tomorrow

EXPERIENCING TECHNOLOGY WITH SCHAEFFLER

In motion

Innovative vehicle engineering,
yesterday, today and tomorrow

From A to B

On two feet, on two or four wheels,
across bridges and oceans

Issue 2/2017 · Motion

SCHAEFFLER

Mo∫tion - ['mouʃən]

Motion [noun] stands for

(1) The action or process of moving or changing place or position; movement

(2) Power of movement, as of a living body

(3) The manner of moving the body in walking; gait

(4) A bodily movement or change of posture; gesture

(5) A proposal formally made to a deliberative assembly

(6) Law: An application made to a court or judge for an order, ruling, or the like

(7) A suggestion or proposal

Source: Dictionary.com

DEAR **READER,**

The world is in motion. And it's moving pretty fast. This is true in a metaphorical sense in the form of technological progress but literally speaking as well. After all, the Earth rotates around its own axis once a day which equates to a speed of 1,670 km/h or 1,037 mph. So while you're relaxing and leaning back to read these lines you're actually rotating around the Earth's axis at the speed of a jet aircraft. Now, if even a subjective sense of standstill involves an enormous pace, conversely, this means: It's not possible not to move. With this little intellectual game I'd like to welcome you to this new issue of our technology magazine "tomorrow." The focus topic – you may have already guessed – is "motion."

Motion is a cornerstone of our company. The aforementioned technological progress, to which Schaeffler provides important impetus, not least by its more than 2,300 patents filed in 2016 alone, is one reason and our expertise in plain and rolling bearings another. Be it the London Eye Ferris Wheel, lock gates in the Panama Canal or rocket engines on their way into space – wherever something is in motion there's a high probability of at least one of our more than 225,000 Schaeffler components being involved – perhaps even in the drill used by your dentist. In this field, we supply high-precision bearings in the millimeter range that rotate at speeds of several hundred thousand rpm. Even though we've contributed a lot to the development of the bearing with our innovations we're not the ones who invented it. After all, the history of the rolling bearing dates back more than 2,700 years – and makes for a really exciting read. More on this starting on page 50.

A device for locomotion that is 200 years old these days is the bicycle. And the older it gets the more popular it becomes. The electrification of the drivetrain helps drive the bicycle's popularity, the so-called pedelecs recording the highest growth rates. With the four-wheel Bio-Hybrid Schaeffler also has a contribution to mobility for tomorrow ready in this area. You can read about the evolution from the draisine to the Bio-Hybrid starting on page 64.

Naturally, the automobile will retain a firm place in the future mobility mix too. It goes without saying that it will have to adjust to new conditions in this context. But the automobile has been doing this ever since Gottlieb Daimler covered the first meters in his motor car. Heraclitus' famous words "There is nothing permanent except change" perfectly fits an industry that looks back on storied times (the related article can be read on page 40 ff) – and for which exciting times are yet to come with the electrification of the powertrain and digitalization (starting on page 104).

The "New Mobility World" is a focal topic at the International Motor Show (IAA) as well. That's why it's no coincidence that the new issue of "tomorrow" is published right in time for the leading trade show in Frankfurt. For those of you who will not have an opportunity to obtain information about our innovations and ideas for mobility for tomorrow at the Schaeffler booth, we have compiled all the details in a Fact Sheet "IAA" and attached it to this issue of "tomorrow."

In closing, I hope you'll enjoy an exciting read about digital nomads on the move, hikers in Britany, connecting bridges, captains at sea, suspended railways, mopeds in Asia and explorers embarking on daring automotive adventures.

Klaus Rosenfeld
Chief Executive Officer

global

A glimpse of the world

in motion

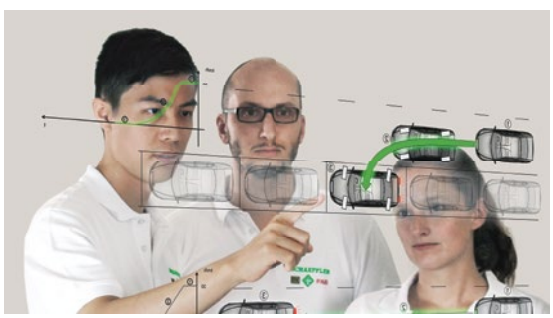
Innovations in the course of time

here and now

Living with progress

outlook

Technology for tomorrow



GREEN LIGHT FOR BIKES

China's long cycling tradition is experiencing a revival in Xiamen. The cityscape of the metropolis with its population of three and a half million in the country's southeast has included an unusual pathway since 2017. The world's longest elevated bicycle route connects the city's five major residential districts with three business centers. Designed by the Dissing+Weitling architectural firm, the "Bicycle Skyway" became reality within the space of just six months. Boasting a width of up to 4.8 meters (157.5 feet), the Bicycle Skyway elegantly meanders underneath a bus rapid transit line high above the road, encouraging residents to switch from motorized transportation to muscle power on a central axis as desired by the city administration. Eleven entry and exit points, including a looped one, connect the Xiamen Bicycle Skyway with eleven bus stops and two subway stations. With 355 rental bikes available, commuters not even need to own a bicycle, although 253 bike parking places on seven platforms also offer ample space to those who do. Read more about bicycles starting on page 64.

» Ride as much or as little, or as long or as short as you feel, but ride

Eddy Merckx (*1945),
Belgian bicycle racing legend

global

A glimpse of the world

MAJOR CYCLE HIGHWAYS*

500 km **Cycle Super Highways** network of 28 cycle lanes in Copenhagen (DK)

100 km **Cycle Highway Ruhr RS1** between Duisburg and Hamm in the Ruhr District (D)

60 km **F35 Fietssnelweg** between Nijverdal and Enschede in the Netherlands

45 km **RS2 Regio.Velo** between Isselburg and Coesfeld in the western Münsterland region (D)

30 km **Cycle Highway Euregio** between Aachen and Herzogenrath in the west of Germany

29 km **East West Superhighway** between Barking and Acton in London (GB)

*partially still in planning stage

360° MOTION

Facts, figures, oddities – a look at the focal topic of this issue of "tomorrow" from various angles.

by Volker Paulun and Alexander von Wegner

HOW FAST IS LIGHTNING?

The answer to this question is indeed impressive. The return stroke (the visible flash) moves upward at a speed of about 100,000 km/s (62,137 mi/s), in other words at a third of the speed of light.

A RECORD-SETTING SCHAEFFLER ENGINEER

If you google Harald Elendt you'll find a large number of patents based on inventions made by the Schaeffler engineer, plus a world record that Elendt set with an e-bike he developed himself. ***He achieved a speed of 102 km/h (63 mph) with the 9.5-hp bike.*** *"As a techie, it was a challenge for me to see what was possible with muscle power and a pedelec," Elendt says, explaining his motivation. For maximum riding stability, he installed an electric motor on both the front and rear wheels to assist his own pedaling energy. Elendt uses the same propulsion concept for the miniseries of production pedelecs made by his factory named Zorque Bikes.*

1925

was the year in which the first Rolls-Royce Phantom was launched on the market, soon to be followed by the eighth generation in 2018. No model name has survived the then 93 years longer than the Phantom.

> ***While accelerating, the tears of emotion have to flow off in a line that's level with the ears***
>
> Walter Röhrl

60 – 150 MINUTES
OF JOGGING PER WEEK PROLONGS A PERSON'S LIFE BY ABOUT SIX YEARS, ACCORDING TO A DANISH LONG-TERM STUDY.

MOVING WITH ANIMAL EFFICIENCY

Due to the way they leap, kangaroos need far less kinetic energy than equally fast four-legged animals of the same weight. Surprisingly, they ***consume less power at 20 km/h (12.4 mph) than at 6 km/h (3.7 mph).*** *The reason is that their muscle fibers and tendons act like spiral springs that are compressed when the kangaroo lands and release the recuperated energy again when it leaps.*

GIANT BIRD

Stratolaunch is a goliath of the airways. The 117-meter (385-ft) wingspan of the world's largest aircraft is almost twice that of a jumbo jet. ***Suspended from the giant wings are two fuselages and six engines.*** *The aircraft with a landing gear that uses 28 wheels weighs a total of 230 metric tons (253.5 short tons). Like its name, Stratolaunch, suggests, the giant bird that might be making its maiden flight in 2019 at the earliest is designed to carry satellites, cargo and even passengers someday into near-earth orbits.*

THE FASTEST **LIVING CREATURES**

70 **Orca** *(fastest swimming mammal)*
Ostrich *(fastest running bird)*

50 **Darner** *(fastest flying insect)*
44 **Usain Bolt** *(fastest running man)*
36 **Gentoo penguin** *(fastest swimming bird)*
35 **Leatherback sea turtle** *(fastest swimming reptile)*
Spinytail iguana *(fastest running reptile)*
9 **Tiger beetle** *(fastest running insect)*

96 **Free-tailed bat** *(fastest flying mammal)*
110 **Indo-Pacific sailfish** *(fastest fish)*
120 **Cheetah** *(fastest terrestrial animal)*
127 **Gray-headed albatross** *(fastest bird in flight)*
322 **Peregrine falcon** *(fastest bird in diving flight)*

km/h

THE FASTEST **MACHINES**

495 **Venturi Buckeye Bullet 2.5** *(fastest electric car)*
420 **Bugatti Chiron** *(fastest production car)*
139.45 Todd Reichert's **recumbent bicycle with a shell**
121.12 **Vestas Sailrocket 2** *(fastest sailboat)*
105.88 **Electric car "La Jamais Contente"** *(1899 first terrestrial vehicles above 100 km/h/62 mph)*
72 **Elevator at the CTF Finance Centre,** *Guangzhou (CN)*

511.13 **Spirit of Australia** *(fastest motorboat)*
563 **JCB Dieselmax** *(fastest diesel car)*
603 **Shinkansen Maglev LO** *(fastest manned rail vehicle)*
634.217 **Ack Attack Streamliner** *(fastest motorcycle)*
1,227.98 **Thrust SSC** *(fastest terrestrial vehicle)*
11,850 **X-43** *(fastest aircraft)*
252,792 **Helios 1 and 2** *(fastest spacecraft)*

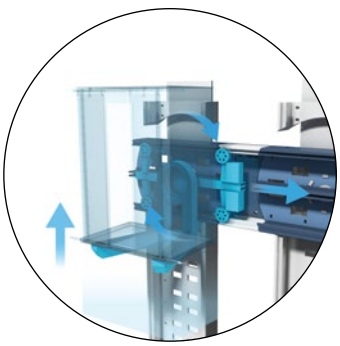
km/h

(IM)MOVABLE PROPERTY

An unrealistic fantasy or an ingenious idea? In the case of the "Analemma" tower that's a question not only debated by experts. Suspended from a "domesticated" asteroid, the futuristic building with a height of several thousand meters is supposed to orbit around the Earth describing an eight – nonstop at a speed of 500 km/h (310.7 mph). **Drones will shuttle people and goods back and forth. Electricity will be generated by solar power and water purified in a circulating system.** On board of the "Analemma," there are greenhouses, shopping centers, hospitals, offices and whatever else people may need for daily living.

MEDICINE IN MOTION: BASED ON THE IDEA OF AN AUTONOMOUS VEHICLE, THE ARTEFACT GROUP HAS DESIGNED A MOBILE CLINIC. IF A PATIENT'S SMARTPHONE REPORTS A MEDICAL ISSUE, AN "AMBULANCE 4.0" IS DISPATCHED. THE PATIENT CAN GET A CHECKUP USING HIGH-TECH DIAGNOSTICS AND CAN EVEN HAVE OVER-THE-COUNTER DRUGS DISPENSED IF NECESSARY OR COMMUNICATE WITH A DOCTOR BY VIDEO CONFERENCING. IF THE NEED FOR A DOCTOR OF FLESH AND BLOOD SHOULD ARISE THE MOBILE MEDICAL UNIT TURNS INTO A REAL AMBULANCE. IT WILL TAKE THE PATIENT TO THE NEAREST HOSPITAL TO WHICH ALL THE KEY DATA HAVE ALREADY BEEN TRANSMITTED.

artefactgroup.com



THYSSENKRUPP HAS PRESENTED AN ELEVATOR THAT CAN CHANGE ITS DIRECTION – FROM VERTICAL TO HORIZONTAL. "MULTI," AS THE COMPANY HAS DUBBED IT, WILL FIND ITS FIRST HOME IN BERLIN'S "EAST SIDE TOWER."

21,000 LITERS (5,547 US GAL)

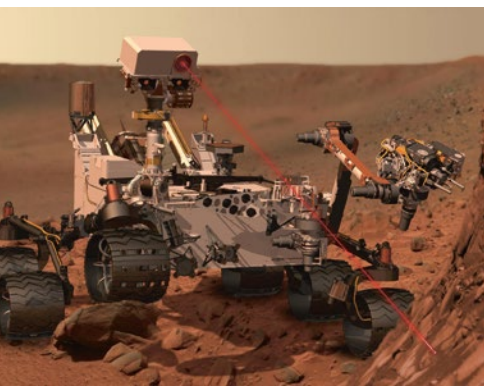
*per year are saved by India's first **solar train.** The solar collectors on the roofs of the cars generate 20 kWh of energy in total per day.*

46,930 cc

distributed to 12 cylinders as thick as a human's upper thigh describes the dimensions of the world's **largest engine installed in a car.** Technik Museum Sinsheim (Germany), which built the one-of-a-kind vehicle in an eight-year project from 1998 to 2006, has appropriately named it Brutus. The giant 12-cylinder power-plant is a BMW aircraft engine that was extracted from a plane shot down in the Spanish civil war in the 1920s. It delivers – at least short-term – 750 hp at 1,650 rpm.

SCHAEFFLER AT THE CES

The focus for Schaeffler at the 2017 Consumer Electronics Show (CES) in Las Vegas was on **new solutions for the future of urban and networked traffic.** One innovative concept is Schaeffler's Bio-Hybrid. It serves as an inspiration when considering new forms of mobility. Watch the video here:



$2.5 BILLION WAS THE COST OF THE MARS ROVER, MAKING THE EXPLORATORY VEHICLE ON THE RED PLANET THE MOST EXPENSIVE AUTOMOBILE IN THE UNIVERSE. SCHAEFFLER BEARINGS ARE USED ON BOARD AS WELL.

RESEARCHING MOTION

A future scenario: You exit a commuter train and then switch to an electric kickboard to take you home the rest of the way. The kickboard's connectivity covers a lot of bases, for instance warning you of impending hazards or alerting you to the need of replenishing your fridge. Ideas like this might result from a recently agreed research partnership between Schaeffler and Nanyang Technological University (NTU) in Singapore, focused on mobility solutions for megacities like Singapore. NTU has a proving ground for forward-thinking mobility. Vehicles using smart technologies are already traveling throughout the university's campus. They exchange data with roadside equipment and video cameras – providing ideal conditions for the development of urban mobility solutions that Schaeffler is working on as well, autonomous people movers, four-wheel bio hybrids (pictured), automatically shifted pedelecs and e-boards being cases in point. "Due to the actions taken by the government, Singapore is superbly suited for the development of technologies for megacities. We want to take advantage of these opportunities and work together with the local, highly educated talent," says Andreas Schick, Schaeffler Regional CEO Asia/Pacific.

DERAILED

Be it a fast or a freight train, a metro or a maglev train, they all need rails to keep them on track. At least, it used to be that way until now. **A streetcar that can do without rails was recently unveiled in the Chinese city of Zhuzhou.** Instead, colored road markings captured by sensors point the way. Ideally, the battery-electric train carries its 300 passengers to their destination without a driver and, thanks to rubber wheels, with minimal noise emissions. The advantage is obvious: there's no need for a complex track-bed, which makes the system attractive also for smaller or poorer cities.

60 components from Schaeffler, on average, are installed in every new passenger car.

107,000 km/h (66,486.7 mph)

is the Earth's average orbital speed around the Sun.

36 METERS (118.11 FT)

is the annual distance the German North Sea island Trischen covers on its eastward migration, which makes it the world's fastest island, according to geologists. Wandering dunes are able to move a lot faster. Researchers from the University of London measured a new record in the Bodélé-Djourab Depression in Chad where small crescentic dunes with a height of about ten meters (32 ft) cover a distance of 200 meters (656 ft) per year.

ELECTRIC

Schaeffler is a pioneer in the FIA Formula E electric racing series. Whereas manufacturers such as Audi, BMW, Mercedes and Porsche are just following, the German company has already celebrated the title win in the 2016/17 season with Lucas di Grassi.

by Lars Krone

LEADER

» We look forward to new, strong competition

Prof. Peter Gutzmer

The joy is boundless. When Lucas di Grassi in the FIA Formula E season's finale sees the checkered flag in position seven of race two in Montreal, Canada, it's clear: The driver of Team ABT Schaeffler Audi Sport is the third Champion of the world's first racing series for electric vehicles. "I'm overwhelmed – now we really did it. Twice we've just missed out by a narrow margin," di Grassi enthuses on crossing the finish line.

Prof. Peter Gutzmer, Deputy CEO and Chief Technology Officer at Schaeffler and one of the first to congratulate di Grassi, is pleased as well: "There arguably isn't a day on which the saying 'never change a winning team' fits better than today. Everyone at ABT and Schaeffler has earned the title in three years of focused and innovative teamwork."

Involvement from day one

Schaeffler is one of the pioneers of Formula E. Since the 2014/15 inaugural season, the German company has been active in the revolutionary racing series that

2012

AUGUST 1, 2012

The FIA announces the inception of Formula E.

2013

SEPTEMBER 10, 2013

The Spark SRT_01E Formula E car is unveiled at the IAA in Frankfurt.

NOVEMBER 15, 2013

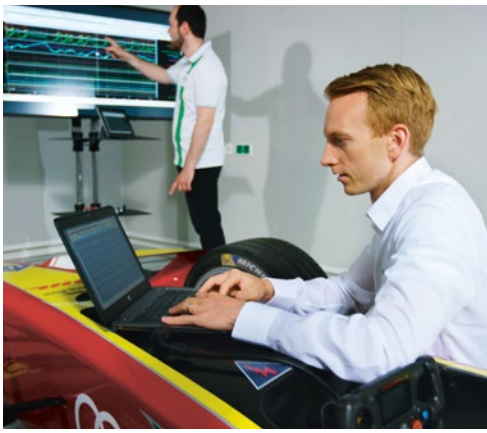
ABT Sportsline announces its entry into Formula E.

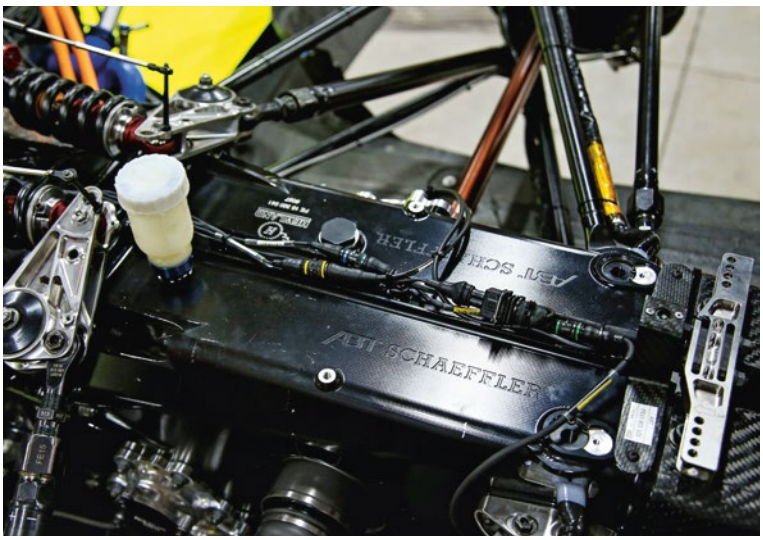
is making an increasingly stronger impact on motorsport. When Formula E was announced by the FIA in 2012 there were many that didn't take the series seriously. Yet unlike many fans and experts, Schaeffler recognized Formula E's potential early. "We're proud to have been involved from day one and having been among those that have shaped the development of Formula E," says Dr. Simon Opel, Director Special Projects Motorsports at Schaeffler. "It was immediately clear to us that this was a new type of racing and an ideal test laboratory for the development of future automotive propulsion technologies. In addition, Formula E is a great opportunity to attach emotion to the topic of electric mobility in the way it's perceived by the general public – not least because its races are held in the hearts of major cities."

Since then, Formula E has become the "in" series in racing and today is already the one with the highest density of automobile

Georg F. W. Schaeffler (right) gets first-hand information in New York from Lucas di Grassi

For Dr. Simon Opel Formula E is a perfect test laboratory for electric mobility





The powertrain developed by Schaeffler claims the title win in just its second season

2014

NOVEMBER 21, 2013

Lucas di Grassi at La Ferté Gaucher (France) tests the Spark SRT_01E Formula E car for the first time.

MAY 15, 2014

ABT Sportsline receives the first Formula E car at Donington.

JULY 3, 2014

For the first time all teams test the Formula E cars at Donington.

Prof. Peter Gutzmer, race engineer Franco Chiochetti and Lucas di Grassi (from left) talking shop

manufacturers and suppliers. While Schaeffler's partner Audi will be the first German automobile manufacturer to enter the series with a factory-backed commitment next season, other German premium brands – BMW, Mercedes and Porsche – are going to follow, then meeting with Renault, DS, Nissan, Mahindra, Jaguar and others. The Fiat Chrysler Group has announced its interest as well. "We look forward to new, strong competition," says Prof. Gutzmer. "It's great to see that more and more manufacturers are getting involved. Clearly, this won't make things any easier and the competition will increase, but for the development of Formula E this is very important."

Three thrilling years

In the 2014/15 inaugural season, the teams are still fielding specification cars as stipulated by the regulations. For Schaeffler's campaigner Lucas di Grassi the world premiere of the racing series in Beijing starts sensationally. The Audi factory driver clinches victory and with that goes down in motorsport history. Afterwards, di Grassi leads the championship for a long time and at the end of the year takes home a strong third place overall. "In the first season, we were at the venues for the races, but without having had any influence on the specification cars," Opel says in retrospect. "But behind the scenes, the analysis was already in full swing in order to specify the requirements for a powertrain of our own."

The reason is that such powertrains have been permitted as of the 2015/16 season. Since then, various technology concepts have been competing with each other. Differences exist in terms of the electric motor – including power electronics, the transmission, the rear axle, the cooling system and the associated software. Schaeffler develops the team's own powertrain together with ABT and other partners such as electric motor specialist Compact Dynamics which now belongs to Schaeffler. The new generation of the Formula E car named ABT Schaeffler FE01 is rolled out in June 2015.

Battery cooling is a key factor with electric powertrains

2014

AUGUST 19, 2014

Schaeffler and ABT Sportsline announce partnership in Formula E.

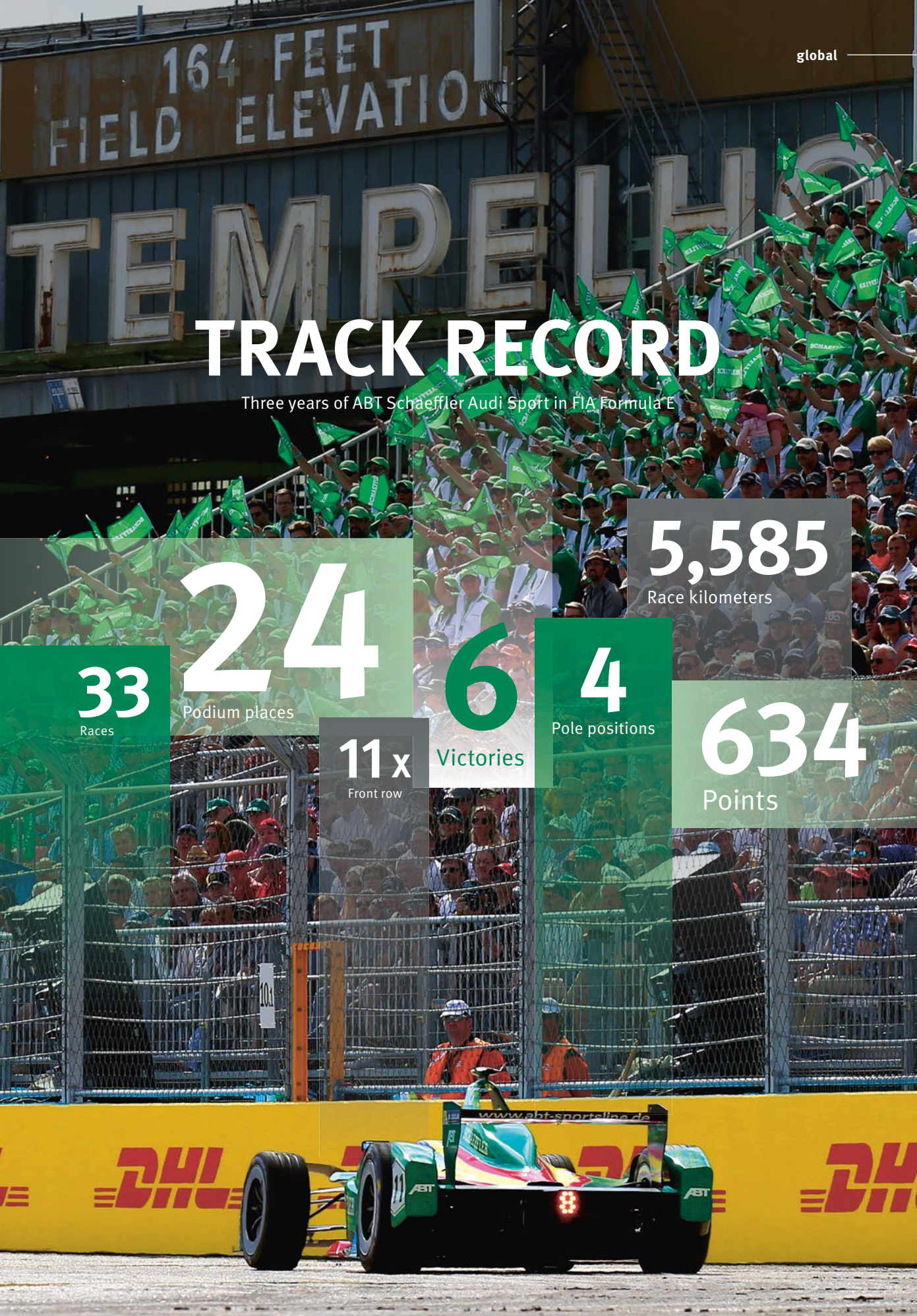
SEPTEMBER 13, 2014

Schaeffler campaigner Lucas di Grassi wins the first Formula E race in Beijing.

2015

FEBRUARY 23, 2015

The FIA announces the eight manufacturers who are allowed to developed powertrains for the second season. They include Schaeffler's partner ABT Sportsline.



TRACK RECORD

Three years of ABT Schaeffler Audi Sport in FIA Formula E

5,585
Race kilometers

24
Podium places

33
Races

6
Victories

4
Pole positions

11 x
Front row

634
Points

Crowd-puller: Formula E delivers motorsport at close range

Only five months later, the vehicle celebrates its first victory in round two of the season in Putrajaya (Malaysia). “That was a special moment for us,” Opel recalls. Di Grassi was again battling for the title for a long time and ultimately finished the year in position three of the standings.

For the third Formula E season, the powertrain is subjected to further optimization and this pays off. Di Grassi in a dramatic finale in Montreal secures the drivers’ title and still manages to intercept Sébastien Buemi who was leading the championship for a long time.

Test laboratory for production

In three years of Formula E, Schaeffler has gathered a lot of know-how which plays an important part in production as well. “We’ve learned a lot about the design of a powertrain,” says Opel, “for instance, the advantages and disadvantages that each motor and transmission concept has. We have a much better system understanding. The electric motor is a key point as well. We’ve learned a lot about the materials, the power electronics or the cooling system. And this knowledge is fed directly into the production components because our colleagues who take care of the

2015

JUNE 2015

Rollout of the ABT Schaeffler FE01.

JUNE 28, 2015

Lucas di Grassi battles for the title up until the finale of the 2014/15 inaugural season in London and ultimately finishes in third place overall.

NOVEMBER 7, 2015

Lucas di Grassi in the second race in Putrajaya clinches the first victory of the ABT Schaeffler FE01 with the new Schaeffler powertrain.

motors for racing develop prototypes for production, among other things, and a direct exchange takes place here." Energy strategy calculation is another point. "We have a lot of discussions about the most efficient strategies and simulation possibilities with the departments that deal with production products."

Opel has already reflected on the future of Formula E. "It would make sense to continue to open up only specific components for further development. From the 2018/19 season on, powerful batteries will be used. The teams are financing their development jointly. Otherwise a cost spiral would be set off resulting in the consequence that the team using the best battery would always win. All other components almost wouldn't really play a role anymore. It would be exciting if in the future recuperation and boosting using a KERS system would also be possible at the front wheels."

For the Formula E team there's something else on the agenda in the near future, though: In December, the fourth season kicks off in Hong Kong – with Lucas di Grassi as the title defender. Consequently, there hasn't been much time to celebrate. Testing has already started.

Formula E venues include Monaco

ENGINEERS OF TOMORROW

Ingenuity, technical know-how, sporting ambitions, efficient management of resources – *that's Formula Student. This constructors' competition is not about pole positions, fastest race laps and champagne showers, though, but about the art of engineering. Within a maximum of twelve months, student teams design a single-seat prototype for one of three classes: vehicles with an internal combustion engine, with an electric motor or – a novelty since 2017 – driverless race cars. Similar to Formula E, Formula Student imposes only few limitations on creativity in terms of the powertrain. The competition is highlighted by worldwide events at which the teams are pitted against each other – an environment that perfectly fits with Schaeffler's corporate philosophy. The technology group has been supporting student teams with know-how and products since 2006 and is featured as the principal sponsor of the German event, Formula Student Germany. The most successful participants are not only rewarded with a place on the podium but, above all, with the attention they attract on the job market. To talented career starters the doors at Schaeffler are wide open.*

formulastudent.de

2016

MAY 21, 2016

In Long Beach Team ABT Schaeffler Audi Sport drivers, Lucas di Grassi (P1) and Daniel Abt (P3), mount the podium together for the first time.

JULY 3, 2016

Lucas di Grassi in the final race of the 2015/16 season in London misses the title win by just two points.

2017

JULY 30, 2017

Lucas di Grassi in the ABT Schaeffler FE02 wins the title in the third Formula E season in Montreal.

TOTING THE OFFICE **AROUND THE GLOBE**

Here today, gone tomorrow. And day after tomorrow? Who knows? Digitalization has produced digital nomads, a new species of workers who, as their name suggests, are constantly on the move.

by Christel Trimborn

A park, a lake, fields of flowers, and trees providing shade. Sitting underneath one is a young man with a laptop, his bicycle lying in the grass. He may be a student writing a paper or a young entrepreneur in the process of crafting his start-up. Who wouldn't enjoy working in such an Arcadian setting? In a picturesque urban park today and a Portuguese surfers' camp tomorrow, or maybe underneath a bamboo roof in Bali? There are more and more people whose professional activities almost exclusively involve the use of digital technologies for whom it's completely normal to work while they're on the move – without a regular desk, real-world colleagues and scheduled working hours. While the feeling this way of life conveys is one of being largely self-directed and independent, a fast and stable internet connection ensuring contact with clients and other business partners at any hour of the night or day is a key prerequisite for enjoying it. "Digital nomads" is the term that has been coined for this growing group of people who keep shifting the center of their life as they please.

» Having the choice of where and when to work definitely has a motivating effect on me and, as a result, enhances my productivity

Janina Roll,
digital nomad

Janina Roll, a graphic designer from Hamburg, is a case in point. Several times a year she works from Portugal's South Coast for several weeks or months. Additionally holding down a number of jobs with various publishing houses and agencies on a temporary basis, she might be called a "light" version of a digital nomad. Yet whenever her regular employment in Hamburg permits, she'll start heading for the sunny south, having produced entire customer magazines this way. The nature of her work allows her to do so. Be it the development of a logo or the creation of layouts for websites and magazine pages – all the equally creative and relaxed art director needs is a laptop, phone and high-speed internet.

Even nomads have colleagues

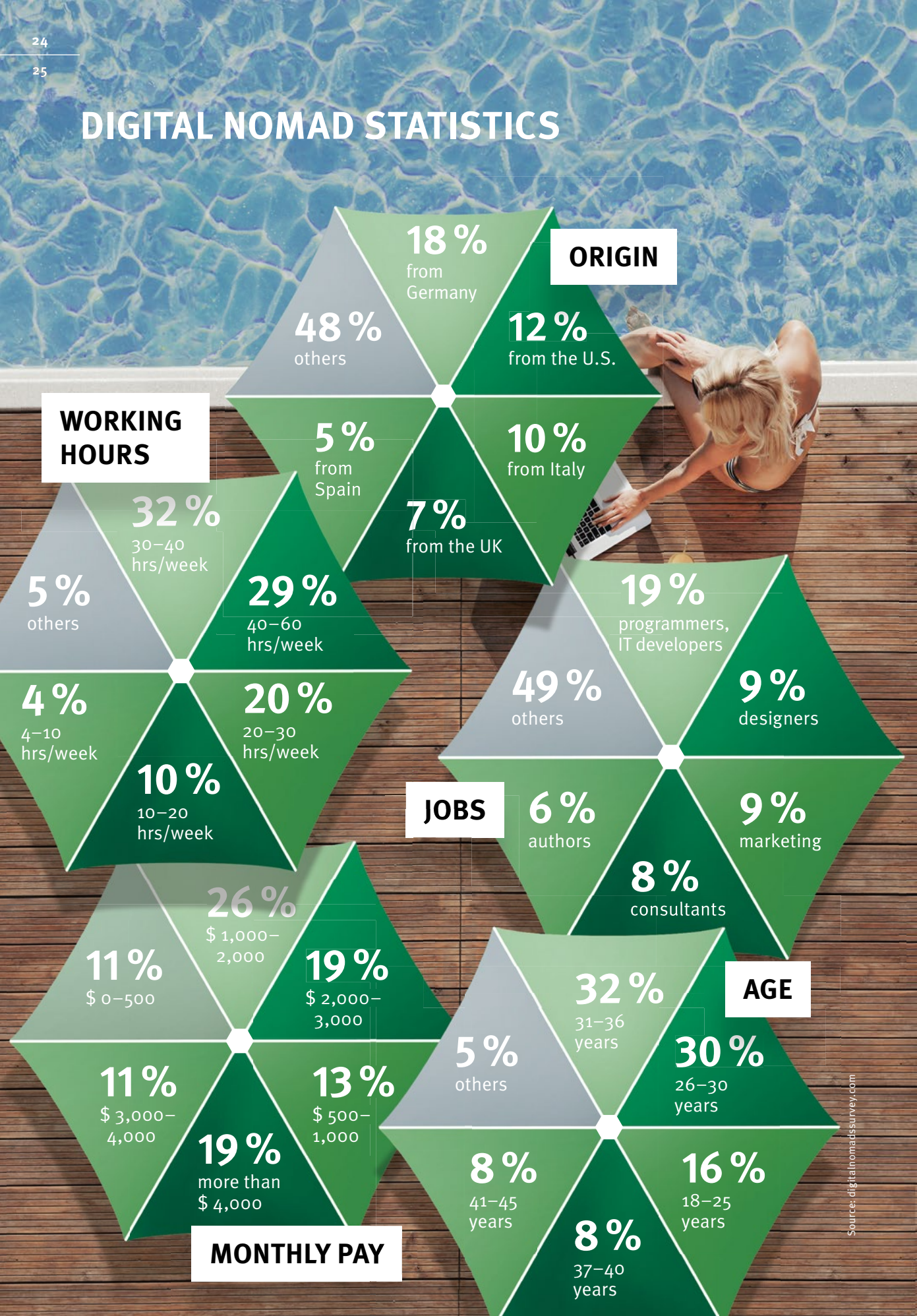
Other digital nomads are a lot more adventurous, though, completely parting with permanent places to live or work to tour the world and to stay in places that please them – typically where the cost of living is low and climatic conditions are pleasant. Exactly these are the reasons why locations in South-East Asia like Chiang Mai in Thailand or Ubud in Bali are currently ranking high on the list of the digital nomads' favorite hotspots. Eastern European metropolises such as Sofia or Timisoara are popular destinations as well which, among other things, clearly shows that digital nomads are rarely alone. Locations where high-speed WLANs enable mobile ways of working frequently turn into places where people from all over the world come together. In so-called co-working spaces, Canadian software developers meet with American photographers, brand developers and designers from Australia with European journalists, stock brokers or salespeople – maximum networking being part of their everyday work and lifestyle.

Online entrepreneurs Felicia Hargarten and Marcus Meurer from Berlin are two people who have turned this type of networking into their business model. In 2012, they founded the DNX movement and in 2014 hosted the first-ever DNX Conference for Digital Nomads. Their vision: "To connect and support all (would-be) digital nomads around the globe." Presentations and workshops held by so-called masterminds of the community draw hundreds of like-minded people to Berlin once a year. Here they try to learn how to come up with a concept that fits their personal needs, how to start a location-independent business or how to combine work and travel.

Conference on a cruise

Johannes Voelkel has been successful with a similar business idea. Prior to founding his Nomad Cruise business in 2015, he was touring the world as a digital nomad for many years himself. Today, he and his team design and organize 15-day cruises tailored specifically to the needs of this target group. The idea is for like-minded people to meet and connect, and to establish new contacts in the middle of the Atlantic. The feedback on his website suggests that particularly digital nomads traveling and working alone appreciate the intensive professional and personal exchange with others of their ilk – not least as a source of new inspiration or as a motivation boost to stick to their ideas. The reason is that even though the lifestyle of these world travelers sounds like one of boundless freedom, personal development and happily generated wealth, it does pose a number of challenges. Discipline and courage are essential traits to cope with commonly encountered uncertainty of being contracted for jobs and associated economic fears. Neither does a healthy dose of perseverance hurt, for instance, when realization strikes that the effort invested in one's own online business by far exceeds that of a secure regular job.

DIGITAL NOMAD STATISTICS



Source: digitalnomadssurvey.com

"DEMOGRAPHICS, DIGITALIZATION AND DIVERSITY ARE **KEY FIELDS OF ACTION"**

An interview with Corinna Schittenhelm, Chief Human Resources Officer, Schaeffler AG.

In the work environment of an integrated automotive and industrial supplier, Schaeffler employees are committed to top quality and innovation excellence on a daily basis. Will we be seeing any changes here? What might they mean for your work and HR?
Everyone senses and realizes that the world of work around the globe is in a state of structural transformation and increasing acceleration. New forms of team play and of organizing work are finding their way into companies. New technologies, globalization and demographic shifts are changing the work environment dramatically – particularly in major corporations and therefore at Schaeffler as well. What type of work we're going to do and how we're going to do it in the coming years is everyone's business. HR is a service function that addresses these changes and plays an active role in shaping them. I see this as a vital and major opportunity to help shape tomorrow's world of work. It'll be more transparent and modern, and it'll also make greater demands on employees' creativity, communication and willingness to learn. As a company, we'll have to continually redefine and reorient ourselves in the changing world of work. Work should be productive, add value, be meaningful and challenging, but not strenuous and overwhelming. An attractive employer must bear in mind that balancing work and family life, and having time for sports and social engagement, is becoming increasingly important to our employees.

Talking about "diversity" – how will it impact Schaeffler's future HR development?
For me, diversity has positive connotations. A diverse society is strong and this is also true of a company's workforce that is characterized by diversity. Here, diversity refers not only to gender, age, culture and view of life, but also to work styles, professional and educational backgrounds, and so on. This diverse interaction holds huge potential of value-adding ingenuity.

Let's turn to digitalization and digital transformation. What are your views: are far-reaching changes in store for Schaeffler that will affect workers?
Demographics, digitalization and diversity – our three "Ds" – are key fields of action in Human Resources at Schaeffler. To achieve our corporate goals, we need targeted measures and flexible resource planning in HR, as well as an appropriate corporate culture and clearly defined values. In my opinion, creative work will increasingly become a basic requirement for the future workforce. Digitalization will affect almost every work area. Even now, around 80 percent of all employees worldwide rely on the internet and telecommunications. Consequently, mobile and flexible forms of work are leading to growing global communication through all channels and social networks. And this refers not only to internal communication, but also to digital collaboration with suppliers and customers.

Constant availability can turn into another real burden. Especially those working on a different continent have to communicate with their clients on the phone or via Skype at times of the day or night which may greatly differ from their own. In a documentary about digital nomads in Bali, the Canadian Patricia Parkinson and the Australian Andrew Crichton comment about another disadvantage: "Most of our friends do not understand what we do. They think we're on a permanent vacation," says Patricia, who for three years has been on the road with Andrew and a mobile digital office providing consultancy to young entrepreneurs. Andrew confirms the lack of acceptance of their nomadic lifestyle by family and friends: "My family keeps asking when I'm going to come back and finally return to work."

The term "digital nomad" was coined as far back as 20 years ago. Published in 1997 was a book with the same title by Tsugio Makimoto and David Manners that gave mobile and technically adept people of the future their name. Even much earlier, in his work "Understanding Media" published in the mid-1960s, the Canadian

media theorist Marshall McLuhan postulated that in the electronic age humans would become "nomadic information gatherers." That the movement has in fact picked up momentum is not least attributable to the requisite infrastructure having become available in the meantime. The miniaturization and mobilization of digital tools such as laptops, tablets or smartphones for one and the availability of WLAN and mobile telecommunications in even the remotest corners of the world for the other are regarded as drivers of the movement.

By the way, the notion of digital nomadism being exclusively reserved to young people is a fallacy. Debbie and Michael Campbell, a married couple from Seattle (Washington) are a perfect counterexample. When the two over 60-year-olds went into retirement, they rented their home, sold their boat and their car, and started their "Senior Nomads" travel blog. Since then, they've traveled to more than 200 cities in over 60 countries across Europe, as well as Israel, Russia, Africa, Cuba, and others. In the meantime, the Campbells have not only written a book about their adventures but also sold their house – to indulge in "real" nomadism along the lines of "Life is too short to be spent at the office – or on the couch!"

THE AUTHOR

Christel Trimborn *is a free-lance journalist with her own office and desk in Bochum (Germany). However, also being a nomad deep down in her heart, she just travels the world as often as possible. One of her favorite destinations is Iceland due to its bizarre landscape, the energy that can be felt anywhere on the island, plus free and fast WLAN, among other things.*

DIGITALIZATION WITH SOUND JUDGMENT

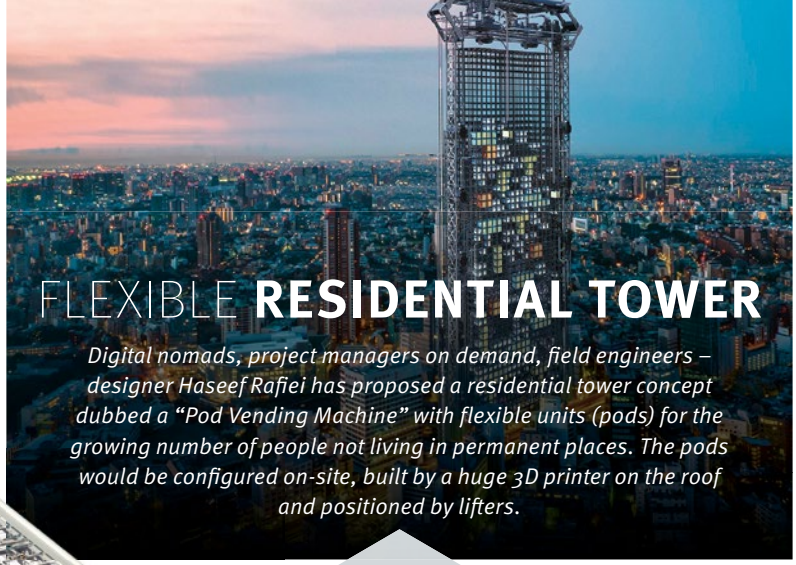
Interview with Gerhard Baum, Chief Digital Officer at Schaeffler

What are the responsibilities of a Chief Digital Officer?
Digitalization takes place on various levels. At Schaeffler, the levels are those of Products and Services, Machine and Processes, Analyses and Simulation, User Experience and Customer Value. My job is to develop new business segments and ideas in all of these areas, and to initiate and organize them together with my colleagues who are their functional owners.

In your view, what are the greatest challenges posed by increasing digitalization?
There are two key aspects. For one, engaging people is enormously important. Digitalization not only transforms what is being done but also how things are done. People have to be involved in these transformations and understand their changed roles. The idea that digitalization destroys human jobs is not per se correct. Digitalization creates jobs – and the number of new jobs it creates exceeds that of old jobs being phased out. The second major challenge is posed by speed. This is another issue many companies still need to work on.

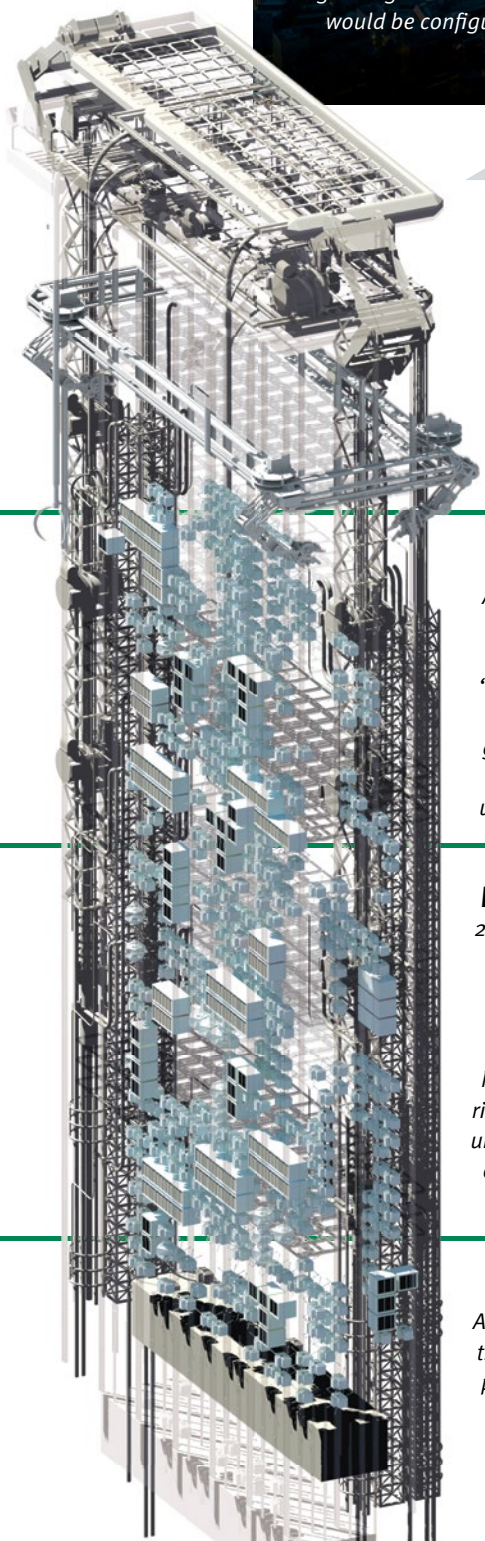
In what ways does digitalization influence work environments?
Freedom on the job is definitely increasing. Even today, we're already working "on the move": on a train, on vacation or between two meetings. Digitalization allows us to work anywhere anytime. The objective is to satisfy the customer – from where we achieve this is immaterial. At Schaeffler, we're working together with very flexible start-ups and freelancers on some projects as well. It always depends on the individual, his or her skills and communication – if all this fits, nothing speaks against working together with "digital nomads."

Being able to work and accessible anywhere anytime – a blessing or a curse?
In my opinion, it's a matter of an individual's mindset. For those who are open-minded and enjoy making things happen, increasing digitalization is truly a blessing. However, we all have to personally use sound judgment in this respect. A reasonable approach to dealing with job requirements and accessibility is definitely necessary.



FLEXIBLE **RESIDENTIAL TOWER**

Digital nomads, project managers on demand, field engineers – designer Haseef Rafiei has proposed a residential tower concept dubbed a "Pod Vending Machine" with flexible units (pods) for the growing number of people not living in permanent places. The pods would be configured on-site, built by a huge 3D printer on the roof and positioned by lifters.



PRINTER ON THE ROOF

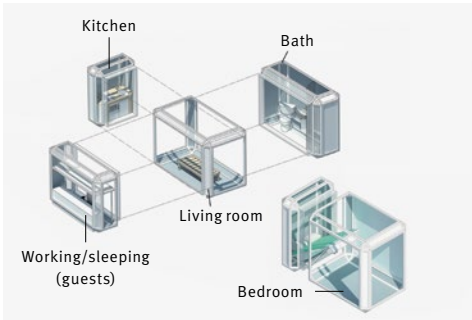
Should the project become reality, the construction unit on the roof might be the world's largest 3D printer. The printing material would be hydraulically transported to the top.

GROWING SIZE

Although unused residential pods would be placed in storage or recycled as printing materials for "new construction" designer Rafiei expects his tower to continually grow. To support this growth, new floors would simply be inserted underneath the printer on the roof.

MODULAR DREAM HOMES

24 hours after they've been ordered, the printed residential pods would be transported to the target floor. A pod consists of a living room to which finished modules such as a kitchen, bath or bedroom (pictured right) would be linked as needed. For units requiring additional space (e. g. offices) "two-storied construction" would be an option.



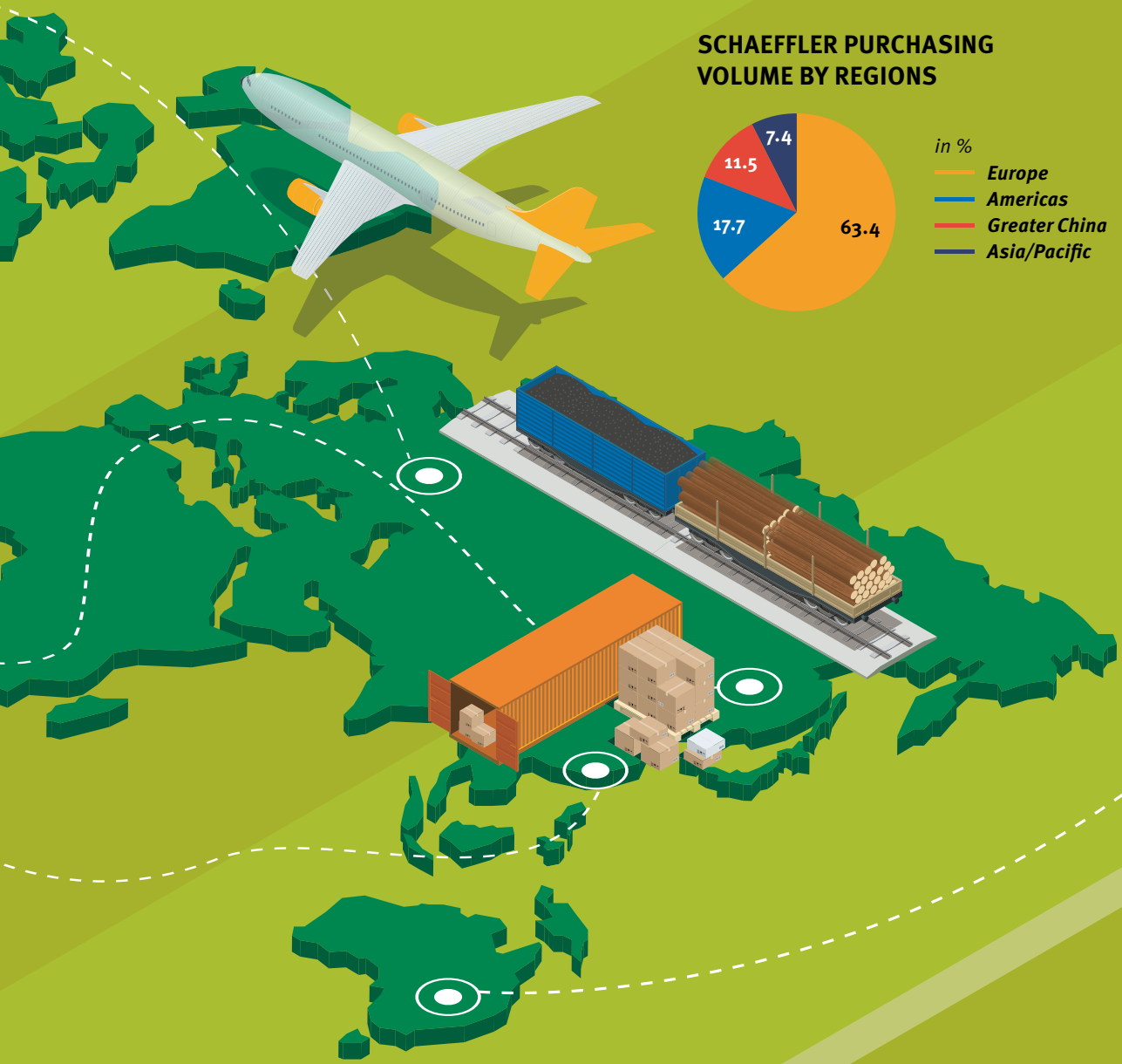
CONFIGURATOR

A number of terminals in the lobby of the tower would make it possible for prospective residents to personally configure their residential pods.

EVERYONE PULLING **TOGETHER**

A different kind of soccer game: A team enters the field and all players including the keeper are connected to each other by a rope. If one player moves all the others have to follow suit in the same rhythm. Only if they do can the team keep the ball rolling and ultimately get it into the goal. The name of the game is: logistics.

by Dr. Christian Heinrich



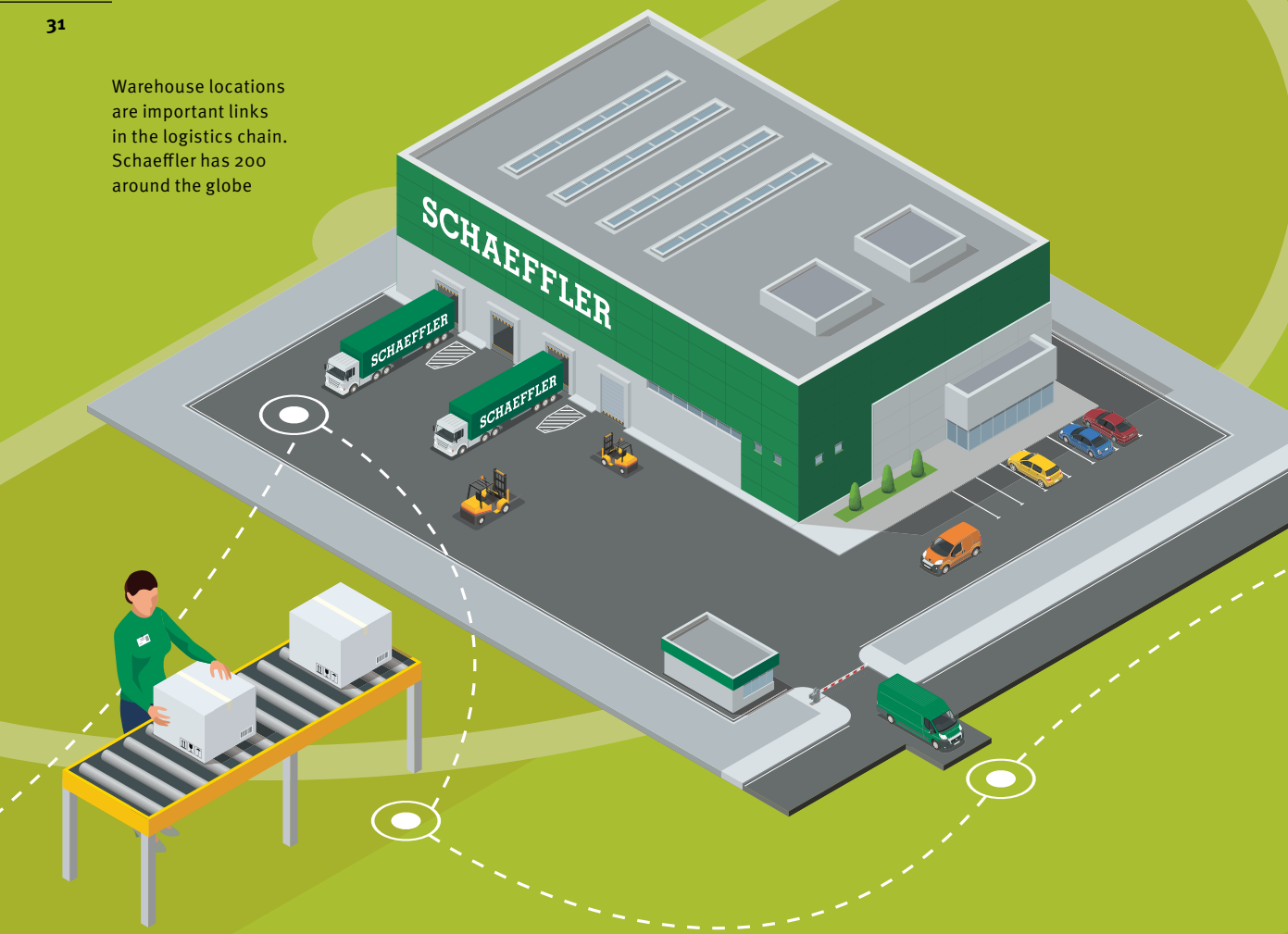
This analogy provides an idea of how logistics work in a modern company today, and thus at Schaeffler, too. Logistics is not an isolated organizational function and neither limited to staging primary products and materials (production logistics) nor to delivering products to the customer (distribution logistics). Clearly, there's a lot more to a modern logistics operation.

Customer demand drives takt time

The game is kicked off by the customer's demand – the customer being the first player to make a move on the team that's tied together in the soccer field analogy. Therefore, Schaeffler has to bring its entire procurement, production and supply chain operations in line with customer demand.

This is no mean feat. Schaeffler as a global player with 75 production plants and nearly 200 warehouse locations serves thousands of customers on all continents. The product range extends from small high-precision bearings the size of a few millimeters for dental drills to larger complete modules such as electric axles through to very large bearings for wind turbines. As a result, Schaeffler's logistics operation has to flexibly adjust to highly varying demand and related requirements.

Warehouse locations are important links in the logistics chain. Schaeffler has 200 around the globe



Everything involves logistics: purchasing of commodities like steel or other materials, transportation of components between the plants and sometimes even between continents, and warehousing operations. Obviously, there are several, seamlessly integrated levels – from global logistics through to production logistics within a plant. Of course, this applies to what happens at the end of the chain as well: shipping the product to the customer.

Pinpoint passing to production

To meet the customer's demand, the flow of materials has to be precisely timed. Employees with the relevant skills consistently plan and control the processes, from material requisition to the production schedule to material supply. Optimizing the value chain is central to Schaeffler's understanding of the game. The game is always opened by an employee in the assembly department (line-back principle). The shop floor as the place where value is added is the central player's position from which all processes – from the inside out – through to the suppliers are systematically optimized. Non-value-adding activities such as the transportation of components are handed over to production logistics. Material transports with high-frequency pull signals, so-called milk runs, handle the task of playing the material – optimally positioned – to the shop floor: the required quantity at the required time.

Efficient build-up play requires perfect passing between the shop floor and logistics – with end-to-end process planning, supported by modern IT systems. This continues in supply chain logistics. Suppliers are integrated so that that they'll deliver their materials based on production demand in exactly the right quantity, the right container and at exactly the right time. In a best-case scenario, the supplier is able to deliver the material directly to the production line (Just in Time, Just in Sequence) without any intermediate storage. The reason is that the best warehouse is a warehouse that's not required – or at least one that ensures supply with minimized inventory. This cuts warehousing costs while enhancing the company's flexibility to respond to the supply and sales markets. A large number of standardized paths and tactics to which all players both on and off the field are committed are elements of an integrated

8.3 b
euros was the **purchasing volume** of the Schaeffler Group in 2016.

34,000
suppliers from 80 countries work together with Schaeffler.

1 m
metric tons (1.1 m short tons) of steel are processed by Schaeffler per year.

Zero tolerance

The Schaeffler Group expects its suppliers to comply with **legal requirements, human rights, and occupational health, safety and environmental regulations.**

Schaeffler saves 70 % energy as a result of **modernized drive technology,** which includes the recuperation of braking energy among other things, in the Herzogenaurach high bay warehouse.

logistics strategy, and thus considerably contribute to the team's success.

Volcanic eruptions, storms and strikes – the threat of fouls looms everywhere

Quick response to unforeseen events is another important requirement for successful logistics. When a player on the team gets out of rhythm, it's crucial to prevent the whole game from grinding to a halt. Logistics, for instance, has to respond to natural events such as volcanic eruptions. Even if they result in airspace closures, customers still need their goods. The same applies when ships don't reach their destinations on time because of storms raging at sea or air cargo is delayed by strikes at destination airports. In cases like these, shipments have to be diverted to other means of transportation or other routes. In this context for instance, rail service on the new "Silk Road" between Europe and Asia is rapidly gaining importance – while offering clear environmental advantages over air cargo. The objective of providing customers with maximum flexibility adds to all these challenges.

Warehouse locations are another important link in the chain. However, unlike in the past, modern warehouse logistics are not just focused on the storage of goods but serve to synchronize the supply chain with customer demand based on precise planning models. To ensure a fast, efficient, on-time flow of goods, warehouses must be supplied with the corresponding range of articles. Schaeffler has invested in the future here as well. In the European region, a completely new logistics network is currently being established, including three new warehouse locations, among other things. These warehouses are state-of-the-art, using automated processes and equipment through to robotic solutions. At the same time, they've been designed with ergonomic aspects in mind to provide employees with optimum working conditions. After all, in spite of all automation and optimization, when it comes to harmonious movement of production and supply chains, people are still the primary players – just like on a soccer field.

THE AUTHOR

*Freelance journalist **Christian Heinrich** (who writes for "Die Zeit," "Geo" and others) can't get the idea of a soccer game in which the members of each team are tied together out of his mind. As soon as the opportunity presents itself, the Hamburg resident plans to give it a try with friends at the City Park. He's already got two suitable ropes ready.*


Hapag-Lloyd

GOING WITH THE **FLOW OF GOODS** AROUND THE GLOBE

Container shipping routes are the lifelines of global trade. Join us for a look at the life of a captain of a large container ship and the development of world trade in the course of the centuries.

by Dr. Christian Heinrich (story), Volker Paulun (info text)

In the middle of the Pacific, slightly south of the Bering Sea, hundreds of miles from the mainland, traveling eastward in the early morning hours toward the rising sun is a small town. At least, a town is how Captain Michael Behmerburg, whose alarm clock is ringing right on time at 5:30 AM, sees his ship. "We produce our own electricity and our own water and we even have a sewage treatment plant on board," says Behmerburg, a bright-eyed 48-year-old man with a beard and a friendly smile. For more than 30 years, he has been sailing the seas for the Hapag-Lloyd shipping company. After a pause, he laughs and adds, "Okay, maybe we don't have quite as many residents as a town." It only takes about 25 men to haul goods that may well be worth several dozen million euros from one continent to another.

The container shipping routes are the lifelines of globalization. More than 30,000 container ships are sailing the world's oceans at this very moment. Behmerburg's giant vessel has a capacity of 13,500 standard (TEU) freight containers and plows through the waves at a speed of 20 knots, which is a little less than 40 km/h or 23 mph. The engines pitching in the hull deliver 80,000 horsepower. You have to rise early to keep all this under control.

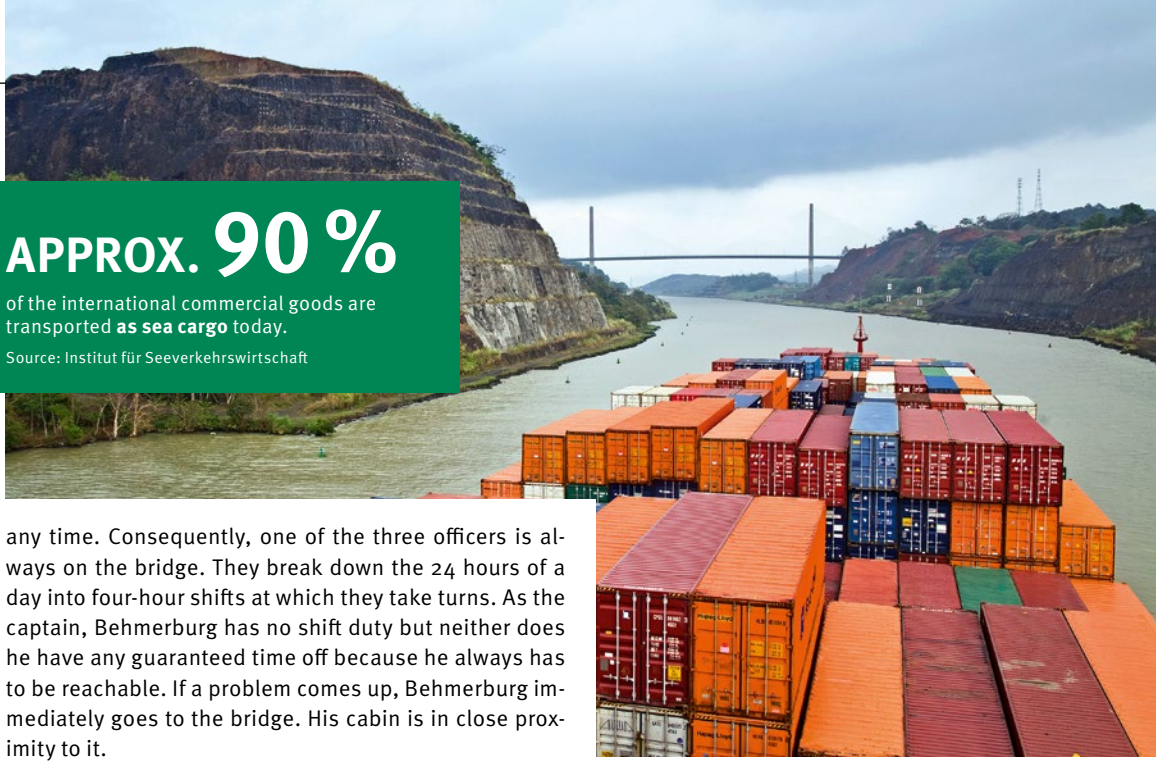
The captain can be reached 24/7

Between 6 and 7 in the morning Behmerburg stops by the bridge which, using the metaphor of the town once more, is something like the town hall. This is the place from which the ship is controlled. Although out at sea it is usually steered by an autopilot that is adjusted every few hours, a human has to be able to intervene at

Goods have been shipped around the globe for thousands of years. *While this has not changed to this day, the type of cargo as well as the senders and the recipients have. In pre-industrial trade, raw materials such as gold, silver, iron and copper were hauled, as well as spices, coffee, cocoa, tobacco, cotton and furs. There was a Salt Road, an Amber Road and, of course, the Silk Road with its branches extending from the Mediterranean Sea all the way to East Asia. But finished products such as china and textiles were shipped from A to B as well and later the disgraceful trading of slaves was added.*

While initially Asian powers such as the Persians, the Ottomans, the Mongolians and the Chinese were actively involved in world trade as well, ***the Europeans around 1800 dominated about 70 percent of it,*** *with the United Kingdom and its colonial network referred to as the empire playing a clearly dominant role up until the First World War, as author Barbara Hahn notes in a book on the development of world trade.*

While global trade between 1720 and 1840 had merely doubled, it virtually exploded afterward, ***the world trade volume having increased twentyfold by the time the***



APPROX. 90 %

of the international commercial goods are transported **as sea cargo** today.

Source: Institut für Seeverkehrswirtschaft

any time. Consequently, one of the three officers is always on the bridge. They break down the 24 hours of a day into four-hour shifts at which they take turns. As the captain, Behmerburg has no shift duty but neither does he have any guaranteed time off because he always has to be reachable. If a problem comes up, Behmerburg immediately goes to the bridge. His cabin is in close proximity to it.

There were no problems during this particular night, so the officer and the captain discuss how the day will go: what will the weather be like, what route will be ship be taking? With the engineer Behmerburg discusses what maintenance work has to be done. Beginning after a subsequent breakfast will be the part of his working day which now takes up most of his time. Around 9 AM, Michael Behmerburg, the container ship captain, the mayor of a floating town, starts sitting in front of his computer and opens his emails.

Preparations for unloading already start on the open sea

Behmerburg views this as both a blessing of progress and a curse. A few years ago, an internet connection existed only every few hours or even only every few days. Today, emails can be read and sent almost constantly. On the one hand, this makes a lot of things easier and creates a certain quality of life. The crew members on board can constantly stay in touch with the mainland,

First World War broke out. *Artificial waterways connecting oceans, such as the Suez Canal (opened in 1869), the North Sea Baltic Sea Canal (1895) and the Panama Canal (1914), enormously accelerated seafaring and thus the development of international commerce.*

Europe, and subsequently America as well, absorbed goods like a sponge, even including whalebone from Greenland to produce corsetry that gave women their fashionable wasp waists. The most heavily traveled trade route at the beginning of the 20th century was the North Atlantic. ***England, beginning with the invention of the steam engine and the resulting industrialization of cloth production, acquired the title "The Workshop of the World."*** *For a long time, the empire was also the world market leader for automobiles. But in Germany, an increasingly stronger competitor began to emerge. Steel, iron, mechanical engineering and the chemical industry were burgeoning there. And thanks to a certain Henry Ford and his Model T that marked the revolutionary advent of*

» Even on a large container ship, a storm on the Atlantic or a typhoon in the Indian Ocean is not exactly pleasant

Michael Behmerburg,
captain of a container ship

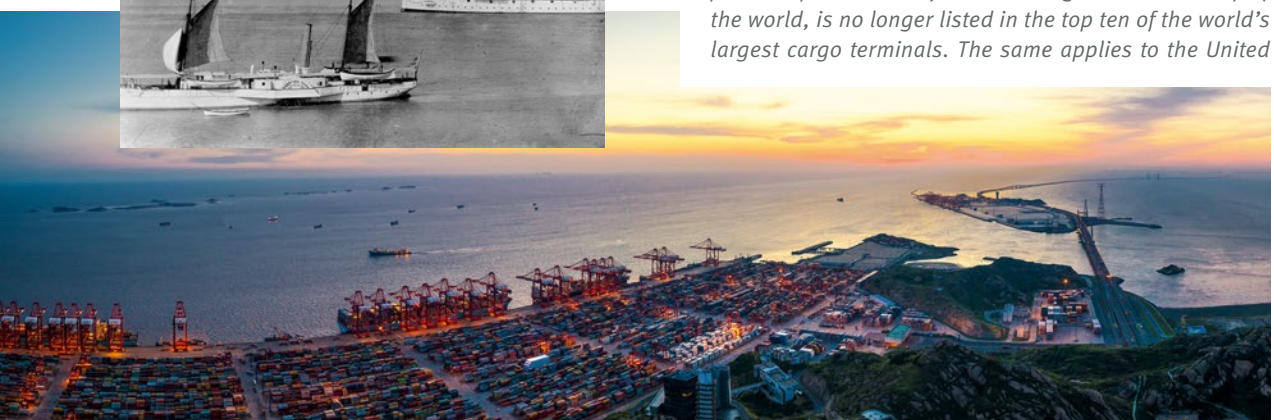
their loved ones at home and the ports the ship is heading for. The downside of this development is that anything that's possible will typically be demanded as well. Several days before their scheduled arrival, the container ships have to send a whole file to the port authorities containing all kinds of information from cargo manifests to applications to forms for expert opinions. "And because we have a scanner on board, we have to scan the crew members' passports and send them to the ports beforehand. Presenting documents and passports once we get to the port is no longer sufficient," Behmerburg says with a sigh. "It's true that computers reduce our workload in many ways but, absurdly, of all the things we need to do it's our administrative tasks that have enormously increased."

More than a million miles at sea

Consequently, this is another day Behmerburg is largely spending at the office, preparing purchase orders for fuel and provisions, completing applications for this and that. Hours go by with Behmerburg hardly having a chance to look at the sky and the horizon on which the spectacle of an equally infinite and fleeting display of clouds and waves can be seen. But whenever he does take a break and looks outside, taking in the sight of the ocean, he still occasionally gets goose bumps of awe, although one might think that there are not a lot of things that could still faze Behmerburg. He's travelled far more than a million miles on the world's oceans, having landed in Shanghai and set sail in Rotterdam, having passed the Cape of Good Hope and Tierra del Fuego, crossed the Panama Canal and the Aegean Sea. And, still, he's stunned by the beauty of the world and the power of the ocean which can also be destructive at times.

"Even on a large container ship, a storm on the Atlantic or a typhoon in the Indian Ocean is not exactly pleasant," says Behmerburg. Basically,

On this picture that dates to 1900, the Shanghai harbor still looks like a maritime beauty spot. Today, it's the largest port in the world. The two pictures impressively illustrate China's rise as a global trade power



mass production on an assembly line America became an automotive power. The First World War then finally caused the United States to rise to the top spot in the global ranking of trading powers.

The Second World War divided the world into East and West and colonial empires shattered. *Still, world trade would soon flourish again. The winners, of all countries, included the two losers of the war, Germany and Japan. In spite of its absolute scarcity of raw materials, Japan even evolved into the second-strongest economy after the United States, with means that had previously caused Germany to step out of England's shadow: high-grade products at affordable prices. Accordingly, flows of goods shifted from and into the region as well.*

And today? *In the United Kingdom, the former "Workshop of the World," the manufacturing industry no longer accounts for a double-digit percentage of the gross domestic product. The banking sector, tourism, retail trade and the service sector have become increasingly important. Although Germany in terms of manufacturing is in a better position, the renowned Swiss economist Thomas Straubhaar quips: "Germany is no longer the workbench of the world, but the country that delivers the workbenches to the world."*

The new "Workshop of the World" is China, which has also been the world's second-strongest economy now for a long time. "At the moment, China dominates world trade more than any other nation has in nearly the past 50 years," the news agency Reuters reported last year. ***Accounting for 13.8 percent of the global export market, China's share in 2016 was as large as that of no other country since the United States in 1968.*** *The development of the ports is also a good indicator of China's market power. Japan, with Tokyo once having ranked at the top of the world, is no longer listed in the top ten of the world's largest cargo terminals. The same applies to the United*

74.5 %

of marine part load shipping is done in freight containers.

Source: Institut für Seeverkehrswirtschaft

the ship cannot capsize and Behmerburg, at least, has never lost a container either. “Still, you feel pretty uneasy out there when the sea is raging.” There’s nothing but wind, waves and water, with a few people in between in a box of steel.

Progress has made the seafaring adventure more predictable

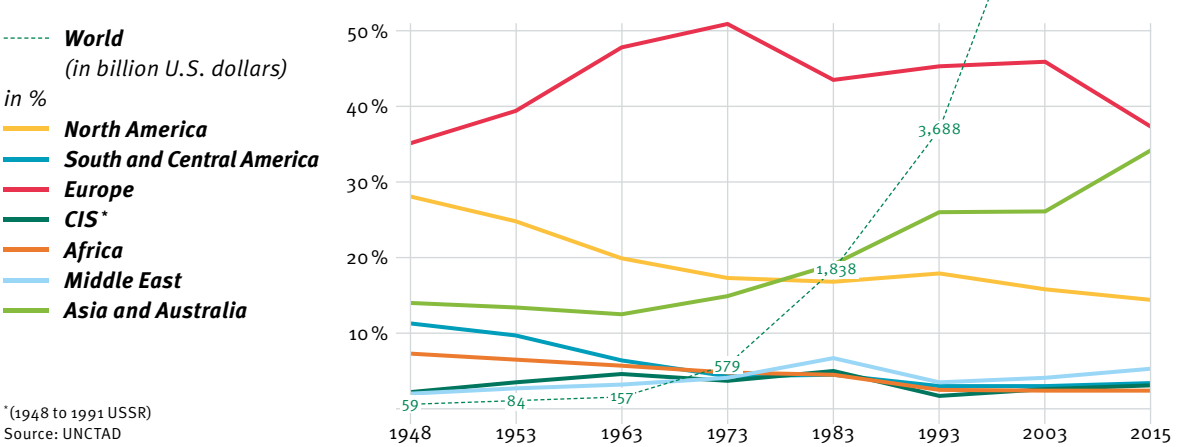
Particularly in recent years, though, Behmerburg has hardly experienced any heavy storms, but not because they no longer exist. Quite to the contrary, they’re often heavier than ever before. However, it’s easier for the container ships to avoid them because current weather information has become more precise thanks to closer satellite coverage and data connections. “Every few minutes, I can watch how a bad weather front is moving – and, as a result, circumnavigate it with ease,” says Behmerburg. The adventure of sailing the seas has been made more predictable by progress.

On the other hand, new imponderables have emerged in recent years. Pirate attacks have increased so that corridors protected by the military have had to be established at the Horn of Africa. If something gets out of balance onshore the crises and problems often spread to the container ships on the oceans as well.

States. Europe at least still has Rotterdam among the front runners. China on the other hand, led by Shanghai, has six of the world’s ten largest ports within its borders. Word that China is not just able to produce cheap, but also quality, goods has spread as well. It gives the country an important selling point to defend its market position against emerging low-cost neighbors such as Vietnam, Indonesia and India.

What does all this mean for the flow of goods? For the “Transportation & Logistics 2030: Emerging Markets – New hubs, new spokes, new industry leaders?” survey, the PWC consulting firm interviewed 90 logistics experts from 28 countries across all continents. ***The result is that in 2030 a large part of world trade will be handled via threshold countries.*** *These countries are also increasingly active in resource-rich developing countries where there establishing logistic infrastructures. Currently, trade between Asia and the countries of the former Soviet Union is growing by 42 percent annually. The quantities being shipped on the south-south route between South America and Africa are clearly recording double-digit growth too. I****n the future, the logistics giants will including India, Russia and South Africa, according to the PWC survey,*** *whereas North America and Western Europe will continue to lose importance.*

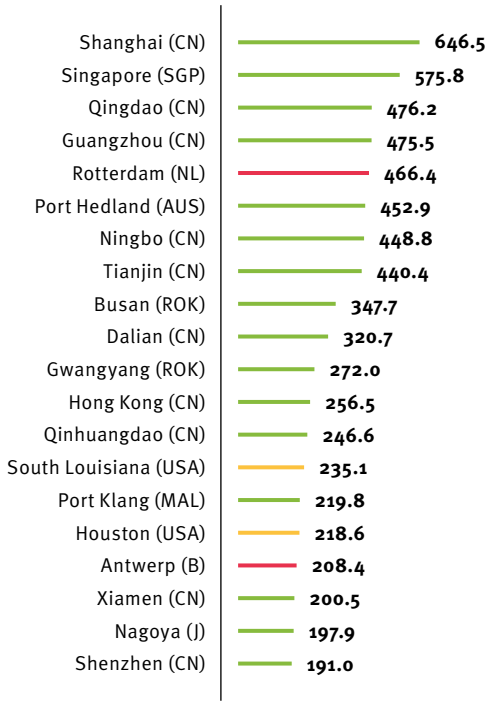
WORLDWIDE EXPORTS OF GOODS BY REGIONS 1948–2015



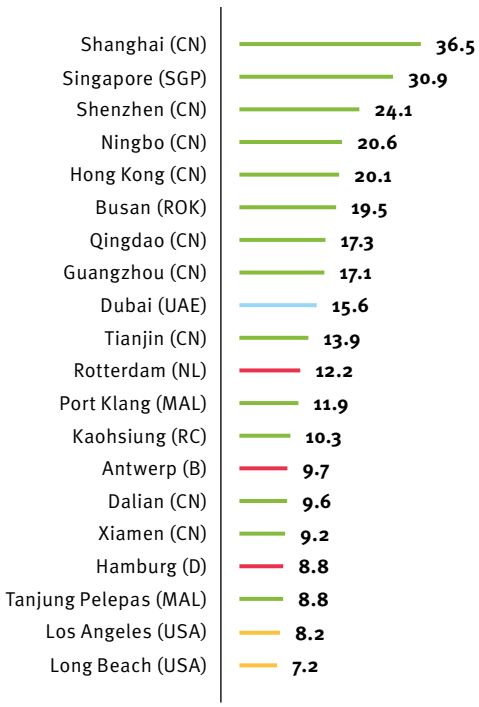
*(1948 to 1991 USSR)
Source: UNCTAD

THE 20 LARGEST PORTS IN THE WORLD

By cargo quantity in million metric tons in 2015



By number of 20-foot containers (TEU) in millions



See legend at left for color allocation

Source: American Association of Port Authorities

For Behmerburg, balance is important in other respects as well. A large container ship sometimes consumes hundreds of tons of fuel per day, equating to the weight of about 70 small cars. Together with his first officer he sometimes has to recalculate the static stability of the ship several times a day in order to re-pump fuel if necessary or to temporarily fill water tanks to prevent imbalance. The cargo load of the containers, the number that fit onto container ships continually increasing, plays a role in this as well.

For decades, there has been an unbroken trend of ships becoming larger and larger, with ever new records being set. Just recently the first ship with a capacity of more than 20,000 containers left a shipyard. Growth, says Behmerberg, tends to be in terms of width rather than length, one of the reasons being that wider ships have less draft and are able to maneuver even in the Saint Lawrence River or head for the Hamburg harbor. Specialization is another trend. There are more and more container ships that are able to transport specific goods with particular efficiency. “From South America to Europe, for instance, a lot of fruit is transported as refrigerated cargo,” says Behmerburg. Container ships that support the required refrigeration units are particularly well suited for these purposes.

And where are the ships going? Apparently, the Workshop of the World is still located in Asia: “China continues to be a frequent destination and the ships are fully laden. Vietnam has been added recently as well,” says Behmerburg. China’s political leadership makes sure that the country keeps its cutting edge: “It’s not uncommon for a new harbor to be built within a few months. That happens very quickly. In Hamburg, by contrast, just a couple centimeters of deepening the Elbe riverbed are the subject of years of discussion,” says Behmerburg. Which is the better way to go? That’s not so easy to answer, he feels, it depends on the interests involved.

Although the ships are becoming larger the size of the crews has slightly decreased in recent years, currently consisting of about 25 members. “Almost all the sailors are Filipinos, the language spoken on board is English and the most important crew member is the chef. But I haven’t said that now,” Behmerburg says with a smile.

At night, around 7, he goes to his cabin that will continue to be his home for the next six weeks. The agreement he has with his employer, Hapag-Lloyd, provides for him to be out at sea for two or three months and then having exactly the same amount of time off. Now wouldn’t that be a great opportunity to spend a vacation at a faraway place? Behmerburg shakes his head. That doesn’t appeal to him often. A vacation, to him, means staying at home.

» ***Flying cars are no fantasy*** Airbus CEO Tom Enders

FLYING CAR SURVEY*

67 % *of all Americans are interested in a flying car.*
41 % *prefer a self-driving and flying vehicle.*
26 % *would prefer taking the wheel themselves.*
80 % *think it is "important" or "very important" that parachutes are on board.*
60 % *have safety concerns.*
60 % *prefer an all-electric powertrain.*
75 % *view shorter travel times as the major advantage of a flying car.*
›80 % *prefer vertical take-offs and landings like in a helicopter.*

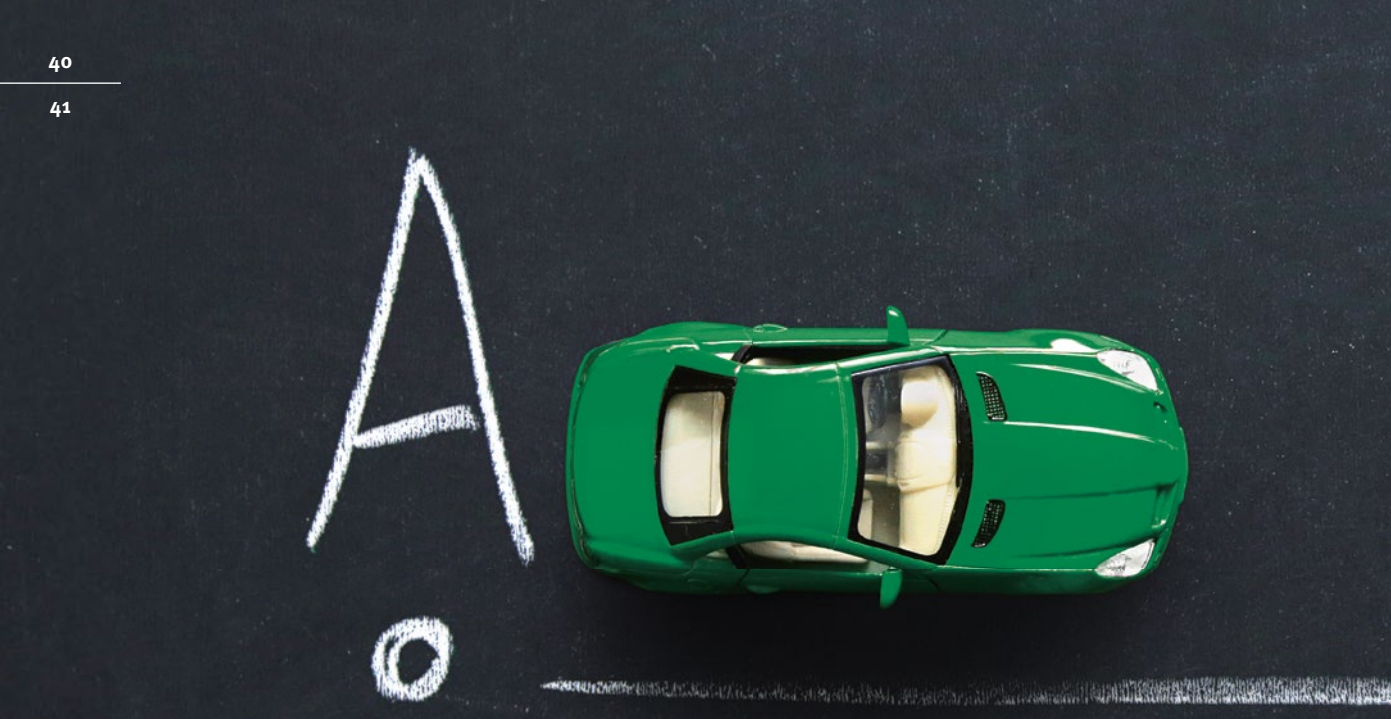
*Online survey by the University of Michigan in 2017

in motion

Innovations in the course of time

UP IN THE **AIR**

The dream of being able to do more with a car than just drive it is as old as the automobile itself, as this postcard of a flying amphibious vehicle with a remarkable screw attachment from the 1890s shows. The world has seen many attempts to make this dream come true. The bit about use on or under water has been possible for a long time – see amphicar & company. Yet this additional qualification never became a hit. And flying? Automotive forays into the air space have been made for decades, the first one as far back as in 1917. But although the "Curtis Autoplane" was briefly airborne after takeoff it never achieved a serious flight. Currently, more than a dozen companies are working on a flying car. Customers can order one from the Dutch company PAL-V that is supposed to be delivered at the end of 2018 for 499,000 euros. Flight hours are included in the price. The problem is that in most countries take-offs and landings are only permitted on airfields or private property. The fact that two heavyweights like Airbus and VW have teamed up and presented the concept of a flying car at the Geneva Motor Show shows that flying cars have a future in spite of many unanswered (legal) questions. The centerpiece of the "Pop up" idea is a capsule which, combined with a chassis, turns into a car but can also fly with a drone. A powerful competitor is literally on the final approach to landing: Carmaker Daimler has acquired a stake in the German aviation start-up Volocopter. Initial demo flights with the drone taxi in Dubai are scheduled before the end of the year. The Volocopter, though, is said to only be able to fly but not drive.



GAME CHAN

Transformations are nothing new in the automotive industry. Vehicles, propulsion concepts and the conditions in which they operate have radically changed time and time again ever since the invention of the motorized carriage. The history of the automobile between epochal strokes of genius and dead-end-street inventions.

by Roland Löwisch

GERS

For the people that lived at the end of the 19th century, it must have been a pretty big shock. Suddenly, as if driven by magic, carriages were traveling the streets – without horses, but with a lot of noise. Today, this might almost compare with a pedestrian seeing a self-driving, electrically powered automobile on public roads for the first time: nobody at the wheel, no noise. But: major transformations and constantly changing trends are nothing new when it comes to vehicles.

Body styles and geographic influences

The first automobiles are motorized carriages that do not have a roof yet. As paved roads hardly exist at the time, their occupants often have to cope with the effects of weather, dust, angry dogs and horse manure. Soon, beautifully curved fenders begin to protect the carriage owners (practically all of whom are wealthy). Around the turn of the century, the first smaller and larger "tonneaus" emerge – open, rear passenger compartments with optional covers. The chauffeur – not least to show that there's a difference between the classes he and the owners belong to – has to stand outside. The term "sedan/saloon" that describes an automobile with a completely closed body only appears around 1910. It's the same year in which Cadillac, as the first automaker to do so, delivers its chassis with closed bodies as standard equipment.

August 16, 1913 marks a game changer with a lasting effect on the auto world. It's the day on which Henry Ford launches his assembly line which soon enables him

to build up to 1,000 cars per day. Selling like hotcakes, the Ford T becomes affordable, thus enabling humanity's mass motorization. 1915 was the first year in which more than one million cars, trucks and buses are produced around the world. They're supposed to be functional. Beauty is typically of secondary importance.

Importance starts being attached to automotive design only in the late 20s. GM is the first automaker to establish a dedicated styling department. Named "Art and Color Section," it's led by Harley Earl. He's one of the people who are responsible for the world's first concept car (Buick Y-Job, 1939) and for the era of the tailfin vehicles. The vast expanse of the country is reflected in its cars as well. America has ample space for big automobiles. Size matters – and still does today.

Not so in Europe. In the cramped Old World, mainly small cars are in demand. In England, the old narrow country roads influence the size of roadsters and sedans/saloons. In Italy, Fiat (as of 1936) produces a large number of the world's smallest car at the time: the 500 "Topolino." Especially after the Second World War, Europeans are forced to economize not only on space but also on money. Available in the entry-level segment are mass-produced low-budget cars such as Citroën's 2CV, the Austin Morris Mini, the Fiat 500 or the VW Beetle which right after the end of the war are still dream cars for many. Consequently, a lower-level niche emerges below them for "microcars" such as the Ape by Piaggio, the Isetta by Iso and later also made by BMW, the Gutbrod Superior, the Fuldamobil, Kleinschnittger, Messerschmidt, and Heinkel Kabine, Staunau, Goliath 700, Zündapp Janus and the Goggomobil. These cute vehicles are not only affordable in terms of purchasing price and cost of ownership but in Germany can even be operated without a car driver's license as long as displacement does not exceed 250 cc. This is a good example of how legal requirements can influence developments in the automobile market, but more on that later.

The situation completely changes again a few years later in the wake of the economic miracle. Germany has become a nation of station wagons/estate cars since the late 70s – there's no other country in which cars with a covered cargo area are equally popular. Americans on the other hand love pick-ups – the Ford F-150 now having been the top-selling vehicle in the U.S. for about the past 35 years. Chinese, by the way, are absolute fans of notchback models – at the moment.

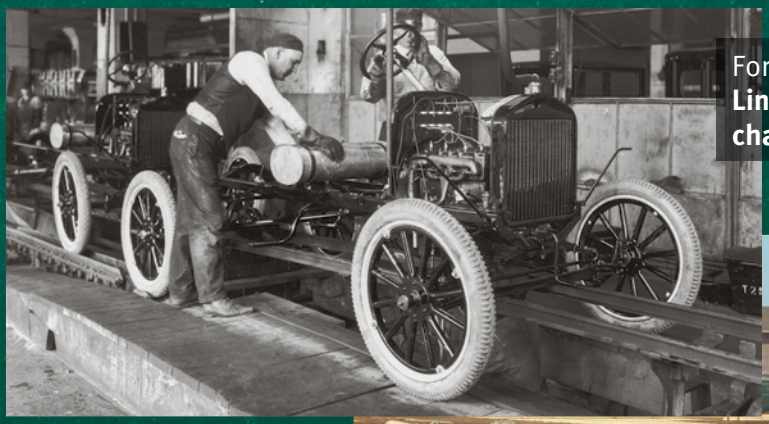

L'ILLUSTRÉ
DU PETIT JOURNAL
ET SON SUPPLÉMENT AGRICOLE
GRAND HEBDOMADAIRE POUR TOUS
TOUS LES DIMANCHES
50c
21-5-33
LA PREMIÈRE VOITURE AUTOMOBILE DANS PARIS
L'apparition de la première voiture automobile de Serpollet, qui portait le nom de "Voiture Mir
dans les rues de Paris, en Avril 1891, fut la cause d'une émotion considérable dont se souvie
encore les vieux parisiens. (Voir l'article page 3).


Januar. 1898.
Motorwagen
Zeitschrift
des
Mitteleuropäischen
Motorwagen Vereins.
INHALT:
Vorwort.
Der mitteleuropäische Motorwagen-Verein, seine Begründung und Organisation.
Motorwagen, welche bei der Begründungsversammlung des m. M.-Vereins zur Vorführung gelangten.
Elektrische Droschken in New-York von Gisbert Kapp.
Motorwagen auf Vollbahnen.
Vereins-Angelegenheiten.
Satzungen.
Maschinenfabrik Lorenz, Ettlingen i. B.
Allgemeine Motorwagen-Gesellschaft (G. m. b. H.)
Berlin NW., Dorotheenstr. 43.
Motorfahrzeuge aller Art.
Lieferung und Verkauf,
Stellung von Motorwagen für bestimmte Zwecke;
Unterhaltung derselben.
Aufnahme von Verkehrseinrichtungen auf Zeit.
Uebernahme regelmässiger Transporte von Personen und Gütern.
Denkbar einfachste Construction
Gefahrlos
Sicher.
Patent-Motorwagen
von 2000 Mk. an.
F. LUTZMANN
DESSAU II.

Attention please: Cover of a French magazine (1933) with a picture of the first arrival of an automobile in Paris in 1891 (left)

Cover of the first automotive magazine (below): Der Motorwagen – Automobil- und Flugtechnische Zeitschrift, Publisher Berlin, Krayn. First issue from January 1898 and predecessor of today's "ATZ Automobiltechnische Zeitschrift" specialist magazine that is celebrating its 120th anniversary in 2018 (www.atz-magazine.com/120-Years)

MILESTONES OF AUTOMOTIVE HISTORY



Ford Model T (1913)
Line manufacturing changes everything

Ford F-150 Pick-up (1975)
U.S. top seller until today

Audi 200 Avant (1984)
Wagon country Germany

Kei car Suzuki Hustler (2013)
Minimalism in Japan

Porsche Mission E (2015)
Vision of an e-car for 2019

On two sides of the Atlantic: Voluminous metal in the land of unlimited opportunities and highways (above: 1957 Cadillac Eldorado Biarritz) vs. the charm of an Italian micro car (below: 1960 Fiat Giardiniera 500)

In the United States, in turn, the progenitor of the sport utility vehicle is born. The Harvester Scout (1960) sets out to prove that fun can be had off paved roads as well. It's followed by Jeep Wagoneer and Range Rover, and when production of the Mercedes M-Class is launched – at a U.S. plant (1997) – if not earlier, the SUV wave hits Germany too. As early as in 2003, one in 20 newly registered vehicles is an off-road sedan – and in 2016, nearly one in four. It's possible that the wagon will soon have outlived its usefulness – after all, the SUV previously ended the minivan boom that was triggered by the Chrysler Voyager in 1983.

Engines, motors and drive concepts

In the early days of the self-propelled vehicle, there are three types of propulsion systems competing for predominance: steam and internal combustion engines and electric motors. Steam is the first to appear on the scene. As early as in 1769, the French military engineer Nicolas Joseph Cugnot is the first to ride in a vehicle without muscle power. His tricycle is equipped with a two-cylinder steam engine. But at the end of the 1920s, if not earlier, steam is literally running out of steam, being too inefficient and too inconvenient. However, electric cars such as the Detroit Electric, Lohner-Porsche and Columbia have no chance against those with IC engines either.

Broadly speaking, Henry Ford and John D. Rockefeller are the gravediggers of steam and electricity as sources of propulsion. Ford, once an official expert in locomobiles and builder of a steam-powered car himself, gets to know Otto's four-stroke explosion engine when

he's asked to repair one. Ultimately, he installs it in his mass-produced "Tin Lizzy." Rockefeller with his Standard Oil Company makes sure that soon there'll be a fuel pump installed around every corner. Between 1910 and 1920, three new filling stations are opened in the Unites States every day. Even in Germany, 10,000 fuel pumps are available in 1927.

Not quite as explosive is the spreading of the diesel engine, patented as a compression-ignition engine by Rudolf Diesel in 1893. With a coefficient of performance of 26 percent, such a heat engine is more efficient than any other engine, but it takes Diesel a long time to get it to work reliably. But even after that's been resolved, there are two downsides to diesel engines: they're sluggish and noisy. Only around 1920 the engine is ready to propel a vehicle and in 1923 is installed in a miniseries by Dornier and Jüdel. In 1936, Daimler-Benz launches volume production of the first diesel-powered passenger car – the 260 D. France is becoming the main diesel country – Peugeot clinching speed and reliability records with the compression-ignition engine in 1965. In 1973, Opel transplants a diesel engine into its GT. And to make its characteristics fit the sports car, it's put under pressure by an exhaust gas turbocharger – invented in 1905 by Alfred Büchi. At the end of the 1980s, the first passenger cars with direct injection and turbochargers hit the market: the Fiat Croma in 1986, the Austin Montego in 1988 and the Audi 100 in 1989. Now the diesel engines are finally morphing from spoilsports into sporty performers – on the freeway, combined with economy at the filling pump. In 2010, the performance excesses of the torque monsters culminate in the Audi Q7 whose V12 TDI accelerates the awesome SUV with 500 hp and 1,000 Nm at levels equaling a sports car. However, the enticing combination of power and efficiency has undesirable side effects such as fine dust and nitrogen oxides. If the engine developers succeed in getting a handle on these disadvantages, the diesel will be able to accelerate powerfully and with a clean conscience on the road toward the future – especially if it's fed with more eco-friendly synthetic fuels and supported by an electric motor.

However, the predominance of the internal combustion engines seems to be ending soon – the electric age is dawning. Actually, unlike steam, the electric motor as a propulsion system for automobiles never completely disappeared. In 1969, GM unveils the GM 512 hybrid with an electric motor and a two-cylinder gasoline engine. BMW, in 1980, begins to experiment with hydrogen as a source of propulsion and in 1992, a large-scale project with 60 electric vehicles from five different manufacturers is rolled out on the island of Rügen in the German Baltic Sea. In 1994, Mercedes presents the NECAR as the first drivable hydrogen car. However, in 1995, only 0.01 percent (4,500) of all the vehicles registered in Germany are equipped with electric motors.

The automotive industry does not give up, though. Audi introduces the first production hybrid car, the duo II, equipped with a 90-hp 1.9-liter TDI engine and a 29-hp electric motor. A year later, GM launches the EV1 as the first all-electric vehicle, but only leases it – with modest success. Toyota, finally, achieves a breakthrough for hybrid technology with the Prius (1997). BMW makes another attempt with hydrogen in 2000, using the 750 hL as a shuttle car at EXPO. But only due to the sales successes achieved by Tesla from 2006 on, electric mobility has moved back into focus and will establish itself in the coming years. The necessary development and innovation momentum is currently being generated – not least in the light of stricter emission control laws. Ranges will increase and prices drop – electric mobility will become mass compatible.

Motorsport and road technology

Competing with others is part of the human DNA. So it's no wonder that the first races are held as soon as self-propelled vehicles meet. The first documented race takes place near Manchester in 1867, pitting two steam-powered vehicles against each other. Carmakers soon realize that successful races are suitable for demonstrating the reliability and power of a product, especially since purpose-developed race cars do not yet exist.

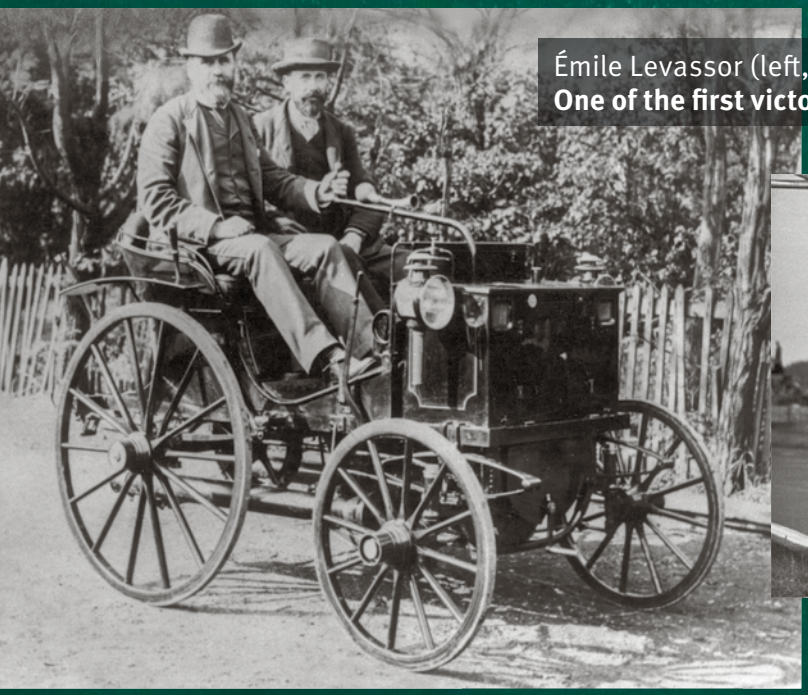
The first genuine races for various types of engines include the Paris-Rouen competition on July 22, 1894 over a distance of 126 kilometers (78 miles). The "reliability tour" is announced as an "international competition for horseless carriages." There are two winners: A Peugeot and a Panhard de Levassor simultaneously arrive in Rouen after five hours and 50 minutes. The French automobile brand De Dion announces the first race for June 11 to 15, 1895 which is only about speed. 16 gasoline, five steam and one electric vehicle contest the event.

These events are followed by hill-climb races, circuit races, endurance races (up to 16,000 kilometers/9,942 miles: Beijing – Paris, 1907), initially held only on public roads. The world's first permanent race track, Brooklands near London, is established in 1907. The constantly increasing loads lead to reinforced

» *What's behind you, doesn't matter*

Enzo Ferrari puts his motorsport mantra in a nutshell

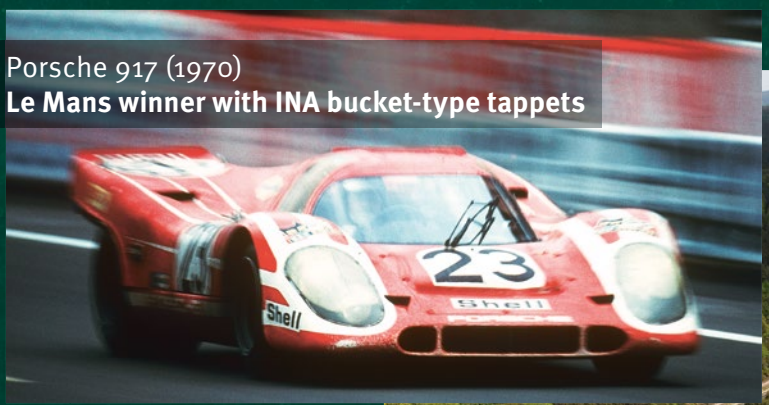
MILESTONES IN MOTORSPORT



Émile Levassor (left, 1895)
One of the first victorious drivers in automotive history

Jaguar C-Type (1953)
Premiere for disc brakes

Ray Harroun in the “Marmon Wasp” (1911)
1st Indy winner: with a rear-view mirror and FAG bearings



Porsche 917 (1970)
Le Mans winner with INA bucket-type tappets

Nürburgring-Nordschleife
The ultimate race and test track

chassis and more powerful engines – for instance by Mercedes and Bentley adding compressors in the 1920s.

But even small advances that are still viable today are owed to motor racing. In an attempt to set a land speed record in his electric vehicle, car industrialist and race driver Walter C. Baker from Cleveland crashes at just over 100 mph (160 km/h) and survives because he uses a leather belt for protection – a predecessor of the safety belt we take for granted today. In the first 500-mile race at Indianapolis on May 30, 1911, Ray Harroun in a Marmon-Wasp races without a co-driver who could tell him what's going on behind his car. The first rear-view mirror meets the same purpose but weighs clearly less. And in 1953, a Jaguar C-Type using disc brakes wins the 24 Hours of Le Mans for the first time. Shortly afterwards sports cars, soon followed by all cars, are equipped with them, enormously shortening the previously long braking distances.

The official names given to the biggest German race tracks built in the 20s prove their characteristics as proving grounds for road-going vehicle development as well. AVUS (1921) stands for "„Automobil-Verkehrs- und Übungsstraße" ("Automobile Traffic and Practice Road"), the Nürburgring that was built 90 years ago is named "Erste deutsche Gebirgs-, Renn- und Prüfungsstraße" ("First German Mountain, Racing and Testing Road"). The Nordschleife, aka "Green Hell," today is still being used by "Industriepool" ("Industry Pool"), an association of several manufacturers for testing the fine-tuning of production vehicles.

The lightweight design trend is owed to motor racing from the beginning as well, perhaps most consistently pursued by Lotus principal Colin Chapman at the time. Chapman also paid great attention to aerodynamics, for instance by building the first ground-effects race car (1977 Lotus Type 78), whereas almost all the early cars emphasizing aerodynamics such as the Rumpler Tropfenwagen, the Chrysler Airflow or the wild Tatras cannot be called successes – unlike the VW Beetle and the Porsche 356. Diesel and hybrid technologies are continually being optimized for the road in motor racing as well, for instance by the top-category LMP1 race cars fielded in the 24 Hours of Le Mans. Such hybrid systems from LMP1 and Formula 1 are increasingly used in road-going cars.

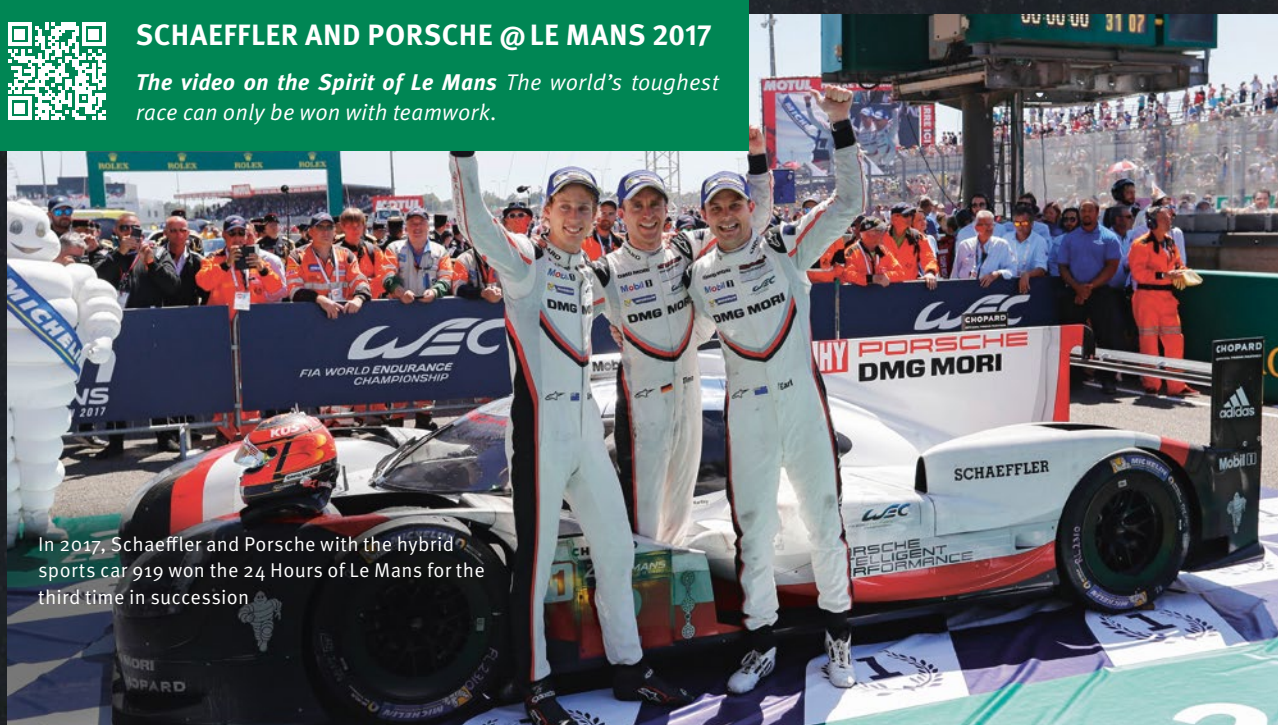
Laws and regulations

Government regulations have always been intervening with technical developments. Here are some examples: In the Holy Roman Empire, the "Sachsenspiegel" law book from 1220 stipulates who has the right of way and is an early traffic ordinance. France in 1487 introduces an initial speed limit for Paris – draft animals are not allowed to trot or gallop. In Berlin, politicians in 1698 simultaneously introduce a tax on wigs and one on carriages.

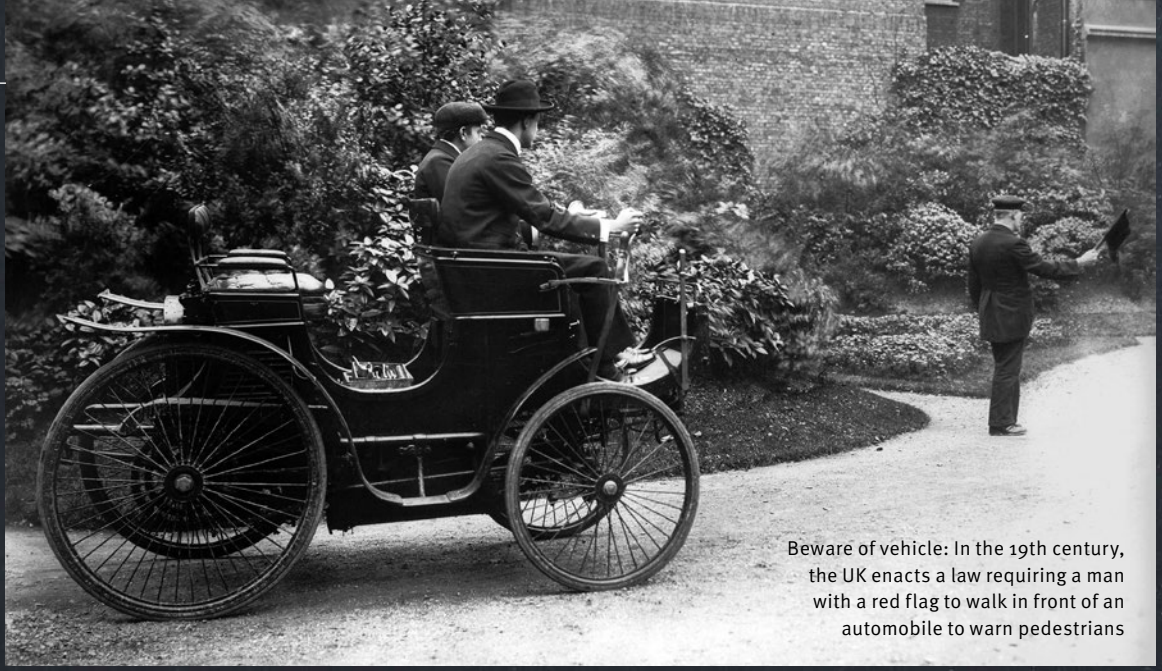
But truly a hindrance to the development of the automobile is the 1861 "Locomotive Act" in the United Kingdom that limits steam vehicles to a speed of 10 mph (16 km) (5 mph in towns) and a weight of 970 kilos (2,138 lbs). A few years later, the Locomotive Act is extended by the "Red Flag Act" requiring a man with a red flag to walk at least 60 yards (55 meters) ahead of the vehicle and imposing a speed limit of 4 mph (6.43 km/h) (2 mph in

SCHAEFFLER AND PORSCHE @ LE MANS 2017

The video on the Spirit of Le Mans *The world's toughest race can only be won with teamwork.*



In 2017, Schaeffler and Porsche with the hybrid sports car 919 won the 24 Hours of Le Mans for the third time in succession



Beware of vehicle: In the 19th century, the UK enacts a law requiring a man with a red flag to walk in front of an automobile to warn pedestrians

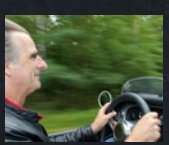
towns). In the light of such restrictions, who wants to continue developing self-propelled vehicles? The speed limit in the UK is not raised until 1896, then allowing vehicles to travel at 12 mph (20 km/h).

An example from the United States: The prohibition causes moonshine hauling bootleggers to soup up their cars in order to run from the law. Later, they become the best race drivers in their cars – which subsequently leads to the formation of the NASCAR series. In 1965, national and international automakers are affected by the consequences of U.S. consumer advocate Ralph Nader's book "Unsafe at Any Speed." Nader pulls the rear-engine Chevrolet Corvair to pieces. As a consequence of this safety bashing, imported cars, for example, have to be equipped with ample rubber bumpers and Porsche invents the "Targa," a convertible with a roll-over bar.

In 1973, the oil exporting countries cut off oil supply. The immediate consequences in Germany are Sunday driving bans and a discussion about the size of engines and their consumption. Downsizing becomes a technical trend: Audi gives preference to smaller five-cylinder turbos over the previously used six-cylinder units. The fuel consumption discussion has never dried up since then. Thanks to the further development of turbo systems (some of them using two or three turbochargers) eight- or six-cylinder engines have been shrinking to four or three cylinders (both gasoline and diesel engines) in recent years.

The U.S. state of California started establishing emission limits for motor vehicles as far back as in the 1960s. Europe has consistently been tightening its emission control standards since 1992 and more and more cities are introducing environmental zones in their centers, also forcing manufacturers to produce cars with lower emissions. Some countries are by now even deliberately guiding consumer wishes through legislation. By granting major tax incentives, Norway has managed to raise the level of electric vehicles to 30 percent of all new registrations – and is even discussing not to permit any more new cars with IC engines as of 2025. Anyone in Japan driving a Kei car (maximum length of 3.39 meters/11.2 ft, maximum 660 cc engine) is exempt from having to certify available parking when buying a car and pays less tax. China in 2015 cut taxes for small cars in half – albeit mainly for economic reasons. In addition, the country plans to introduce an electric vehicle quota in 2018 – every car manufacturer then being required to document that its fleet includes at least eight percent of hybrid and all-electric vehicles. In Germany, the federal parliament recently passed the Autopilot Act (legal provisions for self-driving cars) that opens the door to autonomous vehicles.

This and the progressive electronization of automobiles, which has enabled concepts like car sharing, means that – at least in Germany – the role of the automobile as a status symbol is diminishing particularly among young people. But as a means to an end, i. e. for getting from A to B, cars are far from having outlived their usefulness.



THE AUTHOR

Getting his driver's license in 1978 marked the biggest change in the mobile life of motor journalist ***Roland Löwisch.*** *He passed the test after seven hours of driving lessons in a VW Golf even though he forgot to pay attention to cyclists when he got out of the car after the practical test. As a result, true independence began for him on the first day of the 19th year of his life …*

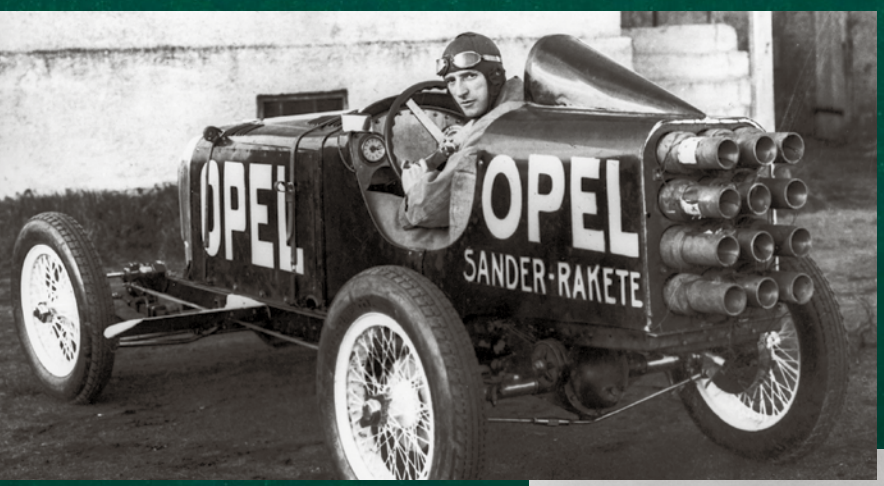
DEVELOPMENTS THAT **MISSED THE MARK**

We may be shaking our heads today – but in the early days of the automobile, people would experiment with just about anything they believed would drive its progress. *In 1897 for example, Joseph Barsaleux was concerned about the psyche of automobile drivers, so he mounted a fifth wheel to the front of his motorized carriage – with handlebars plus eyelets and reins at the top. It was meant to still the chauffeur's fears of the vehicle. Two years later, there are concerns about how horses might be feeling. Uriah Smith obtains a patent for an artificial horse's head mounted to the front of motorized carriages that is intended to calm horses. The Haynes-Apperson Horsey from 1900 actually uses the invention – the only manufacturer to do so. No less comical is the Milton Reeves' Octo-Auto from 1911. It has two axles each at the front and rear to reduce tire wear.*

In terms of propulsion systems, Opel ventures to break new ground starting in 1928, testing a range of rocket cars – initially on the road and then on train tracks. But the technology ultimately proves uncontrollable. Trials with flying cars have similar outcomes, the first one – Robert Fulton's "Airphibian" – actually lifting off the ground in 1946. Inventors are experimenting with flying cars to this day – with uncertain prospects of success. And Rover in 1949 is the first manufacturer to build a vehicle powered by a gas turbine – another futile endeavor.

This is not the case with the rotary engine invented by Felix Wankel. On February 1, 1957, it is tested on a dynamometer for the first time. At NSU, the rotary engine delivers 29 hp at 17,000 rpm. In 1963, it successfully passes a 1,000-hour endurance test and subsequently the NSU Spider becomes the first car with such an engine to be displayed at the Frankfurt International Motor Show. In 1967, it is followed by the NSU Ro 80 and the Mazda Cosmo Sport 110S. Ultimately, only Mazda will stick to the Wankel engine in its RX sports car. Not really enough to call it a success …

> ***» If you do not frequently make mistakes you have not properly challenged yourself***
>
> Ferdinand Porsche
> about innovative engineering



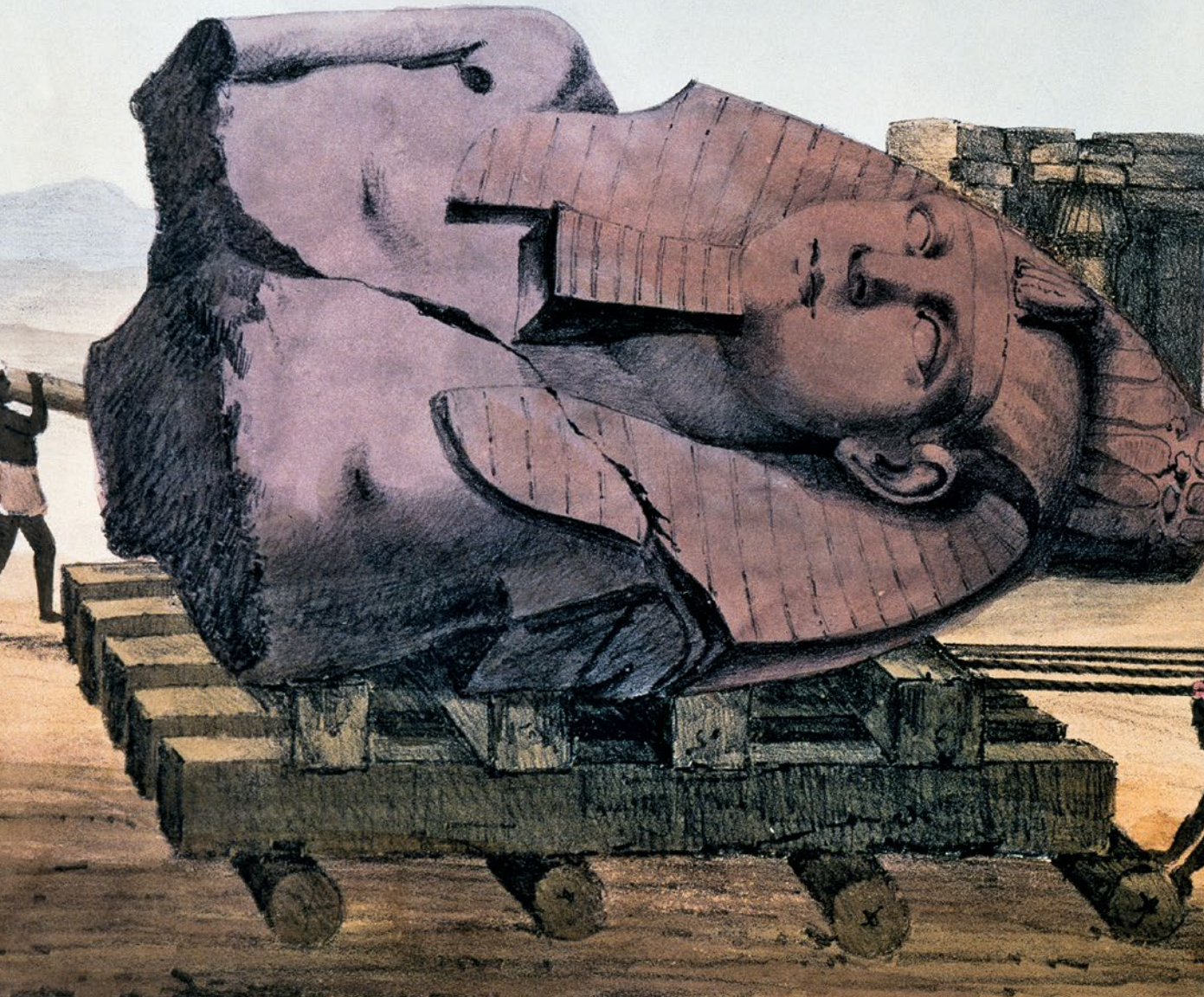
Opel's rocket drive (left) is equally unsuccessful on a large scale as the rotary engine in the NSU Ro 80 (below)

In 1946, Robert Edison Fulton Jr. built the "Fulton Airphibian" flying car. The 165-hp aluminum vehicle had wings "strapped onto it" for flying. Four prototypes were built and even awarded an aircraft specification, but it never went into production

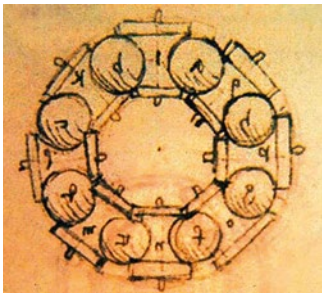
ROLLING

You can rarely see them, practically never hear them but whenever something is moving in the world, chances are that a rolling or plain bearing is involved. Used in the form of logs to reduce friction as far back as in Ancient Egypt, bearings have been making motion more efficient with every new evolutionary stage: a time journey tracing the history of hidden talents.

by Volker Paulun



THROUGH THE AGES



Who invented it? Leonardo da Vinci, of course. The more than 500-year-old picture shows a sketch of a ball bearing by the universal genius

Before we turn to the pre-Christian period that marked the birth of the rolling bearing, let's take a quick look at Schaeffler's company chronicle. In 1883, Friedrich Fischer whose company, FAG, subsequently becomes part of the Schaeffler Group invents the ball grinding machine. The machine makes it possible to manufacture large volumes of hardened steel balls by grinding them to absolute uniformity and roundness. Thanks to Fischer's invention, the ball bearing sets out from Schweinfurt to become a worldwide success. A vehicle that immediately benefits from this innovation in a major way is the bicycle, with the automobile following in its slipstream.

Fischer and his even more ingenious precursor

The ball bearing that achieves its breakthrough as a mass-produced product with the help of Fischer's machine can be traced back to a man who's arguably humanity's greatest polymath: Leonardo da Vinci. The equally sophisticated Renaissance artist, well-read scientist and visionary designer experiments with a wide variety of devices – from hydraulic machines and martial armor to bridges and transmissions, through to helicopter-like flying machines: 500 years ago, mind you. In his experiments, da Vinci keeps encountering the physical issue of friction and around 1490 makes a drawing of a device that is to remedy this problem. The idea of what we define as a ball bearing today is born. Da Vinci fixes in place freely moving balls inside an enclosure without them touching each other, a measure that reduces friction even further. However, as da Vinci uses hardwood for the balls, there are deficits in terms precision and durability. The first ball bearing application based on da Vinci's invention can be found in so-called post mills where the bearings help turn the entire body of the mill that houses the machinery to bring the sails into the wind. Da Vinci himself uses his ball bearings for exploratory drilling projects.

The first ball bearing patent though was awarded to the Welsh inventor and ironmaster Philip Vaughan in 1794 which he had filed under the title "Iron ball bearings for carriage wheel-axles." Vaughan casts the balls from molten iron. Individually made by hand, they are a far cry from the precision achieved by Fischer with his ball grinding mill but, at least, Vaughan's iron balls were clearly more durable than da Vinci's wooden ones.

Back to antiquity

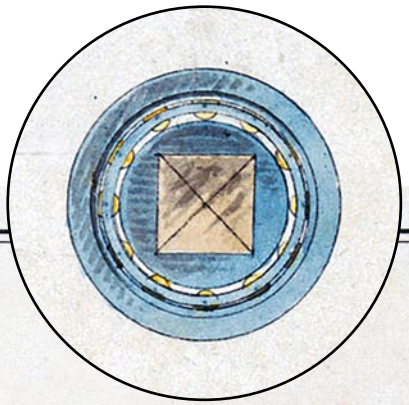
Rolling bearings, though, existed long before da Vinci and Vaughan. How long is a subject of debate between scholars. Antique drawings show that the Ancient Egyptians and Assyrians already used logs as rolling bearings to move heavy monoliths and sculptures. Probably even earlier, humans discovered another way to reduce friction and, as a result, to facilitate motion and reduce wear: lubrication. Again, it's drawings from Ancient Egypt that show water being poured in front of heavily laden cargo slides to make it easier for them to glide.

The principle of plain bearings for rotating objects is about as old as the invention of the wheel, in other words some 5,000 years. To reduce friction, heat and wear, tallow, earth pitch, resin or bee's wax is spread across the mating surfaces. A first wheel guide using a type of rolling bearing was discovered by archeologists on a Celtic chariot that is about 2,700 years old, with beech-wood sticks rolling between the axle and the wheel providing a bearing.

Once again, it's Leonardo da Vinci who's the first to scientifically investigate friction and to note down

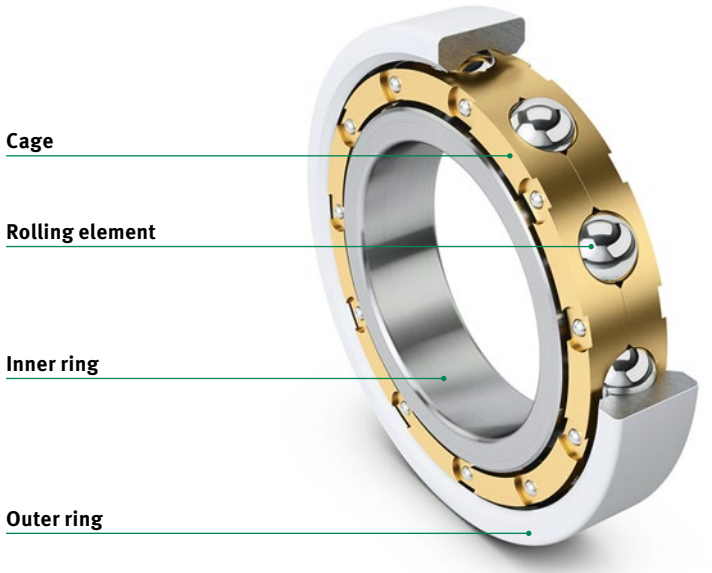
In 1883, Friedrich Fischer by inventing his "ball mill" paved the way for the rolling bearing to becoming a product that would be mass-produced by the billions

Impressive: The London Eye observation wheel revolves by means of two two-row radial FAG spherical ball bearings. The locating/floating bearing combination has an outer diameter of more than 2.6 meters and a total weight of more than eleven metric tons (12.12 short tons)



A grain mill from the 18th century. The various bearings used are easy to detect by the yellow color

TYPICAL COMPONENTS OF A ROLLING BEARING



physical laws that are still valid today. In 1493, he notes in a sketchbook that the force of friction between two sliding surfaces is proportional to the load which pushes the surfaces together. The size of the contact area between the surfaces is immaterial if their weight is identical. Furthermore, da Vinci recommends the use of bearing bushes consisting of 70 mass percent tin and 30 mass percent copper – a similar mixing ratio as that of white metal that's still being used in plain bearings centuries later.

Modern plain bearings do not require oils and greases as lubricants. Instead, surfaces made of sliding materials such as Elgoglide and Elgotex developed by Schaeffler or the metal-polymer composite E40 ensure low-friction operation. The use of plain bearings is recommended for applications involving high rotational speeds, small radial or axial assembly spaces or – due to their good absorption properties – vibrations and shocks. Applications for Schaeffler plain bearings span a very wide range, from automobiles to trains.

A major advantage of the plain bearing is its simple design, which is why it eclipses the rolling bearing for a long time. Innovations like Fischer's grinding machine simplify and reduce the cost of manufacturing rolling bearings – a game changer. In addition, benefits such as lower friction and maintenance requirements help make the rolling bearing a mass-produced product.

The ball and the cylinder have long been joined by other forms of rolling bearings. In 1898, Henry Timken files a patent in the United States for the tapered roller bearing. The barrel and the thinner needle are other forms of rolling bearings. In 1907, the Swede Sven Gustaf Wingquist invents the spherical roller bearing. Developments never stop and if something is not a new invention it's at least an improvement. In 1949, a certain Georg Schaeffler, for instance, while driving through the country, has the idea of individually guiding the needles of a roller bearing in a cage parallel to the axis. This makes the bearings more compact and able to resist higher rotational speeds – perfect for installation in automobile transmissions for example.

"Ever new things to do"

Today, visitors to the website of the company bearing Schaeffler's name will find more than 30 different types of bearings listed there in thousands of variations. The portfolio for instance includes angular contact ball bearings, spindle bearings, spherical roller bearings, axial deep groove ball bearings or linear plain and rolling bearings. Applications extend from a tiny bearing rotating at 100,000 rpm for dental drills to giants weighing several tons such as the bearing that keeps London's Millennium Wheel spinning. In the light of such a large breadth of applications it comes as no surprise that the number of bearings required around the globe is in the range of billions. In a single passenger car, over 100 bearings are installed, quietly and inconspicuously performing their duties there as well.

Even in an increasingly digitalized world, bearings have stood their ground. Equipped with sensors, they provide a connecting link between mechanical systems

Caution counterfeits!

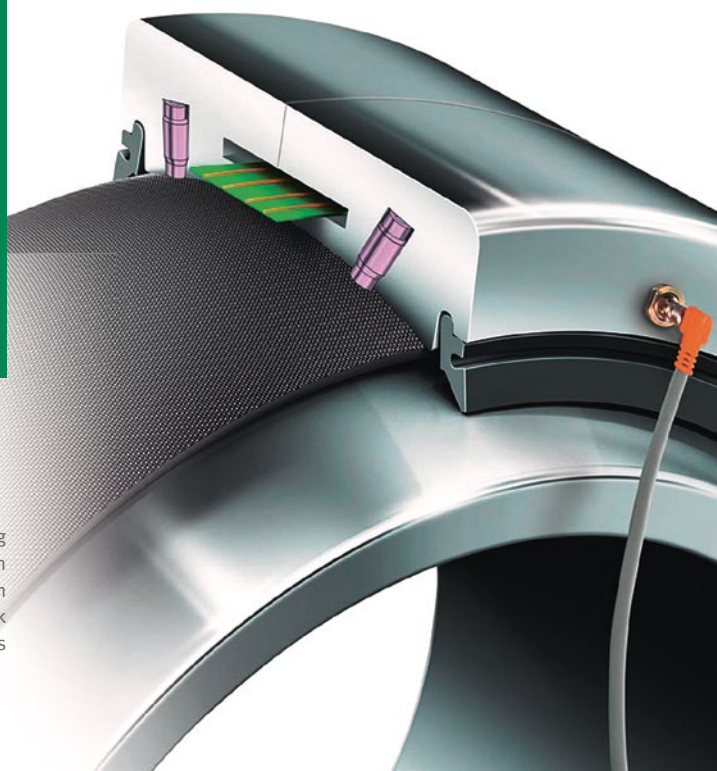
On their way into the scrap press: Schaeffler has **fake spindle, spherical roller, ball and needle bearings confiscated and scrapped by the tons again and again,** and consistently tracks counterfeiting activities and the sale of pirated rolling bearings around the globe. In addition, Schaeffler Aftermarket has established a multi-level security system with codes and labels enabling high-grade original parts to be more effectively distinguished from cheap copies and counterfeits.

2,700,000 km (1,677,702 mi)

Perfect examples of heavy duty and long life: FAG tapered roller bearing units like this one have been operating in the cars of the Istanbul Metro since 1987. Their mileages have long surpassed the seven-digit mark.

and electronics. In this new role, they no longer enhance the efficiency of motion strictly by reducing friction. Schaeffler, for instance, offers sensor bearings for remote condition monitoring. They make it possible to detect impending defects before they result in costly machine failures and downtimes. In addition, maintenance intervals can be calculated more precisely and therefore more cost-efficiently due to the data collected. As busy data gatherers, sensor bearings are important elements in integrating machines in the age of smart factories, aka Industry 4.0. This data can be used to make production processes flow smoother. In mobility for tomorrow, specifically for automated driving, sensor bearings provide information for car-to-car communication and for service providers. At the same time, mechanical bearings have to be prepared to tackle the new demands of increasing electrification with new specifications.

A phrase coined by Georg Schaeffler that he'd occasionally use in jest perfectly fits the storied development of bearing technology that has been going on for thousands of years. The company's founder translated the INA brand name – actually an acronym for "Industrie-Nadellager" ("Industrial Needle Bearings") – to mean "immer neue Aufgaben" (roughly in English: "ever new things to do").

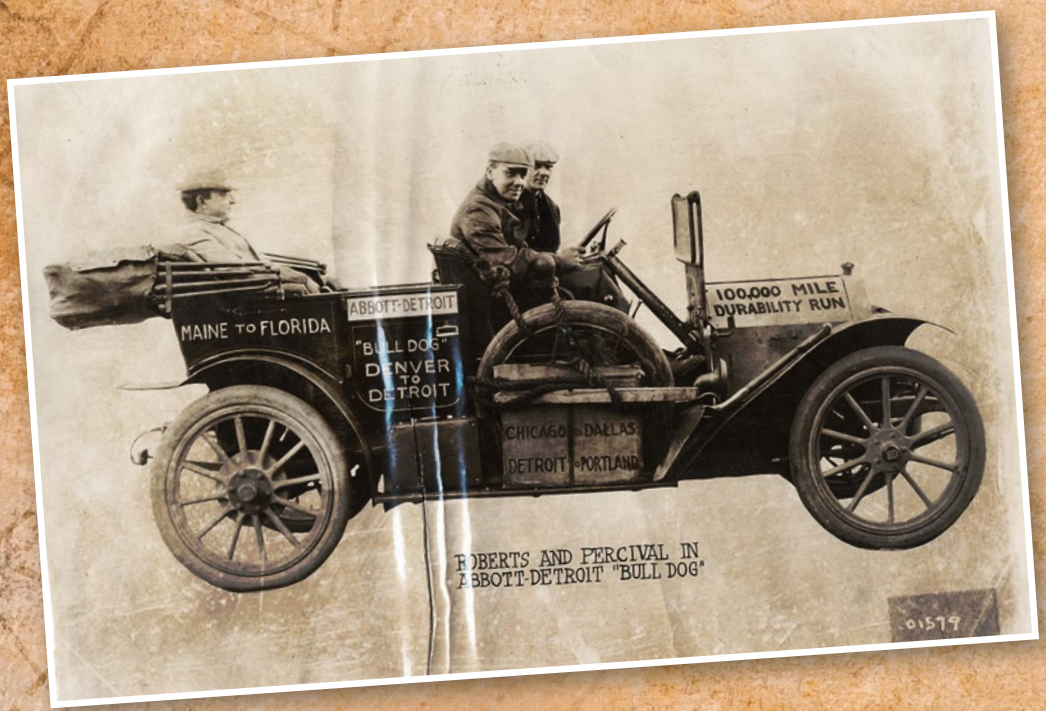


Equipped with sensor functions, rolling bearings and, as depicted here, plain bearings turn into data providers which makes them an important connecting link between mechanical systems and electronics

A JOURNEY INTO THE UNKNOWN

50,000 miles by car through the United States – in 1910, Dr. Charles G. Percival tackles a challenge that seemed an impossible feat in those days.

by Lars Krone



Embarking on a journey by car at the beginning of the 20th century is a bold undertaking. Paved roads are practically non-existent, nearly all of the rural roads are dirt roads full of potholes, or just trails, and the number of bridges can almost be counted on the fingers of one hand. Although the automobile invented in 1885 is becoming increasingly popular it's still a far cry from being a means of mass transportation. About 8,000 cars exist in the United States in 1900. By 1910 their number will have grown to nearly 460,000. Twelve years later – while horse-drawn carriages can still be seen in the streets of New York City – vehicles are surpassing the one-million mark for the first time, not least thanks to the Ford T-Model, the first mass-produced automobile. For comparison: today, more than 260 million cars are traveling on U.S. roads.

When in 1910 journalist Dr. Charles G. Percival, then a writer for the New York monthly magazine

In 1913, a letter of appreciation from Percival inspires FAG to recognize his adventures with a set of postage stamps

"Health," has the crazy idea of crossing the United States in an automobile – from south to north and from east to west – the traffic routes for motorized vehicles are not at all designed for such an endeavor. That same year, though, the adventurer, who has also been working as a war reporter, physician and geologist, embarks on his big journey in Monterrey, Mexico. Ultimately, it will last nearly two years and take him across a distance of some 50,000 miles (more than 80,000 kilometers). His vehicle, a 30-HP Abbott-Detroit which Percival has affectionately nicknamed "Bull Dog," is hopelessly overloaded. The adventurer has just packed anything he believes might be of use to him on his trip: fuel cans, food, a tent, a fishing rod, plus a pistol and a camera with which he meticulously captures his adventures.

Huge strain on humans and hardware

Percival, accompanied by mechanics taking turns doing their stints, goes to the hilt. In California's Imperial Valley, he drives 50 meters (164 feet) below sea level and in the Rocky Mountains, climbs to an elevation above 3,300 meters (10.826 feet). In Alaska, he travels beyond the 62nd parallel – no automobile ever having gone as far north before. It will take until 1978 for another car to arrive there – after a highway has been built. Especially the routes there and in the Canadian Yukon region are grueling. Time and again, Percival and his crew get stuck in the mud of fall that has set in by then. Hungry and frozen, they'll spend hours digging the ground to free the car, cutting trees in order to use their trunks to fortify the trails. At times, they only advance a few miles per day while being exposed to the elements in the open-top "Bull Dog." For lack of negotiable trails, they often drive on railroad tracks.

Percival attracts attention wherever he stops on his journey. As he regularly writes articles for newspapers during his trip, Americans are kept abreast of his progress. Percival becomes a crowd puller whenever he arrives in town. During his trip, he meets with then U.S. president William Howard Taft, some 40 governors and countless mayors. Students are released from school because they want to take a close look at the visionary and his vehicle, often following it on foot for miles. After his return, Percival adeptly goes about marketing his trip. He writes a book in which he acknowledges and thanks his numerous sponsors and suppliers. One of them is today's Schaeffler brand FAG with whose wheel bearings Percival's Abbott-Detroit was equipped and which "caused not a single moment of problems." In 1999, historian James H. Ducker writes about Percival's work that it was "the reminder of a quiet revolution (...) [that] would doom some railroads and drive others to the brink, raise up a new industry concentrated in Detroit, and greatly reshape the geography and the lives of Americans." It marked the beginning of the automotive revolution.

THE AUTHOR

Lars Krone (39) isn't sure whether or not he'd take part in any risky adventures of this kind, but the editor from Hamburg does enjoy traveling. He's particularly fond of Japan with its varied scenery and unique culture, now planning his fifth trip to the Land of the Rising Sun.

On September 25, 1911, Percival arrived in Skagway (Alaska)

Eight vehicles, each with 10 HP, took part in the “Croisière Noire” expedition in 1924/25

AUTO ADVENTURES

Percival was repeatedly followed by others embarking on great adventures in automobiles. *One of these pioneers was the Frenchman André Citroën whose expeditions were primarily aimed at enhancing public awareness of his brand. In 1922/23, his tracked vehicles were the first to cross the Sahara. Subsequently, he initiated the “Croisière Noire” (Black Cruise) on which the participants in 1924/25 covered a distance of some 28,000 kilometers (17,398 miles) across Africa from Algeria to Madagascar and six years later the “Croisière Jaune” (Yellow Cruise) through Central Asia. The latter, however, had to be stopped after crossing the Himalayas because the expedition’s leader, Georges-Marie Haardt, died of pneumonia during the trip. At the same time, the German Clärenore Stinnes caused a sensation. From 1927 to 1929, she was the first person ever to circumnavigate the world in a passenger car. But even today, a zest for adventure still manifests itself now and then. In 2007, the then co-presenters of “Top Gear,” Jeremy Clarkson and James May, ventured out into ice and snow and were the first to reach the magnetic North Pole in a car. In 2009, the German Rainer Zietlow at the “EcoFuel-Panamericana” covered a distance of some 50,000 kilometers (about 31,000 miles) in a natural gas powered VW Caddy in North and South America with stops including Schaeffler locations in Brazil, Argentina, Mexico and the United States.*

Fit for climbing: the tracked vehicles from Citroën in the Himalayas

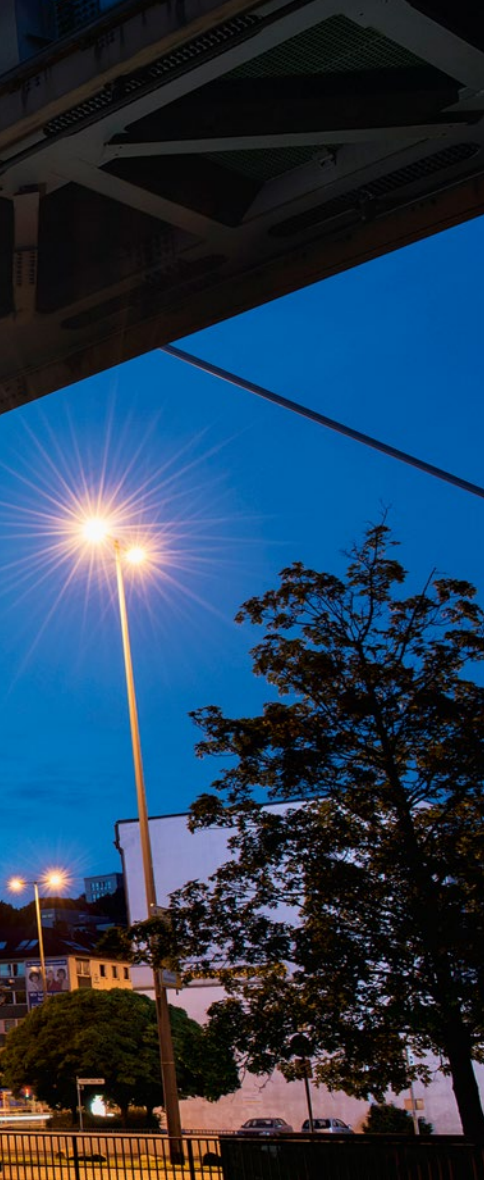
Rainer Zietlow attracted attention to the advantages of natural gas engines in 2009

In 2007, Jeremy Clarkson and James May drove to the magnetic North Pole in a Toyota Hilux

SUSPENDED FROM **A SINGLE RAIL**

Back in 1901 automobiles still have wheels with wooden spokes. The number one source of propulsion is the horse, even pulling buses. Aviation is still in its infancy too, if that much. Such is the pretty straightforward mix of available transportation technology when a transit system that seems to have come right out of a science fiction novel appears on the scene in provincial western Germany: the Wuppertal Suspension Railway.

by Laurin Paschek



The idea of progress that prevails at the end of the 19th century provides humanity with veritable miracles made of steel, the Eiffel Tower in Paris being one example and the Suspension Railway in Wuppertal another. Today, the suspended monorail constructed in Germany back then is still being used as a viable means of public transportation, hauling 65,479 people per day – which equates to 23.9 million per year. Practically no-one, though, would follow the Wuppertal example. The suspension railway in Dresden (Germany), also built in 1901, only takes passengers across a 274-meter (899-foot) distance to a viewing platform and a suspended monorail in Memphis (USA) transports visitors from the city center to an entertainment park, covering a distance of 518 meters (1,700 feet).

In Wuppertal, the suspension railway meanders for ten kilometers (6.21 miles) above the Wupper river and three (1.86) more above the road, traveling at a maximum speed of 60 km/h (37.28 mph). While this has been the case from the beginning, the number of stations has since increased from 18 to 20 – each of them designed individually and suspended from the steel structure like the train itself, with 464 support frames holding the construction. At peak and off-peak times, the service operates 18 trains, while eleven are enough at night. An articulated railcar of the latest generation "15" is 24.06 meters (78.93 feet) long, has an empty weight of 23.4 metric tons (25.79 short tons) and carries a maximum of 175 people.

Special circumstances, special technology

This unusual solution found acceptance because a number of special conditions prevailed in the region at the end of the 19th century. The "Wupper towns" that were merged to form the city of Wuppertal only in 1930 were spread across a 15-kilometer (9.3-mile) distance as a linear city along the banks of the Wupper river. Home to several hundred thousand people, the region between Barmen and Elberfeld was densely populated even in those days. For geological reasons, a subway hardly seemed to be a viable option due to an excessive presence of

» The Wuppertal Suspension Railway is unique in the world and we are proud of contributing to its reliable and safe operation with our rolling bearings and components

Hans Zirwes, plant manager of Schaeffler's site in Wuppertal

underground rock and groundwater infiltration. As the towns had never been seats of princely rulers that would have given them ample urban layouts, there was practically no room for a classic streetcar system either. Instead, the Wupper towns were representative of the vibrant era of rapidly accelerating industrialization for which the Ruhr region has come to be known.

So, how to cater for all these people's needs to get from A to B? The man who came up with an idea of how to solve the transportation problems along the Wupper was Eugen Langen. The sugar producer from the Rhineland who had previously worked on the gas engine together with Nicolaus Otto thought up the suspension railway as a space-saving means of transportation above the river. In 1894, the contract for Langen's idea was awarded, construction commenced in 1898 and three years later, with 19,200 metric tons (21,164 short tons) of steel having been used in the project, the suspension train system was finished.

Schaeffler still has a plant in Wuppertal which, under the name of Jaeger at the time, was specializing in rail technology before Schaeffler's subsidiary FAG took over the site (see info box at right). Even the first suspension railway cars used bearings and other components from this production plant. In the latest suspension railcar generation, Schaeffler is playing a key role as well. Single-row cylinder roller bearings and double-row tapered roller bearings ensure smooth running in the bogie with integrated two-wheel drive that connects the cabin and the track. Together with slewing bearings, axle box bearing housings and axle carriers, Schaeffler

Schaeffler shows its colors on an unusual advertising surface – which, in the case of a suspension railway, obviously has to be visible from the bottom

TRAINS AND CABLE CARS AT A GLANCE

— ***Trains (railroad)*** *A railroad is a transit system consisting of a connected line of rail-bound cars called trains. In terms of construction and operations law, Germany for instance differentiates between streetcars (trams) and railroads, whereas in Austria they're subject to the same laws. By contrast, streetcars in Switzerland are defined as secondary railroad lines.*

— ***Hovertrains*** *These trains do not roll on wheels but hover on a lift-pad similar to hovercraft on water. The trains can either be propelled via a rigid control cable or a linear motor. The Dorfbahn ("village train") in Serfaus, Austria, and the Skymetro at the Zurich airport both run on air cushions and are drawn by cables.*

— ***Maglev trains*** *Magnetic forces keep these trains running on guideways in a state of levitation, propel them and decelerate them. In Shanghai, a maglev train connects the Pudong airport with the center of the city.*

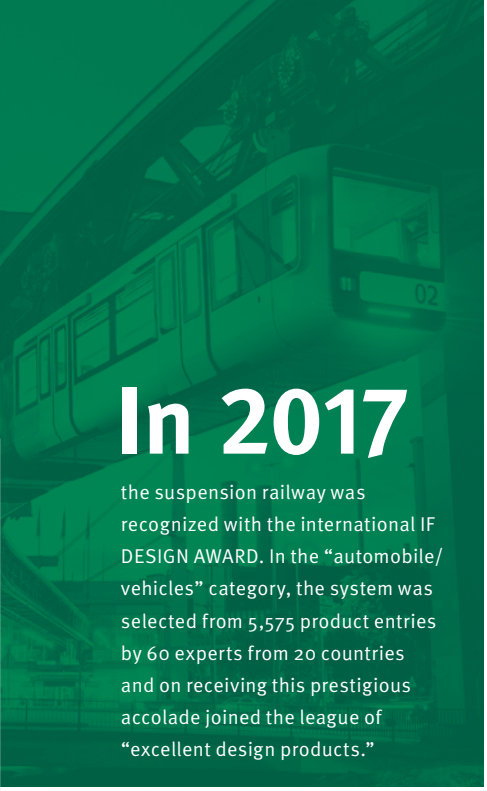
— ***Trains gliding on water cushions*** *This idea dates to the 19th century. A system would push water through holes into sliding blocks running in a flat trough profile. The system's low-noise operation was contrasted by 125 cubic meters (44,414 cubic feet) of water consumption per hour, which is why the concept remained unrealistic.*

— ***Suspended monorails*** *In addition to the Wuppertal Suspension Railway, the Dresden Suspension Railway and the Memphis Suspension Railway, similar transit systems include a suspended monorail (H-Bahn) in Dortmund or the SkyTrain in Düsseldorf.*

— ***Aerial lifts*** *These are conventional cable-operated transit systems using cabins, gondolas, open chairs or similar means above ground.*

— ***Cable cars (rail)*** *These mass transit systems preceded electric streetcars. Rail cable cars are not continuously connected to a cable, but pulled by a continuously moving one as soon as the car grips it. The San Francisco cable car system is a famous example.*

— ***Funiculars*** *Typically, funiculars are steep-grade cable railways using cabins or gondolas traveling in pairs on both sides of a continuously moving cable. They are firmly connected with the cable to counterbalance each other. An urban funicular with the cable being routed underneath the pavement still exists in Lisbon. The cable merely serves to balance mass between ascent and descent while the cars are propelled via the wheels.*



In 2017

the suspension railway was recognized with the international IF DESIGN AWARD. In the "automobile/vehicles" category, the system was selected from 5,575 product entries by 60 experts from 20 countries and on receiving this prestigious accolade joined the league of "excellent design products."

supplies components with an order value of about one million euros.

Still fit for the future even a 100 years later

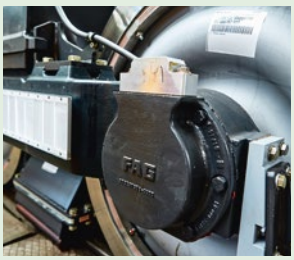
Since recently, every car section has been controlled by its own drive electronics, so that the suspension railway can continue to run even in the event of failure of one of the four 75-kilowatt motors. Previously, this was only possible by means of a dedicated emergency drive mode. Addtionally, in case of transmission failure, it will be possible in the future to take individual wheels out of the system without the whole train suffering a breakdown. In terms of energy, the 15th generation of the train is pursuing new avenues as well, as asynchronous AC motors are being used for the first time to power the transit system, allowing energy to be recuperated during braking events. Like Eugen Langen, who provided the idea in his day, today's engineers continue to develop new ideas that show that the legendary suspension railway is still fit for the future even more than 100 years after its invention.

FOR **HARSHEST** CONDITIONS

At the Wuppertal site, Schaeffler, in addition to rail applications, manufactures products for heavy industry, construction equipment and wind power systems.

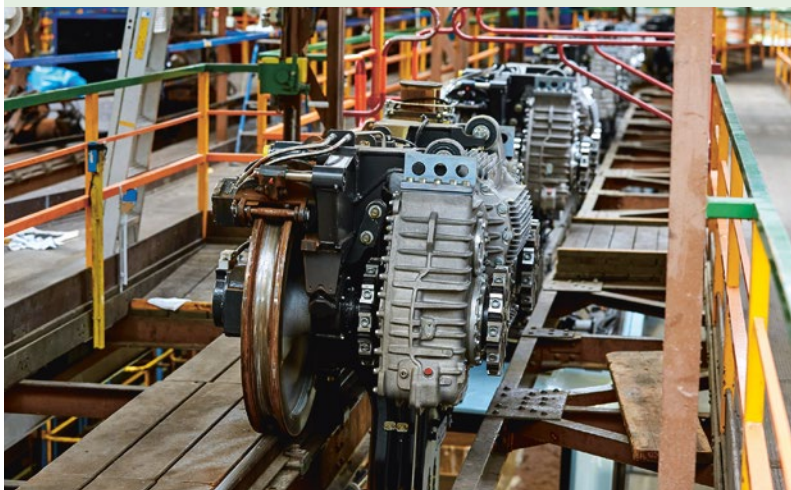
The German technology company by no means serves only domestic customers. Be it the Wuppertal Suspension Railway, high-speed trains in Germany or France, railroads in Russia, China or North America, or heavy-duty rail cars hauling ore in Australia: the axle box and transmission bearings from Wuppertal are successfully used in harshest conditions – not least thanks to a sophisticated product rollout. A launch manager supports the entire process for each production launch, beginning with the specification defined by the application developers at the Schweinfurt location and ending in the finished product.

Once a bearing has been finished, Schaeffler will thoroughly examine every single object using a non-destructive inspection. Ultrasound reveals inclusions in the material while a flux system using magnetized metal powder under ultraviolet light indicates possibly existing cracks. While safety is the top priority, it not only means preventing accidents. In the case of the Wuppertal Suspension Railway, this aspect goes beyond pure accident avoidance, as reliable service must be ensured as well.



FAG, which belongs to Schaeffler, supplies bearings for the drive system of the suspension railway

If technical failures bring the trains to a halt, this may soon lead to a safety-relevant situation. Between stations, panic might break out due to passengers being stuck on the train. Besides that, the trains are operated in carousel mode, turning around at the end of the respective line and continuing in the opposite direction. So, if just one train is disabled, all of them will stop.



FROM THE **DRAISINE** TO THE **BIO-HYBRID**

Karl Drais invented the archetype of the bicycle 200 years ago – today, some pedal-powered vehicles are exceedingly complex high-tech devices. A time journey.

by Roland Löwisch

The Schaeffler Bio-Hybrid as the main act in the multiple award-winning video clip "Trailblazers"

The 12th of June 1817 is a Thursday and presumably the sun is shining in Mannheim, Germany. Had there been attentive neighbors around on that day, they'd have witnessed the birth of a device that would subsequently become the most frequently used machine in the world. Karl Friedrich Christian Ludwig Freiherr (Baron) Drais von Sauerbronn, a forestry official, takes a vehicle out of the garage of his house which has a wheel at the front and rear and a saddle in the middle. The inventor of noble birth straddles his contraption and starts running. Or is he riding?

No matter what, with the steerable "running wheel" he invented exactly 200 years ago, Drais gave proof of the usefulness of a new means of transportation – the bicycle that uses the self-stabilizing gyroscopic forces of the wheels. It doesn't have pedals yet, its main material is wood and its 27-inch wheels are iron-shod, but the entire construction weighs no more than about 20 kilos (44 lb), already uses friction brakes with shoes acting on the wheels, has hinged kickstands at the front, and oiled plain bearings rotating in brass bushings.

Atop or in the middle: The bicycle has gone through many evolutionary stages, and not all of them proved successful, Walter Nilsson's Monowheel from 1935 being a case in point

Velocipede beats stage coach speed

Straddled on this world first, its inventor embarks on the laborious trip from his home to the relay house in Schwetzingen and back on that Thursday in 1817. He manages traveling the distance, his arms resting on a "balancing board," at an average speed of 15 km/h (9.3 mph). And in doing so, proves what he was aiming to prove: that he's faster with his "running gear" than a horse-drawn stage coach. Drais' only written comment about his break-through invention is found in the "Badwochenblatt" weekly paper: "The idea behind the invention was taken from ice skating." The reason was that back in those days, ice skaters in certain regions and ideal conditions were faster than horsemen.

Even prior to this invention, Drais had apparently been spending quite some time on exploring the subject of personal mobility. As early as in 1813, he supposedly built a four-wheeled pedal car with a treadmill and in 1814, a vehicle with a pedal-powered crankshaft between the rear wheels. Drais himself referred to his new device as a "running machine" and in the French patent as a "vélocipède" (velocipede translating into "fast foot," taking its cue from the old German saying "to get on one's fast foot" meaning to "flee" or "escape"). In his honor, the device was also referred to as a "draisine." In Germany, it wouldn't be called a bicycle until 1885, following an agreement among German cyclist clubs.

Crank propulsion starts in 1650

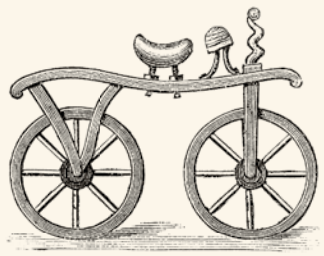
However, vehicles propelled by muscle power were known even before Drais' days – albeit only having been built for very limited uses. Hans Hautsch, for example, around 1650 invented a piece of pedal-operated equipment for the complex move of Emperor Ferdinand III and Stephan Farfler is credited with having invented the first manual self-propelled wheelchair for disabled persons around 1655. Gardening carts powered by the feet of servants purportedly existed as well in order to keep the dung of draft animals out of princely parks. But never before had anyone pursued a project of being faster than horses using a device propelled by human muscle power.

The draisine initially helps Drais achieve a breakthrough. However, due to the relatively precise description of his invention appearing in the press, craftsmen everywhere start copying the vehicle – his invention enjoying patent protection for ten years only in the German territory of Baden and in France, at least, for five years. The sudden rise in the number of "walking wheels" soon leads to conflicts as "velocipedists" are naturally looking for flat surfaces which back in those days are only found on the sidewalks crowded by pedestrians. As early as in December 1817, Mannheim prohibits such outrageous activities, followed by bans in Milan in 1818, and in London, New York and even Calcutta in 1819.

Bicycle milestones: pedals, chains, rubber tires and dog pistols

Still, there's no stopping the success of the running machine and, above all, its continuing evolution. The first bicycle with front-wheel cranks and pedals – the "Michauline" – is presumed to have been invented in 1862 by Pierre Michaux and his son Ernest. Michaux is also the first to use cast iron instead of wood for the frame, soon to be followed by others adopting wrought iron. Aimé and René Olivier embark on the first grand tour on such novel bicycles from Paris to Avignon – covering 794 kilometers (493 miles) in eight days.

In 1865, the Frenchman Louis Sergent is said to have invented the link chain (other sources citing the French clockmaker André Guilmet). The French emigrant Pierre Lallement has the crank and pedal propulsion system for the front wheel patented in the United States in 1866. Appearing soon afterwards in France are velocipedes weighing nearly 40 kilos (88 lbs) that use cranks and have high saddles the rider has to jump on. At least, some of them are fitted with solid rubber tires – for noise



The Racer of 1818. ("*Dandy*," or "*Hobby Horse.*")

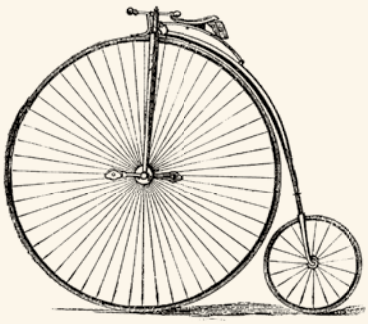


Fig. 1.—The Humber.

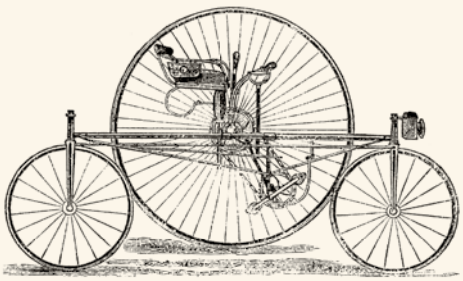


Fig. 3.—The "Coventry Rotary."

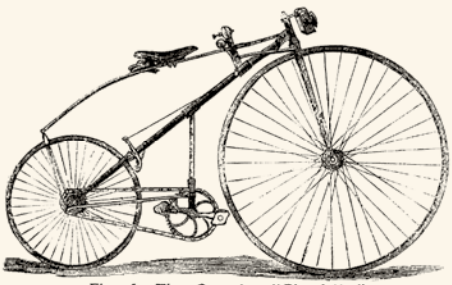


Fig. 4.—The Coventry "Bicyclette."

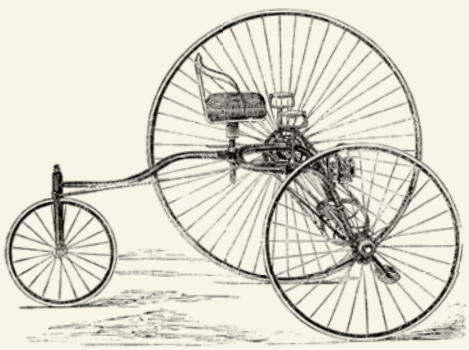


Fig. 6.—Singer & Co.'s "Challenge Tricycle," No. 3.

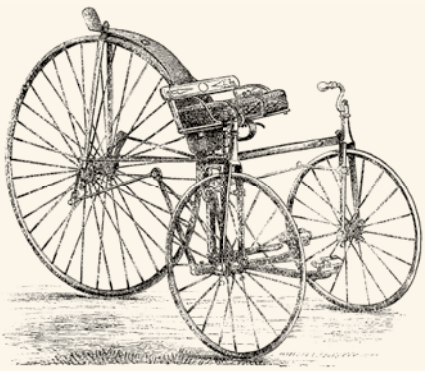


Fig. 7.—Singer & Co.'s "Challenge Tricycle," No. 1.

BICYCLE FACTS & FIGURES

— *No other form of human or animal locomotion* ***requires less energy*** *(joule per transported kilogram and kilometer) than cycling.*

— ***Shaved legs*** *yield time savings of 50–80 seconds in a professional 40-km (25-mile) time trial.*

Source: bike manufacturer Spezialized

— *Kurt Searvogel covered a distance of 76,076 miles (approx. 122,430 kilometers) on a bicycle* ***in one year*** *(2015), equaling Tommy Goodwin's 76-year-old world record.*

— *20 km/h (12.42 miles) is the appropriate average speed for riding the "green wave" on* ***Copenhagen's bicycle highway*** *in the Danish capital.*

— *The Dutch on average spend €844 on a new bicycle –* ***a record amount in the EU.*** *In 2nd place: Germany (€528). Companies at the end of the scale, each spending €110: Croatia, Cyprus, Latvia, Lithuania, Malta and Slovenia.*

Source: EU bicycle industry & market profile 2015

— *By 2024, e-bikes will have a* ***market share of about 40 %*** *around the globe, more than any other bicycle category.*

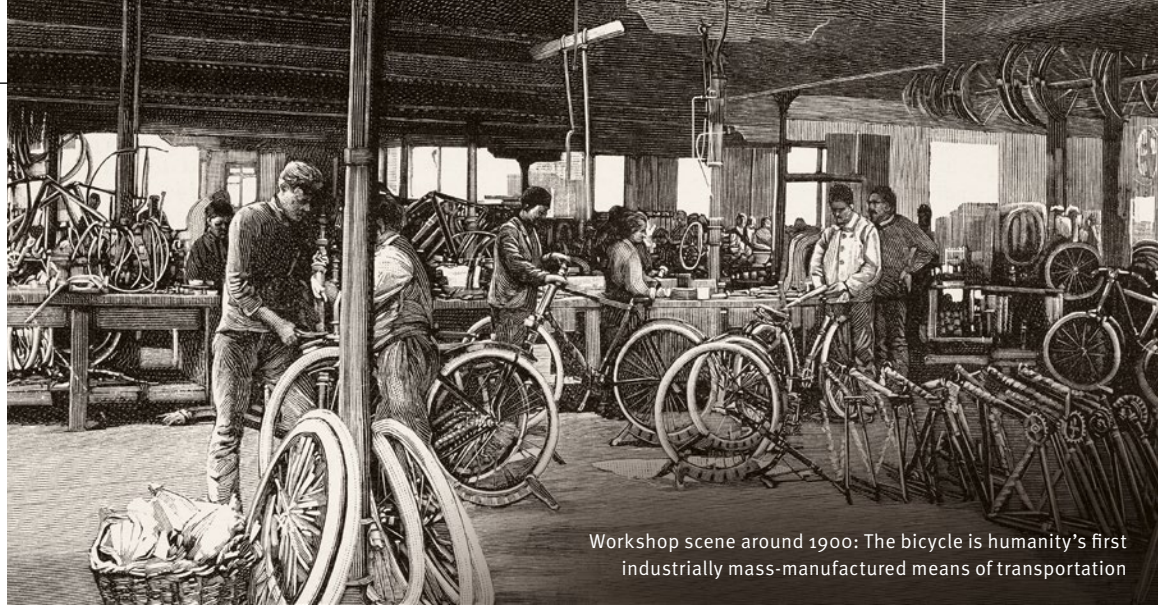
Source: Persistence Market Research (Dec. 2016)

— *The* ***market volume of the global bicycle market by 2024*** *is expected to amount to $62.39 billion, 38 % more than in the reference year 2015 ($45.08 billion). The Asia-Pacific region accounts for 63 %, followed by North America/Europe with 23 %.*

Source: Persistence Market Research (Dec. 2016)

— ***145,000,000 bicycles*** *are expected to be produced in 2017 – twice as many as automobiles. In 1965, production volumes of both – at 20 million – were equal. Since then, the bicycle has continually been getting ahead.*

Source: worldometers.info



Workshop scene around 1900: The bicycle is humanity's first industrially mass-manufactured means of transportation

reduction. To defend themselves against dog attacks, dog whips, dog pistols and even "cyclist petards" – small explosive devices – are offered to riders in the early days of the bicycle.

France is also the country in which the high wheelers emerge that have their heyday from around 1870 to 1890 – as a consequence of the switch from compression-loaded wheels with wooden spokes to tension-loaded wheels with wire spokes. Ball bearings make their way into the bicycle, as well as hollow frames. In 1879, Harry John Lawson builds the first bicycle with rear-wheel chain drive and calls it the "ordinary bicycle" – although the rear driven wheel is still clearly smaller than the front wheel. His design, though, is the first to isolate the steering from the pedal drive. The modern bicycle's breakthrough is achieved by John Kemp Starley who, together with his business partner William Sutton, has a bicycle named "Rover I" patented on January 30, 1885. When the existing high wheeler clientele at first condescendingly calls the bike "unsportsmanlike" Starley organizes a bicycle race, enters an evolution of his bike, the Rover II, and teaches the gentlemen riders a lesson in terms of pace and how it's produced. It marks the birth of the modern bicycle. This bicycle has rear-wheel chain drive, an adjustable saddle, a spoon brake for the front wheel, wire spokes and solid rubber tires.

The latter, though, are not optimal, a realization that also strikes the Scottish veterinary surgeon John Boyd Dunlop in 1887 when his son has no chance on his tricycle in a children's race held in a park. This prompts him to re-invent the pneumatic tire which, although having been developed and patented first by Robert Thompson in 1845, did not achieve its breakthrough back then.

The bicycle becomes increasingly modern. In 1889, the American A. P. Morrow has the freewheel mechanism patented – before it riders had to take their feet off the pedals on a fast ride. In 1890, Humber launches the diamond frame that is still typically used today and in 1893, Ernst Sachs is awarded a patent for the rear wheel hub which is subsequently enhanced when the coaster brake is invented. The first bicycle lights appear on the scene, initially in the form of oil lamps and later as carbide lamps. In 1902, Wanderer in Chemnitz builds the first two-speed gear hub and in 1930, pilot versions of the derailleur gear that only becomes market-ready in 1946 are available.

The bicycle is also humanity's first industrially mass-produced means of transportation. The end of the 19th century sees production volumes skyrocketing. While in Germany in 1882 merely some 2,500 bicycles are produced, their number has increased to 350,000 just 15 years later and to as much as one million in the United States around the turn of the century.

The bicycle has even made a contribution to equal rights for women

EFFICIENT CYCLING – **WITH SCHAEFFLER**

Schaeffler makes cycling easier, *guaranteed by the latest sensory and mechanical bottom bracket units, plus numerous rotary bearing solutions for electric motors and gearshifts. The highlight of the series is the FAG-VELOMATIC automatic shifting system that together with the VELODAPTIC smartphone app ensures excellent riding comfort on conventional bicycles and e-bikes.*

1 | VELODAPTIC app
2 | FAG VELOMATIC automatic shifting system
3 | Communications module
4 | CRONITECT-HYBRID ball bearing
5 | Performance sensor
6 | Freewheel mechanisms
7 | Plain bearing
8 | Angular contact ball bearing
9 | Bottom bracket spindle

Driver of justice

The mobilization of the masses by pedal power has socio-political implications as well. The bicycle even accelerates equal rights for women, according to an article published in "American Wheelman" in 1895. In it, Elizabeth Cady, a leader of the U.S. women's rights movement, predicts: "The bicycle will inspire women with more courage, self-respect, self-reliance …" 120 years later, the bicycle is still a vehicle that accelerates the cause of equal rights, democratization and upward mobility. Even the simplest of bikes allow people to transport five times as much as they could on foot – and at four times the speed of walking, according to calculations by World Bicycle Relief. The bicycle thus creates freedoms in poorer demographic groups (particularly among women) such as the possibility to get to a school that would otherwise be inaccessible.

The stream of time has been flushing road bikes, high-risers, BMX and other special-purpose bikes onto our roads and trails. The most recent development involves the use of electric power to assist propulsion. In the case of an e-bike, an electric motor provides power-on-demand typically activated by a handle-bar throttle whereas in the case of the far more commonly used pedelec (pedal electric cycle) the electric motor can only provide additional power in conjunction with the rider's use of the pedals. The next evolutionary stage on the road to mobility for tomorrow is the four-wheel bio hybrid for urban areas from Schaeffler.

To Karl Drais, the Baron of Sauerbronn, his draisine inventions (besides the "walking wheel" he also thought up the human-powered eponymous rail vehicle) brought neither personal happiness nor riches. Having fallen out of favor with the ruling nobility, Drais, a staunch democrat, dies impoverished on December 10, 1851. But he'll always be remembered for his invention.

THE AUTHOR

When it comes to relaxing in sporty style, there are three things that spontaneously come to motoring journalist ***Roland Löwisch's*** *mind: taking his car out for a fast ride through the countryside, playing squash and riding his bicycle. Admittedly, the grin on his face gets even broader when muscle power allows him to move faster than all the stressed people stuck in a traffic jam.*

» The criminal escaped the cops, but was captured in the crime rate

Erhard Blanck (*1942),
German writer and painter

SOFT-**FOOTED**

Perps watch out: Officers in the United States may soon be quietly going after you. Ford has unveiled the first ever pursuit-rated hybrid police car, a model with the somewhat complex name of Police Responder Hybrid Sedan. Although vehicles with hybrid powertrains in law enforcement are not a novelty per se, Toyota Prius etc. tend to be more suitable for non-pursuit duty than for actually chasing criminals. The electric motor of the Ford and its two-liter Atkinson-cycle turbo engine – enabling an efficient combustion process in which the compression ratio can specifically be influenced – have been calibrated for the car to run in electric-only mode up to a speed of 60 mph (96 km/h). In high-speed chases, the cops will rely on the combined power of the electric motor and the IC engine. The manufacturer presents a detailed calculation of potential savings: with an annual mileage of 20,000 in two-shift operations on 365 days and 4.9 hours of engine idling time in an eight-hour shift, the engine will burn about one liter (0.26 U.S. gallons) less fuel per hour. As a result, police departments could save 3,900 U.S. dollars per year in fuel costs based on current fuel prices in the United States.

here and now

Living with progress

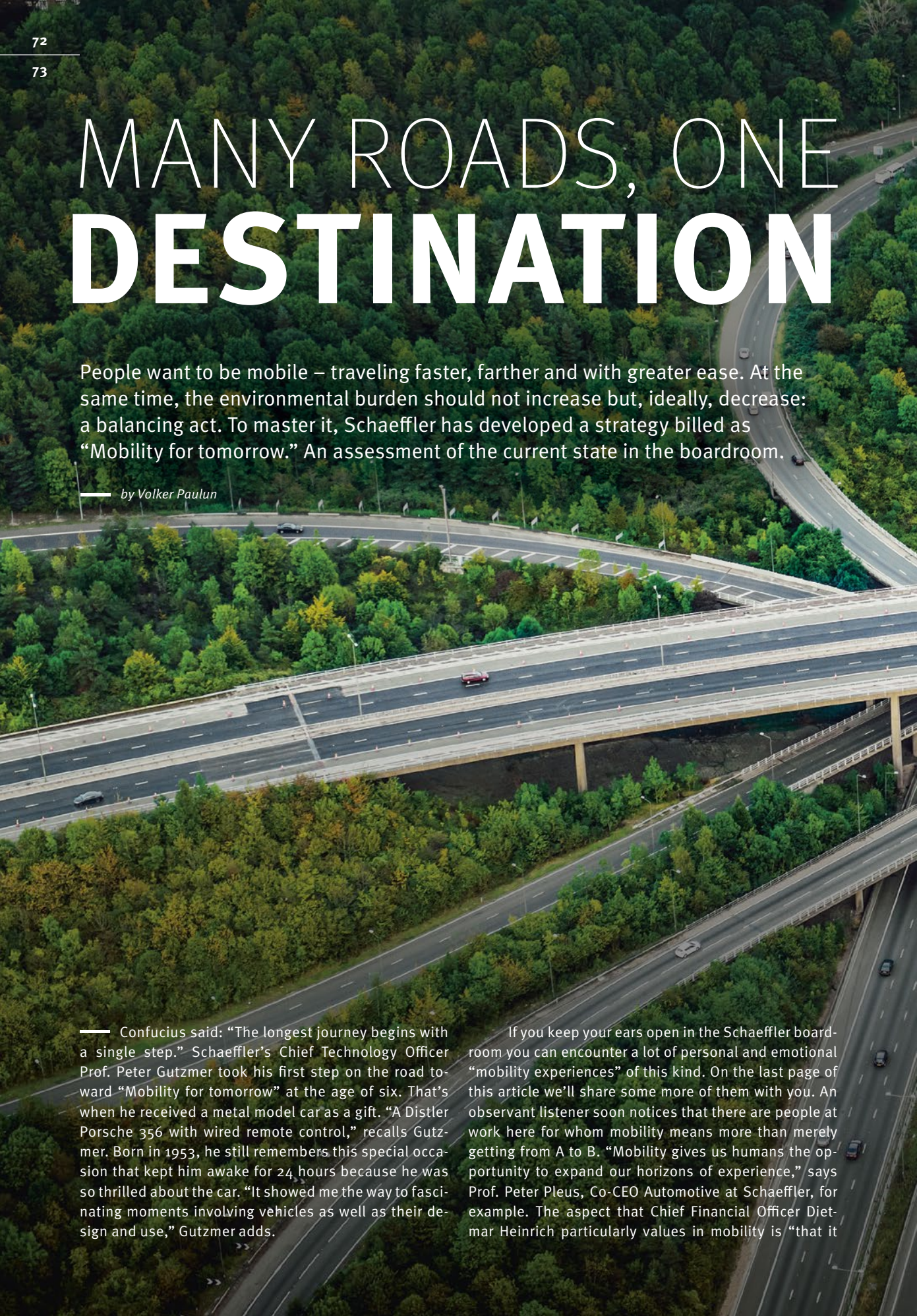
ELECTRIC AND HYBRID POWERTRAINS IN LAW ENFORCEMENT

Police car	*Location*	*Deployed in*	*Powertrain*
Nissan Altima	New York (USA)	2009	Hybrid
Toyota Camry	Arkansas (USA), Hanoi (VN)	2010	Hybrid
Mitsubishi i-Miev	Scotland	2011	Electric
Ford Transit Connect Electric	Scotland	2011	Electric
Toyota Prius	Berlin (D), Pamplona (E), Ukraine, Philippines	2012	Hybrid
Nissan Leaf	Midlands (GB), Cagliari (I)	2013	Electric
Renault ZOE	Saint-Michel-sur-Meurthe (F)	2013	Electric
Volvo V60 D6 AWD	St. Augustin and Pirna (D)	2013	Hybrid
VW e-Golf	Helgoland (D), Tirana (AL)	2014	Electric
BMW i8	Dubai (UAE), Los Angeles (USA), Sydney (AUS)	2015	Hybrid
BMW C evolution	Cagliari (I)	2015	Electric
BMW i3	Milan (I), Los Angeles (USA)	2015	Electric
Tesla Model S	Los Angeles (USA)	2016	Electric
Mitsubishi Outlander	Ukraine	2017	Hybrid

MANY ROADS, ONE DESTINATION

People want to be mobile – traveling faster, farther and with greater ease. At the same time, the environmental burden should not increase but, ideally, decrease: a balancing act. To master it, Schaeffler has developed a strategy billed as "Mobility for tomorrow." An assessment of the current state in the boardroom.

by Volker Paulun



Confucius said: "The longest journey begins with a single step." Schaeffler's Chief Technology Officer Prof. Peter Gutzmer took his first step on the road toward "Mobility for tomorrow" at the age of six. That's when he received a metal model car as a gift. "A Distler Porsche 356 with wired remote control," recalls Gutzmer. Born in 1953, he still remembers this special occasion that kept him awake for 24 hours because he was so thrilled about the car. "It showed me the way to fascinating moments involving vehicles as well as their design and use," Gutzmer adds.

If you keep your ears open in the Schaeffler boardroom you can encounter a lot of personal and emotional "mobility experiences" of this kind. On the last page of this article we'll share some more of them with you. An observant listener soon notices that there are people at work here for whom mobility means more than merely getting from A to B. "Mobility gives us humans the opportunity to expand our horizons of experience," says Prof. Peter Pleus, Co-CEO Automotive at Schaeffler, for example. The aspect that Chief Financial Officer Dietmar Heinrich particularly values in mobility is "that it

» ***Progressive climate change, increasing urbanization and globalization, and digitalization are going to substantially affect and change the way we live and work***

Klaus Rosenfeld,
CEO Schaeffler AG

MEGATREND URBANIZATION

According to forecasts, 70 percent of the world population will be living in conurbations by as early as 2050 – with respective consequences for traffic and transportation.

enables us to shape our lives in a way that our personal needs can be fulfilled." The word "freedom" is often used in the context of mobility as well. This, above all, Pleus cautions, is why "personal mobility must never turn into a luxury for the privileged."

Four megatrends set the framework for action

Nobody at Schaeffler has any doubt about the fact that mobility of tomorrow will be different from the one today. CEO Klaus Rosenfeld outlines four megatrends that in the future will decisively influence the business of the Schaeffler Group he leads. "Progressive climate change, increasing urbanization and globalization, and digitalization are going to substantially affect and change the way we live and work. This is particularly true for the field of mobility." Rosenfeld emphasizes in this context that Schaeffler in shaping mobility of tomorrow is not just focused on the automotive sector.

The four action fields for mobility of tomorrow

As early as in 2014, the global automotive and industry supplier defined two action fields it plans to focus on in the future. The first action field is environmentally friendly drive systems for industrial machines and for vehicles. For the latter Schaeffler offers appropriate solutions for both vehicles with internal combustion engines and for the growing demand for compact and powerful electric powertrains. Undisputedly, in the future there will be no way around this dual-track approach either. Even if in 2030 one in three newly produced cars is powered by an electric system, conversely, this means that 70 percent will have an IC engine on board, including the 40-percent ratio of hybrids. "Therefore, we must do everything in our means to further reduce the emissions of internal combustion engines," says Peter Gutzmer (you can read more on this topic in the Fact Sheet "IAA" attached to this issue).

In the area of urban mobility – the second action field – Schaeffler additionally focuses on two-wheeled vehicles, urban rail transit systems and all-new micromobility concepts such as the Bio-Hybrid or E-Boards. To sustain the flow of movement in the world's metropolises, Yilin Zhang, Schaeffler Regional CEO for Greater China, in addition to energy efficiency, puts particular emphasis on digitalization. "Connectivity and artificial intelligence are absolutely essential for mastering these challenges."

In the field of interurban mobility, rail, air and maritime transportation have to be made fit for the future. The volume of rail, but especially air transportation, will considerably increase. The International Air Transport Association (IATA) predicts that the number of passengers will nearly double from 3.8 billion in 2016 to 7.2 billion in 2035. Therefore, the provision of modern and powerful mobility solutions poses a key challenge in both the rail and aviation sector. A field of interurban mobility and industry not to be neglected is technology for farming and agricultural machines for which Schaeffler is working on forward-thinking solutions as well. They're necessary to cover the increasing demand for food of a growing world population. After all, 11.2 billion people will be living on our planet by the end of the century, according to UN estimates.

Be it environmentally friendly drive systems, urban or interurban mobility: common to all of them is a continuing requirement for energy that is as clean as possible. Both for the utilization of wind and hydropower

and of solar energy Schaeffler is already offering systems and components now. Here the portfolio has to be expanded just like for conventional energy production and conversion.

That Schaeffler is active along the entire energy chain – from energy production through to conversion and use – with its expertise and its products is part of its business strategy. Accordingly, the energy chain forms the fourth action field of Schaeffler's "Mobility for tomorrow" strategy.

"We deliberately practice cross-divisional collaboration, especially in our rolling bearing business. As a result, we not only create synergies but also valuable know-how transfer," says CEO Industrial, Dr. Stefan Spindler.

Matthias Zink, who shares the Automotive CEO's role with Prof. Pleus, attaches great importance to a highly efficient energy chain as well. In his opinion, the fascination that personal mobility holds and its quality can only be sustained if challenges such as environmental and climate protection, resource conservation and urbanization are mastered.

New means of transportation such as the Bio-Hybrid from Schaeffler (pictured) and improved concepts like sharing and optimal networking are important elements of urban mobility in future megacities and their massive traffic volume

Interurban rail and air transportation will significantly increase. Therefore, the provision of modern and powerful mobility solutions in these segments poses a key challenge

Mobility for tomorrow can only be successfully achieved with diverse players: Schaeffler's Chief Technology Officer Prof. Peter Gutzmer, shareholders Georg F. W. Schaeffler and Maria-Elisabeth Schaeffler-Thumann, Federal Transport Minister Alexander Dobrindt and Schaeffler's CEO Klaus Rosenfeld

> ***» Only in concert with society, politics and the business community can the required redesign of personal mobility with all the aspects and challenges involved be successfully achieved***
>
> Prof. Peter Gutzmer,
> Chief Technology Officer
> and Deputy CEO

Increasingly flexible, increasingly efficient

Mobility will also become more and more diversified. The boundaries between local public transit systems and personal mobility are becoming increasingly blurred. Sharing, people movers, on-demand services: digitalization and new propulsion concepts such as Schaeffler's eWheelDrive wheel hub motor are paving the way. Andreas Schick, Regional CEO Asia/Pacific says: "Making mobility even more flexible has to be one of the objectives: automated and pleasant if transportation is all we want and emotive if we'd like to enjoy the pleasure of driving."

All of the in-house experience, ideas and concepts notwithstanding, the executive board members are also clear about this: Schaeffler can only participate in shaping mobility of tomorrow. Aspiring to make it reality single-handedly is outright impossible – for any company. Prof. Peter Gutzmer: "Only in concert with society, politics and the business community can the required redesign of personal mobility with all the aspects and challenges involved be successfully achieved. And only then will we be able to give people the opportunity to live their dreams of freedom and individuality in emotional moments in the future as well."

MOBILITY EXPERIENCES OF SCHAEFFLER EXECUTIVE BOARD MEMBERS

» *My first tour of Germany, France and Italy in a modern classic car, enjoying the fact that the reward was in the journey and the beauty of our continent*

Prof. Peter Pleus,
Co-CEO Automotive

» *Starting up a steep hill on a mountain bike – seemingly simple tasks can be extremely difficult*

Dr. Stefan Spindler,
CEO Industrial

» *The trip from Xining to Lhasa (Tibet) on China Railway has provided me with a particularly lasting memory: 1,956 km on snow-covered mountains at altitudes of 3,000 to 5,000 m. A monument of a human engineering feat*

Yilin Zhang,
Regional CEO Greater China

» *An incisive mobility experience for me was the purchase of my Vespa (about 30 years ago to go to college) which I rode through the city and the countryside with a great sense of ease – accompanied by the unmistakable and wonderful Vespa sound. The scooter is still parked in my garage and occasionally taken out for a ride*

Corinna Schittenhelm,
Chief Human Resources Officer

» *I have my most beautiful mobility experiences on my MV Agusta Brutale 800 in the Black Forest*

Matthias Zink,
Co-CEO Automotive

» *Riding a motorcycle from Geneva to Nice across the Alpine passes. An unforgettable experience*

Oliver Jung,
Chief Operating Officer

» *Cruising on route 1, the famous Pacific Coast Highway in California, in a classic convertible in the evening and taking in the view of the Pacific coast – that's an experience which, for me, compares with nothing else*

Bruce Warmbold,
Regional CEO Americas

ON THE MOVE

In countries like Vietnam, Thailand, Indonesia and Malaysia more than 80 percent of all households use two-wheeled vehicles to satisfy their mobility needs – reason enough to take a closer look.

by Volker Paulun

"Just go ahead and walk." When explaining to tourists how to get around in the busy streets of Ho Chi Minh City Anh Nyguen always looks at incredulous faces. "Just go ahead and walk. At an even pace. The mopeds will get out of your way." And he's right, they do. Like the sea disappeared when Moses parted it, the flood of mopeds actually splits and makes room for the pedestrians. Nyguen adds a word of caution, though: "The trick only works with mopeds, not with cars."

7.4 million two-wheeled vehicles are registered in Ho Chi Minh City, plus another million that are assumed to exist there – in a city of eight million people. The bikes shape the cityscape like no other means of transportation. And the former Saigon is no exception in that respect. Particularly in South East Asia, small motorbikes lend wings to people's yen for personal mobility.

Nothing's impossible

Especially visitors from western countries are always amazed about the miraculous transportation feats performed by these light vehicles. Be it in Jakarta, Hanoi, Bangkok, Kuala Lumpur or Pune, in any of these cities whole families can be seen on them buzzing through the streets, their smallest members crouched somewhere on the fuel tank between the handlebars and the seat. Kiosk owners stack cases of beer head-high behind their backs and two more between their legs. Construction teams arrive on "hybrids" which are a moped at the front and a pick-up at the rear, while others may hitch up a trailer jam-packed with goods and twice as large as the two-stroke vehicle that tows it.

India follows suit full-throttle

In India, 48,000 new two-wheelers are registered per day, totaling 17.7 million in 2016. As a result, the subcontinent has evolved into the world's biggest moped market – even ranking ahead of China (16.8 million) and Indonesia (six million). And further growth is expected, as the "Times of India" reports. One reason is that the Indian government massively invests in rural

BIKE KNOW-HOW AT SCHAEFFLER

With applications in the areas of the engine/ motor, powertrain and suspension, *Schaeffler offers an extensive range of products to make bikes more efficient and durable. Additional information can be found here:*

infrastructure, which also fuels the rural population's desire for personal mobility. Another reason is that upwardly mobile people who can afford a car will often buy an agile moped as a second vehicle allowing them to zip around the permanently congested city streets. As straightforward and affordable urban runabouts, the easy to handle motor scooters are not just popular with men, though. One in three customers of Honda, the leader in the Indian marketplace for scooters, is female.

The flood of two-wheelers clattering through many metropolises in developing and threshold countries is a massive burden on the environment, especially as many of them are two-stroke polluters, which puts worry lines on the faces of mayors and their administrations. Vietnam's capital, Hanoi – almost always on the brink of total traffic collapse like so many other megacities – is targeting 2030 as the year in which the flood of motorbikes will be banned from the city.

Causes, problems and solutions

As switching to cars is not a viable option, there's actually just one which is: the development of a solid local transportation infrastructure. Though the lack of it – besides affordable purchasing prices and cost of ownership – is a major reason why the swarms of mini-motorized vehicles have grown into a plague in the first place.

In China, a second approach to resolving this issue has emerged: electric two-wheelers, from pedelecs through to motorcycles. In 2004, 40,000 of the small electric vehicles were sold in this huge country and currently

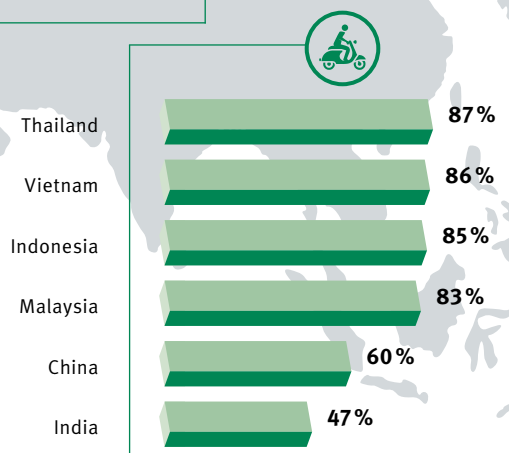
135 m

new motorbikes were sold around the globe in 2016, which is about 50 percent more than cars and light trucks (88.1 million). Both are record numbers.

MEAN MACHINES & MILD MOPEDS
HOUSEHOLDS WITH MOTORIZED TWO-WHEELED VEHICLES

*without motor scooters
Source: pewresearch.org

Electrification and sharing are topics pertaining to small motorbikes as well. The picture shows the Gogoro mobility concept with an e-scooter and battery changing station



20 million are sold per year. For the classification of bikes, the 20/40 rule applies: Anything below 20 km/h (12.4 mph) and 40 kilos (88.2 lbs) is classified as a bicycle and may be operated without a registration and a license, albeit with the corresponding limitations. Everything above these ratings is considered a motorcycle requiring the respective permits.

Sharing makes scooters attractive in Europe as well

In response to air pollution, the Taiwanese company Gogoro has gotten an electrified scooter concept off the ground allowing batteries to be changed at respective stations: energy-to-go in a manner of speaking. Gogoro's business model also includes the sharing principle, particularly in Europe. Following a successful launch in Berlin, the company is now targeting Paris. In addition to companies offering scooters with IC engines, there's another competitor in the market of e-scooter sharing, Emmy, that intends to conquer urban areas as well. The growth rates in this sector suggest that others will follow. In China, Zeebike plans to roll out 100,000 rental scooters in 30 cities. The Spanish electric scooter company Scutum has found a strong partner in energy giant Repsol that has plans for activities in the sharing market as well. Repsol's Electric Mobility Manager Carlos Bermúdez García has no doubts that acquiring a stake in Scutum has been a good investment: "All the studies show that this market is going to experience major growth in coming years." Reason enough to keep an eye on this topic.

THE AUTHOR

*Hamburg, Berlin, Rome, Mykonos – although author **Volker Paulun** doesn't have a motorcycle license, he straddles a scooter whenever the opportunity presents itself. During a one-day stopover in Vietnam his hand was itching to grip the throttle control again but for the sake of his traveling companion, he opted for a walking tour of the city.*

CONNECTING LINKS

They take us across rivers and valleys, connect city districts and cross other roads – whenever motion might be obstructed, bridges pave the way – like these prime examples of their kind.

by Volker Paulun

SIZE MATTERS

Name Jiaozhou Bay Bridge.

Location The bridge crosses the Jiaozhou Bay and connects the Chinese megacities of Qingdao and Huangdao.

Type Prestressed concrete girder road bridge (three lanes in each direction). The bridge includes a highway junction and three navigable sections, the largest one of them with a span width of 260 meters (850 ft).

Dimensions Over 5,000 concrete piles support the 42.5-km (25.84-mi) bridge which is the world's longest bridge over water, according to Guiness World Records. When the gigantic bridge was opened in 2011 it bumped Lake Pontchartrain Bridge (USA, 38.4 kilometers (23.9 miles)) from the top spot it had defended for decades. The longest bridge on our planet is the Chinese high-speed rail bridge from Danyang to Kushan with a length of 164.8 kilometers (102.4 miles – see tomorrow 01/2015).

Other interesting facts The construction project that cost over 1 billion euros and used 450,00 metric tons of steel and 2.3 million metric tons of concrete is said to be able to withstand earthquakes of magnitude 8 and collisions with a 300,000-ton ship.

PAGE FOLDS OUT ►

U.S. CLASSIC

Name Brooklyn Bridge.

Location New York City (USA), between the Manhattan and Brooklyn boroughs.

Type Suspension bridge over the Hudson River with two roadway levels, six lanes for automobile traffic (also for rail traffic until 1950) on the lower level and the upper level including a centerline for pedestrians and bicycles.

Dimensions The landmark with a total length of 1,83 kilometers (5,989 ft) was the world's longest suspension bridge in 1883, the year of its completion. The longest span between the two granite towers which are more than 40 meters high is 486.3 meters (1,595.5 ft).

Other interesting facts 120,000 vehicles, 4,000 pedestrians and 3,100 cyclists per day using Brooklyn Bridge per day make it one of New York City's lifelines. Proof of the city's love for the old lady has been an extensive makeover to the tune of some 800 million dollars that started in 2010.

THE LONGEST ONE OF ITS KIND

Name Akashi-Kaikyo-Brücke.

Location Since 1998 the bridge has linked Kobe on the Japanese mainland of Honshu to the Awaji-shima Island to the south.

Type Six-lane cable suspension bridge for automobile traffic.

Dimensions With a total length of 3,911 meters (12,831 ft) and a longest span of 1,991 meters (6,532 ft), the Japanese island connector is the world's longest suspension bridge. Originally, the two towers were one meter (3.3 ft) closer together, but an earthquake during the construction stage moved them apart.

Other interesting facts The first bridge to have been suspended from towers was the Chagsam Bridge built in Tibet in 1430. The chains were the supporting element for a long time. The Passerelle de Saint-Antoine inaugurated in Geneva in 1823 is regarded as the world's first permanent cable suspension bridge. It was followed by famous bridges like the New York Brooklyn Bridge, the Golden Gate Bridge in San Francisco, the Ponte 25 de Abril in Lisbon and the Storebæltsbroen in Denmark.

HIGH-TECH IN THE YEAR OF 1894

Name Tower Bridge.

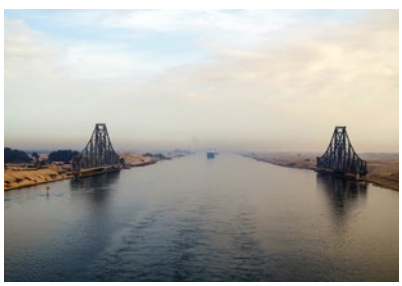
Location In the heart of London, the bridge crosses the River Thames carrying the A100 Tower Bridge Road.

Type Combined bascule and suspension bridge with an additional pedestrian walkway at a height of 43 meters.

Dimensions More impressive than the length of 244 meters (801 ft) of the landmark that was inaugurated in 1894 are its towers that are 65 meters (213 ft) high and resemble those of a castle.

Other interesting facts High technology – from the perspective of the late 19th century – was installed in the Neo-Gothic towers: a water-hydraulic system pressurized by steam engines pushed the two folding elements upward. The system was replaced by an electro-hydraulic one using oil rather than water only in 1974.

THROUGH WINGS OF STEEL



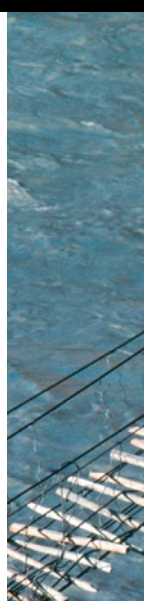
Name El Ferdan Bridge.

Location At the Suez Canal's midpoint, the bridge links the Sinai Dessert with Western Egypt.

Type Two-wing swing bridge for rail (one lane) and automobile traffic (two lanes).

Dimensions The two 340-meter (1,115 ft) long swing segments make the steel construction that weights 13,200 metric tons the longest swing bridge in the world.

Other interesting facts In addition to the El Ferdan Bridge, a tunnel and a cable-stayed bridge cross the canal that is 193.3 kilometers (120.11 miles) long.



THE STATELIEST ONE

Name Khaju Bridge.

Location The bridge over the Zayandeh River links two districts of the Iranian metropolis of Isfahan.

Type Two-level stone bridge with 23 arches that also serves as a dam. It is strictly a bridge for pedestrians.

Dimensions The magnificent structure built around 1650 is 128.7 meters (422 ft) long. At the center of the facility is a pleasure palace which Shah Abbas II, who built the bridge, used as a belvedere. Today, the bridge is a popular meeting place.

Other interesting facts Lord George Curzon, Viceroy of India in the early 1900s, ennobled Khaju Bridge by calling it the stateliest one in the world.

FOR DAREDEVILS

Name Hussaini Bridge.

Location The bridge links the banks of the Hunza River near the village of Hussaini in the north of Pakistan.

Type Suspension bridge made of rope and wooden planks.

Dimensions 194 meters (636 ft) long.

Other interesting facts The Hussaini Bridge that was completed in 1968 – one of several similar constructions in the region – has been rattling around the internet as the world's most dangerous bridge. In fact, the rickety planks shown in the picture don't inspire a lot of confidence, yet the bridge is safer than its reputation suggests, or put more precisely: it used to be safer because in 2010 a monsoon flood destroyed this important connection, forcing the local population to take a 20-kilometer (12.5 miles) detour in case of floods – until, finally, in 2017, a successor (with fewer holes in it) was built across the river again.

A STEEP JAPANESE SLOPE

Name Eshima Ohashi Bridge.

Location The bridge spans the the Nakaumi Lake between the cities of Matsue and Sakaiminato.

Type Two-lane rigid-frame bridge for automobile traffic.

Dimensions 1.7 kilometers (1,05 miles) long and 44.7 meters (147 ft) high, making it the world's third-largest one of its kind.

Other interesting facts The structure is dubbed "roller coaster" bridge. In fact, the uphill and downhill sections of 6.1 and 5.1%, respectively, are impressive, albeit less spectacular than many pictures would have us believe.

FRENCH CONNECTION

Name Viaduc de Millau.

Location Near Millau in the Massif Central in Southern France. The A75 autoroute spans the gorge valley of the Tarn River at a height of up to 270 meters (886 ft).

Type Cable-stayed bridge.

Dimensions With a length of 2.46 kilometers (8,070 ft), it is the world's longest strictly cable-stayed bridge and with a height of 343 meters (1,125 ft), France's highest structure.

Other interesting facts The contractor that built the 400-million-euro bridge is the Eiffage Group founded by Gustave Gustave Eiffel.

H_2, OH!

Name Magdeburg Water Bridge.

Location On the outskirts of Magdeburg where the Elbe Rive (below) and the Mittellandkanal (above) intersect.

Type Canal underbridge featuring a trough design.

Dimensions When filled, the 918-meter (3,012-ft) long bridge weighs 156,000 metric tons – twice as much as the "Queen Mary" luxury ocean liner. Thanks to three locks and a lift lock, vessels can switch between the Elbe River, the Mittelland and the Elbe-Havel-Kanal.

Other interesting facts In westerly direction, near Minden, a second major water bridge awaits vessels. That's where the Mittellandkanal intersects with the Weser River.

AUTHOR'S FAVORITE

Volker Paulun, who heads the editorial team of "tomorrow," lives near Hamburg, the city that has 2,485 bridges – more than Venice, Amsterdam and Stockholm combined. However, his favorite bridge is located 130 kilometers (80.8 miles) further north, in the small town of Lindaunis. There, a drawbridge on which trains, cars, cyclists and pedestrians have to share a single lane, has been crossing the Schlei, a narrow inlet of the Baltic Sea, for 90 years.

PERFECTLY **SUPPORTED**

Bridges must operate properly even without maintenance – be they swing bridges, bascule bridges, draw bridges, vertical lift bridges, suspension bridges or cable-stayed bridges. Particularly well suited for these requirements are Schaeffler's dry plain bearings with an Elgoglide coating. With properties like low friction, suitability for heavy-duty service and no maintenance requirements, they are used in bridges around the globe. Here's a selection:

Izmir (TR)
The fourth-largest suspension bridge spans the Marmara Sea in the Gulf of Izmir. More than 100 maintenance-free spherical plain bearings from Schaeffler are installed in the 2.6-km (1.6 miles) long Osman Gazi Bridge. They connect the road with the suspension cables at the junctions.

Barcelona (E)
The harbor bridge is the world's largest double bascule bridge. The four bascule pivots are equipped with large spherical plain bearings (bore 670 mm/26.4 inch). The hydraulic drive cylinders are joined to the adjacent construction by means of maintenance-free joints. Each leaf is 70 meters long and weighs approximately 2,000 metric tons.

Kappeln (D)
Maintenance-free INA large spherical plain bearings ensure functional safety in the 23.5-million bascule bridge at Kappeln on the Schlei. The leaves weighing 1,400 metric tons are opened about 3,000 times a year.

Rotterdam (NL)
The bascule bridge Van Brienenoord 2 was completed in 1990. The bridge leaf is approx. 80 meters (262 ft) long and weighs 1,900 metric tons, moving in four FAG spherical roller bearings. The bridge leaf is opened and closed using a toothed rack drive – also equipped with FAG spherical roller bearings and full-complement cylindrical roller bearings. A support mechanism was integrated into the bridge to relieve the loads on the rotary bearings during traffic, whose support points and track rollers are supported by FAG spherical roller bearings as well.

Storebælt (DK)
One of the world's longest suspension bridges is the Storebælt Bridge in Denmark. Twelve spherical plain bearings in the damping and connection systems make the bridge "surefire" so that it is able to compensate for all vibrations caused by the wind and traffic.

Buenos Aires (RA)
The Puente de la Mujer pedestrian bridge in the old harbor is an architectural and technical masterpiece. 50 years of zero maintenance was the requirement specified for the bearings supporting the pivoting bridge section: a typical application for INA large spherical plain bearings with bore diameters of up to one meter (3.3 ft).

Rügen (D)
The Ziegelgraben drawbridge for road and rail traffic connects the island of Rügen with the mainland. It consists of three parts: two static bridges each spanning 52 meters (171 ft) and the tilting center bridge section (29 meters/95 ft). FAG had already equipped its successor dating to 1937 with spherical roller bearings. When the bridge was rebuilt in the 1990s Elgoglide-coated spherical plain bearings were installed at all points of rotation (bridge leaf, beam and tie rods).

Oude Maas (NL)
The Spijkenisse vertical lift bridge consists of four 100-meter (328 ft) segments. The two center segments can be raised independently of each other in so-called lift towers by 45 meters (148 ft). The track rollers of the lift towers have a total of 168 FAG spherical roller bearings. 16 cable reels, each supported by two FAG spherical roller bearings, drive the system. The 64 FAG spherical roller bearings of the 32 cable winches have to support a weight of approx. 170 metric tons at a speed of 3 rpm.

Falsterbo (S)
The FAG spherical roller bearings installed in the Falsterbo bridge in southern Sweden have to be turned about every five years to prevent one-sided wear. The bridge has been crossing the Falsterbo canal since 1992. Its predecessor was installed in the same place in 1940 after having been used in Copenhagen for 50 years.

Kampen (NL)
The gold-plated cable sheaves on the Stadtsbrug are literally a shining example. Double-row spherical roller bearings with cylindrical bores support the tremendous weight of the movable bridge section that is regularly lifted and lowered to allow the passage of ships.

EMOTIVE LANDSCAPES

Walking – the original form of getting from A to B: without any technical aids, environmentally correct and extremely healthy. Author Michael Vogeley got into life's slow lane on a customs officers' path, established on Brittanny's rugged coastline in the 18th century for surveillance of smugglers.

by Michael Vogeley

Marvelous, colorful flora and ample fauna above seemingly endless, dazzling sandy beaches are practically our daily companions on this long tour following the tracks of the "douaniers," the customs' officers, plus there are colorful, picturesque harbors. Exploring the beauty of Brittany's wild and challenging coast is a hiker's dream. An awesome tidal range gives the coast in Brittany a different look at any time of day. In some places, the sea withdraws by as far as 20 kilometers (12.4 miles).

Fitness as a key prerequisite

In Saint-Nazaire, our starting point, we meet with our French friend Emile who's invited us to this 1,300-kilometer (807-mile) tour and provides us with an oracle's words of wisdom: "Anyone embarking on this exceptional tour should be in good shape." Obviously, he knows what he's talking about, having tackled this challenge twice before: once on foot and once on a bike. It takes a hiker about two months and a biker still nearly half that time to complete the "grande randonnée," the big hike around Brittany.

The coastal path, somewhat prosaically named GR 34, meanders between heathlands and monoliths, between sandy beaches and the ocean from Saint-Nazaire in the south to Mont-Saint-Michel in the north – a project that takes a lot of time. But when time is scarce you just pick the "cherries" from the miracle of nature that Brittany is. For instance, the rugged, rocky Pointe du Raz promontory at Cap Sizun in the far west with its awesome surf thrashing against the high, near-70-meter (230-foot) cliffs surrounded by bright yellow French broom and purple heather. Emile particularly raves about the impressive backdrop of granite boulders towering on the northern coast. The huge rocks lying on the pink granite coast look as though having been tossed there by a casual hand. As many of them seem to defy

Thanks to good sign-posting, it's easy for hikers to orient themselves. Always popular photo subjects: low tide leaving boats high and dry and the "house between rocks"

the force of gravity, their shapes inspiring human imagination, the beach of Coz Porz that shouldn't be missed is crowded with "turtles" and "witches."

Of smugglers and plunderers

The prosaic name "GR 34" will never pass a local's lips. They call the path "le sentier des douaniers," the customs' officers' path. Civil servants would surveil the rugged coastline from the path established in 1791 to put a stop to rampant smuggling in the many hidden bays. Customs duty was an important source of income in those days, France's kings having put a massive strain on the state's finances with their mammoth expenditures for a life of luxury at court, the building of magnificent palaces and warfare. Day and night, exposed to the elements, customs officers would surveil the coast up until and into the 20th century, patrolling every section three times a day. Officers had to have a head for heights and be surefooted. Where the path comes close to the cliffs it was better to keep one's gaze fixed on it rather than look at the blue sea. This advice should still be heeded by today's hikers too. When commerce became increasingly liberalized during the course of the 20th century, Brittanny's customs' officers abandoned their posts. Nature then recaptured their path little by little – until a few enthusiasts started campaigning to keep the path open for hikers. In 1968, the first section of the GR 34 was officially approved for use again: so much for history.

Protected and tended

With seagulls screaming above us, we finally hit the red-white marking again after one of our rare involuntary detours. Today, the GR 34 is sign-posted well and marked practically throughout. We hike around fjord-like bays, camp on rough rocks and refresh ourselves in the cool sea. At times white sandy bays will dominate and deep fjords at others, sprinkled with colorful fishing boats. We follow the mouth of a river with wild vegetation, hike past old castles, a tidal mill and Breton farm houses with Hortensia-hedges boasting a bold display of colors. Emile tells us: "This natural landscape is closely watched by the French coastal protection authority, the 'Conservatoire du littoral.' Hiking trails have been created, damaged areas restored and automobiles largely banned." The shores in fact are among the most beautiful ones in Europe, not least due to their diversity.

We continue trekking across wild cliffs with stunning vistas, past old military emplacements to the cape with a dream view of the islands of Les Tas de Pois, which roughly translates into pea heaps and which, as a "site de France," have been recognized as a natural monument worthy of particular protection. After having passed the "maison entre deux rochers," the house between two rocks – arguably the most frequently photographed landmark in Brittany – we get to enjoy a special type of tourist fare. Stopping at a fisherman's place, we slurp freshly harvested oysters, the best ones in France growing right here. Besides that, for hungry hikers, Brittany's varied and typically hearty cuisine hits the spot.

Grand finale

Have we really been hiking for six weeks? Not a single day was boring and not a single one was like the other. Emile takes off his backpack and points to the horizon where the world-famous silhouette of the abbey of Mont-Saint-Michel has faintly appeared. Both a pilgrimage destination and a tourist attraction, the UNESCO awarded this unique architectural ensemble the status of a World Heritage Site in 1979. With a difference of 15 meters (50 feet) between high and low tide, this is where the tidal range is the highest in Europe.

From the harbor of Saint-Nazaire to here we've done a near-complete hike around Brittany, having become hopelessly addicted to its enchanting coastal landscapes. We've mastered "le sentier des douaniers en Bretagne," the GR 34. Thank you, Emile!

bretagne.visite.org

THE AUTHOR

Having canoed through the Strait of Magellan, skied across Greenland and gone down into the glacier caves of the continental ice sheet as deep as no human before him, sailed from Greenland to Iceland, taken a canoe into the Sahara and walked to the North Pole, author ***Michael Vogeley*** *has roamed the world, always relying on the forces of propulsion provided by nature.*

The community of not even 40 inhabitants on the rocky island of Mont-Saint-Michel is confronted with 3.5 million visitors per year. The world-famous site is not only a stop for hikers of the customs officers' path but also on the Camino de Santiago, the most famous of all pilgrimage routes

WALKING
FACTS & FIGURES

— *The ancestors of modern humans began to **walk upright** some 7 million years ago – marking the most significant event in human evolution.*

— *Walking upright led to a **division of labor for the limbs:** the legs and feet were used to move around, while the arms and hands were free to grab and hold.*

— *During one step, which scientists divide into **2 phases,** the foot touches the ground 60 % of the time and is in the air 40 % of the time.*

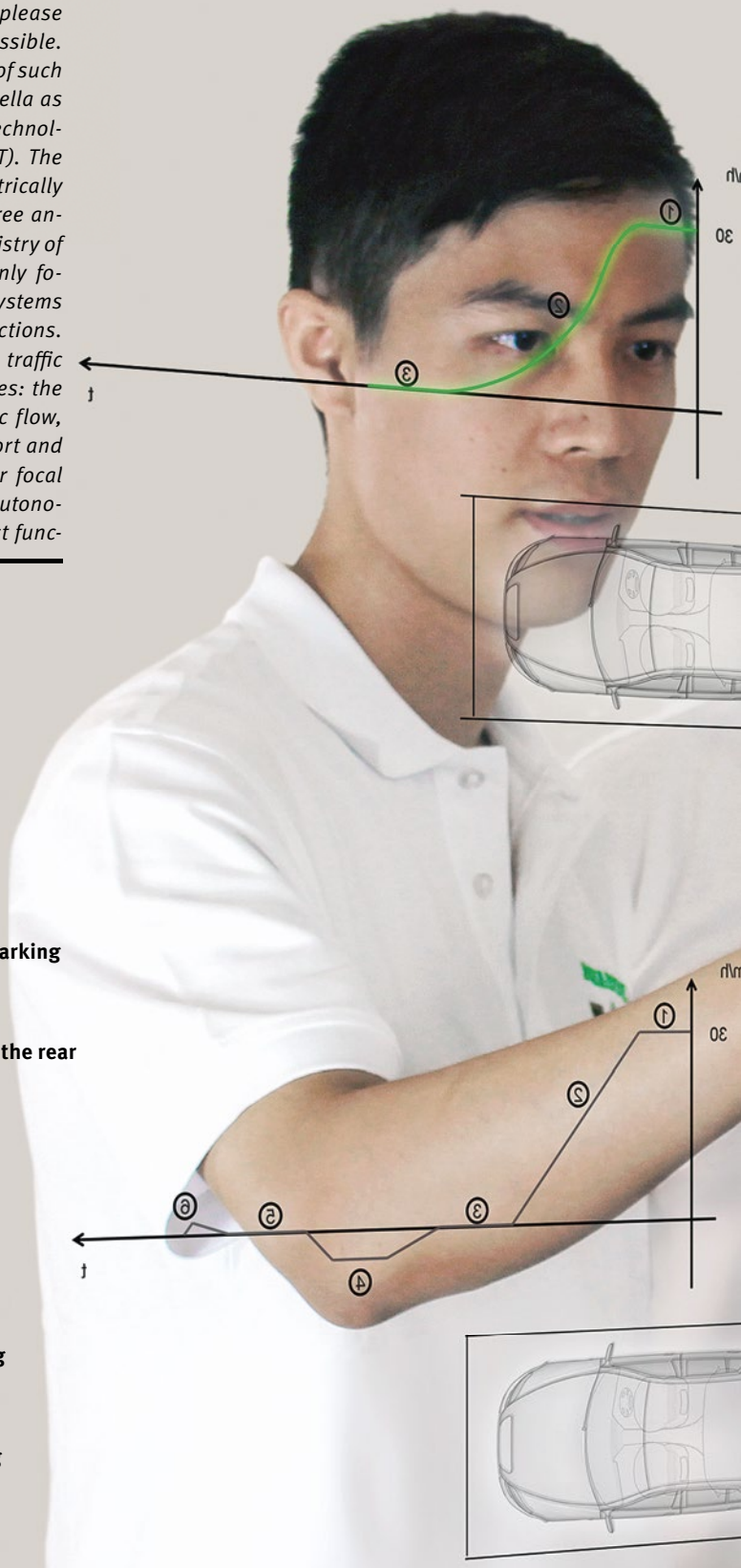
— *The typical **step length** is 63 to 73 cm (2.06 to 2.39 feet). The World Health Organization (WHO) recommends walking **10,000 steps** per day, i.e. a distance of 6.3 to 7.3 km (3.9 to 4.5 miles).*

— *While walking, **impact forces** of up to 1.5 times of the body weight occur both while pushing away from and striking the ground.*

— *Walking consumes about **280 kcal/h,** contrasted by Nordic walking which puts a strain on 90 percent of the muscles, consuming 400 kcal/h.*

IN ALL **DIRECTIONS**

Who hasn't occasionally dreamed of a car like this? A car that lets you turn all four wheels as you please to make pulling into a parking space as easy as possible. Schaeffler is currently engaged in basic research of such a system with its project partners Paravan and Hella as well as the FZI Research Center for Information Technology of the Karlsruhe Institute for Technology (KIT). The project billed as OmniSteer – in other words electrically controlled steering of all wheels up to a 90-degree angle – receives funding support by the Federal Ministry of Education and Research. The research is not only focused on new wheel suspensions and steering systems but also on distance and lane keeping assist functions. Be it maneuvering, turning, lane-changing in traffic jams or simply lateral parking by delivery services: the utilization of four steered wheels improves traffic flow, reduces stress levels and enhances safety, comfort and energy efficiency as well. Automation is another focal topic. A planned demonstration vehicle will act autonomously while the driver is able to track and select functions or intervene if necessary.



PARKING MADE EASIER BY

1951 **Power steering**
Chrysler

1959 **Fin markers, tail fins for orientation**
Mercedes-Benz

1982 **Ultrasonic distance measurements for parking**
Toyota

1991 **Pneumatically extendable guide rods at the rear**
Mercedes-Benz

1991 **Rear-view camera**
Toyota

2003 **Guided parking (parking assist)**
Toyota

2005 **Radar distance measurement for parking**
Mercedes-Benz

2015 **Autonomous, remote-controlled parking**
BMW

outlook

Technology for tomorrow

» Our heads are round so our thoughts can change direction

Francis Picabia (1879–1953), French writer and painter

FASTER AND INCREASINGLY INDIVIDUAL

Route planning seems to be a problem that has long been resolved. Yet traffic jams, blocked roads and the combination of various means of transportation can turn this simple task into a complex one. Computer scientists are working on solutions enabling us to find the fastest way even in tricky surroundings.

by Denis Dilba

Maps the size of kitchen tables, road atlases several inches thick and railroad timetables listing departure and arrival times in endless columns – it was not uncommon for travelers planning a trip in the pre-computer age to require space, plenty of patience and a little luck because "it really wasn't possible to tell if a route tediously selected by hand and apparently suitable was in fact the fastest one because information about the time required to travel the various stages simply wasn't available in those days," says Dorothea Wagner, a professor for theoretical computer science at Karlsruhe Institute for Technology (KIT). If a traveler additionally encountered a traffic jam or blocked section of a road mobility would soon turn into an involuntary adventure. Fortunately, the situation today is different. Travelers wishing to find the fastest way to get from A to B just turn on their satellite navigation systems or their smartphones to ask Google Maps or apps provided by their local transit system operators.

We owe the fact that mobility has become so much faster, comfortable and individual today to the availability of precise data from digital maps and, above all, to modern route planning algorithms. Their success story began with the shortest path algorithm developed by the Dutchman Edsger Wybe Dijkstra as far back as in 1959. The current schedule information systems and route planners essentially still work with the so-called Dijkstra algorithm. However, because the original algorithm, in order to determine the shortest path between city A and city B, calculates the connections to all cities on the map, practically searching the entire map, it has difficulties coping with large data sets. "The Dijkstra algorithm requires more than one second in the case of a digitized road map of all of Europe – and that's too slow today," says Wagner, because when thousands of such queries – as is typically the case today – are simultaneously sent to a server from smartphones and computers, the seconds aggregate and thus become the crux of the calculation.

Calculations in milliseconds

"Therefore, calculations that can be performed within a few milliseconds are necessary for such scenarios," says Wagner. Consequently, the Dijkstra algorithm had to be accelerated considerably in the past decades. "Principally, calculations that enhance the map in advance with information are used for this purpose in order to be able to logically exclude as many paths as possible when processing a query," explains Olaf Meng, Product Manager Traffic at Garmin, the world market leader for navigation solutions based in Switzerland. The methods used, though, are a business secret because the algorithms which are consistently being optimized by

hundreds of engineers are the company's most valuable know-how. However, they function in similar ways as the simple and commonly known solution of dividing a map into square regions. With the benefit of knowing in advance where a destination city is located, all the calculation steps for cities which are not located in the destination region can be omitted. Scientists like Wagner refer to a "reduction of the search space" when discussing such methods.

For route planning which does not include any current components such as traffic jams or road blocks due to accidents, the calculation is fast enough today, according to Wagner. "An intriguing situation arises when we look at real-time data and more complex scenarios such as intermodal mobility. In that case, the algorithms are often not fast enough yet," says the scientist. The reason is that when planning a route that includes any possible means of transportation, from walking, riding a bicycle, a bus, train or taxi through to car sharing systems and flying, you immediately encounter all the problems that exist within the single solutions. "Consequently, the mathematical effort involved in finding the optimum route here is considerably higher as well," says Wagner.

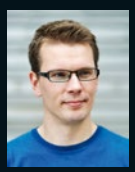
Data volume is (still) an issue

As a result, the existing offerings that include other transportation systems, such as the Qixxit app of Deutsche Bahn ("German Rail") or Daimler's Moovel app, do not yet have a truly independent algorithmic solution. Typically, they still combine the route retroactively from the separately queried transportation systems, Wagner explains. The computer scientist adds that the calculation is slow and does not necessarily deliver the fastest connection from A to B because such apps only work together with selected partner companies and not really with all existing transportation service operators. Consequently, a number of faster alternatives might be excluded as an option to begin with.

One reason for this selective approach is to prevent promoting competitors. For instance, Daimler's app Moovel only integrates the company's own car sharing service Car2Go, but not BMW's DriveNow. Another reason for limiting the service to just a few partners is the extremely high increase of the data volume even when just a small selection is involved. Therefore, the search space for the algorithms is limited wherever this is possible. Bahn.de for instance restricts the radius of walking routes to a specific maximum. Although this omits connections in which a longer walking distance might lead to a faster overall route, the omission, says Wagner, is practically done in self-defense because the data volume would immediately explode if the radius for walking routes were extended.

The computer science professor adds that efforts to resolve these challenges are in progress everywhere. Just a week ago, for example, a Ph.D. student at her institute had submitted a paper on this topic. "The intermodal offerings are becoming faster step by step and I'm expecting really good results in three to five years," says Wagner. Particularly exciting as well, says Garmin's executive Meng, is route planning for electric vehicles in which case power consumption and the distribution of charging stations have to be considered as well. Wagner is working on this topic too. In the future, she says, route planning will generally offer more individual setting options that will quickly and reliably deliver routes tailored to meet the user's needs. These solutions will include additional filters for criteria such as the views to be enjoyed on the route, intermediate stops at specific restaurants and preference of backroads over highways.

For her personal mobility needs, Wagner, by the way, has already found the optimum solution. She rides her bicyle to work on the same route every day. "The calculation time is zero in this case," she says.



THE AUTHOR

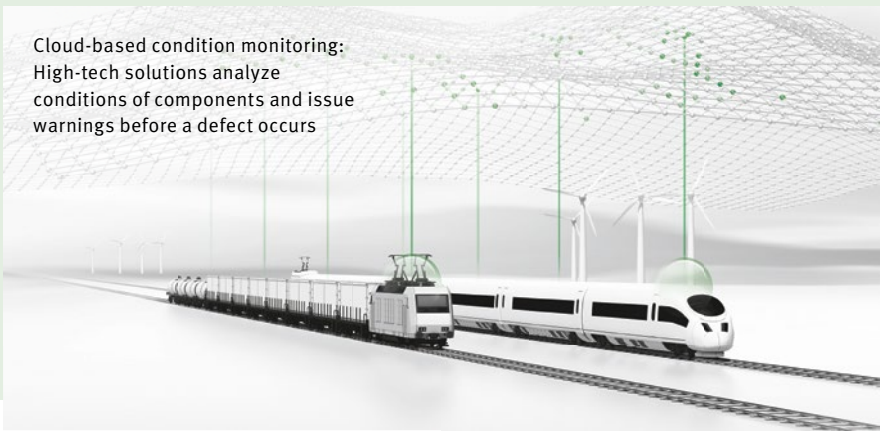
Following his research of route planning algorithms, ***Denis Dilba*** *has come to appreciate the navigation apps on his smartphone even more than before. On hiking tours, though, the journalist specializing in science and technology topics, always takes a map and a compass along to be on the safe side: because they never run out of juice.*

THIS IS HOW SCHAEFFLER FEEDS **ALGORITHMS WITH DATA**

Many of Schaeffler's products today are able to gather data from which important information is derived using real-time analyses and cognitive systems.

The electromechanical roll stabilizer is a good example. It is able to acquire driving dynamics data that may be used for networked driving in diverse ways. Sensor systems which Schaeffler offers for rail applications are diligent data gatherers as well. In cloud-based condition monitoring, such high-tech solutions analyze the condition of a component based on various parameters such as temperature, vibration and speed, and issue warnings before a defect results in failure. The wheelset generator as an autonomous and very reliable electric energy supply system for rail freight cars makes it possible to extend the digitization approaches that have already been realized today.

However, experts from Schaeffler monitor the conditions of thousands of stationary machines and equipment as well. Measured data is edited via flexible interfaces or the Schaeffler pre-processing unit and can be transmitted to the Schaeffler cloud. New algorithms and cognitive methods are used for analysis, prediction and optimization. Irregularities and required actions are indicated and appropriate actions initiated.



Cloud-based condition monitoring: High-tech solutions analyze conditions of components and issue warnings before a defect occurs

HOW ALGORITHMS GUIDE US

We all use them in our everyday lives, yet hardly any of us are aware of how omnipresent and powerful today's computation rules are. Here's a selection.

Alongside Facebook's, the Google algorithm is the most frequently used one on our planet. The things we've searched and clicked in the past are supposed to have a bearing on the search results displayed just like the user's location and the trustworthiness of the results. Critics warn that a manipulation of the results list may influence our decisions. Furthermore, our lives might become more predictable if we only do what algorithms suggest to us.

Today, a computer decides if we can get a loan or a cell phone plan approved, or open a checking account. Credit scores are calculated from data about previous loan agreements, late payments or unpaid bills. Some companies also use Facebook profiles to assess the credit worthiness of their clients.

Nicola Casagli, a geologist at the University of Florence, combines weather data, amounts of precipitation, satellite pictures and information about slope gradients in a region to predict landslides. In areas that are particularly risk-prone, Casagli additionally uses high-precision ground radar that registers even the slightest earth movements. People living in areas concerned can be warned in time by the algorithm.

So-called predictive policing algorithms use data pertaining to the scenes and times of crimes committed, the types of items stolen and modus operandi to predict the probability of burglaries occurring in the neighborhood of the most recently known offenses. As a result, police presence increases in high-risk areas. However, whether a decline in burglary crime rates can actually be attributed to the use of such algorithms is disputed.

Undisputed, though, is the fact that algorithms can decide whether or not we'll get a job we're applying for. Online application portals use them to check if applications have been fully completed and to run searches for keywords. By the way, an application on paper is not immune from such practices as it can be digitized as well and subsequently analyzed by an algorithm.

QUANTITY TURNS **INTO QUALITY**

What Sartre, the search for extraterrestrials and ants have to do with congested highways: Swarm intelligence can improve mobility and enhance safety on our roads.

by Kay Dohnke

Taking cues from nature for technical developments and solutions to problems is increasingly gaining ground in the concept of bionics – why reinvent a wheel that has been successfully spinning in nature for hundreds of thousands of years or even more? So it comes as no surprise that social phenomena in the animal kingdom are increasingly often the subject of study in terms of their emulation potential for technical processes as well.

When huge schools of herring glide through the water like one gigantic body that confuses attacking seals, or when bison gather around their young in a star-shaped formation – horns pointing outward – when threatened by a predator, we like to refer to this as swarm intelligence. This, in fact, is the same process behind such phenomena: Individuals, by behaving in a certain way, turn into a collective with characteristics that are beneficial to all but which cannot be produced by an individual. Is there anything to be learned from this?

Everyone acting in concert – does this already qualify as intelligent action?

Seti and Wikipedia are frequently cited as examples of swarm intelligence. In the case of Seti (Search for Extraterrestrial Intelligence) thousands of privately owned computers are connected in a joint search for indications of extraterrestrial intelligence in the signals that radio telescopes have recorded from the depths of the universe. And on Wikipedia, everyone can contribute articles to the world's largest online encyclopedia or correct and/or expand existing ones.

It's true that Wikipedia articles bear witness to the intelligence of their authors. Yet neither the swarm behavior of fish and bison, nor that of ET searchers or smart authors per se actually results in "intelligence" in the narrower sense. Therefore, synchronization behavior might be a more appropriate term. The animals instinctively react as a group and the collective participation in Wikipedia or Seti does not generate the type of quality that could exclusively be achieved this way but, first and foremost, serves to save time.

Seemingly meaningless data – important for the collective

The key to understanding genuine swarm intelligence is found in the question of whether or not coordinated behavior produces data which is useful to the collective and therefore adds value. Ants demonstrate this on a daily basis. In just a short space of time, they manage to find the optimum way from their nest to a place where food can be found. While searching for food and returning to the nest every ant secretes pheromones. So an ant leaving several scent marks on a short back and forth trail will mark the path more intensively than an ant can on its way to a remote source of food. The pheromones attract other ants to this trail and they'll mark it as well. The faster this cluster of scent marks grows, the more ants will follow this short path to food. This starts a self-steering process. As the volume of individually generated information grows, it becomes increasingly meaningful and useful to the collective. An individual ant would not be able to achieve this.

We can experience a similar process while driving our cars. Information about traffic jams is frequently based on position reports transmitted by smartphones. Every single one of them communicates that it's not moving at the moment. And if a large number of them consecutively indicate "I'm not moving" the exact location and length of a traffic jam can be calculated quickly. This data pertaining to immobility benefits the mobility of the collective – a sufficiently large amount of information creating a new context. None of these phones reveals anything else but its location and currently immobile condition. When this information is combined, it creates a reflection of the traffic situation to which others can intelligently respond. While no individual is able to generate this information as value-added, every one of them is necessarily involved in creating it.

30 legs and 42 wheels in a platoon

When ants migrate a special kind of behavior can be observed – one from which a lot can be learned for our mobility. There are two conspicuous phenomena: Ants always migrate in small groups of five or six individuals that maintain a gap between their own and the preceding group, but will never pass it. This guarantees largely uninterrupted movement even in the event of short-term stagnation. Plus, in the event of cramped conditions the animals will directly contact each other using their feelers which enables them to keep moving forward at a uniform pace even in tight spaces.

ADVANTAGES OF PLATOONING

— *The safety gaps between the trucks of a platoon can shrink from 50 (164) to ten meters (33 ft), cutting the space required by a convoy of three trucks in half.*

— *Slipstream driving in a platoon can improve fuel economy by eleven percent.*

— *Due to the "concertina effect" during braking and acceleration, experts regard ten trucks as the upper limit in a platoon.*

— *In the event that 50 percent of a truck's annual mileage of 150,000 km (93,206 mi) should be driven in a convoy, every one of the linked trucks could save about 2,000 liters (528.34 gal) of diesel per year.*

— *About 90 percent of all truck accidents are partially or fully based on human failure. Platooning could clearly reduce this rate.*

As early as in 2012, Volvo, in the "Sartre" project (Safe Road Trains for the Environment), tested how this might be applied to road traffic by having several mutually coordinated vehicles travel in a convoy. And in 2016, all European commercial vehicle manufacturers demonstrated in the Platooning Challenge that the operation of road trains interlinked by means of electronic data transmission can work. Developers of smart vehicle control systems such as Highway Pilot Connect have transferred the behavior of ants in the form of platooning, i. e. moving in small groups, to road traffic, with several vehicles lining up behind a lead vehicle. Connected to each other via WLAN, almost like by an electronic drawbar, the assistance systems of the first vehicle will pass on all the key information to the following vehicles.

Less space, less consumption

Driving in such convoys – three semitrailers are typically used in tests – yields several advantages, as Thomas Grimm, Vice President Product Management Heavy Duty at Schaeffler, explains: "It reduces the aerodynamic drag of the vehicles following in the slipstream, enhances safety and reduces the required road space." In fact, platooning can reduce CO_2 emissions and fuel consumption by as much as eleven percent. Instead of the normal 150 meters (492 ft), a convoy is only about 80 meters (262 ft) long. This uses the available road space more effectively and the vehicles move at a very uniform pace. The lead vehicle issues a signal when interventions by the drivers of the following vehicles are necessary. This enhances safety, as a driver's reaction time is 1.2 seconds whereas electronic systems provide information to the assistance systems of the following vehicles within 0.1 seconds. But even the best response times require braking systems that ensure reliable deceleration – especially in the light of the minimal gaps in a platoon convoy. "Schaeffler supplies important components for the reliability of brakes," says Grimm. "The detection of axle loads that serves to issue warnings of improper cargo loading which may lead to longer braking distances and

critical braking performance in emergency situations are topics we're working on at Schaeffler as well."

Swarm intelligence on the road

Platooning is a form of applied swarm intelligence – yielding benefits such as reduced fuel consumption, better traffic flow and higher safety. All the technologies required for field operation are available and, to some extent, already installed in the vehicles. "It's conceivable," explains Grimm, "that in the near future smart trucks will autonomously coordinate each other, forming platoons for certain routes, without requiring higher-level coordination" (also see info box below). The environmental benefits, improved road utilization and optimized driving strategy based on a wide set of data speak for the introduction of such systems.

However, in many places, traffic regulations still oppose a wider deployment of platooning systems, frequently stipulating a minimum distance between trucks that is clearly above the 15-meter (49-ft) gaps between the vehicles in a platoon. However, in view of the major advantages of platooning, there should be little doubt about forthcoming adjustments of legal provisions and in that case, truck platoons on our highways will be as natural as the small ant platoons have always been on forest soil.

THE AUTHOR

***Kay Dohnke** is a free-lance journalist in Hamburg whose work is focused on sustainability and mobility. The benefits of smooth traffic flow notwithstanding, the fact that environmental advantages carry equal weight as other aspects of use are particular pluses of this technology in his opinion.*

SWARM INTELLIGENCE AT SCHAEFFLER

***"In Schaeffler's view, one of the keys to forward-thinking concepts in road traffic lies in swarm intelligence,"** says Thomas Grimm, Vice President Product Management Heavy Duty at Schaeffler. "Hundreds of thousands of data-producing commercial vehicles are constantly traveling our roads. We, as a component manufacturer, as well as freight haulers and vehicle manufacturers, regard the collection and analysis of this data as a mission in order to derive maximum benefit for the environment, the road users and the fleet operators from this data."*

Grimm uses four examples to illustrate the point:

***Safety:** Critical road surface or weather conditions (ice, aquaplaning, heavy rain, fog) can be detected by sensors and and passed on to the following traffic via a data cloud. The same applies to changes in traffic flow (formation of a traffic jam, end of a traffic jam). Grimm: "Anyone who has ever had a practice unit in a truck and experienced how long the braking distances can be and how helpless a driver is in such a situation understands the importance of this issue."*

***Driving strategy and shifting behavior:** When vehicles use smart data collection and coordinate their driving strategies, the environmental burden can be reduced. "Every additional shifting event under full load on steep inclines costs about a liter (0.26 gal) of fuel," explains Grimm. "And every unnecessary braking event costs unnecessary energy as well. The more predictively and uniformly a vehicle moves the more efficient and less harmful to the environment it is."*

***Maintenance intervals:** "Sensor data and driving data can be gathered by vehicles and made available to all users," explains Grimm. "The safety windows of wear parts could be optimized and adjusted to the respective vehicle. Components would no longer be exchanged according to time and mileage based intervals but only at the end of their actual useful life. This can provide operators of large fleets with major savings and enhance safety.*

***Road maintenance:** Via the vehicles' onboard sensors, e.g. in rolling bearings, road damage could be detected and repaired at an early stage. This can help avoid major road restorations that are costly and time-consuming.*

***In a nutshell:** Vehicles are becoming increasingly smart and new markets are developing. "Schaeffler contributes its longstanding experience as a supplier there and combines it with new technologies of digitization," says Grimm. "This also includes future business models such as the gathering, editing and provision of data to partners."*

VISION AUTONOMMOBILE

An industry in motion: Research and testing of the modern and networked future of the automobile is taking place around the globe. A visit to four epicenters of the motion modernity.

Stefan Pajung (editor)

CHINA BETWEEN SHANGHAI AND SHENZHEN
A NEW IT AUTOMOTIVE INDUSTRY

"We are distinctly Chinese and have Chinese investors on board," *says the man from Germany. His office is in Hong Kong but he's constantly traveling around the globe, so when Carsten Breitfeld talks about the future of the automobile his words have a cosmopolitan air: "We believe that the two areas, IT and Automotive, have to enjoy equal rights in an automobile. That's why our vehicle is intended to become the next generation of the Mobile Smart Device for which we're building a digital platform." The computer on wheels is being developed in a place that, 40 years ago, was home to nothing but fishermen's cottages. Then the city across from Hong Kong was declared a special economic zone and virtually exploded. Today, twelve million people are officially living in Shenzhen but more than likely the actual number comes close to 20 million.*

"We want to become the Apple of the automotive industry," says Carsten Breitfeld. Now this may sound pretty ambitious for the CEO of a start-up – yet on taking a closer look at Future Mobility (FMC) the idea isn't really far-fetched. Breitfeld had made an international name for himself as the project manager for the BMW i8. When he left the Munich-based automaker in early 2016 he took half the BMW i leadership team with him. They were joined by a number of leading lights from Silicon Valley who used to work on human-machine interfaces and automated driving for Mercedes and Google, plus, not to forget, some top executives from Tesla.

Future Mobility so far has only been known to insiders particularly since one year after its launch only 100 employees are on board. Considering this, the expat Chinese are really putting the pedal to the metal. Before the year is out, the groundbreaking ceremony for a new factory with an annual capacity of 300,000 vehicles will take place in Shanghai. Starting in 2019, an electric mid-size crossover model that will start selling for 40,000 euros is planned to ensure full capacity utilization. "We've just signed the agreements with an investment volume of about 1.5 billion euros in Nanjing," Breitfeld enthuses. China intends to become a leading auto nation with electric vehicles. Arguably, the momentum of a clever start-up backed by the government of a huge country can hardly be topped.

The difference between hope, hype and hard facts is also based on the investors backing Future Mobility: the electronics corporations Foxconn and Tencent. With one billion users the latter's messenger service "WeChat", founded in 2011, is the market leader in China for sending messages and pictures. Additionally, there are digital services such as booking taxis, flights or restaurant tables available via the WeChat account. With ample profits from fees and advertising, and market capitalization of 200 billion euros, Tencent has become one of the world's 50 most valuable companies. Foxconn is known as a contract manufacturer for Apple and others. Both companies undisputedly have major technology expertise.

Schaeffler has been one of the preferred technology partners of the Chinese car manufacturers for years. Regional CEO Dr. Yilin Zhang is intimately familiar with the market in the Far East and is driving business there

» *The Chinese market offers huge potential. By combining mechanical systems, electric motors and electronics we increase our share of value in the vehicle*

Dr. Yilin Zhang
Regional CEO Greater China of Schaeffler AG

New start-ups from China such as Borgward, Linq, Faraday Future or, as said, Future Mobility see the future in electric vehicles and the moment seems opportune: China within a short period of time has evolved into the largest market for electric cars. The government intends to accomplish the country's leap to the top with affordable e-cars. Obviously, the new models are completely networked digital platforms as well. Chinese love high-tech toys. They stand for the upbeat mood in a huge country that only a few decades ago was still far behind others in terms of technology.

It will be exciting to see if China manages the climb to the level of a leading auto nation because obviously the classic "car countries" have heard the signals and work on the electric-digital automobile for tomorrow has already begun. Audi CEO Rupert Stadler puts it in a nutshell: "We will contest the race about the future electrically." All established German automobile manufacturers like Audi, BMW, VW, Porsche and Mercedes have launched major electric car initiatives as well, wielding all their power and automotive expertise – and are announcing a fireworks of electric models to hit the market in the – decisive – next years.

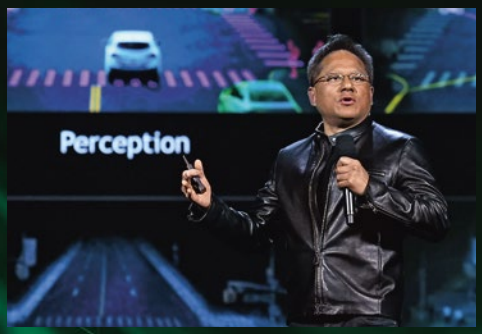
The "classic" Chinese auto industry is among the players as well. Great Wall Motors, for instance, is also aiming to get a piece of the predictably large electric car pie.

SCHAEFFLER IN CHINA: ON COURSE FOR GROWTH SINCE 1995

Efficiency and electrification – two of the key topics for the automobile of the future. *Due to its expertise in these fields, Schaeffler is a desirable development partner also in Asia and has been active in China since 1995. More than 11,000 people are employed in eight plants, numerous sales offices as well as a research and development center. At the end of 2018, Schaeffler Greater China is going to launch the next major production site with an area of about 20 hectares (49 acres) in Xiangtan in Hunan province. Also in planning is an E-Mobility Competence Center in line with the growing importance of the Chinese market in the field of electric mobility. Schaeffler's target in China: doubling sales in the next five years. Currently, three of Schaeffler's eight major production orders for e-axles and hybrid modules are from China.*

SAN FRANCISCO BAY AREA
THE SUPER WAVE FROM THE WEST COAST

California Dreamin' is a bestseller – *not only as a popular song from the 60s but also as a business model of the 21st century. There are only few regions in the world where as much venture capital is on the move as in Silicon Valley. Tech billionaires invest their profits directly in new digital start-ups. Nine in ten ideas flop but everyone is hoping for the "next big thing." Like Apple's iPhone, the Facebook social network or the Google search engine.*



With his company, Nvidia, Jen-Hsun Huang is regarded as one of the big players when it comes to the development of artificial intelligence

Business in the digital world is always about occupying the customer interface. It's almost immaterial whether it's packaged in a car, a networked loudspeaker with a microphone or a smartphone. Google has provided the ideal type of a role model. With their Android operating system for smartphones they passed Apple and are now dominating about 80 percent of the market. "We're experiencing the same thing now with artificial intelligence," explains Arwed Niestroj, who heads the Daimler development center in Silicon Valley: "At the moment, we're seeing initial business models such as the natural-language assistants Google Home or Amazon Alexa. Demand is so high that now Facebook and others are developing many intelligent systems."

So California Dreamin' means letting the next (technology) wave sweep you upward – to the very top. Occupying the new markets so fast that copycats are left standing is a matter of energy and speed. In the case of smartphones, this has been successful. Now the digital party is entering the next round. And in this start-up phase everyone is trying to build their own eco-system around artificial intelligence. "The more promising a platform appears to be the more creative minds it attracts," says Niestroj.

So here it is, the "next big thing." Programmers that used to work on apps and computer games are now tasked to design autonomous applications at reasonable costs. The hype is huge and at the CES electronics fair it's almost become the exclusive topic. IT giants such as Alphabet (Google), Microsoft or Nvidia are paving the way toward artificial intelligence with prepared software tools. "Nvidia not only offers the high-performance chips for neuronal networks but also the developers' environment for such programs," Niestroj explains. In addition, Google and others provide affordable and nearly unlimited computing capacities for machine learning. The business prospects are exciting because in the future everything can be intelligently networked. Be it cars or (flying) robots – the people in the start-up communities around the globe are experimenting with all kinds of applications. Even homes and entire cities are supposed to be self controlling entities using smart technologies. There are a lot of connections between these systems, so it's not just about the automobile as the most complex mobile end device but, ultimately, the entire Internet of Things. No wonder that the prevailing mood in California is that of another gold rush.

SCHAEFFLER AND IBM: STRATEGIC PARTNERS

Digitalization is a key aspect in the strategic alignment of "mobility for tomorrow." *Schaeffler has opted for IBM as an ideal partner for the digital transformation. Schaeffler components such as bearings or clutch systems are installed in automobiles exactly in the places where important condition or motion information is generated. After Schaeffler in recent years has been investing in research and development in order to extend conventional mechanical components by sensors, actuators and electronic control units for the Internet of Things (IoT), this data must be processed, analyzed and used by means of Artificial Intelligence (AI). IBM with its expertise assists in converting the data generated in modern Schaeffler components into valuable information. The objective: networked cars.*

TEL AVIV, ISRAEL
TECH TOURISM AT THE MEDITERRANEAN

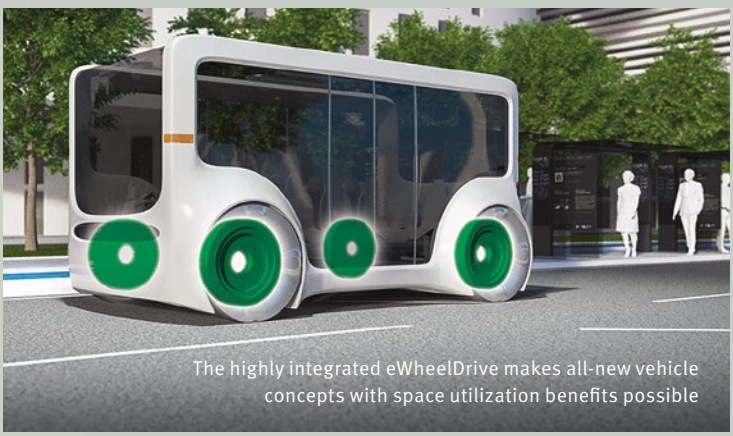
When searching for partners in Israel no-one in the automotive industry can get around Ammon Shashua. *The mathematician was one of the co-founders of Mobileye in 1999. In 2016, the former start-up company was working together with 27 automobile manufacturers around the globe and most recently the partnership with Volkswagen has been added. Mobileye is one of the leading technology companies in the field of vision-based systems. Relatively low-priced mono cameras with reasonable processing power deliver maximum data quality thanks to lean algorithms.*

"We're on pole position to play a decisive role in automated driving," explains Shashua. With BMW and Intel – now the owner of Mobileye after a 15.3 billion dollar payment – the company is working on an open platform for fully automated driving (Level 4). In 2021, the BMW iNext as the first product of this cooperation is supposed to even independently find its way around cities.

Brian Krzanich (Intel), Mobileye CEO Amnon Shashua (M.) and BMW Executive Board Member Fröhlich (r.) present the "interior of the future"

SCHAEFFLER AND AUTOMATED DRIVING: E-WHEEL-DRIVE AS AN INNOVATIVE TRACTION SYSTEM

Zero-emissions, intermodal and urban mobility are high on Schaeffler's agenda. In the electric wheel hub motor the company has developed a technology that is predestined for automated driving. *The so-called "eWheelDrive" shows how traction technology can be shifted to the wheel. In the case of the wheel hub motor, all components such as the electric motor, power electronics, the brake and the cooling system are installed in the rim of the wheel. This saves space and provides freedom for new space concepts. As a result, wheel hub motors are predestined for use in robo taxis – agile and self-driving passenger cars that could haul people in big cities across short distances. The developers are also setting their sights on so-called people movers – ultra-compact, self-driving vehicles that take take passengers from public transit systems home on the so-called "last mile." "We've driven the pre-development of the eWheelDrive to a level now that allows us to start implementing concrete projects," emphasizes Sebastian Wielgos who is responsible for the eWheelDrive development project at Schaeffler.*



The highly integrated eWheelDrive makes all-new vehicle concepts with space utilization benefits possible

HERZOGENAURACH, GERMANY
THE COUNTRY IN WHICH THE CAR WAS INVENTED

These words could have come from a modern founder: "All my passion is focused on inventions that can cause us humans to advance," *a man by the name of Carl Benz wrote to his subsequent wife, Bertha, 140 years ago. "Even if it should end in failure instead of success: It is my way that I have to pursue." Bold visionaries and lateral thinkers like the then 25-year-old got the automobile rolling in the face of all opposition. However, those who want to reinvent it today, using the means of microelectronics have to be team players. Slogging away in the solitude of a small workshop like Carl Benz did no longer works. That's why new partnerships are being forged also in tradition-steeped Germany.*

Luxury cars made in Germany are exported around the world with great success. Nearly half of all sales in domestic vehicle engineering are generated with product innovations – an uncontested record in an industry comparison. Accordingly, the domestic suppliers are well-prepared for the challenges of the future, says Matthias Wissmann: "The German suppliers are innovation drivers. Their contribution to the automotive value chain amounts to 75 percent. One third of the research and development expenditures of the German automotive industry are made by suppliers, the President of the VDA (German Association of the Automotive Industry) emphasized last year.

Mechanical engineering is clearly the forte of the closely interlinked auto nation. Although innovations were heavily driven by mechatronics in the past ten years, the components were still mechanical ones with data cables sticking out of them. The next step will go beyond this level into data driven services. "In the future, the car will be part of an information chain of the kind we've already been seeing in smartphones. The subordinate success factor will be in the hardware while the real success will be based on software and analytics," says Prof. Peter Gutzmer. Schaeffler's Chief Technology Officer is not a computer nerd but a mechanical engineer with a PhD. Consequently, what the expert for internal combustion engines had to say at CES was all the more amazing.

At the beginning of 2017, Schaeffler was represented at the world's leading consumer electronics show. Las Vegas has long become a top venue for the IT industry to meet with the automotive sector. "The software giants are realizing that the world of the complex machines has not been worked on yet to a large extent. As Schaeffler, this is exactly where we're seeking to establish contacts, knowing that the interfaces and the resulting models are still completely open," says Gutzmer. The 63-year-old is both a forward thinker and Deputy CEO – a kind of top-tier revolutionary: "The automobile will continue

Prof. Peter Gutzmer in an interview at CES 2017

» The automobile will continue to require rolling bearings in the future. We want to make them so smart that they'll be relevant to the Internet of Things

Prof. Peter Gutzmer, Schaeffler CTO

At CES 2017 in Las Vegas, Schaeffler fascinates numerous visitors with e-mobility topic

On the way to the great new auto world, Schaeffler uses the IBM platform Watson that demonstrates the possibilities of automated driving with the bus "Olli"

to require rolling bearings in the future. We want to make them so smart that they'll be relevant to the Internet of Things."

Schaeffler uses the IBM platform Watson to intelligently analyze the operating data. Thus, the bearing becomes a sensor with a cloud connection – and provides the basis for digital business models. "If we make sensor data available in specific formats so that they can be integrated in the new networks – then we'll also be able to perform some of the related digital services ourselves," Gutzmer explains. Sounds logical but is quite a paradigm change in the industry. Mechatronic components are currently purchased by the vehicle manufacturers including the software. Data services which are separately paid for are largely new ground to be broken.

"In the future, we're going to use the analytical expertise we've developed in the design software as a prediction for real-world operation and turn this into a complementary digital business model," says the CTO. The only element that's still missing for this great new auto world is the required program code artists. "By 2020, we'll be hiring 500 software specialists," Gutzmer reveals. Response, he says, is good and partnerships like the one with the Factory Berlin founders' campus and universities around the world make Schaeffler visible around the scene. Yet all the boldness to tackle transformation notwithstanding, the CTO remains realistic: "We must refrain from just running up costs during this period but also create business models that are successful." After all, burning money – will arguably never be as popular in Germany as it may be in Silicon Valley.

SCHAEFFLER AND FACTORY BERLIN: COOPERATION SIGNED AND SEALED

Exchanges with start-ups, medium-size companies and major corporations – *these are the hopes Schaeffler is pinning on a new collaborative partnership. At the beginning of 2017, representatives of the company and the Factory Berlin founders' campus signed a partnership agreement for a so-called "Innovation Hub." It is intended to provide Schaeffler with a professional environment and optimum resources for its digitalization and innovation initiatives.*

From left: Gerhard Baum, Chief Digital Officer Schaeffler AG, Prof. Tim Hosenfeldt, PhD, Senior Vice President Corporate Innovation Schaeffler AG, Sebastian Müller, Senior Innovation Strategist Factory Berlin and Florian Flick, Venture Manager Corporate Innovation Schaeffler AG

FILLING UP IN THE FUTURE

That filling stations will continue to exist is beyond dispute. But they'll look different than the ones today. Plus, they're going to offer clearly more services than convenience shopping, washing and refueling cars. Indications of what the future may look like can already be observed.

by Frank Urbansky

A place for shopping, refueling, battery charging, meetings, banking and a sharing station, e. g. for the Schaeffler Bio-Hybrid: The filling station of tomorrow combines everything under a single (solar) roof

A good example of what the filling station for mobility of tomorrow might look like can be found in Germany's capital, Berlin. Near the trade fair grounds on Jafféstrasse, the French Total Group has been offering a wide-ranging energy mix since 2014, serving all current types of propulsion systems. Even hydrogen for fuel cell vehicles is available there, plus several standards catering for the increasing number of electric vehicles: quick-charging stations that "fill up" the batteries in 15 to 30 minutes, as well as the Menneckes plug prescribed by the EU and the CHAdeMO standard exported from Japan. Other energy corporations such as Shell, BP and ExxonMobil have launched similar pilot projects or at least have them in the planning pipeline.

In the light of an increasingly varied powertrain mix of electric, hybrid and fuel cell systems, as well as diverse IC engines, it's only logical that energy diversity is the way to go at the filling station of the future as well. Nonetheless, not only experts at Schaeffler expect 70 percent of all cars (and even more in the case of commercial vehicles) to still have an IC engine on board in the decade after next – even if it were just to generate electricity for the electric motor. This is matched by estimates made by the Shell energy group according to which even in 2040 the preponderance of all fuels at the filling station will still be liquid types.

The liquid power for internal combustion engines, though, will no longer exclusively be fossil gasoline and diesel, and their blends with first-generation biofuels. The biofuels of the second generation do not entail the food-versus-fuel issue, in other words fuel production at the expense of food production. The new synfuels are produced either from residues or, by means of electrolysis, from air and water. This has the major advantage of making it possible to retain the existing infrastructure of filling stations as well as logistics from the refinery to the depot and through to the retail point of sale.

Electricity – (not) a business model

Battery charging columns at filling stations are going to spread particularly along the highways. Time will tell whether or not this business model will also be viable for filling station operators in urban areas

SHRINKAGE AND GROWTH

One in two filling stations in the UK has been closed in the past 25 years and one in four in the U.S. during a similar period of time. The situation in Canada, Japan and Germany is comparable. Whereas the filling station networks in most industrialized nations have massively diminished, they're currently becoming increasingly dense in threshold countries, particularly in India. After deregulation has opened the local market to private players, business has practically begun to boom. BP is planning to open 3,500 stations as soon as possible, its Russian competitor Rosneft 1,000. Indian Oil, one of the three government-owned companies that used to be the sole players, is countering with 1,000 new filling stations as well – per year. With a market volume of 116 billion U.S. dollars, it's not surprising that everyone is trying to secure as large a piece of the pie as possible.

Sources: Daily Mail, National Association of Convenience Stores, Wikipedia, BP, Bloomberg

This is the futuristic look already sported by Linde hydrogen filling stations today

Charge and go: E-station vision with inductive charging by Siemens

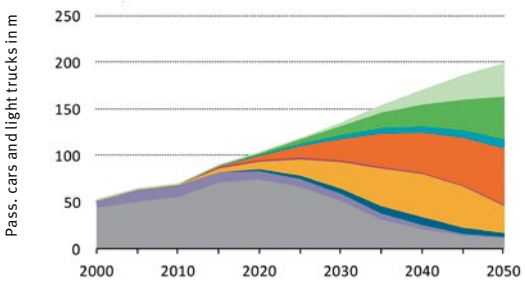
because consumers can recharge their vehicle batteries at home as well or at work if their employers allow them to do so. Patrick Carré, Shell's General Manager Retail for Germany, Austria and Switzerland, in an interview with the newspaper "Die Welt" said: "Charging columns at filling stations will only be conceivable for us as a business model when the charging time has clearly been reduced to a few minutes and the sustainability of an electric powertrain has been proven."

Fuel business is shrinking

For filling stations, the sale of fuels, no matter what kind – and no matter how good their future prospects may be – remains a tough business. Following massive market adjustments in recent years, the number of filling stations in industrialized nations seems to have bottomed out (see info box), but growing electrification, more efficient engines, other mobility offerings and lower margins are nibbling away at sales. ExxonMobil's "Outlook for Energy" expects the worldwide average fuel consumption of cars and light trucks to drop from 9.4 liters per 100 kilometers (25 mpg) in 2014 to 5.2 liters (45 mpg) in 2040. That's good for the environment, but bad for the cash register that must be filled in other ways. Even today, the filling stations of Germany's market leader, Aral, are covering over 60 percent of their income from the convenience store business.

WHO WILL BUY WHAT FUEL IN 2050?

*With this **mix of vehicle registrations,** the climate goal of keeping global warming below 2 degrees might be achieved in spite of an overall growth in vehicle sales.*



Source: Global Transport Outlook 2050/International Energy Agency

- ***Gasoline***
- ***Diesel***
- ***Gas (CNG/LPG)***
- ***Gasoline hybrid***
- ***Diesel hybrid***
- ***Plug-in hybrid diesel***
- ***Plug-in hybrid gasoline***
- ***Battery-electric***
- ***Fuel cell***

At Shell as well, only 35 percent of the customers exclusively buy fuel.

So, additional service offerings as sources of income are welcome. And they're being developed, for instance, in cooperation with delivery services. UPS is already depositing undeliverable shipments at some Star filling stations. Shell is planning to get a similar project off the ground with Amazon. The opening hours of filling stations, which in many places are clearly longer than those of other local retail businesses, are a major advantage. Banking, bakery goods and coffee – all this is already completely normal at filling stations today and in some places even hair salons and other providers of everyday services have joined them.

Mobility remains core business

IT specialist T-Systems has developed a vision for the future in which the filling station has even a lot more to offer. It makes workplaces available, even for meetings and naturally offering WLAN, to customers refueling their vehicles. Mobile payment systems are used for billing – rental for the workplace, refueling and a possible car wash, plus the purchases that can be made at the station as well. As a result, the filling station will remain what it has always been – a communicative hub.

Obviously, the filling station also – or even particularly – has a future when it comes to services surrounding mobility, its actual core business. Why shouldn't filling stations transform themselves into mobility services providers, renting cars and even bicycles or be active in car sharing? The filling station has a special advantage: it's expected to deliver anything surrounding mobility, in other words, learned behavior. A vision which the Hungarian energy group MOL is planning to make reality in ten to 15 years looks like this: customer suse an app to order a car sharing vehicle at the filling station in which all of their purchases made at the station's convenience store are already deposited upon their arrival. Promising prospects – happy refueling!

THE AUTHOR

***Frank Urbansky** has been working as a specialized author since 2014 and founded the "EnWiPo" blog. His focal topics are alternative propulsion systems, energy management and markets. The publications he writes for include "Autogas Journal" and "Brennstoffspiegel." In addition, he used to support the website of the "tankstellenWelt" trade magazine. He has a special affinity to motorcycle racing.*

HIGHER, **FASTER**, FARTHER

Transportation concepts for the future? That almost sounds like a hackneyed phrase in this day and age when automobile manufacturers primarily define themselves as providers of mobility services. But for Charles Bombardier (left) the world of motion is a veritable mental Olympiad. He thinks several steps ahead at once: from production-based solutions to imaginative means of ground transportation. Even between the stars he maps out ideas that are bold, witty, amazingly obvious and sometimes utopian.

by Alexander von Wegner

Charles Bombardier's Alumaïd ideas have been converted into an animation by designer Martin Rico

His think thank is called Imaginactive and its ideas create a stir. With the ease of a futurist and the know-how of a professional engineer, Charles Bombardier reflects on human mobility. Together with industrial designers from all over the globe, he publishes renderings of his concepts, providing the whole world with free access to his ideas. From a four-seat snowmobile for Canada to an urban people moving system using suspended chairs through to a supersonic aircraft that's suitable for space travel, the inventor comes up with hundreds of concepts for the near and more distant future. Their realization? Uncertain. But that's not what matters to him.

Creative genius runs in the family. His grandfather, Joseph-Armand Bombardier, founded the samenamed industrial company and in 1937 invented the snowmobile. From airplanes to trains through to quads, motorized sleds, boats and the Can-Am Spyder made by Bombardier's subsidiary Recreational Products, the Canadian company stands for mobility on rails, roads, snow, in water and in the air. "tomorrow" presents five of Charles Bombardier's idea and has asked Schaeffler engineer Professor Tim Hosenfeldt, PhD, for his opinion.

ALUMAÏD

The Alumaïd spacecraft combines existing technologies into a new system. *An Orion spacecraft, two Bigelow Aerospace modules, one Axiom space station, a Crew Dragon spacecraft and a cargo hold equipped with Canadarm 2 mobile grip robot form a unit.*

One of the outstanding features of this construction is that it not only moves in an orbit but that two rockets from Masten Space Systems attached to each end could accelerate the Alumaïd to new destinations in the solar system. "The exploration of space interests me very much," says Bombardier. "The Alumaïd is a module of this future. Naturally, this is a continuing process. We want to create a vision of what space exploration might look like in the next 20 years."

The crew would consist of four astronauts and the Alumaïd could carry up to eight passengers in the age of commercial space travel. The inventor envisions 160-day trips to Mars. The Crew Dragon spacecraft would be a radiation safe haven and emergency escape vehicle and the Bigelow modules would be used as sleeping quarters. The Axiom module could be used for daily activities. Finally, the cargo hold accessible by the Canadarm2 translational robot would contain the cargo brought to orbit by heavy lift rockets.

Additional concepts at
www.imaginactive.org

PARADOXAL

While no civilian supersonic aircraft has been commissioned anymore since the Concorde disappeared, Charles Bombardier in his Paradoxal concept is aiming to combine two types of speed beyond the speed of sound. *The flying wing is designed for both supersonic and hypersonic speeds – in other words Mach 5 and above.*

In commercial aviation, the Paradoxal would follow a suborbital, parabolic path. In other words, to travel the 12,000-kilometer (7,855-mile) distance from Los Angeles to Sydney, the Paradoxal would ascend to an altitude of 70 kilometers (43.5 mi) above sea level and reach its destination in less than three hours.

A Rim-Rotor Rotary Ramjet (R4E) engine, invented at Université de Sherbrooke by Jean-Sébastien Plante, David Rancourt and Mathieu Picard, would provide the power to lift off, climb to 60,000 feet and reach Mach 3. At that point, the injection of liquid oxygen (LOX) into the gas exhaust port would turn the engine into a rocket engine. Two air jets flowing in opposite directions on the plane's leading edges reduce thermal loads and overall drag when the plane climbs and subsequently re-enters the Earth's atmosphere. They are generated by so-called LPM (Long Penetration Mode) nozzles – invented by NASA – with air from the engines or from compressed air tanks.

The visual design of the Paradoxal concept by Juan Garcia Mansilla

ESCATEK

Standing in line at the airport is a procedure that costs time and nerves particularly in international travel, and in more ways than one. *Passenger and baggage checks as well as going through passport and immigration control require a lot of patience.*

Charles Bombardier would like to integrate all these procedures into a single process during the escalator ride to the gates. "My wife had the idea for the Escatek concept," says the Canadian. "We travel quite often and she recently asked me if it was possible to improve the screening process using existing technologies and infrastructures."

Instead of waiting in a separate security line, travelers would just walk toward the nearest Escatek, place their passport on the left side of the machine and their luggage on the right. A linear robotic passport conveyor would then check if the passport is valid and if the passenger is booked on a flight. The system would subsequently perform all other necessary checks, register the passenger for the flight or alert airport security or airline personnel if something was wrong. The parallel luggage conveyor would check if the bags contained dangerous or prohibited items, photographing, weighing and automatically associating each suitcase with its owner. Large bags would be sent into the cargo hold while hand luggage would be picked up by the passenger upon exiting the Escatek. In case of problems, personnel, just like now, could be used to intervene at the end of the escalator. The Escatek could even ask the passengers questions and record their answers. In addition to airports, Charles Bombardier sees shopping malls, theaters or sports facilities as potential markets for scaled-down versions of the Escatek.

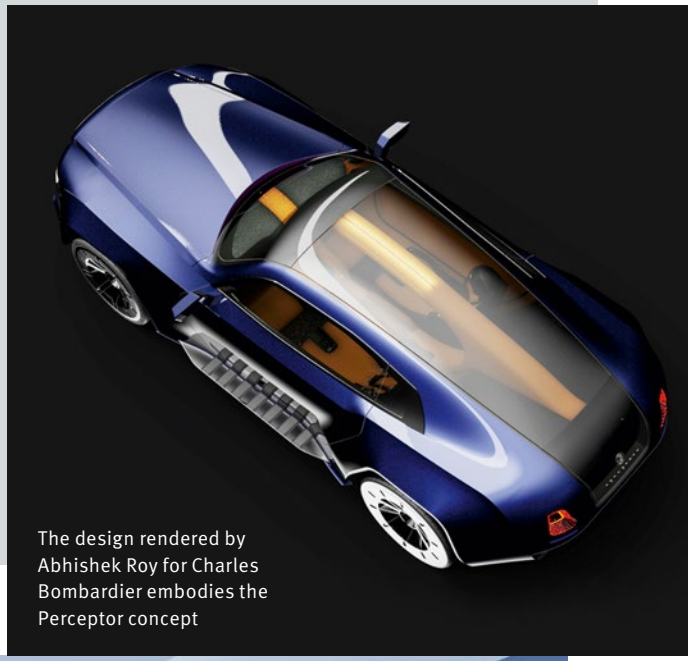
PERCEPTOR

The Perceptor is not just a simple coupé featuring a mix of retro and avant-garde styling. *The inventor rather defines it as a novel system that could embody various automobiles. The keyword is Artificial Intelligence.*

"This system would be with you every time you drive," says Charles Bombardier. "When you change cars, the Perceptor's Artificial Intelligence would follow you, so it would always be there to assist you. I wanted to give the driver a truly unique experience that goes beyond autonomous driving."

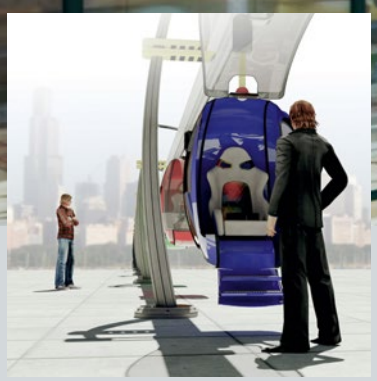
The data of this Artificial Intelligence would reside in a cloud and theoretically be available for all types of vehicles – including motorcycles, boats or helicopters. In addition, Perceptor would learn its owner's preferences: scenic routes or fast connections, preferred routes or avoidance of specific places or roads.

Subsequently, the system could make recommendations and even recognize the driver's mood. An autonomous mode could be activated as well if the driver was under the influence of drugs or alcohol. In addition, the Artificial Intelligence could autonomously drive the vehicle to a garage for maintenance while the owner is at work.



The design rendered by Abhishek Roy for Charles Bombardier embodies the Perceptor concept

Industrial designer Ashish Thulkar has rendered this vision of the Escatek system based on the inventor's ideas



URBANIA

No parking space in your own neighborhood and none at the office? *Congested streets? Inadequate public transportation? In that case, there's not much left besides a two-wheeled vehicle – with or without a motor. Unless big cities recognize the value of the Urbania mobility concept and are willing to invest in a new infrastructure.*

At first glance, the people moving system looks as though it had been transplanted from an amusement park or a ski resort into the heart of a city. Simple solo chairs protected by a plastic canopy would be suspended from an electromagnetic rail. Charles Bombardier envisions a modern transit system that could be built along major traffic arteries in big cities – for commuters as well as for people who have problems walking, or for tourists. The inventor envisions an elegant, multifunctional design. The electromagnetic rails would be designed so they would be integrated into lamp posts using LED lights and also integrate wi-fi electricity ports for cars and buses.

Using a smartphone app, passengers could "hail" a chair that lowers and rises for ingress and egress but travels above the heads of pedestrians and cyclists. The propulsion system could be a simple electric motor located inside a pneumatic wheel or an advanced maglev system. The inventor has covered all the bases, from an emergency brake to a hidden step ladder in case a passenger needs to exit fast.

Industrial designer Adolfo Esquivel created the 3D renderings of the Urbania

INTERMODAL FUTURE

The Senior Vice President Corporate Innovation at Schaeffler assesses the five ideas.

Professor Tim Hosenfeldt, PhD

"At Schaeffler, mobility for tomorrow above all means that we'll be moving in safer, cleaner and smarter ways on Earth and in its atmosphere. At the same time, as a member of the Astronomical Society, I'm fascinated by Cha concepts for aerospace. As a supplier, for instance to the Space Shuttle and the Mars Rover, Schaeffler has already gathered experiences with extraterrestrial mobility. The Alumaïd concept creates an innovation from the combination of existing solutions. The Paradoxal flying wing opens up the opportunity to very important persons from business and politics that have to commute between continents to reach almost any point on the Earth within a maximum of one day. However, for mobility of the general public, space and supersonic travel are no major gain from our point of view.

We believe that intermodality, in other words the combination of personal mobility and mass transit, are central. In the future, transportation strictly at ground level in two dimensions will no longer be sufficient. In that respect, the Urbania concept is an attractive solution above the ground. The second path is a subterranean one, using elevators and underground people movers for example. Urbania should be designed so that the other traffic could be routed underneath it and a passenger boarding or exiting should not delay the ones in the following pods. Maybe even small vehicles like our Bio-Hybrid could be taken along in larger Urbania pods. The future will also bring drones, be it for cargo, transport pods or people.

The Perceptor concept also plays a role in intermodal transportation. People want to be able to choose how to get from door to door and an operating concept "to go" makes it easier to switch between different modes of transportation. Furthermore, Escatek could provide a major simplification. Anyone frequently standing in line at airports will experience this as a major efficiency gain."

THE AUTHOR

*Author **Alexander von Wegner** is not eager to travel in space but Escatek or Urbania could find favor with him. Still, he found every one of the concepts equally fascinating to deal with.*

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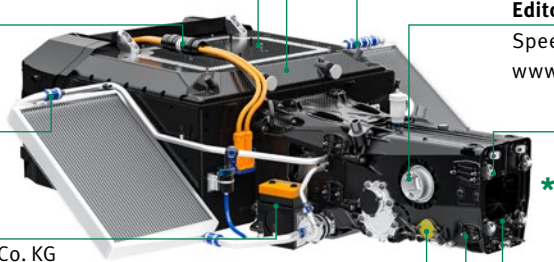

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** The motor-generator unit ABT Schaeffler MGU 01+, pictured here with the battery (rear), is the centerpiece of the 2016/2017 Formula E championship-winning car. In addition to the 270-hp (200-kW) electric motor, the power electronics, the 3-speed transmission, the rear axle, the cooling system and the associated software are part of the powertrain developed by Schaeffler and ABT and trimmed for efficiency.*

tomorrow

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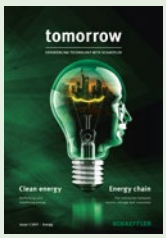

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