò Technical Center will be further upgraded to become a testing center in which all mobility innovations around the world can be tested, such as in the fields of e-mobility, autonomous vehicles, and digital infrastructure.

Colossus on caterpillar tracks: the 100-metric-ton full-width paver was charged with creating a parabolic banked curve without critical longitudinal and lateral grooves.

All clear in southern Italy: Malte Radmann (left), until mid-2019 CEO of Porsche Engineering and chairman of the shareholders' committee of the Nardò Technical Center, and NTC Managing Director Antonio Gratis re-opened the legendary track after the construction work.

Ready for new tests: in addition to the Car Circular Track, the 106,000-square-meter Car Dynamic Platform also got a new asphalt surface.

The Nardò Technical Center in brief

The NTC has roughly twenty test tracks with a total length of 75 kilometers. There are also workshops, administrative buildings, and a canteen. To meet customer requirements, the Nardò Technical Center also provides engineering services for the purposes of testing the durability and reliability, vehicle dynamics, target and benchmark setting, vehicle type approval, vehicle diagnosis, and wear.

The NTC employs more than

150

people.

The new mat is comprised of multiple layers. At the very bottom the road builders applied a thin layer of asphalt to smooth over old irregularities and fill the old cracks. On top of that they laid a reinforcement lattice—mats of soft bitumen reinforced with a glass fiber grid. As soon as the five-centimeter-thick, final asphalt layer was applied at a temperature of 160 degrees Celsius, the bitumen melted and bonded the grid between the asphalt layers. The effect: thermal tension between the lower and upper layers is absorbed by the grid, preventing new cracks over the long term.

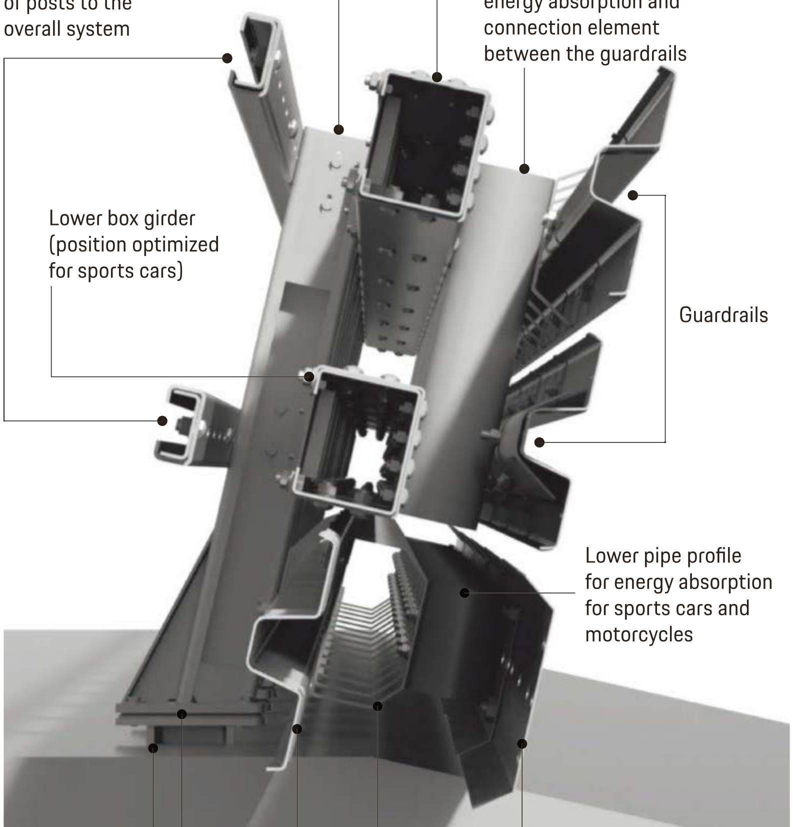
Thereafter, the construction workers rolled the mat at regular intervals to optimize the surface and make it extremely smooth. “We’re talking about irregularities in the millimeter range, which at high speeds would be clearly noticeable in the vehicle,” explains Antonio Leuzzi, project manager at Nardò Technical Center. “Bear in mind that the vehicles on the Circular Track can reach top speeds of over 300 kilometers per hour.” But Nardò is not principally important to the automotive industry as a record-breaking track—quite the contrary: “Here we provide a test track on which vehicles can be tested and optimized under constant conditions and under extreme continuous loads,” says Leuzzi. “Thanks to the special shape and quality of the track, it is possible to compare measured values over a long period of time, which is an important foundation for continuous improvement of vehicle systems.”

Patented guardrail system

The modernization of the Car Circular Track also included the renovation of the guardrail system. The newly installed solution was specially developed and patented by Porsche Engineering for the high-speed track at Nardò. It consists of two box profiles with three guardrails, including one for motorcycle riders. Deformation elements inside the system ensure that the vehicle is absorbed even at high speeds and the vehicle is smoothly guided back onto the track—with the objective of preventing a spin-out and excessive acceleration forces on the occupants. “Safety was our highest priority. To that end, over one hundred

Protection at high speeds

Maximum safety: the new guardrail system consists of two box profiles with three guardrails, including one for motorcycle riders. Deformation elements inside the system ensure that the vehicle is absorbed even at high speeds and smoothly guided back onto the track. The system also takes account of the changes in vehicle weight.



simulations and physical tests were carried out in order to find the best solution," explains Jaroslav Jirásek, project manager and Senior Manager in the Body and Safety department at Porsche Engineering Services in Prague, whose team carried out the extensive crash calculations. The innovative system also takes account of the changes in vehicle weight: today, SUVs, for example, are significantly heavier while simultaneously reaching high speeds.

Along the external patrol lane above the Car Circular Track, Porsche Engineering executed a third modernization measure: the construction of an IT infrastructure for the future state of the art. A pipe system houses electricity and data cables, with an access shaft every 100 meters. This will allow the installation of radio antennas that will enable tests on the basis of state-of-the-art wireless technologies like 5G. Automobile manufacturers will be able to test and develop connected mobility functions under real conditions. That runs from driver assistance systems to systems for highly automated driving and even autonomous vehicle concepts.

The advantage of having an in-house network: here, individual transmission cells can be switched off for testing purposes or transmission speeds reproducibly modified in order to test the effects of network utilization and malfunctions. The track also allows the use of future wireless transmission standards. The new IT testing capabilities are slated to become available for use in Nardò in 2020.

Porsche Engineering invested 35 million euros in the renovation of the Car Circular Track and the large Car Dynamic Platform. Now they are once again open to customers from the automotive industry year-round—the favorable weather conditions in southern Italy make it possible. In 2018 alone, over 90 different companies came to Apulia, including important manufacturers in the automotive industry. And thanks to the modernization of the test center, at least that many can be expected in the future as well.

IN BRIEF

Porsche Engineering has renewed large sections of the driving surface, the Circular Track, and the Car Dynamic Platform, installed a patented guardrail system and outfitted the NTC with a new IT infrastructure equipped for future technologies. But the expansion is far from finished. Further investments in fields such as e-mobility and autonomous driving are in the works.

Ethics expert: Professor Christoph Lütge wants to work in interdisciplinary teams to investigate the social questions raised by the use of artificial intelligence.

The conscience of artificial intelligence

Text: Monika Weiner Photos: Simon Koy

Professor Christoph Lütge heads one of the world's first research institutes for the ethics of artificial intelligence. At TU Munich, interdisciplinary teams will examine the consequences of software decisions. A central topic will be autonomous driving.

What if I simply stopped doing anything? The question shot through the mind of Professor Christoph Lütge as he drove in a highly automated car on the A9 from Munich to Ingolstadt for the first time in 2016. The test route had been opened a year earlier and vehicles that can accelerate, brake, and steer independently are allowed to use it. When a warning signal sounds, the driver has ten seconds to reassume control of the vehicle. And if the driver does not? What criteria does the on-board computer use to decide how to proceed? How does it prioritize? Lütge couldn't stop thinking about these questions. He had come across a new, cutting-edge field of research.

The 49-year-old professor of business ethics at the Technical University of Munich (TUM) has been researching how competition promotes corporate social and ethical responsibility for the past nine years. Before his test drive on the A9, he had had only a casual acquaintance with artificial intelligence (AI). Then he read studies, researched, talked to manufacturers. It quickly became clear to him that AI raises a number of ethical questions: who's liable if something goes wrong? How comprehensible are the decisions made by intelligent systems? The transparency of the AI algorithms is also still insufficient: it is still often impossible to understand the criteria on the basis of which they make their decisions—the AI becomes a black box. "We must face up to these challenges, whether AI is used for diagnosing medical findings, fighting crime, or driving cars," says Lütge. "In other words: we need to address the ethical issues surrounding artificial intelligence."

The idea that our life in the future will be determined by machines that know only logic but no ethics is an unsettling one for many people. In a survey conducted by the World Economic Forum (WEF) in 27 countries, 41 percent of a total of 20,000 respondents said they were concerned about the use of AI. 48 percent want stronger regulation of companies, and 40 percent more restrictions on the use of artificial intelligence by governments and authorities.

Ethics of autonomous driving

Autonomous driving is a particularly topical and difficult field, because it very quickly moves into the realm of human lives being at stake. For example, what should the AI algorithm do if the brakes fail and the fully loaded vehicle can either collide with a concrete barrier or drive into a group of pedestrians? What priorities should the AI set in this case? Should it value the lives of occupants higher than those of passers-by? Should it prioritize avoiding child victims as opposed to older people? "These are typical dilemmas that are explored by social scientists," says Lütge. They also played an important role in the Ethics Commission on Automated Driving set up by the Federal Ministry of Transport and Digital Infrastructure, to which Lütge belonged. "We agreed that there should be no discrimination based on age, gender, or other criteria. That would be inconsistent with the Basic Law." However, programming that minimizes the number of personal injuries is permitted.

"Even in normal road traffic situations, autonomous vehicles will ultimately outperform people."

Prof. Christoph Lütge

The question of liability is also a completely new one. If the vehicle was driven autonomously, the manufacturer would be liable—because then product liability applies. Otherwise the driver is liable. "However, in the future we will need a kind of flight recorder in the car," says Lütge. "It will indicate whether the autonomous driving functions were switched on at the time of the crash. This, of course, gives rise to questions concerning data protection." Despite all the challenges, the scientist is convinced that autonomous vehicles will make traffic safer. "They will be better than humans, because beyond not getting tired or losing focus, their sensors also perceive more of the environment. They can also react more appropriately: autonomous vehicles brake harder and evade obstacles more skilfully. Even in normal road traffic situations, they will ultimately outperform people."

Lots of AI competence at the Munich location

So there are many exciting questions for Lütge to chew on at his new Institute for Ethics in Artificial Intelligence at the TU Munich. It is being financed with 6.5 million euros by Facebook. There were no strings attached, he says. But of course Facebook is interested in the scientific results—it is, after all, one of the first research institutes to get started in this field. Munich was an obvious choice due to the TUM's reputation for AI expertise. Moreover, data protection is taken particularly seriously in Germany, and the population is generally comparatively critical of technological developments. At the new research institute, these skeptics will also find a hearing: "We want to bring together all the important players to jointly develop ethical guidelines for specific AI applications. The prerequisite for this is for representatives from the worlds of business, politics, and civil society to engage in dialog with each other," says Lütge.

For the research on ethics in AI, the scientist wants to form interdisciplinary teams to investigate the ethical salience of the new algorithms: "Technicians can program anything," says Lütge. "But when it comes to predicting the consequences of software decisions, you need the input of social scientists." That's why he wants to form interdisciplinary teams, with each tandem consisting of one employee from the technical sciences and one representative from the humanities, law, or social sciences. In addition, Lütge is planning project teams whose members will come from different faculties or departments. They will examine concrete applications, such as the use of care robots, as well as the ethical questions that arise in this context.

Lütge is already convinced that AI will find its way into many areas of life—because it offers enormous added value, for example in traffic: "In a few years, autonomous vehicles with varying degrees of automation will be part of the traffic landscape," predicts the researcher. According to the rules set forth by the Ethics Committee, the prerequisite is fulfilled when the autonomous vehicles are at least as good as a human driver—for example in terms of assessing the traffic situation and their reactions. Personally, he's looking forward to it: "When I get into an autonomous vehicle, I always feel a certain uncertainty in the first few minutes—until it becomes clear that the car reliably accelerates, brakes, and steers. Then I can hand over the responsibility very quickly. I enjoy the situation, because then I have time to think." For example, about what would happen if autonomous vehicles cross borders: would the same ethical decision algorithms apply there? Or would you need an update at every border? Such questions will undoubtedly keep Lütge busy for a long time to come.

Prof. Christoph Lütge is an expert in business and ethics. Since 2010 he has held the Peter Löscher Endowed Chair of Business Ethics at the TU Munich. Lütge is also a visiting researcher at Harvard University.

Guidelines on ethics and AI

EU High-Level Expert Group:
Ethics Guidelines for Trustworthy AI (report from April 2019)

In setting forth ethics guidelines, a High-Level Expert Group on artificial intelligence aimed to create a framework for achieving trustworthy AI. The guidelines are intended as an aid for the potential implementation of principles in socio-technical systems. The framework addresses concerns and fears of members of the public and aims to serve as a basis for promoting the competitiveness of the EU across the board.

Ethical fundamentals/principles in the AI context

1. Respect for human autonomy
AI systems should not unjustifiably subordinate, coerce, or deceive humans. They should support humans in the creation of meaningful work.

2. Prevention of harm
AI systems should not cause harm. This entails the protection of mental and physical integrity. They must be technically robust to ensure that they are not open to malicious use.

3. Fairness
AI systems should promote equality of access to education and goods. Their use should not lead to people being impaired in their freedom of choice.

4. Explicability
Processes and decisions must remain transparent and understandable. Long-term trust in AI can only be achieved through open communication of its capabilities and uses.

View the complete guidelines at:

Bundesministerium für Verkehr und digitale Infrastruktur

Ethics Commission:
Automated and Connected Driving (report from 2017)

The interdisciplinary Ethics Commission convened by the German Federal Ministry of Transport and Digital Infrastructure developed guidelines for automated and connected driving.

Automated and Connected Driving: Excerpt from the rules

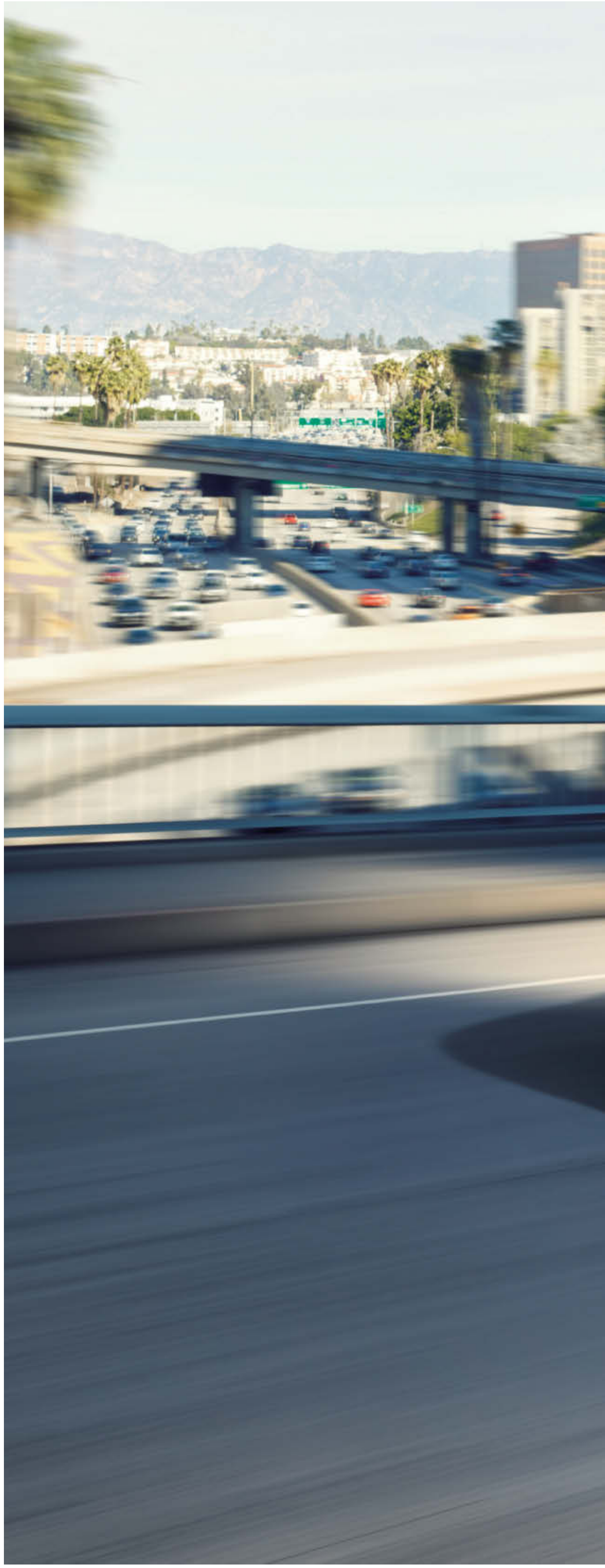
Rule 2
The licensing of automated systems is not justifiable unless it promises to produce at least a diminution in harm compared with human driving, in other words a positive balance of risks.

Rule 7
In hazardous situations, the systems must be programmed to accept damage to animals or property in a conflict if this means that personal injury can be prevented.

Rule 9
In the event of unavoidable accident situations, any distinction based on personal features (age, gender, physical or mental constitution) is strictly prohibited.

Rule 10
In the case of automated and connected driving systems, the accountability that was previously the sole preserve of the individual shifts from the motorist to the manufacturers and operators of the technological systems and to the bodies responsible for taking infrastructure, policy, and legal decisions.

View the complete guidelines at:



Like a bolt

Text: Hans Oberländer

Contributors: Holger Meister,
Dr.-Ing. Bernd Propfe, Volker Watteroth

The Taycan is setting new standards for electrically powered sports cars: innovative, state-of-the-art technology, trimmed for the everyday needs of drivers. One particular highlight is the range management functions developed by Porsche Engineering.

With the Taycan, Porsche is ushering in a new, all-electric era. And how! A touch of the accelerator pedal uncorks the astonishing power of two electric motors on the axles. An overboost output of up to 560 kW (761 hp) propels the Taycan Turbo S as if it were shot like an arrow. With only minimal sound, it goes from 0 to 100 kilometers per hour in just 2.8 seconds and hits 200 kilometers per hour in 9.8 seconds before finally topping out at 260 kilometers per hour. No question: both the Taycan Turbo S and the up to 500 kW (680 hp)strong Taycan Turbo are thoroughbred Porsche sports cars, with all the virtues that have been associated with their combustion-engine relatives for decades. Yet the four-door and four-seat coupé is also decidedly different from all other Porsche models. The vehicle is designed from the ground up as an all-electric sports car; its engineers took advantage of every freedom to extract the maximum technical potential from the vehicle concept.

Porsche Taycan Turbo

Electricity consumption
(in kWh/100 km) combined: 26.0
CO_2 emissions combined: 0 g/km
Efficiency class:
Germany: A+
Switzerland: B

Porsche Taycan Turbo S

Electricity consumption
(in kWh/100 km) combined: 26.9
CO_2 emissions combined: 0 g/km
Efficiency class:
Germany: A+
Switzerland: B

The dawn of a new era: the Taycan is the first all-electric vehicle from Porsche.

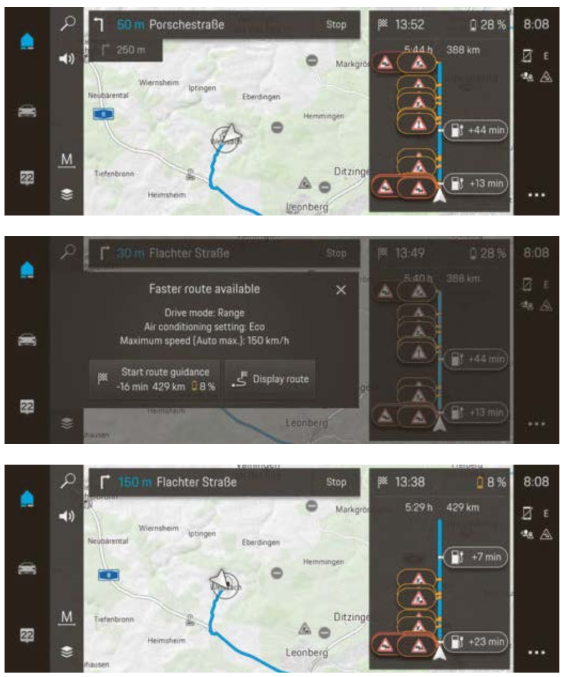
Selection of driving modes: Sport Plus and Sport are especially agile, while Normal and Range optimize the range.

"The important thing was to fine-tune the battery performance for strong, sustained performance," says Dr. Bernd Propfe of Porsche AG. The project manager for the Taycan platform drove the sports car over many thousands of kilometers in road tests. "The Taycan brings its strengths to bear in everyday situations in particular: as long as there's power in the battery, the full performance is available at all times." The Taycan is very easy to drive, says Propfe: "I looked forward to every roundabout." The integrated chassis control analyzes and synchronizes all chassis systems in real time, from the air suspension to the electromechanical anti-roll stabilization. When the car brakes, it's usually by way of the two electric motors and without activating the wheel brakes—a feat made possible by the high recuperation capacity of up to 265 kilowatts.

Best aerodynamics of any Porsche model

The just five-meter-long and two-meter-wide Taycan owes its outstanding handling not least to the battery, which packs 93.4 kilowatt-hours of energy and weighs in at roughly 630 kilograms, including frame and cooling. The skateboard, as it is known, features indentations in the back-seat floor—"foot garages" for the passengers in the rear. This allows them to ride in comfort in spite of the Taycan's typical Porsche silhouette with a sloping rear roofline. The aerodynamic design contributes to the Taycan's c_d value of 0.22, the best figure posted by any current Porsche model—which lowers the fuel consumption and increases the range.

For many drivers, these are the decisive criteria when buying an electric car. Measured with the WLTP method, the Taycan Turbo has a range of up to 450 kilometers, and the Turbo S up to 412 kilometers. The two cars are the first series vehicles to use a system voltage of 800 volts rather than the usual 400 volts. That significantly reduces charging times: at the maximum charging capacity at a DC fast charging station, the batteries can be charged from five percent to up to 80 percent within 22.5 minutes; just about five minutes of charging time is good for roughly 100 kilometers of driving. Connected to an AC wall box with eleven kilowatts at home, the 80% charge takes around six hours.



Precise forecast: upon starting, the Porsche Charging Planner determines a remaining charge of 28 percent at the destination for a trip in "Normal" mode with two charging stops. The optional Porsche Intelligent Range Manager can automatically optimize the route if the destination can be reached more quickly through shorter charging stops if, for instance, the top speed is simultaneously restricted. In Range mode, the battery would have a remaining charge of eight percent at the destination.

> **"As soon as the driver inputs a destination, an intelligent algorithm precisely calculates the range based on knowledge of the route ahead, the current traffic situation and other environmental factors."**
>
> Holger Meister,
> Development Engineer

The range is highly impacted by the individual driving style of the driver and the selection of one of the four driving modes of the Taycan. They provide special settings to make optimal use of the capabilities of the powertrain. For an especially agile and dynamic drive, Sport or even Sport Plus are the right choice. For those seeking maximum range, the Normal or Range settings are preferable. "In Range mode, a maximally efficient all-wheel drive distribution is applied. The top speed is limited to 90 to 140 kilometers per hour, though it can always be overridden with the accelerator pedal," says Volker Watteroth, a Development Engineer at Porsche Engineering. "Cooling air flaps, chassis level, and rear spoiler are set for minimum drag in Range mode. The air-conditioning system, hydraulic pumps, air suspension, and main headlights are operated in the most efficient mode."

All this extends the trip, but even here the battery is eventually spent. And it's like in motor racing: a well-timed pit stop is key, and no one wants to run out of juice mid-race. To ensure that doesn't happen, Porsche introduced three clever functions with the Taycan that will make long-distance drives with an electric vehicle considerably more convenient. One is the range calculation, which has been in development at Porsche Engineering since 2012. "As soon as the driver enters a destination, an intelligent algorithm precisely calculates the range based on knowledge of the route ahead, the current traffic situation, and other environmental factors," says Holger Meister, Development Engineer at Porsche Engineering.

The system learns kilometer by kilometer

The range calculation also analyzes data from the vehicle. What is the preferred driving speed? What's the setting of the air-conditioning system? The system keeps learning with each additional kilometer and estimates the range—in real time: a traffic jam changes the estimated arrival time, as does a swift trip in the passing lane. This approach is also used by the Charging Planner, the second new function in the Taycan. As part of the navigation function, the software plans charging stops to ensure that the Taycan still has an adequate minimum range at the destination.

"We want to keep the charging stops as short as possible," says Watteroth. For this reason the Charging Planner prefers High Performance Chargers (HPC), which offer a charging capacity of 350 kilowatts. To charge there with maximum performance, the battery is pre-conditioned to the optimal temperature.

The functional scope of the Charging Planner can be augmented with the optional Porsche Intelligent Range Manager (PIRM), the third new Taycan function. Through the optimal selection of system parameters, the travel time in drive mode Range can be substantially shortened compared to the route in other driving modes. To achieve this, the charging stops, the speed profile, and air-conditioning settings are optimized. "During testing in France, we managed more than 400 kilometers between charging stops without having to dispense with the comfort of the AC system, and we arrived at the destination significantly earlier than the group that traveled without PIRM," says Watteroth.

Porsche Engineering has been developing the range management functions with the aid of a virtual Taycan since 2015. "It features a drivetrain model validated in terms of driving performance and consumption, a cabin model for interior air conditioning and a thermal model for the high-voltage battery," says Watteroth. "To check the functions, we have created a model that contains route data including charging stops and simulates traffic situations and driving behavior. Even before the Taycan was approved for road use, we were able to conduct long-distance journeys with the virtual Taycan and optimize the travel time. The series application was also done on the virtual vehicle."

The engineers at Porsche Engineering are meanwhile already at work on a new generation of range management. "We will pay very close attention when we get some initial feedback from the Taycan customers and optimize accordingly," says Meister. And because the range calculation function developed by Porsche will be used throughout the entire VW Group across all drive types, the team will be bringing its expertise to future Porsche and VW Group models as well. To borrow an old notion: the better is the enemy of the good.

800 volts

of system voltage ensure significantly shorter charging times.

2.8

seconds

are all the Taycan Turbo S needs for its sprint from 0 to 100 kilometers per hour.

450 km

is the maximum range of the Taycan Turbo in the WLTP test cycle. In the more powerful Taycan Turbo S, the figure is 412 kilometers.

Powerhouse: the new six-cylinder naturally aspirated engine is the latest member of the legendary boxer engine family from Porsche.

718 Cayman GT4 / 718 Boxster Spyder

CO_2 emissions (combined): 249 g/km
Fuel consumption:
Urban: 15.6 l/100 km
Highway: 8.1 l/100 km
Combined: 10.9 l/100 km
Efficiency class:
Germany: G
Switzerland: G

718 Boxster/Cayman

CO_2 emissions (combined):
186 g/km–180 g/km
Fuel consumption:
Urban:
11.3 l/100 km–10.8 l/100 km
Highway:
6.3 l/100 km–6.2 l/100 km
Combined:
8.1 l/100 km–7.9 l/100 km
Efficiency class:
Germany: F
Switzerland: G

911 Carrera S

CO_2 emissions (combined): 205 g/km
Fuel consumption:
Urban: 10.7 l/100 km
Highway: 7.9 l/100 km
Combined: 8.9 l/100 km
Efficiency class:
Germany: F
Switzerland: G

911 GT2 RS

CO_2 emissions (combined): 269 g/km
Fuel consumption:
Urban: 18.1 l/100 km
Highway: 8.2 l/100 km
Combined: 11.8 l/100 km
Efficiency class:
Germany: G
Switzerland: G

Modern continuation

Text: Christian Buck Contributors: Markus Baumann, Thomas Wasserbäch

The current Porsche 718 Spyder and 718 Cayman GT4 models are powered by a newly developed, six-cylinder, naturally aspirated boxer engine with four liters of displacement and 309 kW (420 hp). It is the latest member of a family of boxer engines featuring a modular design that has been continually expanded since 2015.

The legendary 550 Spyder of 1953 is considered the forerunner of the entire Porsche Boxster family. Ever since then, the mid-engine and roadster concept, low weight, and high agility combined with maximum driving pleasure have been typical for the sports cars from Stuttgart-Zuffenhausen. Although the Spyder was the first model specifically developed for racing, it was also available in a street-legal version.

The 550 was followed by other Porsche Spyders for racing use, such as the 718 RS 60 of 1960, the Bergspyder of the 904, 906, 908 and 909 series, and the 936 Spyder. The RS Spyder made its debut in 2005 and became a regular winner in the American Le Mans Series. Among the road sports cars, the designation was revived in 2007 with the Boxster RS 60 Spyder special model and in 2010 with the Boxster Spyder. The successor of 2015 with the internal designation 981 received a 3.8-liter, six-cylinder engine with 276 kW (375 hp), which had been derived from the 911 Carrera S (type 991) and was based on the 9A1 modular engine system.

High emotionality, better driving performance

Now the task was to continue the success story. To this end, Porsche has developed a new six-cylinder, four-liter, naturally aspirated engine for the 718 model series (type 982), which is used in both the 718 Spyder and the 718 Cayman GT4 (9A2evo B6S). It is based on the 9A2 boxer engines and delivers 309 kW (420 hp). “The requirements for the new boxer engine were clear,” says Thomas Wasserbäch, Head of Development for Boxer Engines and E-axle Sports

Cars at Porsche. “It had to have a high level of emotionality and enhanced driving performance as well as the unique, characteristic sound of a boxer engine from Porsche. It was also clear that we wanted to keep the mid-engine configuration and the typical vehicle design.” Also required were a low engine height, a low center of gravity and low weight. Reducing fuel consumption and complying with the latest legal requirements were also key points on the list of requirements.

Since the performance characteristics of the engine have a significant influence on the driving experience, Porsche relies on six-cylinder naturally aspirated engines for the 718 Spyder and 718 Cayman GT4 models, focusing on characteristics such as immediate response and linear power delivery. Another certain source of emotion behind the wheel will be provided by the enhanced revving ability as well as the boosts in nominal and maximum engine speed, which are now at 7,600 and 8,000 rpm, respectively. Heightened driving pleasure is also provided by the high-revving configuration, which ensures a steady increase in torque up to a maximum of 420 Nm—at engine speeds between 5,000 rpm and 6,800 rpm.

Based on the 9A2 modular system

The engineers derived the basic engine from the existing 9A2 modular system and optimized it for the requirements of a high-speed naturally aspirated engine. “For use as a naturally aspirated engine, we have essentially completely redeveloped the valve train, the cylinder head with cross-flow cooling, the intake system and the exhaust gas routing,” says Wasserbäch. “We were able to adopt proven systems such as the integrated dry sump with a plastic oil pan, the timing and belt drive as well as the thermal management with switchable water pump from the 9A2evo turbo engine with minor adjustments.” This showed the advantage of the modular design: on the one hand it allows the use of identical parts; on the other hand, modified parts can be machined on the same production lines.

The three-part intake system with complex internal geometry is manufactured with the sand casting method. The system integrates two plastic resonance dampers with a diameter of 75 millimeters and 110 millimeters, respectively, which are vacuum-controlled depending on the engine load and speed. Both flaps are closed in the default state. Behind the throttle valve, the incoming air is distributed via a collection volume to the two cylinder banks. By opening the flaps, further volumes for crosstalk between the cylinder banks can be coupled step by step.

The fuel system was derived from the three-liter turbo engine for the piezo nozzle combustion process and adapted for use in the naturally aspirated engine with a mid-engine configuration. The piezo nozzles of the engine are supplied with fuel by two high-pressure fuel pumps via distributor bars. The high-pressure systems of the two cylinder banks are separated and monitored by separate sensors. Fuel is supplied to the pumps via a cross-bench low-pressure system. The pumps are arranged on the cylinder heads in the same way as the 9A2 modular system and are driven by the intake camshafts via roller plungers. For the high-speed naturally aspirated engine, the developers have modified the drive cams of the high-pressure pumps compared to the turbo engines of the 9A2 modular system.

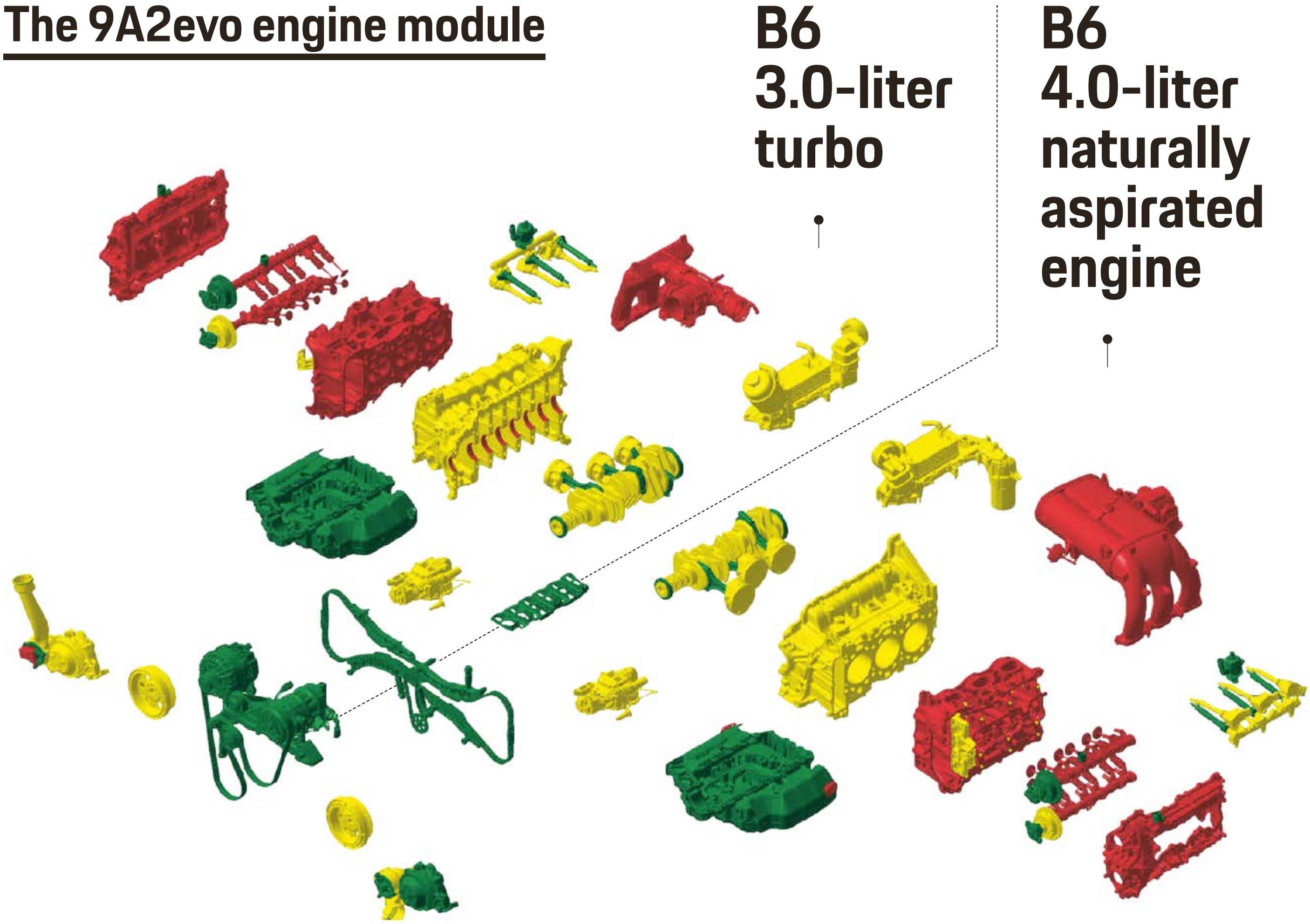
The cylinder head package proved to be a particular challenge for the new naturally aspirated engine. “We had to achieve high cylinder charges, which leads to significantly larger valve diameters than with turbo engines,” says Wasserbäch. “On the basis of our experience with the central injector system in three-liter turbo engines, we decided to reassess the arrangement of the spark plug and injector in the combustion chamber for the naturally aspirated engine.” Tests with a single-cylinder engine confirmed the new positioning of the injector in the combustion chamber roof area on the exhaust side—this opens up a considerably longer

Technical data

Four-liter, six-cylinder naturally aspirated boxer engine

Displacement: **3,995 cm³**	Ignition sequence: **1-6-2-4-3-5**
Output: **309 kW (420 hp)**	Bore: **102 mm**
Max. torque: **420 Nm**	Stroke: **81.5 mm**
Cylinder spacing: **118 mm**	Compression ratio: **13**
Number of valves: **4**	Exhaust: **EU6 DG**

The 9A2evo engine module



● Identical parts ● Identical technology ● Parts especially for turbo or naturally aspirated engines

time window for multiple injection strategies. "The spark plug thus reassumes the central position in the combustion chamber, which supports more even and symmetrical flame progression," explains Wasserbäch.

For the exhaust system, the developers have adopted the proven two-flow basic principle of the predecessor, which consists of exhaust manifolds with catalytic converters close to the engine, exhaust routing over the rear axle and a central silencer. In order to comply with the EU6 DG emissions legislation, one gasoline particulate filter is used per cylinder bank. In addition, the new combustion process with a piezo nozzle ensures particularly low raw particle emissions. The silencer has been completely redesigned. "Its design emphasizes the higher engine orders," says Wasserbäch. "This produces a unique sound with a high recognition value, as is expected from a six-cylinder boxer naturally aspirated engine from Porsche."

118

millimeter cylinder spacing: this also applies to the latest addition to the boxer engine family. It thus remains true to the tried-and-tested basic concept in place for decades.

The new engine is part of the Porsche boxer family. It consists of a whole range of naturally aspirated and turbocharged engines with four or six cylinders and displacements between two and four liters, delivering 220 kW (300 hp) in the 718 Boxster/Caman, 331 kW (450 hp) in the 911 Carrera S, and 515 kW (700 hp) in the GT2 RS. Over recent decades, engineers have consistently advanced the technology and have thus been able to continuously enhance performance, efficiency and emotionality. Nevertheless, the basic concept is still recognizable—maintaining a constant cylinder spacing of 118 millimeters, for example. "The boxer engine, with its success story spanning more than 70 years, will continue to play a central role at Porsche in the future," says Wasserbäch. "But of course it has further potential for improvement, for example through electrification or operation with climate-neutral synthetic fuels." It will be interesting to see how the venerable engine family will grow in the future.

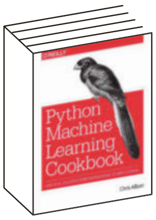
Outside the box

Deeper knowledge

DIY neural networks

If you're keen to try your hand at making your own neural network, why not give the programming language Python a try? This book, currently only available in German, will guide you through the first steps, as well as introducing you to Google's TensorFlow AI library.

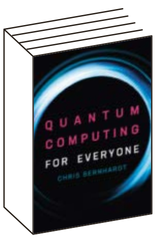
Neuronale Netze programmieren mit Python
Roland Schwaiger, Joachim Steinwendner
Rheinwerk 2019



AI recipes

If you're interested in delving a little deeper into machine learning and would like to know more about how to prepare data and the many other AI methods such as support vector machines, this book will prove useful source material.

Machine Learning with Python Cookbook
Chris Albon
O'Reilly Media 2019



Taking a look around quantum physics

Qubits, entangled states, and quantum gates: The author offers a readily comprehensible introduction to the alien world of quantum computing. You'll need to bring a bit of linear algebra—but it's worth it.

Quantum Computing for Everyone
Chris Bernhardt
MIT Press 2019

The big picture

The gates of tomorrow

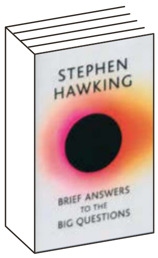
In their German-language podcast *t3n*, editors Luca Caracciolo and Stephan Dörner invite celebrity guests to talk about the latest in digital issues—for instance about the future of the automobile.

***t3n* podcast**
www.t3n.de/podcast

A life without news

The author recommends unplugging and consuming less news. The rewards that beckon are a stress-free digital life, the ability to think more clearly, and less hustle and bustle.

Stop Reading the News
Rolf Dobelli
Sceptre 2020



A genius's legacy

The world-famous scientist's last book takes on the really big questions—to name just a few: Where do we humans come from? Are there other intelligent species out there in the universe? Does God exist?

Brief Answers to the Big Questions
Stephen Hawking
John Murray 2018

For the child in all of us

Mission E all the way

Secret agent Rex Dasher always cuts to the chase in his flash, white, electric Porsche “Mission E.” In *Playmobil: The Movie*, he drives it through many an adventure; in real life you can play with the e-sports car. Remote-controlled, it’s a joy to use for both young and old Porsche fans.

Playmobil: The Movie **(movie)**
Playmobil: Rex Dasher’s Porsche Mission E (toy)

Mini computer, max power

Just the thing for those long Yuletide days: the Raspberry Pi 4 lets you control robots, set up a smart home, or run desktop apps. The single-board computer you won’t be able to put down.

Raspberry Pi 4
www.raspberrypi.org

Experimenting with AI

The single-board computer Jetson Nano features a quad-core CPU and an integral 128-core GPU. This gives it sufficient computing power to play around with AI software.

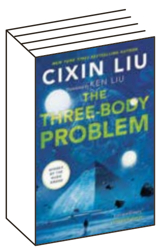
NVIDIA Jetson Nano Developer Kit
www.nvidia.com

Intelligent entertainment

In love with an android

Captivating sci-fi movie about artificial intelligence: the programmer Caleb (played by Domhnall Gleeson) falls in love with the android Ava (Alicia Vikander)—but she’s only using him to make good her flight.

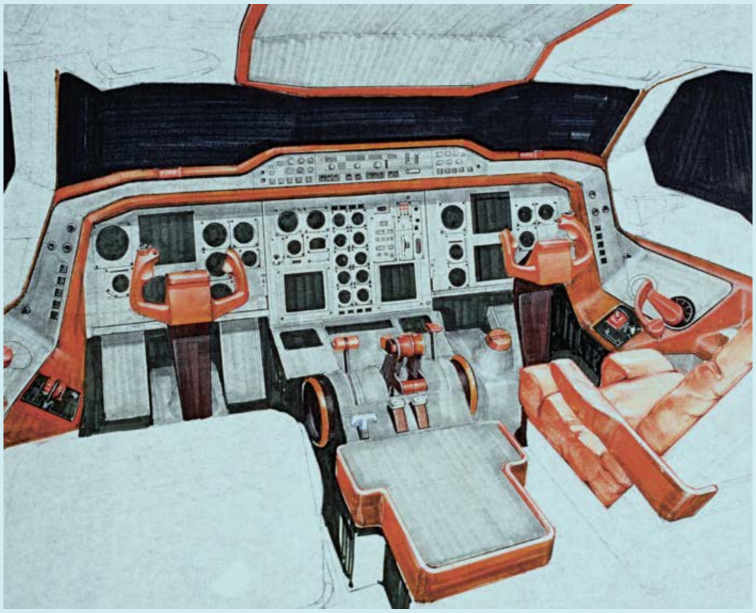
Ex Machina
Alex Garland (director); DVD (Universal Pictures)



Award-winning science fiction

In his book, the lauded Chinese science fiction author describes first contact between humankind and an extraterrestrial civilization, whose home plant is part of a triple-sun system. The story received the acclaimed Hugo Award for best science fiction novel in 2015.

The Three-Body Problem
Cixin Liu
Head of Zeus Ltd. 2015



A glimpse of the future: this was the designers' vision of the cockpit in the Airbus A310.

Model: Porsche set up the new cockpit in Weissach.

1980

The beginning of an ambitious joint venture: Porsche and Airbus develop a completely new cockpit layout. Clear design is intended to make the pilots' workplace more ergonomic, plastic replacing sheet metal and steel to produce gentler contours. The new cockpit saves weight and space and also improves maintenance access.

Right off the bat, the December 1996 issue of Airbus's *FAST* magazine hinted at a revelation to come: Airbus Industries, it said, had chosen "industrial designers of global fame" to devise a cockpit that would make for a pleasant, comfortable, and modern workplace for the crew. The color scheme had been chosen based on ergonomic criteria and implemented consistently: "Light blue for dashboards, dark blue for paneling and worktops, black for handles, and gray for buttons and knobs." The lighting had been afforded particular focus: large illuminating surfaces provide brightness without shadows in the Airbus cockpit. Even the pilots' seats had been redesigned, including "optional headrests and lots of ways to adjust the seats." And it is here that, in what is hardly more than an aside, the text finally reveals who the mysterious designers reworking the cockpit actually are: "The seats will be upholstered in the same material used in Porsche vehicles."

It all started in July 1980. Following early talks between Airbus Industries and Porsche, work on the new Airbus cockpit began in Weissach. The objective was to improve the airplane crews' working conditions and to refine the styling. Porsche had the first drafts ready no later than August. These were well received, leading to the definition of detailed project specifications—which included among other things improving the seats and reworking the controls. In May the following year, Airbus Industries awarded Porsche the job of designing a new cockpit for the A310. Instead of sheet metals and steel profiles, the designers at Porsche went for gently curving, softer plastic surfaces, with a keen eye to a harmonized color palette. The collaboration, which went on until 1984, would set in motion a key trend with the idea of using monitor screens in place of the previously conventional analog instruments—today, digital displays are the norm in cockpits.

For a short while, Roland Heiler was on the team, too. "In 1981, I was studying at the Royal College of Art in London," he remembers. Today, he is head of the Porsche Design Studio in Zell am See. "I spent six weeks in the summer break as an intern in Weissach." At the time, there was a true-to-scale model of an Airbus cockpit there, for the designers to play with new ideas. "The aim was to prepare the cockpit for the new electronic flight controls," Heiler says. "Myself, I joined in working on the new seat designs. We spent a lot of time making detailed models from foamed material, and later from clay."

The article in the 1996 issue of *FAST* proves that many of the ideas dreamed up in Weissach really made it into new Airbus airplane models. How many pilots today still know whom they have to thank for their cockpits?

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