tomorrow

EXPERIENCING TECHNOLOGY WITH SCHAEFFLER

Visionary ideas

How digitalization and high tech change our lives

Through the ages

Humans, machines, materials – yesterday, today and tomorrow

Issue 1/2018 · Transformation

SCHAEFFLER

Transformation [trænsfə'meɪʃən]

A change into someone or something completely different or the process by which this happens.

Source: Macmillan Dictionary

DEAR **READER,**

Welcome to the current issue of our technology magazine “tomorrow.” If you have a collection of all the previous issues on your bookshelf – and, needless to say, we’d be delighted if you did – and count them, you’ll note that we have a reason to celebrate: The most recent “tomorrow” marks the tenth issue of our periodical. This is also an appropriate occasion to thank you for taking the time to join us in delving into the multifaceted world of technology that we present to you in “tomorrow.” In addition, we’d like to thank you for providing us with positive feedback as well as constructive ideas and suggestions for improvements, for nothing is so good that it couldn’t be changed for the better – which takes us to the focal topic of this issue: transformation.

From day one, in other words for the past 4.6 billion years, our planet has been in a constant state of flux. Life has emerged, as well as continents and cultures. Whereas transformation per se is by no means a present-day phenomenon, the extreme pace of technological change is. In many areas, today’s evolution no doubt resembles a revolution. Progress has long ceased to be a steady flow but has turned into a massive current. Channeling it as best we can, allowing it to carry us in a positive sense, making the best possible use of the resulting energies to take us to new levels – these are the great challenges of our times that we all need to collectively tackle. Arguably, for me the key statement that the popular science journalist Ranga Yogeshwar made in his interview with our magazine is this one: “Those who think that any company or any country can shape a common future for everyone are wrong. I believe that this is a task we all have to assume.”

Progress, however, does not inevitably mean moving full speed ahead. Sometimes turning the dial back a few notches may be a form of progress as well. If you’d like to see some examples, please go to page 20. There you’ll find old arterial roads that have been renaturated or desolate port facilities being creatively reclaimed as urban spaces for people to live and work.

The transformation of mobility: My fellow executive board member Peter Gutzmer used the opportunity of a visit to the “Henry Ford” in Detroit for a quick survey, presenting his favorite exhibits to you starting on page 42. An account of how modern technologies are going to change the design of future automobiles is provided by Paolo Tumminelli, a professor for design concepts, starting on page 66. So-called “smart materials” will be playing an increasingly important part in the development of new vehicles as well – more on that starting on page 102. However, new and better materials have not only been inspiring change in vehicle engineering for generations. The story of the evolution from wood to graphenes and other high-tech materials is another topic in this magazine as well as the role that coincidence plays in technological progress.

I’d like to close my introduction with a highly fitting quote by evolution scientist Charles Darwin: “It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is most adaptable to change.”

And now: enjoy the read of the tenth issue of our technology magazine!

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

global

A glimpse of the world

» To invent an airplane is nothing. To build an airplane is something. But to fly an airplane is everything

Ferdinand Ferber (1862–1909), French aviation pioneer

ON THE **WATERFRONT**

The airport on Barra, a small island of the Outer Hebrides in front of the Scottish coast, has three runways – more than London Heathrow. But that's by far not the most remarkable thing to be reported about this landing site. When the tide is low the Barra bay transforms into the world's only airport on a beach – until high tide interrupts air traffic again. Due to the changing water levels, even a stranded shark once had to be collected off the runway – besides the almost daily accumulation of flotsam. Tourists, too, regularly have to be run off the runway. In spite of these unusual circumstances Barra is a regular airport for scheduled flights with two daily connections to Glasgow. However, it's up to the tide to decide when the DHC-6 Twin Otter propeller plane can take off or land.

OTHER UNUSUAL AIRPORTS

St. Maarten – *on the approach to the Caribbean island the jets fly so low over Maho Beach that it seems like you could touch them.*

Jumbolair Airport – *Hollywood star and hobby pilot John Travolta, like a few other multi-millionaires, has built his mansion directly next to one of the two runways of the private airport. Whereas normal citizens drive their cars to their doorstep Travolta arrives in a Boeing 707.*

Gibraltar – *when a passenger jet approaches or takes off there the British colony is cut off from the Spanish mainland because cars or pedestrians have to cross the runway in order to enter or leave the enclave.*

Will Rogers Airport – *passengers landing here may be serious perps: one of the gates of Oklahoma City's airport leads directly into the cell block of the local prison.*

360° TRANSFORMATION

Facts, figures, oddities – a panoramic view of a changing world.

by Carsten Paulun

FLEXIBLE **FAÇADE**

Like a chameleon, this office building adapts to its surroundings and actually seems to merge with them thanks to its reflective façade designed like a crystal rock. In 2020, construction of “The Milestone” created by the Dutch architectural team MVRDV is planned to begin at a former freight depot in Esslingen, Germany. Other transformational construction projects can be discovered starting on page 20.

HIGH AIMS

A fortress yesterday, a farm today and a rocket tomorrow. A master of transformation turned 60 this January. In 1958, the tubes-and-studs system of the Lego bricks that still exists was patented. Today, it’s assumed that every person on Earth owns 100 Lego bricks on average. The number of Lego figurines produced to date alone ranges in the billions – in 2019, even more of them than humans are expected to populate our planet.

REDUCED TO THE MAX

WITH A FLICK OF THE WRIST THE 26-INCH REVOLVE WHEEL IS TRANSFORMED INTO A PORTABLE BUNDLE, NOT LARGER THAN AN IPAD. THE ITALIAN INVENTION MIGHT MAKE TRANSPORTING BICYCLES AND MAYBE EVEN WHEELCHAIRS A LOT EASIER – OR STEALING TEMPORARILY WHEELLESS VEHICLES MORE DIFFICULT. HOWEVER, THE WHEEL’S INVENTOR, ANDREA MOCELLIN, HAS NOT YET DISCLOSED THE PRICE OR LAUNCH DATE FOR HIS IDEA.

AUTONOMOUS CARS MOBILIZE SENIOR CITIZENS

Self-driving cars will establish themselves not least because older people living in rural regions will use them for transportation, according to the consulting firm Roland Berger. “The discussion to date has largely been centered on autonomous vehicles in cities and on highways,” says Wolfgang Bernhart, a partner at Roland Berger, “although rural regions with their less complex traffic scenarios are much better suited as testbeds and areas for driverless mobility offerings.” The mobility experts at Roland Berger for instance expect driverless buses to meet with favorable response particularly by older people. Autonomous vehicles for the so-called “last mile” might assist senior citizens in continuing to take part in community life.

» We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten

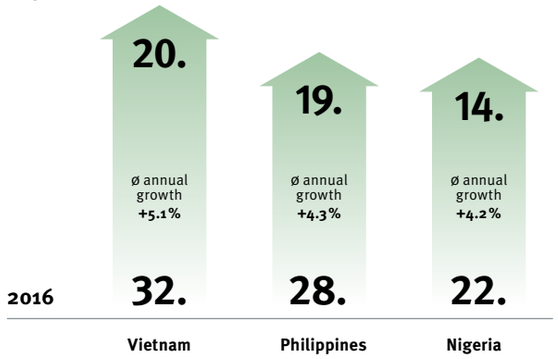
Bill Gates, founder of Microsoft

TRANSFORMATION OF THE WORLD ECONOMY

THE TEN LARGEST ECONOMIES

2016		2050	
China	1.	China	▶
USA	2.	India	▲ + 1
India	3.	USA	▼ – 1
Japan	4.	Indonesia	▲ + 4
Germany	5.	Brazil	▲ + 2
Russia	6.	Russia	▶
Brazil	7.	Mexico	▲ + 4
Indonesia	8.	Japan	▼ – 4
United Kingdom	9.	Germany	▼ – 4
France	10.	United Kingdom	▼ – 1

THE THREE FASTEST-GROWING ECONOMIES



Source: PWC “The World in 2050” (2017)

50 %

of executives in the automotive, high tech, food, tobacco and pharmaceutical sectors view **flexibility as a key business strategy.**

Source: representative survey of IT manufacturer Zebra (2017)

91 %

of the people in Australia, France, Germany, the United Kingdom and the United States say that technology has **a positive impact on their lives.** 70 percent of the respondents tend to perceive this impact more in their private than their professional lives.

Source: Axway survey (2017)

1,000 times

less energy consumption per bit: The soon-to-launch 5G cellular network outstrips the current LTE standard by this factor and additionally enables ten times faster data transmission resulting in extremely low latency. **That’s why experts are already assuming that 5G will replace domestic WLANs.**

Source: Kathrein KG

LIGHT IN A NEW FORM

In the first automobiles, candles were used to illuminate the road for drivers. Candles were followed by carbide lamps, the first electric lamps and, later, halogen, xenon, LED and even laser lights. Now, headlights are beginning to communicate. Before the year is out, the light on the Mercedes-Maybach S-Class is supposed to project warnings and other information onto the road – in HD resolution. “With a resolution of over one million pixels per headlamp, Digital Light not only creates ideal light conditions for every driving situation; it also extends the visual support from our driving assistance systems,” says Ola Källenius, Member of the Board of Management of Daimler AG.

SEGWAY BECOMES **AUTONOMOUS**

In May 2018, Segway will launch a “little brother” to join its electric two-wheel PT transporter. “Loomo’s” special features include autonomous operation, evasion of obstacles and following its owner when he or she’s not riding it. Unlike the Segway PT, Loomo no longer has a handlebar. Instead it’s equipped with an integrated screen, cameras, a microphone and a loudspeaker. It recognizes visual commands, responds to gestures and can be remote-controlled. Its range is 35 km (21.7 mi).

135 YEARS AGO

A SWISS SMITH DEVELOPED WHAT’S ARGUABLY THE WORLD’S MOST ADAPTABLE TOOL: THE POCKET KNIFE. IT HAS ALREADY BEEN TO MOUNT EVEREST AND OUTER SPACE. THE MOST VERSATILE MODEL COMBINES 141 FUNCTIONS, WEIGHS 1.3 KG (APPROX. 2 LBS.) AND COSTS NEARLY 1,000 EUROS. VERSIONS WITH A USB STICK AND BLUETOOTH MOUSE HAVE LONG BEEN ADDED TO THE RANGE AS WELL.

DESIGN RETHOUGHT A phone without push-buttons. A vacuum cleaner with no bag to be changed. Seemingly impossible ideas like the iPhone or the Dyson vacuum cleaner that can disrupt entire markets are typically the result of the work of designers approaching products from the perspective of users and their needs instead of what’s technically feasible. “Design thinking,” a method that’s increasingly being applied to regular project development as well – also at Schaeffler – describes exactly this approach. Crucial to its success is that people from various functions come together to think about new solutions with no holds barred. Small colorful notes, modeling clay and Lego bricks ensure that no ideas are lost. The next steps follow in quick succession: testing, obtaining feedback from potential users and making changes as needed.

New approaches require creativity: Schaeffler experts like Olaf Mackert support the company’s departments in conducting in-house design thinking workshops

MODERN TECHNOLOGY KEEPS THE PAST ALIVE

70 percent of all Porsches ever built are still on the road. Porsche is planning to increasingly use 3D printing to produce spare parts for the cars which in some cases have become rare classics. Steel and light-metal parts are produced by selective laser melting and plastic components by selective laser sintering. Porsche is already producing nine spare parts for classics this way – without any loss in quality compared to the original, as the sports car manufacturer assures. 20 other components are to follow. The spares can be produced on demand which eliminates tooling and warehousing costs.

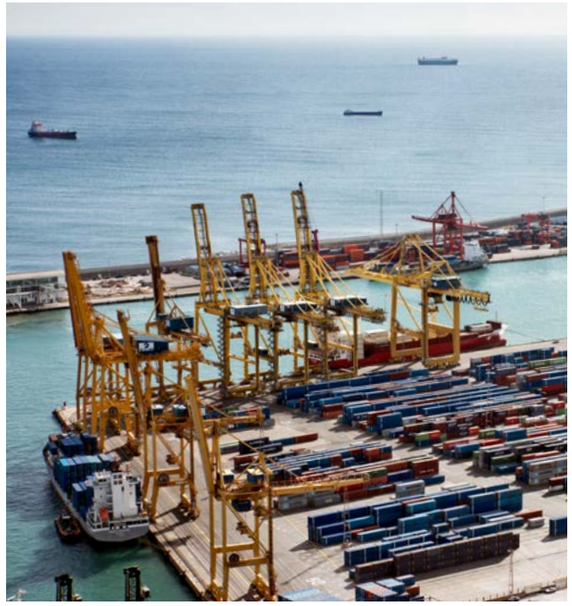
MIGRATION 2.0

THE URBANIZATION OF THE WORLD IS ONE OF THE GREATEST PRESENT-DAY CHALLENGES. 66 PERCENT OF THE WORLD POPULATION WILL BE LIVING IN CITIES BY 2050. POPULATIONS IN METROPOLISES LIKE JAKARTA OR KARACHI HAVE INCREASED TENFOLD OVER THE PAST FIVE DECADES. A GROWTH COMPARISON OF THE WORLD'S TEN BIGGEST CITIES.

City/country	Population in 1965	Population today	Growth in percent
Tokyo-Yokohama/Japan	21,017,000	37,900,000	80.33
Jakarta/Indonesia	3,150,000	31,760,000	908.25
Delhi/India	2,900,000	26,495,000	813.62
Manila/Philippines	2,900,000	24,245,000	736.03
Seoul-Incheon/South Korea	3,700,000	24,105,000	551.49
Karachi/Pakistan	2,100,000	23,545,000	1,021.19
Shanghai/China	10,872,000	23,390,000	115.14
Mumbai/India	4,700,000	22,885,000	386.91
New York City/USA	16,325,000	21,445,000	31.36
São Paulo/Brazil	5,450,000	20,850,000	282.57

THE WORLD'S SMARTEST PORT

From Europe's largest to the world's smartest port: Rotterdam is planning to interconnect the entire port area with sensors capturing data streams about water levels, weather, wind, availability of berths, visibility conditions, tides and currents. In the future, these data are supposed to be analyzed and converted into information by IBM's cloud-based IoT technologies. The objectives: reduced waiting periods and optimized loading and unloading of ships. Savings potential: up to 80,000 U.S. dollars per ship.



WORDS TO REMEMBER

» In the next 10 to 15 years, the automotive industry will presumably change more fundamentally than it did in the previous 100 years

Ford Germany CEO Gunnar Herrmann about the mobility business in "auto, motor und sport" magazine

» If you get up in the morning and think the future is going to be better, it is a bright day. Otherwise, it's not

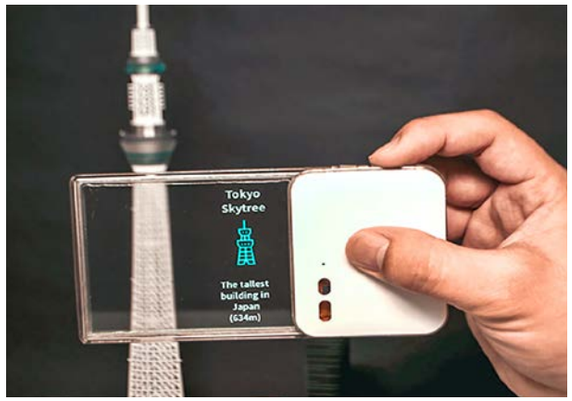
Elon Musk, CEO of Tesla and SpaceX

»The ability to think systematically and ambidexterity, the gift of acting with 'both hands,' are important keys to success. This means to further develop things that have stood the test of time while concurrently tapping new potential

Professor Peter Gutzmer, Chief Technology Officer of the Schaeffler Group

A SMARTPHONE SUCCESSOR?

The iPhone launched in 2007 has changed the world like no other technical device before it (also see article starting on page 34). And many people are already asking themselves what the "next big" thing will be after the smartphone – perhaps the "omotenashi" made by the Japanese telecommunications company NTT? A fully transparent LC display accounts for two thirds of the device that combines smartphone capabilities with the virtual worlds of AR (Augmented Reality) technology. Whenever omotenashi recognizes familiar shapes information pertaining to the respective object appears on the display. In addition, it's supposed to provide simultaneous translation, initially in Japan and English. Maybe that's why the device has been named omotenashi, which means "hospitality" in Japanese.



CHANGE IN NAVIGATION

The Global Positioning System (GPS) has fundamentally changed the way we find destinations. The first GPS satellite was sent into orbit in 1978, so 2018 marks the 40th birthday of this digital guide. The first satellite navigation system, called Transit, is even 20 years older. Both Transit and GPS were initially intended strictly for military uses. In 1983, the United States released the GPS signal for civilian purposes, albeit with an intentional inaccuracy of 100 meters (328 ft). The misguidance was only discontinued in 2000. Today's systems operate with positional accuracy of 30 centimeters (0.98 ft). Alternatives to GPS today are the Russian GLONASS and, starting in 2020, the Chinese Beidou and the European Galileo systems.

MOVING FORWARD RETRO-STYLE

Every movement produces a countermovement. In the case of increasingly accelerating technological progress, it's the retro style that's been manifesting itself in a large number of markets. Vinyl records are experiencing a renaissance just like Nokia cell phones and mechanical watches. After musician Lenny Kravitz had plugged the coiled cord of a handset replica into his iPhone the 30-dollar gadget started selling like hotcakes. Car models like VW Beetle and Buzz, Ford Mustang or Chevrolet Camaro, Mini, Fiat 500, or the most recently resurrected James Bond Aston Martin, are surfing the retro style wave as well. "Never before has nostalgia been as relevant as it is today," says author Daniel Rettig ("Die guten alten Zeiten – Warum Nostalgie uns glücklich macht" – "The Good Old Days – Why Nostalgia Makes us Happy"). For him, nostalgia is a feeling that's literally linked to smell, taste and sound and an occasional dose of it may well add meaning to life. "Nostalgia," says Rettig, "inspires familiarity and shared memories provide its foundation."

“WE’RE LIVING IN VERY EXCITING TIMES”

Schaeffler’s CEO Klaus Rosenfeld about the opportunities and challenges of present-day technological change.

Interview Volker Paulun

Transformation is not only the focal topic in this issue of “tomorrow.” The whole world seems to be changing in practically all areas of life at a pace never seen before. A blessing or a curse?

I’m basically an optimistic person and therefore clearly say that change is good. Wherever things change new things emerge. This is a positive – if we embrace change as an opportunity. The world has been changing for millions of years. Transformation is not a present-day phenomenon. Today, we’re living longer and better than ever before in many parts of the world. However, the pace of change is faster than it’s ever been before. I can understand that this provokes anxiety in some people. We have to be considerate of such fears. I feel that we’re living in very exciting times. 20 years ago, who would have thought of all the things we can do with a phone? And, honestly: would you want to do without digital achievements like the internet and the smartphone?

Definitely not. But the disruptive force of these two technologies in particular has shaken up practically all sectors, which has contributed to people’s fears. What arguments do you use to dispel such concerns among your employees?

There’s a saying in China: “When the wind of change blows, some will build walls and others windmills.” Figuratively speaking, we want to build windmills, in other words, use change to our advantage. It’s a fact that innovations and technological revolutions, besides numerous opportunities, always entail risks as well. We’re conscious of this at Schaeffler. Working worlds are going to change as a result of continually progressing technologization and digitalization. New products will emerge, the way we create value will change and we’re going to redefine requirements. Of course, some tasks will cease to exist as well.

So you don’t see a risk of massive unemployment?

No, I don’t. But, obviously, job profiles and activities are going to change. As a company and as an executive board we are responsible for taking an active part in shaping the necessary transformation process in the interest of our employees. But this is not a one-way street. All employees should have the opportunity to take action and assume responsibility for adapting to change and advancing their professional education. We’re endeavoring to assist them in this with appropriate qualification activities. That’s why our forward-thinking “Agenda 4 plus One” program specifically includes a “Qualification for Tomorrow” initiative. Furthermore, we intend to promote the innovation culture in our company in general.

» Schaeffler has continuously developed further – with great success

How exactly is Schaeffler planning to keep pace with change or, in line with your intentions, take an active part in shaping it?
Those who take a close look at our company's history will find that Schaeffler for decades has been on a path of continuous further development and gone through transformation processes – with great success. This is part of our DNA. Just remember how our company's founder, Georg Schaeffler, wittily translated the INA brand name: "Immer neue Aufgaben" ("Ever new things to do"). This is exactly the kind of positive spirit that drives the way we want to approach change. In the past two years, we very systematically set up a wide-ranging forward-thinking program billed as "Agenda 4 plus One."

What exactly does this program stand for?
"Agenda 4 plus One" is our forward-thinking program to prepare the Schaeffler Group for the challenges of the future. It covers a wide range of areas and builds upon the positive experiences with our first transformation program, "One Schaeffler." As the next level, so to speak, we've developed a tailored program of excellence that consolidates our 20 key global strategic initiatives in five categories. That explains the name "Agenda 4 plus One." These five categories are: "Customer Focus," "Operational Excellence," "Financial Flexibility," "Leadership and Talents," and – as "plus One" – securing long-term competitiveness and growth of value. The underlying 20 initiatives are highly diverse: ranging from concrete business initiatives such as "E-Mobility" or "Industry 4.0" through to initiatives which aim to enhance our internal operational excellence. This, for example, concerns the optimization and harmonization of our group-wide processes – a project that can only be successfully accomplished through further development and modernization of our IT infrastructure. Of course, this also includes our "Digital Agenda" initiative with which we plan to make Schaeffler fit for the digital age.

This does sound like a large-scale and complex transformation process. How is Schaeffler planning to accomplish all this?
Any strategy is always only as good as its execution. Therefore, in the process of developing our Agenda, we put a particularly strong focus on how we're able to implement our plans as efficiently and consistently as possible. The execution of "Agenda 4 plus One" is based on the project management approach we developed and successfully implemented for the "One Schaeffler" program. According to this approach, the concept, implementation and control of the 20 initiatives follows standardized rules and criteria. Each initiative is overseen by a member of the executive board who assumes responsibility for it as a sponsor and led by a project manager.

Obviously, all this cannot be put into action from one day to the other. What period of time are we talking about?
The name of the "Agenda 4 plus One" program also derives from the fact that it's designed for a period of 4+1 years. It was incepted in 2016 and we plan to successfully complete it by the end of 2020. To achieve this, we've established a program organization that systematically monitors and supports the implementation of the five categories and their initiatives. This also includes regularly tracking the state of completion, the so-called "completion ratio." The ratio is currently at 35 percent. At the moment, 1,000 employees around the globe are involved in executing the program. In total, we're going to invest about one billion euros in conjunction with our forward-thinking program.

What part does the customer as an externally acting force play in the transformation process that has begun?
A very crucial one. Even our company's founder was consistently pursuing customer intimacy and had a knack for sensing the customer's needs. And just like Georg Schaeffler in his day, our research and development departments are always driven by the question of how we can help our customers make their products better. By pursuing this path, for instance, we advanced into ever new areas in the automobile. Initially, we offered bearings, then components for the powertrain such as the dual-mass flywheel or variable valve control …

… and today you've arrived at electric axles and hybrid modules.
Exactly. Particularly in recent years, we've been growing successfully because we've been using the opportunities that present themselves due to new technologies in a highly dynamic market and competitive environment. Electric mobility is not a new topic for us. Schaeffler has been investing in this field for years. Today, we're driving electric mobility as one of the key initiatives of our forward-thinking program – with increasing success! At the moment, we have a total of eight production contracts for electric axles and hybrid modules from various automobile manufacturers around the globe. With respect to the other megatrends that concern the automotive industry, we're moving forward as well. And don't forget our Bio-Hybrid or our novel Peoplemover with wheel hub drive that we showcased at the Schaeffler Symposium in Baden-Baden.

Is the Industrial division as a second pillar and part of your core business in an equally innovative position?
Here digitalization and the "internet of things" offer us many opportunities for growth that we're planning to use more intensively, particularly with respect to establishing and expanding our expertise in mechatronics. Take our mechatronic sensor bearings for example. If we manage to turn our bearings into smart data suppliers, we'll open up completely new possibilities for our customers. This is why we implemented the "Industry 4.0" initiative as part of our forward-thinking program. It's the counterpart of our "E-Mobility" initiative. In the end, both initiatives involve expertise in mechatronics. This is one of the reasons why we're an automotive and an industry supplier.

And data, as everyone knows, are the new gold …
Yes, you can put it this way. Data are becoming a key component of value creation. For Schaeffler, as well, this is an attractive field. Our mechatronic components and systems are installed in machines and automobiles exactly where the most important primary data are generated. This results in new opportunities for Schaeffler to develop new data-based business segments and service offerings. Not to be neglected either is the internal utilization of these "golden data" to enhance the efficiency of our workflows and the development of innovative products and solutions.

Many people feel that the "internet of things" will be the "next big thing" of digitalization. Do you share this view?
Yes, I do. In just a few years from now, machines that surround us at home or at work will be connected across the board and, thanks to the enormous progress being made in the field of artificial intelligence, increasingly communicate with each other without human intervention. The rapid development of the "internet of things" equally concerns Schaeffler in the automotive and industry sectors. There we have to position ourselves in a way that combines real capital with data-based value creation. In other words, we have to integrate mechatronic components, systems and solutions from Schaeffler into the rapidly growing world of the "internet of things" and – as mentioned before – develop new business models based on digital services to market level. This is where the "Industry 4.0" and "Digital Agenda" initiatives of our forward-thinking program converge. There are still plenty of "new things to do" in this area.

So, the saying "Cobbler stick to your last" has finally become obsolete?
Looking at the bigger picture in business has never hurt anyone. But even in times of rapid transformation, not everything will fundamentally change overnight. As long as there are components in the world that rotate or generate friction in contact with each other there'll be a need for high-performing roller and plain bearings. Neither will the conventional IC engine disappear from the market in the near future. We expect that by 2030 about 30 percent of the new vehicles will strictly be battery-operated. In the other ones, including those with hybrid drive systems, an IC engine will be installed. In the fields of conventional bearings and conventional powertrain technologies

» Data will become a key component of value creation – also at Schaeffler

we've developed extensive product and manufacturing know-how in recent years. Risking this strong market position would be a reckless move. That's why we'll continue to invest in these areas.

To what extent does transformation on the product and demand side of the house require a change in thinking by the company?
Both have to go hand in hand, also with respect to speed. In an increasingly accelerated transformation process, we have to become more agile, faster and more courageous. This is why we launched our forward-thinking program. In my view, the ability to shape things at a fast pace is a key management skill. This is where the action is!

Sounds like a hybrid of a global group and a startup.
You could put it that way. If we wish to use the opportunities in the areas of Digitalization, E-Mobility and Industry 4.0 we have to further develop our structures, our ways of thinking and of doing business. The creation of a dedicated "E-Mobility" business unit is a case in point. By as early as 2020, this unit is planned to contribute about 15 percent to the total sales volume of our automotive OEM business. In our industry division, we have concentrated all activities from our mechatronics business and the digital services business in the "Industry 4.0" organizational unit. Due to compact, specialized and more powerful units, we're developing additional growth potential.

What about access to external expertise?
What exactly do you mean by that?

What is Schaeffler's position, for example, on acquisitions of startups, which has practically become the order of the day in the automotive and supplier industries?
If necessary, we intend to strengthen our business through such acquisitions as well. Compact Dynamics, a developer of electronic drive systems, and autinity systems, a company specializing in data acquisition and analysis, are two current examples. However, such acquisitions remain in a range of 100 to 500 million euros. In parallel, we're pursuing collaborative partnerships. To ensure our exchange with universities and research institutions, we've launched the "Open Inspiration" event. In addition, we're investing in new innovation spaces outside the company. The basic idea behind this new concept is to bring together people outside their daily work environments for a certain period of time in order to develop new ideas. Collaborative partnerships with universities are an effective tool to retain future professionals for our company.

You already addressed the important role the customer plays in the consistent transformation process at Schaeffler. How does digitalization change this role?
Due to digitalization, we'll become even more closely interlinked and will align our business models even more intensively and precisely with the needs of our customers. Yet, there's one thing we shouldn't forget: the geographic proximity to our customers that we've developed through our production and development sites around the globe over the past decades. In China, we're going to shortly establish a second E-Mobility competence center in line with the growing importance of this market in the field of electric mobility.

China is also the place where Schaeffller's first "factory of the future" is being built. How is the transformation process reflected there?
The pace of technological development results in increasingly shorter production cycles. The importance of machines that keep producing the same things for years or even decades on end may diminish. That's why in the future our factories will be equipped with modular manufacturing machines that can be adapted practically overnight by using the "plug and produce" principle.

What, actually, are the driving forces behind the current high-speed transformation process?
Changes in demand and competitive pressures have always existed. Currently, the key transformation driver is technological progress, particularly due to digitalization. The computing power we're carrying in our pockets today in the form of smartphones corresponds to that of a supercomputer 30 years ago that weighed tons and cost millions. All the things that digitalization is enabling now, and will enable in the future, never cease to amaze me. The role of policymakers should not be underrated in this context either. We can see what government funding of electric mobility has achieved in Norway. In June 2017, electric vehicles with a market share of 53 percent outstripped those with IC engines for the first time. In China, electric mobility has been developing faster than here as well thanks to government regulation. So policymakers, by means of laws, directives and other regulatory actions, are able to positively influence transformation processes.

Defining valid development objectives in the light of the required pace and many unknown quantities is no mean feat. What time frame are we talking about?
In our annual "Technology Dialog," we establish the basic direction of our research and development activities for the next five to ten years. We think for the long term because we're a family-owned company. In spite of all change, this will continue to pay off in the future as well.

Thank you for the interview.

» We have to further develop our structures, our thinking and the way we do business

TRANSFORMATION

FROM A FINANCE PROFESSIONAL TO AN INDUSTRY LEADER

Klaus Rosenfeld (born in 1966) starts his career as an apprentice with Dresdner Bank. *After earning his degree in economics and business administration, he returns to the bank in 1993 and steadily works his way up the career ladder before, in 2002, at the age of only 36, he's appointed as chief financial officer, which makes him the youngest member of a major German bank's executive board at that time. In 2009, Rosenfeld switches to Schaeffler, also in the role of CTO. There, with a range of complex transactions, he realigns the company's organizational and capital structure, which earns him the accolade of CFO of the Year by "Finance" magazine. In June 2014, he's appointed as chief executive officer of the Schaeffler Group. Under his leadership, the company makes its initial public offering in October 2015. That Rosenfeld, a father of four, feels comfortable with the automotive and industry supplier has concrete reasons. The manufacturing industry, he feels, is more direct, pragmatic and faster than the banking sector which, says Rosenfeld, expands both scope for action and responsibility. In an interview with the newspaper "Die Welt," he described his managerial responsibilities in these words: "When you're at the helm of a global technology group today with more than 80,000 employees, your role is primarily one of developing a reasonable strategy, recognizing the right trends and selecting the right people. You have to optimize structures, provide guidance and serve as a role model." In addition to his role as CEO, Rosenfeld's activities include serving as a member of the supervisory boards of Continental AG and the wind power company Siemens Gamesa and as a member of the presidential board of the Federation of German Industries (BDI). In his scarce spare time, Rosenfeld enjoys sports. He plays golf, goes skiing or tackles the challenges of triathlon competitions. In addition, the avid violinist likes listening to classical music.*

IAA 2017: Georg Schaeffler, Klaus Rosenfeld and Peter Gutzmer welcomed Federal Chancellor Dr. Angela Merkel to the Schaeffler trade show booth

MASTERFULLY **MORPHED**

Everything is subject to change – including mobility. Ships, airplanes or automobiles are sent to the scrapyard when progress has made them obsolete. But what happens to the infrastructure they once used? “tomorrow” shows examples of successful transformations.

by Volker Paulun and Frederick Unflath

ROADS RECLAIMED AS **LIVING SPACE**

Even at this juncture, more than a billion motorized vehicles are traveling the world’s roadways. By 2035, their number is expected to double. Numerous roads aren’t able to cope with this growth. Because they crumble under their daily loads. Or because they can’t grow anymore themselves. The obliteration of such concrete varicose veins may literally have an invigorating effect.

EMBARCADERO, SAN FRANCISCO

What it used to be

The Embarcadero Freeway built in the 1960s used to be regarded as “by far the ugliest site in the city.” For 30 years, the double-decker freeway separated the coastal region and the Ferry Building (pictured) from the city center. In 1989, an earthquake put an end to it. The collapsed blight by the bay was torn down in 1991.

What it is now

A palm-lined boulevard replaced the freeway. Plazas and parks were created and lines of the famous cable car established. Today, the Embarcadero is a popular place for a night walk, Pier 39 west of the Ferry Building one of the city’s central tourist attractions.

CHEONGGYECHEON, SEOUL

What it used to be

Cracked asphalt, ruptured concrete. Seoul’s city highway had to go. Demolition without reconstruction – this plan met with plenty of approval, but also with protests and even threats of suicide. Many citizens predicted traffic chaos in the light of 168,000 cars per day traveling the 5.7 km (3.54 mi) long four-lane, 35-year-old highway section. Even so, the transformation project was launched in 2002.

What it is now

The demolition exposed the Cheonggyecheon river again that had been covered by the highway, so this body of water was renaturated. Since the project’s completion in 2005, fauna and flora have been thriving there again and so has a new quality of life. The neighborhood, now suddenly turned into a hip place, has been attracting businesses that create jobs and strengthen the economy. In addition, the average temperature along the river has dropped by a remarkable 3.6 °C (38.5 °F). Equally remarkable: The traffic chaos feared by many did not materialize, not least because drivers – more or less voluntarily – switched to public transportation. So, Cheonggyecheon has set an example: in Seoul, where other highways have since been removed, but also for urban planners from other places who’ve been carefully studying this transformation.

MORE PLANES, MORE SPACE

More and more takeoffs, more and more landings, more and more passengers, larger and larger airports. Aviation is booming around the globe. The number of passengers per year, from four billion in 2017, is predicted to nearly double to 7.8 billion per year in 2036. By 2050, even up to 16 billion passengers are anticipated. In Europe alone, 70,000 scheduled flights are supposed to take off per day by that time. Many airports inside or close to cities are no longer able to keep pace with such growth, not least due to stricter environmental controls, and have to move to the surrounding areas. Some of them already have, like Berlin, Denver, Liverpool, Munich, Oslo and Hong Kong. Runways have been reclaimed there as places to live, work and play.

TEMPELHOF, BERLIN

What it used to be

In 1909, the first motorized airplane took off from the former military parade ground. Scheduled air service started in 1923 and was discontinued 85 years later. The airport terminal that was begun to be constructed in 1936 was the world's largest building in terms of floor space until 1943. During the Berlin Blockade, planes carrying supplies as part of the airlift would frequently land at Tempelhof at merely 90-second intervals.

What it is now

After aviation operations ceased in 2008, the Tempelhof airfield became an urban recreational area. The impressive terminal including the apron is used by tenants from a wide variety of business sectors and as an event area, for instance as the venue of Team Audi Sport ABT Schaeffler's Formula E home round on May 19, 2018.

KAI TAK, HONG KONG

What it used to be

The approach over Hong Kong's street canyons to the Kai Tak airport that was built in 1954 and closed in 1998 used to be one of the most dangerous in the world, not least due to the treacherous wind conditions. That's why the airport that in the 1990s was the fourth most frequented hub in the world was also dubbed "Kai Tak Heart Attack." Its successor, located 39 km (24.23 mi) away from the city, is China's second-largest passenger airport and the world's largest cargo airport.

What it is now

Ocean liners instead of airliners are now heading for Kai Tak. In 2013, the cruise ship terminal, which cost one billion dollars according to media reports, was taken into operation. On the former Runway 13, golf can be played today. 158,000 trees and shrubs were planted for the Runway Park. For ambitious construction projects, roads were paved and utility lines installed, but the planned buildings have not been erected – yet. Now they're supposed to become reality and the former airport be awakened to a new urban life with some 50,000 apartments, offices, shops, sports and recreational facilities.

MESSE RIEM, MUNICH

What it used to be

When Munich's Oberwiesenfeld city airport was inaugurated in 1919 it was actually too small even then. An alternative "far away from the city" was needed: In 1939, the first airliner landed in München-Riem. But this airport, as well, was swallowed by the expanding city. As early as in the 1960s, officials started looking for an alternative site even farther away from the city limits and found it in an area called Erdinger Moos.

What it is now

On the Oberwiesenfeld premises, the Olympiapark for the 1972 Games was built. In Riem, a "trade fair city" emerged – the construction project encompassing a residential and exhibition building, a park and a shopping mall was the second-largest one in the city's history after the Olympiapark. Riem is the venue of the world's largest trade show: the "Bauma" construction materials and construction machines exhibition. The airport that replaced the one in Riem, the intercontinental Franz Josef Strauß airport opened in 1992, is 30 km (18.6 mi) away from the city or a 45-minute ride on a commuter train.

THE LINE ENDS HERE

During industrialization in the 19th and at the beginning of the 20th century, factories mushroomed, not on greenfields like in today's industrial parks but in the cities. A continuous flow of materials had to be ensured to keep manufacturing operations running. Freight trains proved very efficient for this purpose, so rail networks kept expanding. In the course of further developments, the greater flexibility of trucks increasingly caused cargo hauls to be shifted from rail to road. Furthermore, the growing need for office and residential space forced many larger manufacturing operations out of urban sites. Structures that bear witness to past inner-city freight transportation can still be seen in many major cities today. Most of them are in a state of dereliction, but there are exceptions (see examples at left). Unlike rail cargo, rail-based urban passenger transportation is flourishing – which has consequences as well. In many places, more efficient routes have to be established and more modern stations built. Still, old infrastructure doesn't necessarily have to be torn down for good. With plenty of creativity new life can flourish in abandoned facilities.

WATERLOO STATION CATACOMBS, LONDON

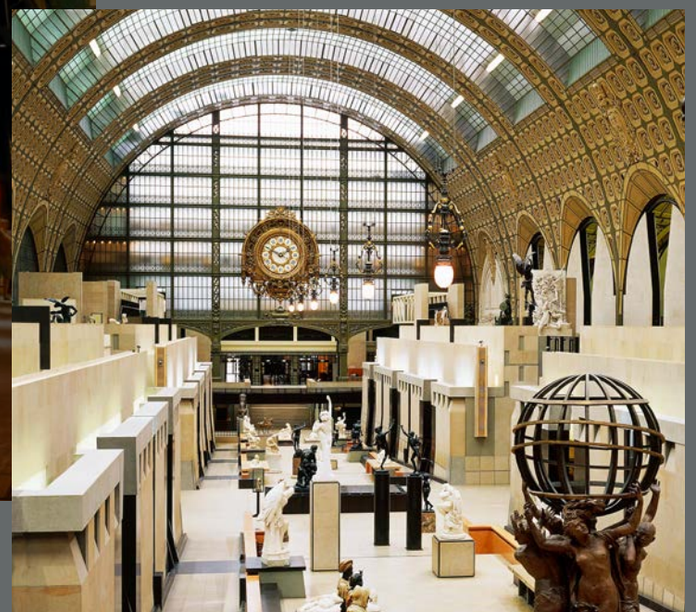
What it used to be
In parallel to the continuing expansion of rail-based transportation, London's central Waterloo Station that was inaugurated in 1848 kept growing as well. In 1854, a curious building was erected adjacent to the main hall on the west: the Necropolis Station from where trains with London's dead and their mourners would depart for a cemetery on the city's outskirts. In 1902, the station of the dead moved to the Waterloo south side. Before embarking on their last journey, the mortal remains were kept in the same place as before – the catacomb labyrinth underneath Waterloo Station that had consistently grown as well – until the service was discontinued in 1941.

What it is now
Following the last service of the Necropolis Railway the catacombs fell into oblivion – until the London art scene turned its attention to them after the turn of the millennium. Cultural centers moved into the underworld of the UK's busiest train station (some 100 million passengers per year): the "Vaults Theatre" on the east side, the "House of Vans" into the Old Vic Tunnels on the west (pictured) including London's first indoor skate park. Now the idea of transferring the concept to the Mayfair underground station at Hyde Park that has been disused since 1932 is being pursued.

HIGH LINE, NEW YORK CITY

What it used to be
In 1847, the prospering Meatpacking District, an industrial area in the west of Manhattan, was connected to the rail network by the West Side Freight Line. When road traffic kept increasing at the beginning of the 20th century the train tracks in the streets interfered – in 1932, the Freight Line became a High Line. But as early as in the 1950s, freight transportation was shifted from the elevated railroad spur back onto the road – into trucks. In 1960, an initial section of the High Line was torn down and the last train ran in 1980.

What it is now
The "Friends of the High Line" saved the last 2.3 kilometers (1.43 miles) of railroad history and transformed it into an elevated park. Since its completion, some five million people per year have been visiting the greened tracks in the middle of their creative neighborhood.



MUSÉE D'ORSAY, PARIS

What it used to be
The Gare d'Orsay in Paris, inaugurated in 1900, with its elaborate ornaments was too beautiful to admit dirty steam engines, so d'Orsay went down in Paris city history as the first terminus for electric trains. However, as early as in 1939, the station became too small for long-distance trains and after the end of the Second World War no commuter trains stopped there anymore either – the magnificent building was threatened to be torn down.

What it is now
At the end of the 1970s, then President Valéry Giscard d'Estaing personally supported a plan to convert the station into a museum of art from the period between 1848 and 1914. Every year, the exhibition attracts 3.8 million visitors, so making the former train station a busy place.

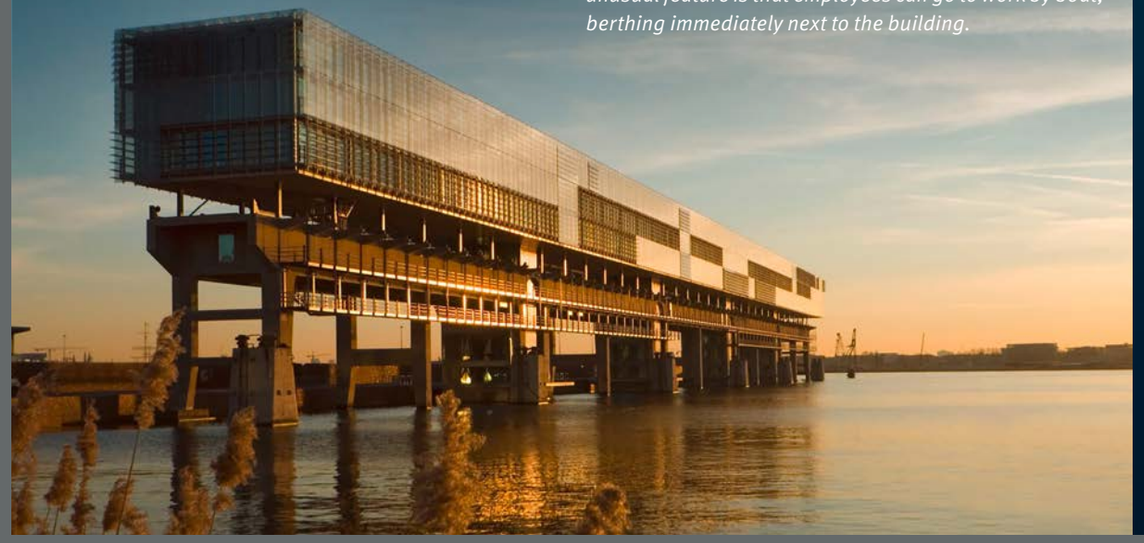
NEW BERTHING WORLDS

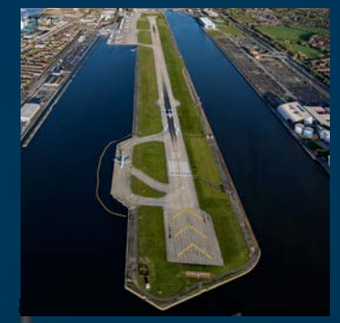
Due to globalization, world trade has grown by a factor of 19 since 1960 – three times as much as the global economy. And here's another astonishing figure: 90 percent of the export trade is handled by sea. In parallel to sea trade, the ships have grown as well. A view from the decks of the "Cap San Diego" museum ship to the container terminal at the Hamburg port where the really large vessels berth reveals the differences: The general cargo ship built in 1960 is 160 m (525 ft) long and had a cargo capacity of 10,000 metric (11,023.1 short) tons. The current 400 m (1,312.3 ft) long cargo ships can carry 18 times as much – and only require half the crew. One of the most important game changers of world trade was first dispatched in 1956: the intermodal container. Today, some 30 million of these 20- or 40-foot long standardized metal boxes are traversing the oceans. The world's largest container vessels – the G-Class of the OOCL shipping company – can each carry 21,413 intermodal containers. These giants of the seas are unloaded in two to three days' time on highly automated high-tech terminals. Many of the old port facilities around the world were unable to keep pace with the rapid changes in this sector. However, their locations directly on the waterfront make these areas highly attractive for use as residential and business districts.

KRAANSPOOR, AMSTERDAM

What it used to be
The Dutch metropolis of Amsterdam has been a port city since the 13th century. Complex work on canals kept opening up new paths to the North Sea. In the 1950s, the western part of the port was extended which caused the importance of the northern and eastern sections to diminish.

What it is now
In 1990, the abandoned areas began to be transformed into living, working and recreational spaces. A particularly intriguing example of the development there is "Kraanspoor," an elevated office building (270 m/885.8 ft long and just 13.5 m/44.3 ft wide) erected 13 m (42.7 ft) above water on top of an old crane-way. A particularly unusual feature is that employees can go to work by boat, berthing immediately next to the building.





WATER **TURNS INTO AIR**

London pursued a different path. In the area of the former "King George V Dock," the London City Airport was built. While other city airports are closing, the one on the Thames is growing: a redevelopment project is planned to increase capacity to eight million passengers per year.

HAFENCITY, HAMBURG

What it used to be
The Hamburg port, first mentioned in the 9th century and officially established on May 7, 1189, during the course of its existence continually expanded from a berthing place in the old town on the northern banks of the Elbe river toward the southwest. Since the 1970s, container vessels have been the dominant sight while importance of the northern part of the "Speicherstadt" (warehouse district) kept diminishing and large areas were no longer used.

What it is now
In 2001, the ground was broken for the new HafenCity, currently Europe's largest urban development project covering a total area of 157 hectares (388 acres). After completion of the development with a university, a shopping mall, schools, childcare centers, offices, residential buildings, subway stations, the conservation of the old warehouses, a skyscraper and, naturally, the world-famous "Elbphilharmonie" concert hall by 2030, 120,000 people are expected to live and work in the district.

THE AUTHORS

*The authors, **Volker Paulun** (left, a native of Hamburg) and **Frederick Unflath** (a resident of Munich), discovered so many exciting urban transformation projects that they could have filled half the magazine with them. Some of them, like the monumental Michigan Central Station in Detroit, are still like sleeping beauties just waiting for some bold "transformers" to awaken them.*

in motion

Innovations in the course of time

» We are turning a post company with a little bit of logistics into a logistics company with a little bit of post Peter Kjær Jensen, CEO of Post Danmark

WHEN THE **POSTMAN** RINGS NO MORE

Even the ancient Egyptians, Greeks and Persians dispatch mail. The Roman Emperor Julius Caesar introduces a state postal system. The Cursus Publicus, however, is not intended for personal mail. Franz von Taxis is deemed the founder of modern postal systems. He and his successors from the House of Taxis, commissioned by the widely ramified Habsburg family dynasty, establish a network of couriers. Begun in 1490, it's continually expanded until it covers the entire western part of Europe by the middle of the 16th century. The postal stations where the riders and carriages stop turn into important hubs in the evolution of villages and towns. Postal services become increasingly established as a means of communication. Letters and postcards even resist disruptive attacks by telegraphy and telephony, telefax and email. Even today, albeit in clearly declining numbers, billions of them continue to be sent. However, that mail will still be delivered by human couriers in the future is doubtful. Autonomously acting machines like the Schaeffler Cargo Mover shown here in the form of a self-driving packing station are increasingly outstripping mail carriers of flesh and blood.

425 bn

euros in sales were generated by the **postal sector** around the world in 2016. 2 % more than in the previous year.

Source: International Post Cooperation (IPC)

300 bn

letters were sent worldwide in 2016. At the turn of the millennium it had been 130 billion more.

Source: Universal Postal Union (2018)

70 bn

parcels were sent in 2016. In western countries, the number has doubled since the turn of the millennium, having virtually exploded in China. With 31.3 billion parcels in or from China the country accounted for a world market share of nearly 50 % in 2016.

Source: China State Post Bureau (2016)

THE COINCIDENCE THAT CHANGES THE WORLD

We like to think that we're able to predict technological revolutions or even deliberately control them. This is an illusion, though, as coincidences play an important part in our world.

by Florian Aigner

What will the weather be like in New York in three years' time? Nobody knows. That's not because our meteorologists aren't smart enough, that they're not using adequate measurement systems or that their computers lack precision – it's due to the basic laws of physics.

This realization is a relatively recent one. It was only in the 1960s that the discovery of what physicists today call "chaos" was made. It means that even small, seemingly meaningless details may have enormous effects. Let's assume we had the best imaginable meteorology simulation computer capable of calculating in advance any action of an atom in our atmosphere with perfect accuracy – and then, unexpectedly, somewhere in the Brazilian rain forest, a butterfly gently flaps its wings. An infinitesimal, incidental event which, triggering a chain reaction, renders all forecasts completely worthless – the so-called "butterfly effect" (see info box). In that case, there may be tornados in regions for which the computer had forecast fair weather – or vice versa. Given that it's completely unthinkable to include every minor, incidental event in the entire universe in our calculations, even the best computer is never able to calculate the future of the weather for the long run. From a perspective of physics, even infinitesimal events may be enough to completely upset the run of things.

This appears strange to us. We like to think that the future is by and large predictable. People who are familiar with the scene will tell us with total conviction which technology start-up will become a resounding success. The Bitcoin price will probably go up again. Our refrigerators will soon automatically reorder our milk supply. In the 2040s, NASA astronauts are going to set foot on Mars. Now, while all this is possible, we shouldn't rely too much on predictions of the major transformation processes this century. Coincidence plays a major part in our world and therefore the future can neither be controlled nor predicted. This is what physics teaches us – and so does historic experience.

Coincidence as an inventor

In 1945, U.S. engineer Percy Spencer was working on microwave radar systems. He happened to have a peanut butter candy bar in his pocket and was surprised to find that it was beginning to melt. This marked the birth of the idea for the microwave oven.

Charles Goodyear was seeking to improve natural rubber that would become sticky in heat and brittle in cold. Goodyear's experiments were unsuccessful for a long time, even his attempt to heat rubber with sulfur was. However, one day in 1839, he purportedly forgot to remove the compound from a hot stove – and suddenly it transformed into something elastic and stable.

THE **BUTTERFLY EFFECT**

The significance of coincidence in weather forecasts *was discovered by U.S. meteorologist Edward Lorenz in the 1960s, not surprisingly by mere chance. Lorenz had started one of his meteorological computer calculations a second time and was astonished to see that this time they delivered a totally different result. As it turned out, he had made a minute mistake while entering the initial data. Consequently, the basic conditions for the second weather calculation slightly differed from the first ones. Now one might assume that a minute variation in the initial data would also produce just a minor variation in the final result, but this is not the case. The difference between the two weather developments which, initially, are practically identical will grow faster and faster until the two will ultimately have nothing to do with each other anymore. Errors will grow exponentially – this is the core element of chaos theory. Therefore, theoretically, a minute event such as the flapping wings of a butterfly can make the difference between a tornado and tranquil summer weather. However, this cannot subsequently be proven, nor predicted or even planned.*

» *Surprise always takes place where one did not expect it*

Wilhelm Busch, German humorist

Goodyear had accidentally discovered the vulcanization of rubber.

Alexander Fleming accidentally left a dish with a culture of bacteria in his laboratory before going on vacation in the summer of 1928. On his return, a fungus had spread on the dish which, to Fleming's surprise, was killing all the surrounding bacteria. It marked the discovery of penicillin.

Events like these illustrate how great the part is that coincidence plays. However, if Spencer, Goodyear, Fleming and others had not been able to correctly interpret the potential of their unexpected results, the door they accidentally opened would have quietly shut again. So, in addition to a strong dose of abstraction ability, a high level of subject-matter knowledge and persistence are definitely crucial factors of accidental inventions.

Aside from coincidence, there are countless linchpins of history that weren't recognizable as such at the time and appeared completely insignificant, like the flapping wings of a butterfly. Who knows, maybe Isaac Newton, who laid the foundations of classical mechanics, might have nearly fallen off a bridge as a child, but was held just in time by a passer-by? If James Clerk Maxwell's mother had not died when he happened to still be very young, he might have developed in a different direction, might not have been interested in physics and might never have discovered the basic equations of electricity that were to completely revolutionize our technology?

Coincidence is a co-ruler even in the realm of inalterability

Obviously, this doesn't mean that nothing at all can be predicted about the future. While the flapping of a butterfly's wings may have an influence on whether or not it's going to rain in Hamburg on the 7th of August, it's a fact that it'll basically be warmer there in summer than in winter. Similar things apply to technological change as well. That electronics will continue to develop, albeit perhaps not as rapidly as in the past, seems to be pretty certain. That various environmentally compatible technologies will be playing an increasingly important part in our world due to our climate issues is undisputable as well. Such developments, though, do not follow a predictable course, but happen in random leaps that are hardly controllable.

So, it comes as no surprise that even the predictions of smart, educated people prove to be false time and again. Alex Lewyt, a manufacturer of vacuum cleaners, in 1955 announced that within the next ten years there would be a vacuum cleaner using nuclear power. Futurist Matthias Horx as late as in 2001 publicly stated that the internet would not become a mass medium. At least "Popular Mechanics" magazine in 1949 correctly assumed that one day there would be a computer weighing less than 1.5 tons.

Uncertainty is the only certainty

How our world is going to change is unpredictable. We have to accept this – and that's good, too, because only pretty boring, simple systems lend themselves to long-term predictions. The fact that our society is a complex system in which chaos ultimately rules as well makes our world truly intriguing. This much, however, is certain: the world is going to change – as it always has done.

We should make every effort to help shape this transformation and to steer it into the right direction to the extent that this is possible. But where is all this going to lead us? To distant planets? Into virtual worlds? Into a bionic age of living machines? We're not able to tell. We can only be excited and boldly look ahead.

OPABINIA, COINCIDENCE AND US

Opabinia is an animal species that became extinct some 500 million years ago. It had a body without a skeleton, five functional eyes and a proboscis with a gripper underneath the head. There's not a single animal on Earth today that even remotely resembles Opabinia. So, why has evolution produced such a diversity of modern vertebrates while Opabinia's relatives became totally extinct? "It may be sheer coincidence that 'tomorrow' readers are not creatures with green scales and a proboscis, but that the human species has survived as a result of countless random events," says science explainer Florian Aigner

THE AUTHOR

Florian Aigner *is a physicist and science explainer. He obtained his PhD with a thesis on theoretical quantum physics. Today, he writes about science and technology. His publications include his column "Wissenschaft und Blödsinn" ("Science and Nonsense") on futurezone.at. In his current book, "Der Zufall, das Universum und du" ("Coincidence, the Universe and You") that recently won "science book of the year" recognition, Aigner embarks on a search for the deeper meaning of coincidence for the universe, for life and for all of us.*

MULTI**TOOL**

In 1996, Nokia presented the Communicator as the first “pocket-size office.” If nothing before it, the launch of Apple’s first iPhone in 2007 marked the beginning of the smartphone’s unrivaled success story. By now, this digital multi-talent has completely changed all aspects of our everyday lives. Today, smartphones account for half of the worldwide web traffic. 66 % of the world population owns such a pocket-size computer. And this revolution is far from having reached its end. Here are some examples from the world of swiping and tapping.

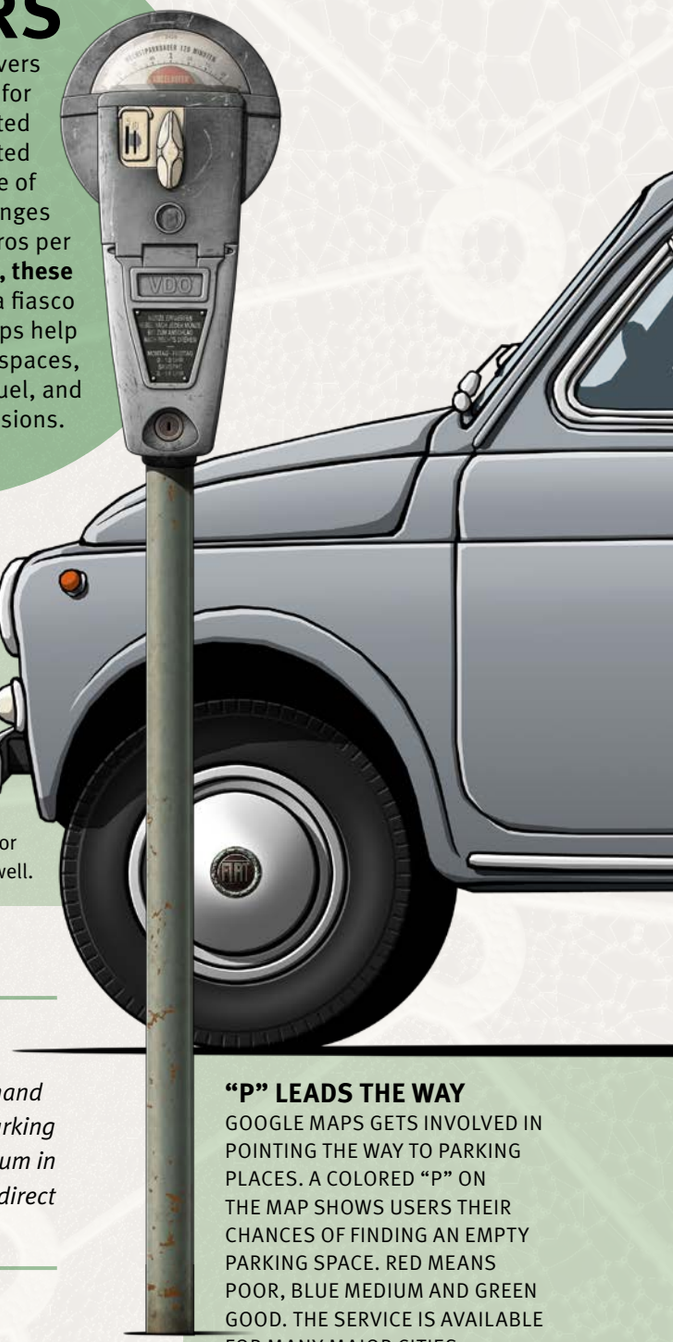
by Denis Dilba

Source: INRIX Global Traffic Score Card (2017)

41 HOURS

This is the average time drivers in Germany spend looking for a place to park. In the United Kingdom, it’s 44 and in the United States still 17 hours. The value of the time wasted this way ranges between 300 and 900 euros per person. **Projected to countries, these amounts add up to billions –** a fiasco for national economies. Apps help users find empty parking spaces, which saves time and fuel, and reduces emissions.

More and more cities are making it possible to **buy tickets for parking places using smartphones.** Drivers load the software onto their phones and then have to register themselves and their vehicles. App-based parking provides the benefit of more precise charges – if users spend more time shopping or visiting a doctor’s office than planned they can extend the validity of their tickets from a changing booth or waiting room – plus, the search for small change has become a thing of the past as well.



AS IF BY MAGIC

Completely on their own, just guided by a command sent from a smartphone, two E-Class cars find parking spaces in the garage of the Mercedes-Benz Museum in Stuttgart. Sensors in the garage’s infrastructure direct the test vehicles toward vacant spaces.

“P” LEADS THE WAY

GOOGLE MAPS GETS INVOLVED IN POINTING THE WAY TO PARKING PLACES. A COLORED “P” ON THE MAP SHOWS USERS THEIR CHANCES OF FINDING AN EMPTY PARKING SPACE. RED MEANS POOR, BLUE MEDIUM AND GREEN GOOD. THE SERVICE IS AVAILABLE FOR MANY MAJOR CITIES.

CONVENIENT MANEUVERING

A driver’s best friend: the smartphone as a multi-functional parking assistant.

GIGABYTE GUZZLERS
THE DATA CONSUMPTION FOR STREAMING SERVICES CAN QUICKLY AMOUNT TO SEVERAL GIGABYTES. SKY GO AND DAZN REACH 1.5 GB PER HOUR, NETFLIX AND AMAZON VIDEO 1 GB AND 0.5 GB RESPECTIVELY. ALL OF THESE VALUES STAND FOR OPTIMUM QUALITY. IN ECO MODE, THE APPS DRAW SMALLER DATA VOLUMES – BUT ALSO DELIVER LOWER RESOLUTIONS.

Source: KasperskyLab (2017)

51 %
of all smartphone owners **use their devices to watch TV/videos –** ranked in third place of all online uses, trailing email (59 %) and social media (55 %). Listening to music follows in 9th place (36%).

AUDIO-VISUAL ENTERTAINMENT

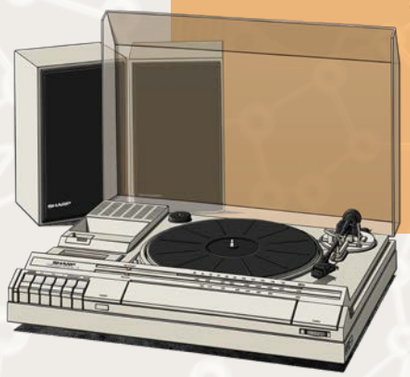
Be it for films or music: the smartphone as the ultimate audio-visual jukebox.

80 PERCENT

of the global internet data volume in 2019 will consist of video streaming, according to IT corporation Cisco. Two thirds of the videos are expected to be watched on wireless devices. Another stunning statistic: in 2019, videos with a total length of 5 million years are expected to be streamed per month.

People listening to music on a smartphone today rarely play their own audio files anymore. *Especially young people use music streaming services like Spotify, Apple Music and Deezer, etc. 61 % of 14- to 29-year-olds listen to their music streamed to smartphones, tablets or laptops, compared to 40 % among 30- to 64-year-olds. Even one in four people who are 65 and older streams audio files from the internet.*

Source: Bitkom

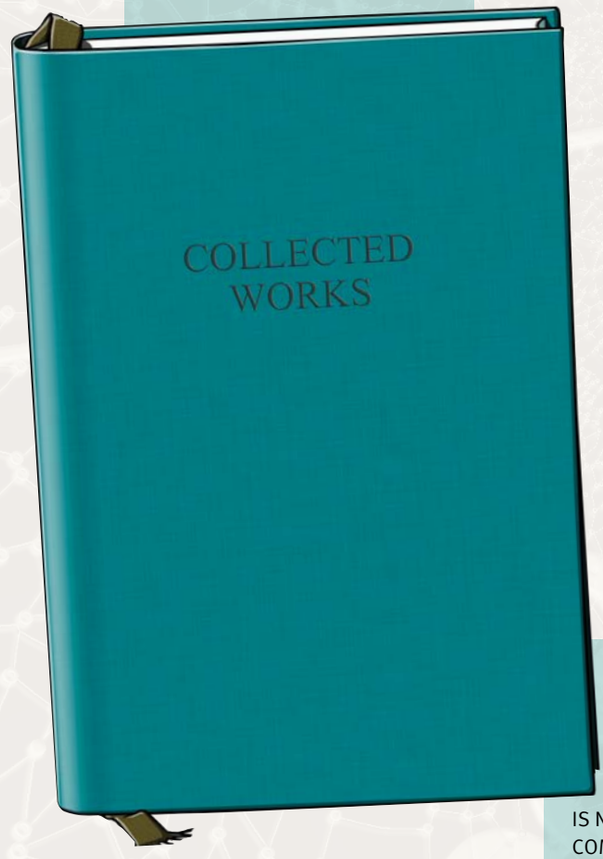


CONCENTRATED INFORMATION

More knowledge and reading material than any library: smartphones provide access to 16 zettabytes of data (a number with 21 zeros) on the internet – global knowledge to go.

39 PERCENT

of people **reading e-books use smartphones** for this purpose. Thanks to increasingly larger displays, smartphones have outstripped tablets (29 %) as the preferred alternative to dedicated e-book readers.



NO. 1 INFO SOURCE

Paper is slow, smartphones are fast – this is another reason why 50 % of all owners of iPhones & company use these digital multi-talents as their "major" source of news. TV, print and radio follow by a large margin. However, users prefer the digital offerings of classic media while social media are (still) playing a subordinate role in this field. Not even one in five users watches news in social media.

Source: Reuters Institute Digital News report (2017)

Over 300 million
times the "YouVersion" Bible app has been downloaded to mobile end devices. This also makes **the world's most frequently printed book** a digital bestseller. Millions of Koran apps have been downloaded as well.

FOR 244 YEARS
THE FAMOUS "ENCYCLOPEDIA BRITANNICA" APPEARED IN PRINT – UNTIL 2012. THAT'S WHEN THE PRINTED VERSION WAS DISCONTINUED. THE ENCYCLOPEDIA'S ACCUMULATED KNOWLEDGE IS NOW AVAILABLE ONLINE IN SMARTPHONE-COMPATIBLE FORM AT BRITANNICA.COM

25,700

is the number of selfies average "millennials" are expected to have shot with their smartphones **by the end of their lives.**

Source: Elsa Godard in the book "I Selfie Therefore I Am"

1.2 TRILLION PHOTOS

were taken by the world population last year. Especially the increasing use of smartphones has been causing the number of pictures shot around the globe to continually increase for years. Accordingly, some 85 % – more than one trillion – of all photos were taken with these mobile multi-talents. Conventional digital cameras now only account for a market share of 10.3 %.

Source: Bitkom survey "The Future of Consumer Technology" (2017)

NEW IMAGERY

Cameras for photos and videos, image editing and editing stations: none of these are needed by anyone who owns a smartphone.

SOCIAL MEDIA TURBO

Social media posts with pictures receive **53 % more "Likes", 104 % more "Comments" and are shared 84 % more frequently** than posts without pictures. The largest number of these pictures by far is shot with smartphones.

Source: Dupdate "Photo sharing: trillions and rising" (2016)

2 megapixels

This was the resolution of the camera installed on the first iPhone in 2007. The current model achieves 12.2 MP and competitor models such as the Huawei Mate 9 **even 20 MP.** In addition, smartphone camera lenses today are twice as light-sensitive as they used to be.

NO NEED FOR CASH

Coins, bills and cards – will soon be history. Smartphones are the wallets of the future.

By 2020 payments by means of smartphones using NFC technology are expected to be possible **at all cash register** terminals in Europe equipped with EC and credit card readers.

Source: Visa, MasterCard, Maestro

Mobile wallet

Most of the so-called mobile wallet apps use NFC (Near Field Communication) technology for smartphone-based payments. This wireless technology transmits only small data volumes over a range of a few centimeters. That makes NFC perfectly suited for exchanging the payment data between a smartphone and a cash register terminal. Purchases of up to 20 or 25 euros can be made this way without a confirmation prompt – larger amounts require a code to be tapped in.

BY 2021 THE ANNUAL WORLDWIDE SMARTPHONE-BASED TRANSACTION VOLUME IS EXPECTED TO GROW TO USD 870 BILLION.

690 MILLION PEOPLE CURRENTLY HAVE DIGITAL WALLETS INSTALLED ON THEIR SMARTPHONES – THE ANNUAL GROWTH RATE IS 25 %.

Source: mobilepaymentsworld.com

CASH & CARRY

The British Co-op chain has been testing a cashless payment method in a store in Manchester since March 2018. Customers use their smartphones to scan the products themselves while placing them into their shopping carts and when finished pay for their purchases by tapping the phone's display.

TEST MARKET INDIA

In India, WhatsApp has extended its smartphone app by a payment function. The Facebook subsidiary not only selected India as a test market due to its more than 200 million WhatsApp users but also because 70 % of the country's internet users do not use a PC but a mobile device to surf the worldwide web.

SMART TRAVEL

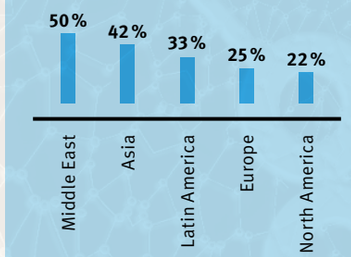
Calling a taxi, renting a bike, checking in at the airport or even booking a whole trip – smartphones can do all this and are increasingly turning into mobility tools.

UTILIZATION OF MOBILITY APPS

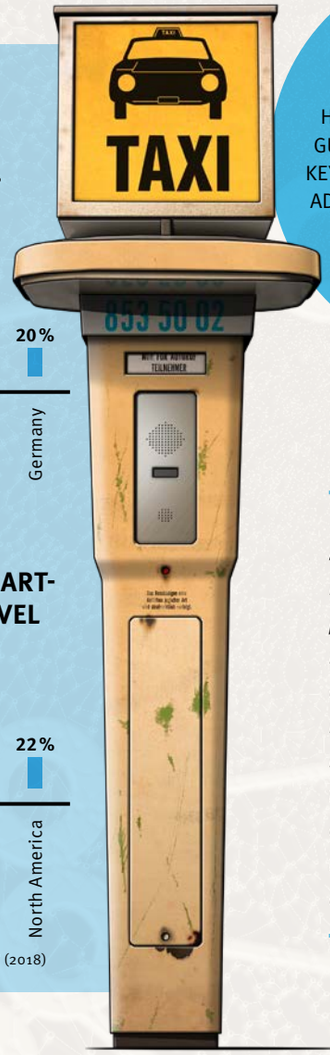
by smartphone owners (14–65 years) for taxis, rides, bicycle/scooter rental and car sharing.

Source: Dalia Research (2017)

PERCENTAGE OF SMARTPHONE ONLINE TRAVEL BOOKINGS



Source: criteo "Travel Flash Report" (2018)



SEVERAL 100 MILLION DOLLARS

HAVE BEEN INVESTED BY THE HILTON GROUP TO PROVIDE HOTEL GUESTS WITH SMARTPHONE-BASED KEYLESS ACCESS TO THEIR ROOMS. IN ADDITION, MORE AND MORE HOTELS ARE OFFERING CHECK-IN AND CHECK-OUT SERVICES USING SMARTPHONES.

A 26 PERCENT

increase in the use of local public transportation was recorded by the participants of an Austrian intermodal mobility research project in Vienna. The main reason for this growth was the simple fact that the test app clearly showed them that public transportation was the faster alternative.

BETTER CONNECTIONS

Lest we forget, smartphones of course can also be used to make phone calls …

20 %

of all people around the globe had **a land line** in 2005 – a historic peak. In 2016, this percentage had dropped to 13.5 %. During the same period, the number of cellphone contracts increased from 34 to 101.5 per 100 people.

794 g (28 oz)

was the weight of the world's **first commercial cellphone**. Motorola's DynaTAC 8000X, released in 1983, was 33 cm (about 13 in) long, offered between 30 minutes and one hour of talk-time, was able to store 30 numbers – and cost 3,995 U.S. dollars. Even so, the smartphone's ancestor was sold 300,000 times within a year.

TAPPING INSTEAD OF TALKING

70 percent of all smartphone users in the United States send messages to contact others, followed by telephony (62 %) and email (54 %). In the United Kingdom, one in five people is no longer using a smartphone to make phone calls. German digital expert Gerald Lembke shows evidence of these trends: "All surveys have revealed that the telephone is hardly in use any longer. On average, people across all age groups talk on the phone for a mere eight minutes per day. However, in the group of users up to 17 years of age, the time is hardly measurable anymore."

THE ILLUSTRATOR

Helge Jepsen *started his career as an illustrator at the age of eight, regularly reaping the awards in children's drawing competitions in Bredstedt, North Frisia. Later, the communication designer and book author caught the attention of magazines such as "Stern," "Playboy", "Wirtschaftswoche", "auto motor und sport" as well as major advertising agencies et al.*

LEARNING FROM HISTORY

A meeting of the past and present can sharpen our focus on the future, says Schaeffler's Chief Technology Officer Professor Peter Gutzmer. During a visit to the legendary Henry Ford Museum in Detroit, he shared his views with us.

by Jörg Walz

In early January, the automotive world traditionally celebrates the event that kicks off its new year: the North American International Auto Show (NAIAS). At the Cobo Center in Downtown Detroit, the "Big Three" from Motown showcase their most recent models and enjoy the pleasure of company from Asia and Europe. With equal tradition – in line with the transportation infrastructure of the vast Midwest – large sedans, light trucks and SUVs dominate the scene in what used to be the world's largest vehicle market. Even though by now clearly more passenger cars are being sold in China (24.17 million in the People's Republic vs. 17.13 million in the United States) almost five times more cars than in Germany (3.44 million new registrations in 2017) find new owners in America every year.

Former U.S. President Barack Obama, in a speech to Congress, once declared the auto nation the cradle of the automobile. While Europeans and particularly Germans know better than that, the honor of being the birthplace of the moving assembly line and – to put it in modern parlance – market penetration no doubt belongs to the Americans.

About half an hour away from the Cobo Center trade show complex, on the campus of the Ford Motor Company in Dearborn, Henry Ford and his descendants have assembled a remarkable collection of eclectic exhibits in a museum that impressively traces America's history of industrialization and transportation. The collection ranges from the Detroit Electric, the Model T (obviously!) and the VW Beetle to the Tucker Torpedo, Bugatti Royale, presidential state cars and Le Mans winning race cars (Ford GT40 and GT), to locomotives and airplanes. Far more exciting than the exhibits themselves though are the stories they tell and the messages they convey. Those who take a closer look can even discover the secret of successful – and not-so-successful – ventures. "The factors Henry Ford analyzed are still valid today, no matter what the tasks look like that entrepreneurs and enterprises tackle," explains Schaeffler's Chief Technology Officer Professor Peter Gutzmer during our tour of the exhibition. "They always involve curiosity, leadership, experimentation and cooperation, a willingness to take risks and the important ability to learn from mistakes."

Driven by the curiosity of inventing a motor, Henry Ford swaps ideas with friends and associates around the turn of the 19th century and uses a model setup on his kitchen table to experiment on an internal combustion engine. Together, they get the engine to run. "Ford in his

1941

ALLEGHENY STEAM LOCOMOTIVE

Length/width/height *38.1 m/3.40 m/5.02 m (125 ft/11.17 ft/16.46 ft)*
Weight/power output *352.9 metric tons (389 short tons), 7,500 hp*
Built by the Lima Locomotive Works, the Allegheny was one of the world's biggest steam locomotives. About a decade later, these behemoths were replaced by diesel locomotives.

1924

FORD MODEL T

Until 1972 – then topped by the VW Beetle – Ford's Model T was the world's top-selling car. The model depicted here shows the constituent parts optimized for assembly on a moving line.

1922

DETROIT ELECTRIC MODEL 90 COUPÉ

Frame Body *steel ladder frame*
Engine *DC electric (200 amperes, 96 volts, app. 19 kW), range approx. 110–160 km (70 to 100 mi)*
Top speed *approx. 48 km/h (approx. 30 mph)*
Detroit Electric built electric vehicles from 1907 to 1942, after 1930 only by special order.

day began as a 'startup' – as we'd call his business venture today," says Gutzmer. He develops the machine to production level and then musters the courage to put all his eggs in one basket: In 1896, he starts the Detroit Automobile Company … and fails. His second business, the Henry Ford Company, is no success story either. Success only comes with his third venture, the Ford Motor Company, which still exists today.

Infrastructure as a success factor

"He achieves his breakthrough when he adapts innovations from other sectors of the economy to his company. Ford follows the example of a moving assembly line of the kind commonly used in meat-packing plants in those days and designs his vehicle accordingly," Gutzmer explains. The Model T is in fact engineered for easy and fast assembly. Step by step the constituent components are put together to form a whole. An exploded Model T suspended by thin wires impressively illustrates this. And it also shows how an automobile can be manufactured from a few – pre-assembled – components. "The Model T is the first vehicle to have been optimized for maximum manufacturing simplicity. Today we call this industrialization," says Gutzmer. "The fact that Ford not only looks at the properties of the vehicle but also focuses on the production operation and the logistics behind it is a key aspect," comments Schaeffler's Chief Technology Officer. "The suppliers are committed to delivering prefabricated parts such as the wooden floor boards. And black paint in those days is cheaper than any other color. Plus, it dries faster so that cycle times can be reduced." This explains why Henry Ford back then offers his car in any color … so long as it's black. Today, this holistic engineering approach has long become standard practice and represents the difference between products made in small-scale and large-scale manufacturing.

"At that time, it's not clear yet which technology will win through," Gutzmer explains, pointing to the Detroit Electric, a carriage-like vehicle produced between 1907 and 1942 in which four passengers sit facing each other – like in the current Schaeffler Mover. "Around the turn of the century there are more electric cars in the streets of Detroit than automobiles with internal combustion engines. Steam-powered vehicles are on the road as well. "The issues in those days are similar," says Gutzmer, referring to range and battery technology. The IC engine, however, is far from being as easy to operate as it is today. Plus, the infrastructure has not been developed yet, which, in those days, means filling stations rather than battery charging devices. Only further inventions and the supply of fuel that becomes readily available as a result of the emerging petroleum industry accelerate the success of the IC engine. "Concurrently emerging systems and a powerful product that convinces the customer are keys to Ford's breakthrough. After all, Henry Ford purportedly stated that if he had asked his customers what they wanted they would have said faster horses," Peter Gutzmer remarks. "However, if the customers' fear of novelty can be dispelled and the advantages of innovative achievements are obvious an invention will be able to establish itself."

Success as an innovation inhibitor

Ford sustains his success with the Model T for a long time. The company repeatedly manages to reduce its prices while concurrently raising the pay of its workers, thereby helping to steadily grow its clientele. "However, Ford also experiences the risk that all successful innovators are exposed to," Gutzmer notes. "People who are successful may fail to challenge the ways in which they've been doing business when the time has come to do so, when new innovations should be pursued." Henry Ford, for instance, refuses to introduce hydraulic brakes even as late as in

1928

FORD 4-AT-B TRI-MOTOR AIRPLANE

Length/width/height *15.24m/23.16m/3.89 m (50ft/43.5ft/12.76ft)*
Power output *3 x 220 hp*
Engines *3x nine-cylinder Wright J-5 radial engine*
In the plane named after his fellow explorer Floyd Bennett who had died after a plane crash shortly before, Richard Evelyn Byrd was the first to fly over the South Pole.

the thirties, and while the competition has begun to offer stylish vehicles he insists on sticking to tradition. "That's why it's important for successful companies to pursue various paths at the same time. The term ambidexterity stands for the ability to manage – essentially conflicting – characteristics with equal skill. It's one of the prerequisites for sustainable success which is only achieved if in parallel to traditional ways new ones are developed or permitted." Moving on to the Allegheny locomotive, one of the biggest steam locomotives ever built, weighing more than 600 tons including the loaded tender and able to pull 160 coal cars, each with a 60-ton load, Schaeffler's CTO calls the exhibit "an impressive piece of mechanical engineering although in the forties the days of the steam locomotives are already counted. Whenever energy can be supplied directly, electric motors are the better choice, so having come out on top, whether in households or in transportation." The electrification of railroads – as well as the efficiency and output of diesel engines – bumps the spark-spraying iron horses off the railroad tracks.

The collection at the Henry Ford Museum also shows that it pays to widen one's viewing angle from time to time. Examples of constant change can be found in numerous areas – be it with automobiles and trains, in aviation, agriculture, energy production or manufacturing technology. Based on the example of the Model T, Henry Ford also produces tractors and airplanes at low cost in order to offer these technologies to a more extensive clientele. Soon, increasingly large passenger planes emerge with impressive radial "star" engines: complex designs with up to twelve cylinders, all of which are arranged in a circle around the rotational axis. As a result, the air-cooled units are powerful yet compact. Aircraft engineers also value their lower weight compared to that of in-line units. However, jet engines (see "tomorrow" 03/2017) will soon replace the reciprocating piston engines on airliners.

1949

VOLKSWAGEN BEETLE

Length/width/height *4.06 m/1.54 m/1.55 m (13.32 ft/5.05 ft/5.08 ft)*
Weight/power output *726 kg (1,600 lb)/30 hp*
Engine *air-cooled four-cylinder boxer type*
Although the Beetle radically differs from typical U.S. automobiles it shares the spirit of Ford's Model T as a simple, reliable and economical car.

Looking at the big picture

Even more impressive is the transformation in the power generation sector. Here huge steam power-plants with tall boilers towering above the ground sate the energy hunger that industrialization entails. They produce large amounts of steam for conversion into electrical energy to power the stamping cycles of presses and the rotation of drive belts for lathes, milling and drilling machines. Then the "blessings" of nuclear energy suddenly appear to make energy production easy, "But today we've long become aware of its disadvantages," Gutzmer points out. "That's why, logically, we're now in the process of massively accelerating energy production from renewable sources. It always pays to look at the big picture and the nexus of individual details. Frequently, it is specific events, changing requirements and general conditions that initiate and accelerate transformation processes. With regard to nuclear energy, Fukushima caused such a disruption." The automobile, for example, experiences one of these disruptions in the early seventies due to the oil crisis which makes the dependency on the Middle East obvious. The crisis provokes an abrupt change in thinking and the immediate emergence of smaller, more efficient cars. Shortly afterward, harmful emissions become an issue. Increasing traffic density and smog prompt the first emission control regulations to be issued in 1967, initially in California and subsequently, from 1976 on, in Europe as well. "Human ingenuity keeps finding solutions," Gutzmer concludes, "but, for this to happen, it's crucial to define objectives instead of technical solutions. This is essential to finding new approaches and making inventions. Strictly sticking to time-tested solutions obstructs the view of totally new directions and inevitably leads to limitations."

Thus, the success factors analyzed by Henry Ford can easily be applied to our times. "Only those who remain curious and are open-minded toward innovation are able to develop new business opportunities for their companies. Otherwise the history of large corporations finding themselves being forced by disruptors to look at new technologies and products keeps repeating itself. Plus, it takes great courage and the right organization to actually try something new. Even in the light of continual change, the logic of the steps that build upon each other remains valid. And this is also true even though, today, the role of the risk taker is increasingly played by startups," says Gutzmer. And thus a look at the past also provides opportunities to discover paths going forward.

"THE HENRY FORD"

Extending over an indoor and outdoor area of ***more than 40 hectares (approx. 90 acres),*** *it is the largest museum in the United States. The automobile and technology exhibition is just a small part of the collection The Henry Ford has put together since 1920.*

Museum hours	*Daily from 9.30 am–5 pm*
Tickets	*Children (5–11 years of age) $17.25* *Senior citizens (>62 years of age) $21.00* *Adults $23.00*
Address	*20900 Oakwood Blvd.* *Dearborn, MI 48124, USA*

www.thehenryford.org

THE AUTHOR

That the Henry Ford Museum contains some rare automobiles to be admired was clear to auto expert and enthusiast ***Jörg Walz*** *in advance. But then the encounters with trains, planes, farming machines, production and power-plant technology intensified his enjoyment and awe of humanity's mobility achievements beyond his expectations.*

URBAN STORIES

Transformation means progress and nowhere else can it be felt more distinctly than in our cities. Pulsating metropolises that grow, prosper – and change. Survey the pictures on the following pages and share our amazement.

by Carsten Paulun

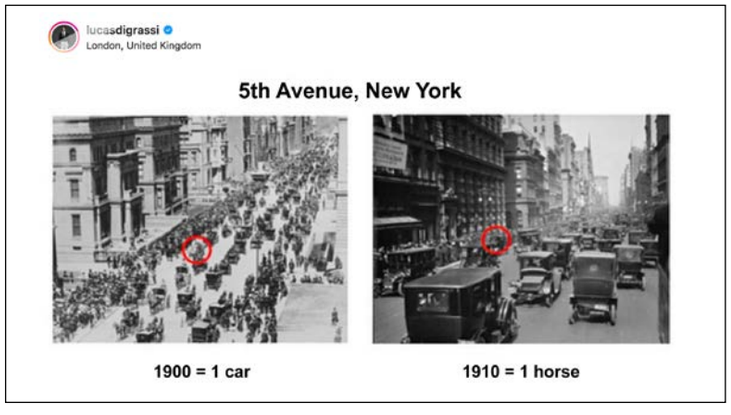
SHEIKH ZAYED ROAD

Dubai, United Arab Emirates

The origins of Sheikh Zayed Road date back far to the Bedouin age. *Used as an old trade route and paved over the course of the centuries, this is the place where the tallest building in the Middle East, the tower of the Dubai World Trade Center with a height of 149 meters (489 feet), is inaugurated in 1979. Dubai's economic success is reflected in the ensuing construction boom. The ruling Sheiks invest their petro dollars and transform the economy: from oil to real estate, construction, trade, transportation and tourism. One after the other, skyscrapers pop up from the desert soil along the main street that has since been named Sheikh Zayed Road. They include Burj Khalifa that with a height of 828 meters (2,722 feet) is currently the tallest building in the world. A driverless metro system connects the city center with famous tourist attractions and the airport. The shelters of the bus lines are fully air conditioned. By the way, today not even five percent of the emirate's gross domestic product is generated by petroleum. The origin of this wealth is a simple trade route in the sand …*

TIMES SQUARE New York City, USA

Around 1900 – when New York City already has a population of 3.4 million – the junction of Broadway and Seventh Avenue is still called Longacre Square and home to the carriage trade and horse stables. *The busy square only becomes Times Square when the famous "New York Times" erects its new building there in 1904. Times Square also receives a stop of the metro system that is inaugurated the same year. Above ground, the square bustles with automobiles, trucks, streetcars and – even as late as after the end of the First World War – also still with carriages as can be seen in the background of the photograph (above right). Times Square soon becomes an attractive place for theaters, bars and elegant hotels fittingly accompanied by the advent of the traditional large, colorful billboards. However, the growing popularity of television subsequently causes a decline in movie and musical audiences and spreading of adult theaters and strip clubs. In 1976, the New York Police Department declares Times Square the most dangerous place in the city. Starting in the mid-1980s, the area is "cleaned up" and made attractive for investors. Companies like MTV, Sony and Condé Nast move in, tradition-steeped hotels are reopened and attract local residents as well as tourists from all over the world. Today, pedestrians are afforded a lot more space than automobiles as the large picture clearly shows.*



The rapid pace at which change may take place can also be seen in an Instagram post by Formula E Champion Lucas di Grassi. In 1900, there's just one car among countless carriages on Fifth Avenue, just two blocks away from Times Square. Only ten years later, it's exactly the other way around

TOKYO-EKI Tokyo, Japan

In 1868, Tokyo – then a city of 600,000 – becomes the Emperor's seat and capital of Japan, which marks the beginning of a population boom. *By the time the First World War starts two million people are living in Tokyo. Only three decades later, the population has grown to 6.5 million. The infrastructure has to keep pace with this growth and rail transportation is one of the central aspects. Today, the Tokyo-Yokohama Metropolitan Area has the world's most extensive and most heavily frequented urban rail network. Tokyo Station, called Tokyo-eki in Japanese, is the most impressive terminal. At the beginning of the 20th century, Franz Blatzer is commissioned to plan the station, but the ideas of the German engineer who previously participated in the construction project of the Berlin rail network and studied Japanese architecture is rejected by the officials as being "too Japanese." Instead a station is built that has been designed by Japanese architect Tatsuno Kingo, a Neo-Baroque building bearing some resemblance to the Amsterdam central station. In 1914, Tokyo Station – Japan's most modern one at the time – is inaugurated. Particularly prominent besides the two buildings with rooftop domes is the large square in front of the station. Following its near-complete destruction in the war, the station is rebuilt bit by bit after the end of the war. Since 2012, it has been completely restored – albeit in a totally transformed environment as you can tell when opening this spread …*

PAGE FOLDS OUT ►

1936

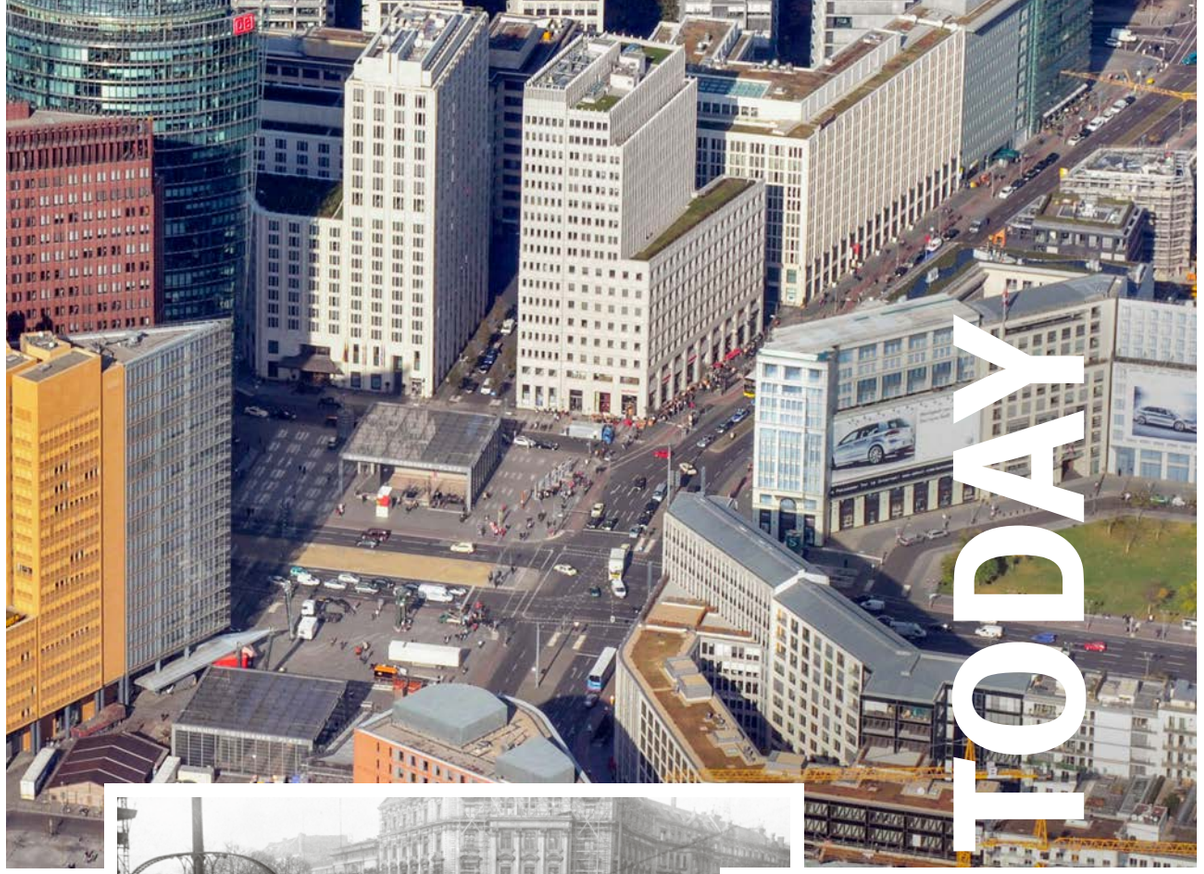
TODAY

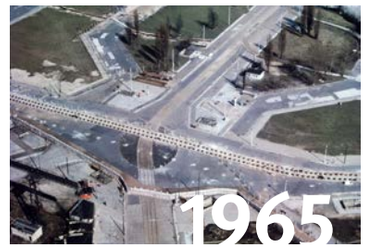
TOKYO-EKI Tokyo, Japan

Tokyo Station is located between the Emperor's Palace and the Ginza shopping and entertainment district. *Restored by 2012 to its original condition from 1914 and subsequently made earthquake-proof, the station that today is located between skyscrapers brings back memories of less hectic times even though it's still one of the traffic hubs of Tokyo-Yokohama, the world's most populous metropolitan area with 38 million residents. Ten platforms of the Shinkansen high-speed train meet with an equal number of tracks of the Japanese JR-East regional train and two lines of the Tokyo Metro.*

CHAMPS-ÉLYSÉES Paris, France

The world-famous boulevard in the French capital dates back to the reign of Louis XIV who in 1667 has the first section built of the Champs-Élysées, then called the "Grand Cours." *As the picture from 1900 clearly reveals, the magnificent avenue is a catwalk for the members of genuine and moneyed aristocracy. Horse-drawn carriages chauffeur the rich and famous down the 1,910 meter (6,266 feet) long and 70 meter (2,230 feet) wide Champs-Élysées which, except for these carriages, has very little traffic. The following decades see an increasing democratization of mobility – between Place de la Concorde and Arc de Triomphe just like everywhere else in the western world. After the Second World War, the automobile becomes a means of mass transportation and starts flooding the cities – including the Champs-Élysées. However, the picture changes again, as it does in many other metropolises of the world. Only the rich can afford to pay the astronomically high rents in city centers. Average earners have to move farther and farther into suburbia. In cities like Paris and London, people with average incomes are already spending two hours a day commuting to work: not in their own cars, though. City tolls, the scarcity of parking places and areas from which automobiles have been banned (since May 2016, the Champs-Élysées has been closed to motorized vehicles every first Sunday of the month) are now driving normal motorists out of city centers.*





POTSDAMER PLATZ Berlin, Germany

No more than a trade post outside Berlin's Customs Wall in the 17th century, Potsdamer Platz starts becoming increasingly relevant with the first train station in 1838. *By the late 19th century, Potsdamer Platz has evolved into a center of commerce and culture. From 1920 to 1930, it's the busiest square in Europe. The largest department store and the largest restaurant in the world are located here. From 1924 on, the city government attempts to control the chaos of streetcars, automobiles, carriages, cyclists and pedestrians by installing Germany's first traffic light – more or less unsuccessfully, so plans are made to transform the square. Pedestrian traffic is supposed to be routed through tunnels. The economic crisis and the war prevent these plans from becoming reality. From 1945 to 1989, the inner German border runs right through the middle of Berlin and the totally demolished Potsdamer Platz. In the 1990s, the area is one of Europe's largest construction sites. At the turn of the millennium, life begins to pulsate again in Berlin's old and new heart: urban transformation in fast forward mode.*

THE ULTIMATE PUZZLE

Stone, wood, metal, plastics – humans have been combining increasingly better materials which has led to ever new top technological achievements. What'll be next?

by Dr. Christian Heinrich

The world is a box of bricks. If you assemble several different things you create something new. This may be an easy project: open a box of Lego bricks, assemble the bricks the way they should fit together – and you've got yourself a fire station. However, a project may also be a lot more complex. Take this example from antiquity: stack 2.6 million stones, each weighing as much as a mid-size car, on top of each other, carefully and systematically for years on end, with enormous amounts of muscle power supplied by workers – and you've got yourself the Great Pyramid of Giza. This edifice is so huge that it can even be seen from a spacecraft. However, a closer look reveals that, above all, the Great Pyramid, just like a Lego house and anything else, is the sum of its parts.

Construction materials: They've fundamentally changed our lives. Entire epochs in human history have been named after the building materials that defined them. The Stone Age, at the end of which plaster and bricks of clay are widely used as construction materials too, begins more than three million years ago with the oldest tools that have been found and lasts until roughly 2200 BC – the Great Pyramid of Giza having been built a few hundred years earlier.

Material progress

Stone and wood are the original construction materials that made initial strides in human civilization possible: from tools to huts and on to larger buildings. These materials are readily available in nature and can be used directly without complex processing steps.

The Stone Age is soon followed by the Bronze Age and finally, starting around 800 BC, the Iron Age. Humans have learned that after heating ore in a smelting furnace for longer periods of time the residues, aside from ash, also include lumps of iron. When these lumps are heated to a red glow in a charcoal fire, they can be put on an anvil and beaten into any desired shape by means of heavy hammer. Not only weapons and armor are created this way in those days but, above all, agricultural and other hand tools like hammers, saws, sickles, axes, scythes and plows. A forward leap!

More and more construction materials are added over the course of the centuries and others undergo further development. The first glass objects date to the Bronze Age after which the use of glass rapidly spreads. Although cement-like building materials were already known by the Romans the success story of cement only begins when it is rediscovered and further developed at the beginning of the 19th century. The list of usable materials becomes longer and longer. Buildings of concrete and asphalt roads define the planet's face. Today, plastics have invaded practically every part of our everyday lives – and, unfortunately, also increasingly pollute our oceans. Light metals in particular inspire vehicle engineering on water, on land and in the air. The packaging and construction sectors are major users of light metal as well.

Which of the many construction materials is used for what purpose, primarily depends on price, availability and the user's requirements. Nobody, at least not exclusively, would build a home of glass, not least due to its poor thermal insulation. Neither would anyone use

> ***Due to nanotechnology, component surfaces achieve previously unattainable functions and will gain increasing importance***
>
> Dr. Yashar Musayev, Senior Vice President Surface Technology at Schaeffler

cement to build a car. Admittedly, such a vehicle would be pretty safe, but also bulky and too heavy to drive.

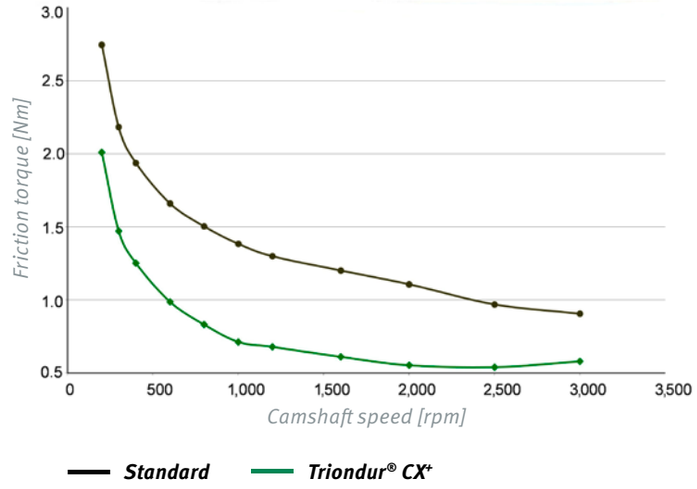
Different prerequisites

However, especially in recent years, another factor has become important aside from functionality: sustainability. "Today, in production and construction, the question of what will happen when everything is torn down again or disposed of is increasingly considered," says Eddie Koenders, a professor at the Institute of Construction and Building Materials at TU Darmstadt. Heightened environmental awareness is not the only reason for this. As the prices for many construction materials have generally been on the rise, recycling increasingly pays off as well. Legislation is becoming tighter too, so "mining" has been gaining importance. Houses to be torn down become "mines" for recyclable raw materials including glass, metal and concrete.

Humanity may well be on the verge of entering another new age, not only due to sustainability. Materials turn into high tech – and technological transformation is galloping ahead at top speed here as well. Super high-strength grades of steel and carbon marked the beginnings to be followed by the next step of refining materials using nanotechnology at the level of individual atoms. In the area of surface coatings, nanotechnology is already playing an increasingly significant part. Schaeffler, for instance, has developed a surface coating called Triondur which predominantly consists of carbon and reduces friction and wear to a minimum: an investment in a material that pays off. "If there's too much friction in a single machine then that's a minor problem. But if it happens a million times then it's a global challenge," emphasizes Dr. Yashar Musayev, Senior Vice President Surface Technology at Schaeffler. Friction, wear and corrosion devour about 4.5 percent of the gross national product in industrial countries, amounting to 144 billion euros in Germany alone. "Due to nanotechnology, component surfaces achieve previously unattainable functions and will gain increasing importance, for instance in energy systems such as batteries and fuel cells, as well as in components with sensory properties," Dr. Musayev adds.

150 million
components with micrometer-thin Triondur surfaces are delivered by Schaeffler per year. Triondur is a **nanostructured carbon-based coating system** that can be tailored to meet diverse requirements due to selectable, application-specific hardness values. Applied to valve train components, for example, **Triondur reduces friction by 50 percent** (see graphic).

THANKS TO SCHAEFFLER'S TRIONDUR: FRICTION OF VALVE TRAIN COMPONENTS IS CUT IN HALF



6 times
lighter than steel but equally tough is a **"super wood"** which two wood experts, Professors Liangbing Hu and Teng Li, from the University of Maryland have developed. Plus, it's pliable and formable. The super wood might even compete with carbon. To develop such "super powers," chemically pre-treated wood is compressed under high pressure and heat, which produces special nanofibers. **"This type of wood might be used in cars, aircraft and buildings,"** says inventor Hu.

New wonder materials

Modified carbons that arrange themselves like honeycombs at a 120-degree angle, provide the basis for graphene that was first produced in 2004. This "wonder material" exhibits a range of interesting properties. Its tensile strength is 125 times greater than steel, plus – due to its thickness amounting to only a single layer of atoms – it's extremely lightweight. In addition, it's particularly conductive. "A combination of such properties can't be found in any other material," enthuses materials expert Professor Max Lemme from RWTH Aachen University.

The versatile talents of graphene open up a range of possible applications. The material, for instance, can be used to make displays scratch-proof or even flexible. Due to its enormously light weight combined with tensile strength, some engineers are even dreaming of a space elevator. On account of its conductivity, graphene might also replace silicon in computer processors someday – or revolutionize battery technology. Widespread use of graphene is currently inhibited by its price. In spite of significant downward adjustments, an extremely thin piece the size of a fingernail still costs 75 dollars.

Due to the combination of several materials, so-called smart materials as well as biomaterials (see info "superwood" at left) are gaining increasing importance. Smart materials are defined as materials which, in addition to serving as shaping elements, perform a variety of other functions. "In the future, a wall of a house, for example, will no longer be simply a wall of a house. Ideally, it will also be able to store energy like a battery and release it again as needed. Materials that store heat during the day and release it again at night already exist today," says Professor Eddie Koenders from TU Darmstadt.

The development of biomaterials inspires dreams of new possibilities as well. A U.S. startup, for instance, is planning to replace plastics by fungi, and bacteria might be keeping surfaces clean in the future. These are other examples of areas in which the the potential of many new methods might multiply if they're combined with other construction materials and applications. The world is a box of bricks.

THE AUTHOR

***Dr. Christian Heinrich**, a freelance author who writes for "Süddeutsche Zeitung" and other publications, believes that, thanks to 3D printing, construction materials will soon become attractive for all of us. Using a friend's 3D printer, he tried out the technology by printing a plastic component: a red Lego brick that, albeit, is still a little too large. All beginnings are difficult.*

here and now

Living with progress

SHAPE**SHIFTERS**

Humans are said to be creatures of habit. Perhaps that's why we're so fascinated by the ways in which a number of other living things are able to adapt to their surroundings. The mimic octopus, for example, is a master of camouflage. It not only changes the color but also the texture of its skin, which allows it to mimic other animals and plants in order to elude its predators. Peculiar as well is a phenomenon exhibited by clownfish. They live in schools made up of one female and several males. If the female dies, one of the males will change gender and become the new feminine head of the colony. Arguably the most commonly known transformation, though – and one of the most unusual lifecycles in the animal kingdom – is that of an unimpressive caterpillar turning into a majestic butterfly (see below).

» What the caterpillar calls the end, the rest of the world calls a butterfly

Laotse

4–5 weeks

Feeding

The caterpillar is the larva of the butterfly and a veritable eating machine. Every day, it devours leaves amounting to a **multiple of its own body weight.** Due to its rapid growth, it has to molt several times.

1–2 weeks

Pupation

For its wondrous transformation the caterpillar suspends itself upside down from a branch, spins a **silk button** and forms its chrysalis. The caterpillar's organs are transformed and some of them completely decomposed.

1 hour

Hatching

Following a period of complete immobility, the insect awakens in a new body. **Blood is pumped into the – initially soft – wings** that will solidify in the air.

Up to 12 months

Life

The results of this metamorphosis: an altered digestive tract, several pairs of eyes merged into a single pair, a new proboscis, new antennae and new wings. The animal is now ready to mate.

THE MIX MATTERS

Emission limits, emissions-gate, driving bans: The IC engine has to become cleaner. Solutions include the DiesOtto that's designed to impart the fortes of diesel to gasoline (aka otto) engines. "tomorrow" explains the technology behind it.

by Carsten Paulun

In spite of the current development toward large-scale electric mobility, the internal combustion engine is far from having outlived its usefulness. Schaeffler experts also expect an IC power-plant to be operating in two of three new vehicles in the medium run. But the engine will have to become even more efficient and cleaner than it is today. That this will be achievable with diesel engines at reasonable costs, particularly for sub-compact and compact cars, is rather unlikely from today's perspective due to the more expensive emission control technology required for diesel systems. But, even so, we won't have to sacrifice the benefits of the diesel engine – low consumption and the related low CO_2 emissions – because engineers are mixing its advantages with those of the gasoline (aka otto) engine. The result is a DiesOtto – a high-torque, fuel-efficient and clean power-plant. The idea behind it has been fermenting in the R&D tanks of several automakers for a long time. Mercedes, for instance, presented an initial drivable concept – the F700 – with a DiesOtto system as far back as in 2007 and also coined the name for this hybrid engine.

> ***» The homogeneous lean mix operation of the gasoline engine makes it possible to achieve efficiencies on the level of diesel engines while minimizing NOx emissions, but makes high demands on mixture formation and the ignition system***
>
> Dr. Martin Scheidt,
> R&D Manager BU Engine Systems
> at Schaeffler AG

Ignition by spark plugs and compression

The engineers combine the combustion principle of gasoline, in which the fuel-air mixture is ignited by an external ignition spark, with that of the self-igniting diesel. Self-ignition occurs when the air in the combustion chamber is extremely compressed by the piston. During this process the air becomes so hot that the injected fuel immediately ignites with explosive force. Decisive for the heat build-up is the compression ratio which ranges between 15:1 and 16:1 in a modern diesel engine. Compression in a gasoline cannot be as high as in a diesel engine because the fuel-air mixture would be ignited in an uncontrolled manner. That's why the efficiency of a gasoline engine is lower than that of a diesel unit. However, the problem with a diesel engine is that the time in which the fuel is injected into the combustion chamber and has to evenly mix with the compressed air is extremely short. As a result, diesel is not as clean as gasoline combustion and produces soot particles. A combination of these two combustion principles did not seem possible for a long time because it requires highly precise sensor and control technology.

Now Mazda has further developed the DiesOtto principle which engineers refer to as homogeneous charge compression ignition (HCCI). Mazda's Skyactiv-X engine also uses technology from Schaeffler such as the tappets for the high-pressure pump. The pump plays a crucial part in the actual compression-ignition process. To prevent uncontrolled self-ignition of the fuel-air mixture Mazda injects a very lean, non-ignitable mix during the intake stroke. To start the cycle, a tiny amount of fuel is injected near the spark plug. The pressure and temperature increase which occurs in the subsequent ignition process is sufficient for the surrounding lean mixture to self-ignite.

The advantage of this system over pure self-ignition is that it ensures that self-ignition functions in clearly wider load and engine speed ranges. Due to the lean mixture, fuel consumption and CO_2 emissions drop by 20 percent on average while efficiency increases nearly to the level of a diesel unit. Plus, the lower combustion temperature results in clearly less nitrogen oxide emissions, which reduces the complexity of exhaust gas after-treatment. Using compressor supercharging, Mazda not only compensates for the lower torque resulting from the lean mixture but even increases torque by up to 30 percent compared to a current Mazda gasoline engine. The market launch of the new engine technology is planned for the end of 2018.

Even more efficient due to 48-volt technology

To further enhance the efficiency of the DiesOtto it can be combined with elements of the 48-volt on-board electrical system from Schaeffler. The 48-volt system is able to transmit more electric power using smaller cable cross-sections – the higher voltage can be used to operate a range of efficiency-enhancing components from actuators to compressors and through to hybrid modules and electric axles.

“NEW TECHNOLOGIES WILL LEAD TO A RADICALLY NEW CAR DESIGN”

How will trends like electric mobility, automated driving and car sharing affect automobile design? If you’d like to know, read on – Professor Paolo Tumminelli, a recognized design critic, has some answers for you. This much is certain: the changes will not please everyone.

— *Interview: Carsten Paulun*

Professor Tumminelli, digitalization is now also massively driving the automotive industry. A blessing or a curse?
It’s neither a blessing nor a curse, but the natural evolution of a product that continues to be the backbone of our society – a digitally connected society needs a digitally connected automobile, plus modern forms of mobility. This goes hand in hand with a philosophical paradigm shift. In the 20th century, the automobile made physical speed possible and a tangible experience. The digital world of the 21st century cancels this sensation – speed evaporates in the millisecond between a click and a download. Thus, digitalization, for instance via smart traffic control, is going to lead to a paradox: The car of the future will be traveling at lower speed yet we’re going to get from A to B in it in less time. Following a necessary transformation stage, the consequence can only be a radically new automobile design concept.

How much will automated driving affect vehicle design?
There’s no general answer to this question because we have no knowledge whatsoever of how automated driving can be experienced in the first place. Basically speaking, the specifications for the design engineers used to be pretty clear. Cars were designed from the driver’s perspective. But if we no longer drive our cars in the future, but are allowed to sleep or work or even just communicate in them, this results in a wide range of possibilities that need to be explored first. Anyone who has already experienced automated driving knows that just sitting in the front seat and looking out of the windows can’t be the solution. We need something that replaces the steering wheel. Without a steering wheel new hierarchies and new lifestyles will emerge in cars. At the moment, research is merely focused on what’s technically feasible. But it should also investigate how the time we spend in a car can be shaped from the human perspective, for instance in terms of the occupants’ privacy or sociality. If you imagine a sleeping-car that would take you from Cologne to Berlin on a slow, relaxing ride, the self-driving vehicle might be a windowless cocoon. Or there might be completely open, transparent architectures that requalify cars including their occupants as social beings – like communities on wheels. Both imply all-new horizons for our lives.

Will electric mobility determine the design of our vehicles more than other technologies? If so, in what areas and with what effects?
We shouldn’t forget that electric mobility is as old as the automobile itself. Yet automotive development has been decisively shaped by the internal combustion engine. In retrospect, we’d have to agree with the great Fritz B.Busch [a notable German motor journalist, editor’s note] *when, somewhat ironically, he postulated that in automotive engineering there wasn’t a lot that had happened since the Ford A from 1931. In fact, systematic focusing on electric powertrains will have to lead to a radically new design concept of the automobile. Looking at today’s Tesla & company, we can see that we’re still in the infancy of this development – somewhat like we were with the automobile in 1899.*

Will we be able to recognize electric vehicles just by their exterior design in the future?
Nothing speaks against retrofitting a 1965 Rolls Royce with an electric powertrain and transforming it into a fantastic vehicle. But everything speaks in favor of the electric car assuming a multiple identity – which would also be very contemporary. Especially because the electric powertrain opens up all-new possibilities various directions will initially be pursued. On the other hand, it’s also conceivable that a single player with a unique design concept will cause a breakthrough disruption. Like Ford did in his day with the Ford T that occupied 50 percent of the market at the time or, later, the iPhone that went on to shape a globally valid product typology. An iPhone on wheels is something that many people are dreaming of.

Will there be a two-class design: sleek and futuristic for electric vehicles, conservative and posh for cars with IC engines?
There’ll be no two-class design. Unless a special law was enacted it would take about 30 years to completely replace the entire fleet of privately owned vehicles in Germany. Consequently, cars with IC engines and electric vehicles will have to co-exist for a long time. A dual model is conceivable. Electric vehicles will initially shape our cityscapes. And if governments do their job properly these cars will be rather compact ones like the Japanese Kei-Cars. Cars with IC engines, though, will continue to dominate in boundary regions much longer. After all, the IC engine also offers advantages – just take costs, range, the time it takes to refuel and the availability of

» *Without a steering wheel new hierarchies and lifestyles emerge in the automobile*

battery charging stations, for example. Therefore, not only from a historico-cultural perspective but also from an economic point of view it's important not to allow a witch hunt of IC engines. Let's not forget that the more electric vehicles we have on our roads the less the overall burden will be that's caused by IC engines, which by now have become very clean anyway.

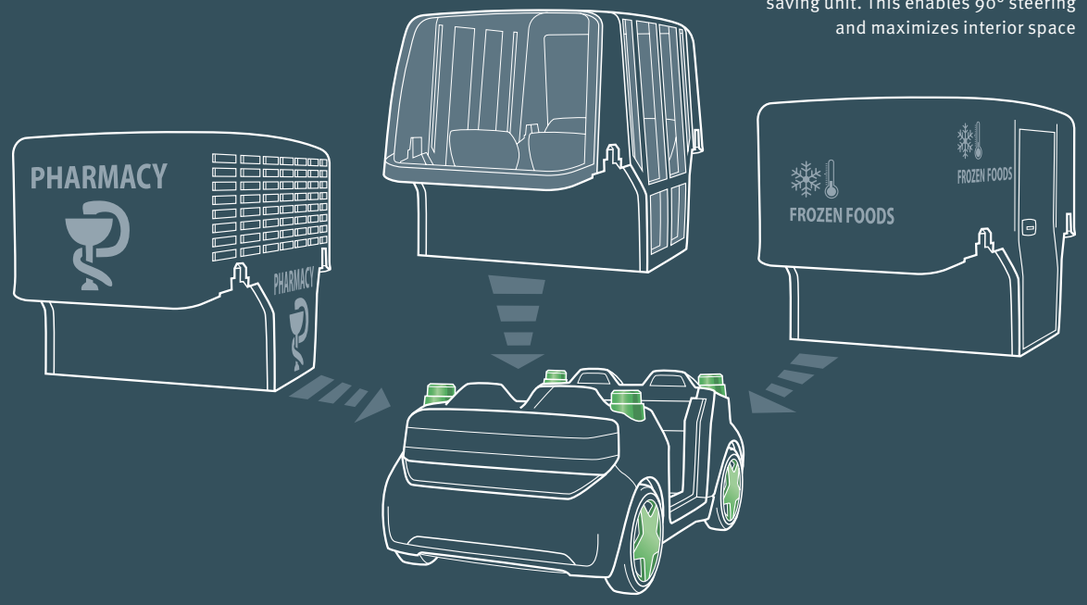
We already know and can see that an element defining a vehicle's identity such as the radiator grill is superfluous on an electric vehicle. What will engineers and designers instead be using as a differentiating feature?
Not only the radiator grill but, essentially, an engine compartment would become superfluous – except if it were converted into a trunk like in the case of Tesla or on the old 911. The question of identity, however, is a crucial one. People view the front of a car as a face. That's why character is also referred to as a design value. Naturally, personality can also be created without a radiator grill – as it used to be with the Beetle. But scope for development needs to be shaped. It's possible that future cars may no longer have "eyes" and a "mouth." Designers will have to search for substitutes for them – because, let's face it, cars are not refrigerators. There's no doubt, though, that OLED lights on the one hand and the technology required for automated driving on the other will provide new accentuating details.

Will electrical components such as the wheel hub motor completely change a car's design?
From the E-Golf we've learned that the combination of an electric traction motor and a battery does not necessarily have to change a car's design completely. However, it would be embarrassing for the engineers not to take advantage of the opportunities of the new technologies to define a new automobile architecture. This would be as if the cell phone had been designed in the shape of a normal phone – except without a cable. Wheel hub motors provide additional degrees of freedom for design. The reason is that if the motor is completely "absent" there's even greater freedom for design. When there's no motor or engine you don't need an engine compartment, a hood and definitely no radiator grill, plus new possibilities emerge such as for pedestrian protection. Ultimately, though, the decision about the forms of propulsion that will dominate the future will be of an economic nature. Before any standard will win through we're going to see a wide variety of possible configurations. I'm sure that this is going to be very exciting.

» *Even millennials desire to own a car, but for them other parameters than, for instance, size and power output are decisive*

More and more people are using car sharing systems. Privately owned cars have had their day particularly in big cities, also as status symbols. To what extent will such a trend influence design?
This development is the result of a mobility policy that has been heading in the wrong direction for decades, one that has stripped driving of its quality, especially in urban areas. Germany in particular is a poor example. Preference has been given to extravagant automobile concepts instead of promoting the use of city-friendly models – Japan and Norway are better at this. Furthermore, there are many countries that have hardly been investing in better, future-proof infrastructure. Car sharing is an interesting concept that becomes highly visible in the cities because these automobiles ostentatiously use public space. In spite of car sharing accounting for just a small percentage of overall personal mobility its low-cost accessibility motivates young people to use and love automobiles – and the manufacturers that operate these systems in the private sector are perfectly aware of this. Having become accustomed to using a car intensifies the millennials' urge to personally own one. But for them other parameters than, for instance, size and power output are decisive. These parameters include eco-friendliness, parking space, individual design options and, of course, the integration of digital entertainment and communication technologies. The brand policy pursued by many automakers has not adequately taken these trends into account so far. New technologies such as electric mobility and automated driving are now offering the opportunity to correct this to some extent. But I'd caution anyone to imagine the car of the future to be a thrifty one-size-fits-all type of vehicle. I rather believe that due to the western consumer culture we're going to see a wide variety of lifestyles and mobility forms.

Finally, a personal question: Would you name two or three of your personal icons of automobile design and tell us what current car is your favorite in terms of design?
Every epoch has its icons. At the same time, it must be noted that the days of icons are over. Botox and silicone are keeping past legends alive, such as the Porsche 911. Personally, I'm thrilled by the intelligence of the automobile from the 80s. Aside from passive safety and emissions control technology – and far from digital gimmicks – design in those years achieved conceptual perfection. Modern icons, clearly, are Giorgetto Giugiaro's Fiat Panda, Toyota Land Cruiser J7, which is still being produced and operates in the world's harshest environments, and Mercedes-Benz 190 – Bruno Sacco's masterpiece, unrecognized simply because it was "small." You know that I take a critical view of current automobile design. In terms of styling, I find Volvo and Jaguar Land Rover's lines esthetically appealing. If I were to look for a new Euro 6 car that should above all be sustainable, economical and pleasing I'd choose a Morgan 4/4. This is also a tribute to yesterday's car while looking forward to tomorrow's.



The Schaeffler Mover with wheel hub drive offers a platform for autonomous and electrified mobility solutions such as robo taxis or transport vehicles. The drive and suspension components have been consolidated in a single, space-saving unit. This enables 90° steering and maximizes interior space

» *Wheel hub motors result in additional degrees of freedom for design because in the "absence" of the motor the designer gains additional freedom*

THE INTERVIEWEE

Paolo Tumminelli *warmed up by studying architecture in Milan, sped into design, slid into marketing, rushed through strategy brand consulting and landed as full professor for design concepts at the Faculty of Cultural Sciences at Cologne University of Applied Sciences. In his generalist approach, he sees design under the perspective of a global consumption culture. The focus of his research is on automobility. On these issues Prof. Tumminelli provides advice to entrepreneurs and corporate executives. Besides he was – and still is – a publicist, author, speaker, curator and moderator.*

WHEN **DAVID AND GOLIATH** JOIN FORCES

Not a week goes by without a major corporation teaming up with a startup somewhere in the world to form an “innovation lab” or a “digital hub” – thereby acquiring what seems to be an admission ticket to the world of disruptions.

by Oliver Jesgulke

Will the future see the automotive industry at the end of the value chain no longer making money with its traditional sales and leasing business? Just imagine: a brand new SUV, ready to drive – and completely for free. Here’s the catch though: All the customer gets delivered to his or her driveway is a barebones version. Of course all the systems relevant to driving and safety are functional, but the holographic navigation, the WLAN-capable high-end surround system and the multimedia lounge with the most recently released movies for the rear-seat passengers to watch are disabled. Plus, the vehicle will not travel faster than 130 km/h (about 80 mph). In order to be able to use additional functions and services the driver can book them by voice command for an extra charge before or during a trip. Of course all the features including the vehicle’s top speed can also be enabled without any limitations by purchasing an all-inclusive package: fiction or soon-to-be reality? Far away from their routine business, some companies in the automotive industry are radically challenging their current business models and the ways in which mobility exists today. Welcome to the exciting new world of ideas populated by “innovation labs,” “accelerators” and “digital hubs.”

There are various terms used for a novel cooperation and working model that’s moving in across all industries. Established companies are joining forces with startups in order to drive digital transformation and all-new business models outside of entrenched structures. For a while venture capital firms and startup funds used to be the primary investors, but in recent years more and more major corporations and mid-sized companies have been investing in and partnering with startups as well. Especially in the mobility sector such shareholdings and partnerships are very common now. An international ranking prepared by Oliver Wyman strategy consultants shows a leap in corporate venture capital for 2017. Large corporations invested in more than 50 young tech companies, particularly in the mobility services sector, but also in fresh ideas for eco-friendly powertrains as well as connected and automated driving.

The best from two worlds

There are a number of good arguments supporting cooperative partnerships or acquisitions. On the one hand, young companies bring innovative ideas for digital business models or new technologies and a clear customer focus to these ventures. Plus, they develop at a rapid pace. Anyone who hasn’t been to the office for a few days will be baffled by the number of changes

» Sustainable success stories of corporates and startups are based on mutual trust and require a lot of patience and perseverance by both parties

Prof. Tim Hosenfeldt, Senior Vice President Corporate Technology, Strategy and Innovation at Schaeffler

that have occurred in their absence. Young tech companies are also highly willing to take risks and to learn combined with a culture of trial and error, and bouncing back from failures. By contrast, the large corporates not only have sufficient capital but also contribute their know-how that may have matured over several decades, plus their large networks. In addition, these companies know how to win through over the long haul and prevail against fierce competition in a tough global market environment. There are further fortes which are typical of established companies: processes, discipline, adherence to budgets and commitment. Particularly these aspects pose genuine challenges to young entrepreneurs, so the advantages of established and startup businesses need to be interlinked as systematically as possible.

Competition for ideas

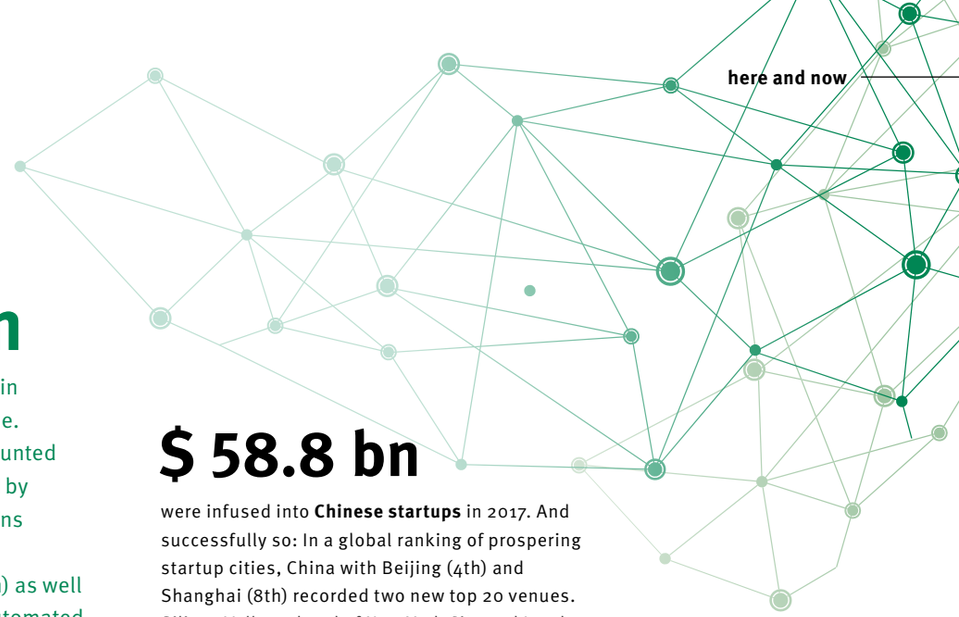
The Daimler Corporation for example is pursuing a successful dual strategy with the "Startup Autobahn" accelerator project and "Lab1886." Like a headhunter, in a manner of speaking, "Startup Autobahn" examines startups outside of the corporate universe and invests in them as appropriate. "Lab1886" on the other hand serves as a corporate-wide network of the best internal ideas and talents. Both concepts complement each other in that ideas from "Startup Autobahn" are migrated to "Lab1886" for the purpose of developing them into sustainable business models. This process is divided into several levels: Visions – created either by a specific department, an interdisciplinary team or an external source – are pitted against each other in a multi-level pitch following a previous in-depth examination. In the end, a decision is made as to whether or not an idea appears viable. In the incubation stage, in addition to financial support and free co-working spaces, professional mentoring plus assistance by diverse experts are added to this all-inclusive support package. Within a very short period of time, technical prototypes, service offerings or pilot projects for entire business models are created this way. If the concept remains viable, it will be followed by commercialization. In this final stage, these – still young – approaches are further developed to the level of marketability and, to this end, either integrated into a Daimler organizational unit or spun off together with the team.

The highest bidder will fail

"Sustainable success stories of corporates and startups are based on mutual trust and require a lot of patience and perseverance by both parties," says Professor Tim Hosenfeldt. Schaeffler's Senior Vice President for Technology, Strategy and Innovation knows the challenges that exist at the interface between the corporate and the startup worlds. As part of its "Mobility for tomorrow" strategy Schaeffler actively drives digitalization by supporting young companies. This includes strategic acquisitions as well. "Pure M&A activities, however, are no panacea. The highest bidder will not be successful over the long run because the majority of young entrepreneurs don't want to be acquired or incapacitated. They want to continue to be able to act freely and advance their projects on a level playing field," says Hosenfeldt who also teaches at Friedrich-Alexander University Erlangen-Nuremberg as an honorary professor. The selection of suitable partners requires agility, he adds. For this purpose, his unit has implemented an innovation radar function that scouts for suitable startups in specific niches, topics and technologies. For the first Schaeffler Venture Forum on Sensor Technology, Data Value Creation and Autonomous Systems more than one hundred applications were received of which 15 were selected. Hosenfeldt and his colleagues have a solid network in the startup world. "We scout around the globe, including Silicon Valley and Israel. We do not, however, use a 'shotgun approach' in our selection process. We take a careful look at whether or not the model is scalable and what makes the people behind the idea tick," Hosenfeldt explains.

GERMANY'S INNOVATION LABS

In the past five years, *the number of innovation labs in Germany has tripled. More than half of the DAX-listed corporations either operate such labs or are planning to. Being home to 32 of the 98 innovation labs in Germany, Berlin ranks ahead of Munich (16), Stuttgart (11) and the Rhine-Ruhr Region (11).*



$ 20 bn

were invested in 2016 in **mobility startups** alone. Mobility services accounted for 16 billion, followed by eco-friendly powertrains (1.9 billion), sales and aftermarket (1.5 billion) as well as connectivity and automated driving (0.8 billion).

Source: Oliver Wyman survey (2017)

$ 58.8 bn

were infused into **Chinese startups** in 2017. And successfully so: In a global ranking of prospering startup cities, China with Beijing (4th) and Shanghai (8th) recorded two new top 20 venues. Silicon Valley, ahead of New York City and London, is still the unchallenged stronghold for startups.

Sources: techinasia.com, The Global Startup Ecosystem Report (2017)

Different mindsets and speeds

At the beginning of 2017, Schaeffler forged a cooperative partnership with "Factory," a Berlin-based founders campus and most important think tank for developments relating to the Internet of Things in Germany. Here large and medium-sized enterprises are able to obtain support for the transformation and digitalization of their business models. "The capital city is an ideal place for us to engage in cross-industry exchanges with startups and digital talent, and to jointly shape the future," says Tim Hosenfeldt. Far from Herzogenaurauch, Schaeffler employees develop prototypes there in cooperation with startups.

In addition to its Berlin commitment, Schaeffler is one of the founding partners of the "Zollhof Tech Incubator" in Nuremberg. There both parties profit from active and open exchanges in various event formats such as so-called Corporate Pitches, Hackathons or TechSpace Hackdays. While startups appreciate "amenities" such as office space, coaching, access to investors and other companies, Schaeffler is able to make use of skills and resources, and to also present itself as an attractive employer.

The experiences gained so far in Berlin and Nuremberg are exciting and positive. Hosenfeldt: "The differences in what makes them tick were dawning on the players on either side after just a few weeks. However, in spite of a clash of different mindsets and speeds the process has been working out so far. That's why engaging in constant exchange and being open-minded toward one's counterparts is central. Otherwise, small things will cause these projects to fail." Which brings us back full circle to a culture of trial and error, and rebounding from failure.

THE AUTHOR

Oliver Jesgulke *works as a communication consultant and editor. A large number of the Berliner's clients are faced with the challenge of making their core business fit for the future, so the capital city as the center of the German open innovation and startup scene is an ideal place for reporting about these developments.*

WITH HEAD, HAND & HEART

How does novelty find its way into the world? And how is a good idea transformed into a successful product? Schaeffler engineers Thorsten Biermann, Patrick Lindemann and Tomas Smetana not only have a part in several hundred patents but are also responsible for developing products for large-scale manufacturing.

by Johannes Winterhagen

Whereas Carl Benz or Rudolf Diesel shaped the automotive world with the innovations they developed in seclusion Schaeffler's engineers typically work on mobility for tomorrow as a team. Even so, an individual's ideas are still important. Innovative drive systems such as the lightweight differential, the integrated torque converter or the electric axle are based on the achievements of outstanding brains: Thorsten Biermann, Patrick Lindemann and Tomas Smetana. Although today they're working on three continents, their paths kept crossing. All three joined Schaeffler immediately after earning their degrees and were encouraged by Wolfgang Reik, who was head of development at LuK at the time, to challenge the status quo and to try something new, and all three know the painstaking path from an initial idea to large-scale production. Innovation, after all, is more than just having a good idea.

"**GOOD IDEAS** ALMOST ALWAYS EMERGE IN A DIALOG"

THORSTEN BIERMANN, HERZOGENAURACH (D)

*When Thorsten Biermann (42) is supposed to present a new generation of Schaeffler's electric axle to a German premium manufacturer he's skeptical at first. Actually, the powertrain concept for the coming electrified vehicle generation has already been finalized and he has only 15 minutes for his presentation. After ten minutes, the customer's highest-ranking representative leaves the conference room. "I guess that was it," Biermann thinks. But when the customer returns a little later he says: "I cancelled all my meetings for the next three hours. Please explain your idea to me in detail again." **A great moment like this is not a product of chance, but of intensive work on new ideas**. They include the lightweight differential, in the development of which Biermann had a major part, which makes it possible to achieve very high power density of the final drive.*

*Biermann, though, is unassuming: "Actually, the idea of the lightweight differential has many creators." The ones he refers to include the American engineer and inventor Alexander Timothy Brown who in 1902 had the first spur gear differential patented. However, it takes further good ideas to turn an initial one into a product that can be manufactured at reasonable costs, especially ideas from the teams that have to develop the concept to production level. **As well as "problem solving skills" Biermann names a healthy dose of tenacity as a key competency engineers must possess** because a large number of technical challenges have to be mastered before a fully industrialized prod-*

uct has been achieved. Especially the slim design of the differential, which yields a significant advantage in terms of the required assembly space, soon led to new issues that had to be resolved first in order to be able to reliably transfer and support the high torques. and rotational speeds via the driven wheel. "I always believed in the product," Biermann says today. ***"Initially, though, we no doubt had to learn the hard way here and there." Even so, Biermann was not deterred from pursuing his objective of developing the product to production level.***

When Tomas Smetana and Biermann start working on electric final drive systems in 2008 the advantages of the lightweight differential's extremely compact design become apparent. "Together we were driven by the ambition of doing something completely new," recalls Biermann who has since assumed responsibility for the production development of electric axles. It's a challenging task because the production of three transmission model ranges is launched practically at the same time in Herzogenaurach. Although supporting the launches leaves hardly any time for him to pursue new product ideas Biermann can't completely let go of his quests for innovation either. ***A copy of a guidebook on the "Theory of Inventive Problem Solving" is still on his desk today.*** *Biermann uses the method invented by two Russian scientists that encompasses more than 40 individual problem solving principles whenever he feels a need to think about fundamentally new approaches. But methodology isn't everything. The phenomenon of the "flash of genius" that seemingly just comes to the inventor out of the blue still exists as well. Biermann, though, is convinced that only the technical discussion with colleagues leads to the final successful solution because "good ideas almost always emerge in a dialog."*

"GO AHEAD AND **GIVE IT A TRY**"

PATRICK LINDEMANN, WOOSTER/OHIO (USA)

Is this the only way to do it or can it be done differently? Even as a fledgling engineer Patrick Lindemann (49) learns to ***keep looking for new approaches.*** *In 1995, just after having joined Schaeffler, the dual mass flywheel has to be made fit for the volume market. In other words, an existing, innovative product is supposed to be manufactured at clearly lower costs in order to serve the diesel passenger car market that was seeing strong growth in those days. When he assumes responsibility for supporting Ford two years later he soon realizes that his English is clearly in need of improvement. Lindemann doesn't want to take a language course but asks his supervisor to send him to the United States for two years – where he's still living today.* ***There he's not only responsible for the site in Wooster, Ohio, but also for the development of transmission and e-mobility systems in America.***

In 2007, Lindemann assumes responsibility for the development of torque converters that provide the positive engagement between the engine and the gearbox in automatic transmissions. "Back then, our converters looked like all the others," he recalls. ***Once again, Lindemann's initial approach is to make the product simpler and more cost-efficient – while simultaneously increasing its performance.*** *"However, we soon reached a point at which everyone said that there wasn't a lot of room for further improvement." Lindemann thinks about the function and physics of a converter in a more fundamental way. On a long trip between Detroit and Wooster, he comes up with the solution: the oil flow from the turbine can be used to actuate the lockup clutch instead of a separate piston.*

The elimination of the piston makes a clearly more compact design possible. ***Schaeffler owes the fact that today more than one million units of the integrated torque converter (iTC) are produced per year to a bold move by Lindemann.*** *He presents the idea to Ford's head of transmission development who at the time is working on a new ten-speed transmission. The transmission that uses a conventional converter is almost finished and contracts are supposed to be awarded to suppliers just a few weeks later. Lindemann spontaneously decides to buy a car and then modifies it within the space of three weeks. The result convinces Ford.* ***The automaker changes the design specifications and Schaeffler has its first customer for the new product.***

As a leader, Lindemann encourages his young engineers to keep thinking out of the box. "Even if something goes wrong now and then engineers need the freedom to try out new things." Shared reflection and hardware are more important to him in this context than producing a plethora of paper. "In many cases, there's a lot more to be learned from just going ahead and building a component." When it comes to selecting future leaders for his own team their attitude toward innovation is important to Lindemann. ***"That won't work," is a statement that doesn't find his favor.*** *The United States, which he now calls home, provides a nurturing environment: "There's a high willingness here to think positively and to try new things." After all, there's usually a way to do things differently.*

“SUDDENLY IT WAS ALL THERE”

DR. TOMAS SMETANA, YOKOHAMA (J)

Breaking new ground even though things are going pretty well: Tomas Smetana (43) has experienced this situation in his life not just once but on numerous occasions – most recently about two years ago when the engineer decided to relocate to Japan in order to assume responsibility for Schaeffler’s technology activities in the Asia-Pacific region. Prior to his move, Smetana had been responsible for the production launch of the first electromechanical roll stabilizer. ***Above all, though, his name is closely linked to the electric axle, one of the products with which Schaeffler intends to accelerate entry into the age of electric mobility.*** *The development of the axle begins in 2005 with a question that at first glance has nothing to do with electric drive systems: Would it be possible to manufacture planetary carriers for automatic transmissions using forming technology that would enable lighter weight and a more compact design? It doesn’t take long to verify the proposition’s basic technical feasibility, but there’s only a limited market for the product at that time. Instead, Smetana tests the utilization of planetary technology in a lightweight differential which is additionally supposed to enable active torque distribution between the wheels of a driven axle. Initially, a hydraulic system is used to vary torque until Smetana with his pre-development team challenges this principle by asking if an electric system could be used as an alternative.* ***“And all of a sudden, we had all the components for an electric final drive,”*** *recalls the mechanical engineer who’s convinced that innovations often are the result of combining the right ideas with each other. For Smetana, “What other customer-relevant functions can be achieved this way?” is one of the key questions engineers should ask themselves. In 2010, the first prototype of an electric axle with integrated, active torque distribution has been achieved based on a Škoda Octavia.* ***The demo vehicle hits the road with two electric axles even before the “National Electric Mobility Platform” is formed in Germany*** *or China starts discussing quotas for vehicles with alternative powertrains. Production of Schaeffler’s first electric final drive system is launched at the end of 2017.*

Even though Smetana is happy that his ideas are bearing fruit ***he personally lives in the future.*** *Japan as the home of robotics – 65 percent of all robots sold around the globe are made by Japanese manufacturers – is a fascinating playground for the curious engineer. At the moment, a generation of collaborative robots is in the making there, intended to work hand in hand with humans, outside security fences. “These lightweight, agile and humanoid Cobots require completely new kinematics with appropriate sensors and control systems,” Smetana explains.* ***“We’re currently experiencing a systems change in robotics that’s similar to the impact of electric mobility on automotive engineering.”*** *His enthusiasm can be clearly felt. It’s the joy of a boy who grew up in the Czech Republic and was working on model airplanes before the fall of the Iron Curtain. Components were in scarce supply, so he had to put together the remote control with a lot of imagination from whatever was available. This, too, is innovation: combining the right existing things to create something that’s all-new.*

THE AUTHOR

Trade journalist ***Johannes Winterhagen*** *(47) has been writing about technological innovations for more than 25 years. His research has taught him that behind every great idea there’s at least one individual driving the innovation to implementation.*

outlook

Technology for tomorrow

> ***In the future, utopia will have to hurry to keep up with reality***
>
> Wernher von Braun (1912–1977)

UPGRADE FOR **LICENSE PLATES**

Numbers and letters stamped on simple, flat aluminum – this more or less describes a license plate attached to a car somewhere at the level of its bumpers. It's been around for over 100 years. In the era of connected cars, though, it's high time for this to change. "Reviver Auto," a San Francisco based startup, decided to make exactly that change happen and developed a digital license plate together with the California Motor Vehicle Department. The 12 x 6 inch digital display is suitable for retrofitting or embedding into the rear bodywork of a vehicle. While an analog plate has few capabilities, its fully digitized counterpart has a whole host of them. When a registration has expired, a large "X" will appear on the digital plate. The revalidation will be issued by a simple mouse click and the new date directly inserted. While the car is parked, the plate may morph into a digital store window and touch point via geo-fencing technology to display dynamic advertising by the surrounding retailers. In front of a hardware or furniture store, for instance, information on its product range or special promotions might appear. In return for any message displayed, the driver may receive either cash or discounts on the store's products or services. At the "social interfaces" of pedestrian crosswalks or traffic lights, drivers can simply have their contact details displayed as needed. Connectivity with online services provides official warnings or traffic-related information in real time. And car theft will trigger a rapidly flashing message in caps ("STOLEN"). So, thieves beware, you're in for hard times.

HIGH-PRICED LICENSE PLATES

10 MILLION EUROS *This sum was paid by Saed al-Khouri from the Emirate of Abu Dhabi for a single "1" on his license plate.*

8 MILLION EUROS *The Dubai license plate number "D5" was worth this much to billionaire Balwinder Sahni. D is the fourth letter in the alphabet, plus 5 equals 9 – Sahni's favorite number.*

600,000 EUROS *Briton Afzal Khan paid this amount for the abbreviation "F-1" on his license plate. In the following years, he purportedly refused offers to purchase the plate worth several million.*

208,000 EUROS *A man in China spent this amount on a plate with the fourfold lucky number 8 sold at an auction.*

159,000 EUROS *A Swiss paid this amount for "VS-1," his license plate of choice.*

“WE NEED TO CHANGE, PURSUE **NEW PATHS**”

“Next Exit: The Future” is the title which the renowned science journalist Ranga Yogeshwar selected for his new book in which he analyzes the transformation of diverse spheres of life. Inseparably linked to all of them is technology. In an interview, Ranga Yogeshwar answers the most pressing questions.

Interview by Kay Dohnke

Transformations presuppose decisions. But the decisions we make today may have effects for several years, if not decades. This said, how can we chart the course for a future we don’t even know yet?
Obviously, we don’t know our future, but we’re able to define goals. Above all, we have to decide what we really want. For many of us it’s the desire – one that’s definitely worth striving for – to leave the Earth to our children and grandchildren in a better state than we found it ourselves. This includes the planet itself, as well as our social interactions. You see, a look at humanity’s environmental footprint, the changes caused by agriculture, by urbanization, by major construction projects like hydropower dams which change nature’s topology shows that in several respects we’ve already become shapers of this planet …

… which can even be seen on satellite pictures of Earth at night that show increasingly vast expanses of light.
Our planet is indeed shining brighter and brighter. I often think of my childhood which I spent in India – India back then was dark and regarded as backward. Today, the whole country is illuminated. There are two things that electric light, which has spread across this planet in a very short period of time, shows: one of them is the diffusion of progress. The highly technologized nations used to be islands and now the entire planet has become illuminated. The other aspect, of course, is the growing resource and energy consumption which is indirectly reflected by the emission of light. One of these two, the spreading of technological progress, is a good thing and the other one is a challenge we need to master in the next few years. Our limited resources are insufficient if we continue to do business as usual. We need a change of heart and pursue new paths so that all human beings can sustainably benefit from progress!

The pace of technological progress is virtually breath-taking at the moment. Too fast for many people. For normal citizens, key technologies like artificial intelligence and the algorithms behind them are as cryptic as quantum physics. Does this ignorance perhaps make us too careless, are we letting too much digital power slip away from us?
This risk does exist. Many of us surround themselves with devices like Amazon Echo or Google Home without really knowing how these technologies work. We use social networks but hardly any of us can see through the algorithms that structure and are essential to these networks. Digital neuronal networks are already in use today although even experts do not understand how these complex systems really function. At the moment, when it comes to new technologies, we’re like children that unwrap a gift and immediately start playing. What we’re lacking is a kind of user manual for progress.

> ***» We’re lacking a kind of user manual for progress***

In 2010, Google’s CEO Eric Schmidt made a memorable statement: “We know where you are, we know where you’ve been and we can more or less know what you’re thinking about.” Sounds scary.
Data-gathering platforms like Google or Facebook are so large now that they’ve become systemically relevant. A network with such massive influence on the interactions within a society should disclose its algorithms. Digital culture offers us a new form of interaction we didn’t know a few years ago. We first need to learn its rules and actively address its opportunities. It would be very unfortunate if digitalization blew up in our face because we failed to do our homework.

So, how well has the automotive sector done its homework?
OEMs and suppliers have been optimizing vehicles bit by bit over the past decades, making them safer and more efficient. But the great opportunity that presents itself to us lies in thinking on a broader scale, in other words not in terms of optimizing an individual vehicle but in terms of optimizing new mobility concepts. The need for this is very obvious in practically any city where only a single occupant can typically be seen sitting in the cars passing by. If Martians were to look at this they’d think that Homo sapiens must be peculiar creatures – moving a ton and a half of steel in order to carry 70 kilos of a human being back and forth …

… and to then park the steel without further use for most of the day.
Exactly. The plethora of cars parked in our streets costs space – which really is of no benefit to anyone. For comparison: Looking at today’s car sharing concepts shows that a single shared car replaces about 20 individual vehicles. This accounts for about 200 square meters (about 2,153 square feet) which could also be used to enhance traffic flow. Technological progress unleashes plenty of new potential – but we’re not fully tapping into it if we continue to think in old categories. Sometimes you need to jump – into a new perspective.

Could regulations, decrees and laws facilitate this jump?
To some extent, they could. A positive example is the catalytic converter for vehicle emissions that was introduced in California in 1968 by legislation and has since become a worldwide standard. But, as said before, this has made individual cars better, but not the traffic situation or mobility as a whole.

If laws are not enough to cause us to tap into existing potential and to give us a jump start, then what or who will?
Looking at young urbanites for instance who often choose not to own a car and tend to rely on alternative mobility concepts like car sharing shows that the new potential, specifically digitalization in this case, has been more

» A paradigm shift is not only necessary – it's also possible

conducive to establishing this form of mobility than legislation. Regulations are important, too, but creativity tends to be inspired whenever we realize that we have to reflect on existing issues again. A closer look at this in the context of mobility reveals the beginnings of a change in thinking: personally owning a car – which, by the way, isn't a desire that's based on a natural instinct – doesn't necessarily matter anymore. What does matter is efficient vehicle utilization. Particularly young people are recognizing this. The number of young car buyers has been declining in recent years, especially in urban areas. And there are indications that the auto industry has recognized this as well and is in the process of accelerating the development of new concepts.

So we're on the verge of a general paradigm shift?
This paradigm shift is not only necessary – it's also possible. The latter aspect is particularly important because we sometimes wish for a different future but are not able to see how to make it happen. And that's where the innovations in recent years and even decades have been pointing out new paths, too.

Outside the realm of mobility as well?
In any area, at least as far as I can see, there are promising approaches. Let's take energy production. Factually, we have no energy problem. The sun – whenever it shines – radiates with an intensity of about one kilowatt per square kilometer (0.39 square miles). One thousand watts is quite a bit. A look at the efficiency of today's solar collectors in the field of photovoltaics shows that – after a very small percentage just a few years ago – it's now in the double digit range so that considerable amounts of solar energy can be used. The next step will be to efficiently store this energy for those moments when the sun doesn't shine or in order to balance the grid. Power-to-gas systems or synfuels produced with electricity are highly interesting technologies in this context.

Another example please.
We're discussing pollinator decline and, linked to this phenomenon, the use of herbicides and insecticides in agriculture. We all notice that we're facing an increasing problem because we're applying massive amounts of toxins, yet many of us can't see a real alternative. It's clear to anyone who takes at least some interest in agriculture that we can hardly do without such agents at the moment. But now we're suddenly seeing the advent of artificial intelligence, of robotics, of automated vehicles and I can definitely imagine that in ten years from now we're going to see autonomously acting robots clearing our fields of weeds. This new technology might replace the use of chemicals in agriculture in similar ways as solar power is going to replace coal someday.

Are ideas like these that result from out-of-the-box thinking the key to success?
They definitely are! But exactly this type of thinking that goes beyond previously learned patterns is so difficult. A look at history shows this as well because we're not the first generation that has dreams of the future. At the beginning of the 20th century, people were dreaming of railroads, steamships and Zeppelins flying through cities. In a way, this shows that every generation, when dreaming of the future, cleaves to its own categories. This means that we "think our world" and then extrapolate – we're hardly able to comprehend or, what's more, to anticipate any leaps in advance. Only ten years ago, no one had any idea of the fundamental transformations the smartphone would lead to. The exciting part about this is that with any of these technological options we always need to check social, and perhaps ethical, principles as well. We should be careful not to make any visions reality that are strictly technology-driven. I rather believe in what I refer to as reflected progress which means giving serious thought to the goals we pursue and then, in the next step, to think about what technologies we might be able to use to achieve them.

How sustainable can or must such reflected progress be?
Anyone who advocates sustainability in the spirit of sacrifice compared with the status quo will fail. We've seen this in recent years. There have been plenty of activists, dedicated people, saying that we need to consume less – without realizing that this isn't a road that leads to success.

And what would be a road to success?
We're already starting to see a certain change of heart in some areas. Although large-scale synthetic-industrial production of food is no problem today, it's interesting to see that more and more people decide to cook their meals at home for a change and to buy regional produce. Essentially, these are some initial indications of responsible choices being made in favor of sustainability. But, in the light of the enormous changes we're facing, what all of us need to do together as members of society is to get clear about our goals. Where do we really want to go?

In such debates about the future, the phrase "great transformation" can often be heard. What will it take, on the part of industry and the economy – here and in the world at large – to achieve a kind of transformation that's fit for the future?
It may take this vision of imagining a world in 10 or 15 years from now in order to realize that change involves a lot more than just a detail in a particular manufacturing process or industry. Perhaps, in some areas, we're now able to delegate a major part of our work to machines for the first time. On the one hand, this gives us more time to take care of other things in life which are important for our society, such as education and culture. On the other hand, we need to think about the distribution of income and thus of food and consumer goods because a society that at some point in time will turn a minority into winners and the rest into losers is not stable. That's not going to work. Some initial approaches to this discussion already exist, such as unconditional basic income …

… which is rejected by many. After all, a large part of humanity defines itself through work.
That's right. And revising precisely this concept of ourselves, departing from the old categories of our forebears, to really break these molds and to set new categories is easier said than done. Especially since such change of heart has to occur across borders because our global economic system requires a certain synchronicity of insight. However, inertia with respect to change is particularly evident in nations that are very successful – like Germany. Our economy is doing well at the moment and, as a result, many people have mental blocks, saying, 'let's continue to do business as usual because everything's okay.' Many people don't understand that we're in the midst of a fundamental transformation process that we need to keep pace with so that we won't fall behind.

So, Germany and the world will have to leave the beaten track and take the "next exit: the future" – to touch upon the title of your book. What will happen if we miss the exit?
The historically provable fact that major epochal changes often went hand in hand with crises, with wars, with many people suffering, should be a warning to all of us. My hope is that this time we'll manage to avoid this. But this will require all of us to actively work together and to jointly shape this future. Those who think that any company or any country can shape a common future for everyone are wrong. I believe that this is a task we all have to assume. My optimism, though, is inspired by the opportunities, freedoms and possibilities that technological progress on balance brings in its wake – no matter how unsettling it may seem here and there. However, in the light of this progress happening at such a tremendous pace and with obvious effects on so many spheres of life, the need for philosophical, social and ethical reflection is vital. —

THE INTERVIEWEE

Ranga Yogeshwar *is a "native speaker" of several languages. In his childhood days, his mother spoke Luxembourgish with him and his father English and Tamil, his teacher Hindi, their housekeeper Kannada and their gardener Malayalam. Later, he learned to speak French and German as well. Asking the man in his late fifties with a degree in physics about his national identity is another complex question: Does he feel more like an Indian, a Luxembourger or a German? Above all, he says, he feels like Ranga Yogeshwar. A question of much greater relevance to him, though, is the one about his personal "operating system": the Age of Enlightenment and the German Constitution. In 1986, after the Chernobyl disaster, Yogeshwar made his debut on camera as a technology explainer. Coming from a multicultural background, he was a rare exception among German TV presenters back then. Fortunately, times have changed in this respect.*

ENERGY ON TAP

There’s hardly an industry changing as fast as the energy supply sector. Thanks to sun and wind, smart grids and new forms of storage, any consumer can become an electricity producer – or tap the surplus energy generated by an organic farmer around the corner. In just two or three years from now, the energy market might look completely different than it does today.

by Claus Gorgs

At first glance, Wildpoldsried seems like a normal village in Southern Germany’s Allgäu region: cows grazing on lush green pastures, white-washed houses and a small church – all in front of a picturesque Alpine backdrop. Even the wind wheels on the horizon and the solar panels on the roofs are not really an unusual sight any more nearly 20 years after Germany embarked on its transition journey toward sustainable energy known as “Energiewende.” Yet this community with a population of 2,600 is something like an energetic model village – and a nightmare for the electric power industry. What can be seen here, not far from the Austrian border, might become standard in many places in just a few years from now: villagers covering their entire energy requirement themselves. Electricity from local wind farms, solar panels and biogas power plants has completely displaced conventional coal and nuclear power. And that’s not all because the village produces more electricity than it consumes and sells the surplus at a profit.

The energy sector is in a state of transformation. In Germany, major utility groups such as Eon or EnBW are parting with their old power plants for a complete shift toward renewable sources. French energy giant Engie is pursuing the same strategy – in a country that until recently was unconditionally committed to nuclear power. At the same time, new, innovative providers are emerging with plans to penetrate the market with local power generation concepts and digital technologies. “There’s something very substantial happening at the moment,” says Dr. Patrick Graichen, director of the Berlin think tank Agora Energiewende. “In the context of renewable energies, the whole market is turning at the moment.”

The race about the future of the power business has begun, with the major energy corporations on one side of the playing field and young attackers on the other – such as German green electricity pioneer Sonnen that made it possible for Wildpoldsried to evolve into a self-sustaining energy village. The new players promise to supply people with cheap green electricity produced in their immediate neighborhood so that traditional utility companies are no longer needed. “At the moment, there are two parallel energy market systems existing in Germany,” says Thomas Fritz, a partner at consulting firm Oliver Wyman. “In the next two or three years, we’re going to see a large number of new business models, in five to ten years they’ll be internationally scalable and after that we won’t be able to recognize the market anymore.” Around the globe, self-sufficient energy projects on the scale of big cities are emerging (see info box on next page).

Green electricity meets digitalization

This comprehensive transformation fundamentally changes electricity distribution, in other words the

structure of the grids, as well. Whereas in the past a few central large-scale power plants assured supply today millions of solar panels on countless roofs, thousands of small biogas power plants and wind farms all over the country do. “A decentralized system with a multitude of players is emerging,” says market expert Fritz. “Any household, any business can be both a producer and consumer. If you generate more electricity than you consume you sell it. If you generate less than you need you buy the difference. There’ll be new business models controlling this modern energy world.”

SELF-SUFFICIENT CONSUMERS

New concepts for local, self-sufficient energy supply are being pursued all over the world.

— ***The Canary island of El Hierro has converted its entire electricity supply from fossil fuels to wind power.*** *A pumped storage power plant in the crater of an extinct volcano serves to store the electricity so that the islanders in terms of energy supply are completely self-sufficient.*

— *A highly ambitious project is being driven by former Siemens CEO Klaus Kleinfeld in* ***Saudi Arabia.*** *In the making to the tune of more than 400 billion euros is a* ***fully networked megacity adjacent to the Red Sea that will be supplied with clean electricity by several huge solar power stations.*** *The first construction phase is scheduled for completion by 2025.*

— ***Copenhagen*** *has set out on an even greater venture. Like a kind of XXL-size Wildpoldsried, the Danish capital by 2025* ***intends to become the world’s first big city to generate its entire electricity consumption from renewable sources directly on location*** *– in view of the changeable weather in the Nordic country, this poses a real challenge, not only in terms of generating but also with respect to storing electricity.*

Digitalization is the enabler of this new age. Smart meters that precisely capture and project the consumption of every single electrical device are able to control energy flows with much greater accuracy than before. Using blockchain technology, any electricity customer might soon be able to do business directly with a producer – taking advantage of special rates offered by a major corporation today and tapping the green electricity from an organic farmer next door tomorrow. “In the future, households will be using apps to buy electricity for a price that’s best for them,” says Stephan Kohler, a longtime former CEO of the German Energy Agency (Dena). “Energy suppliers are going to transform into service providers offering customized plans for every consumer. The companies offering the best overall package will be the winners.”

Today, Kohler is an energy entrepreneur himself, supplying Berlin’s Euref district around the old gasometer in Berlin-Schöneberg with green electricity. He’s particularly proud of the company’s energy storage system with a capacity of 1.5 megawatts that ensures that the lights on campus won’t go out even if consumption happens to be greater than the local production. “This is what the future of energy supply will look like,” he’s convinced. In private households, storage systems in the basement or parked electric vehicles might assume the role of such buffers in the long run. In scenarios like these, who needs country-wide energy suppliers?

Electricity from Apple or Google

However, it’s by no means clear that traditional energy corporations will be the big losers of the new electricity age. The utilities-turned-green from the coal and nuclear age still have millions of customers and power connections – plus, they’re loaded with cash. Just by selling Uniper, its conventional power plant division, German electricity supplier Eon earned some 3.8 billion euros at the beginning of the year. What’s more, it’ll likely take years to upgrade the many analog meters to smart energy management systems, which is a prerequisite for the new, smart electricity suppliers to succeed. “All the major utilities have realized that they need new business models. But that’s not enough. They have to become more agile and dynamic,” says energy expert Fritz from Oliver Wyman consultancy. As costs tend to drop due to digitalization, clever startups have realistic chances of success.

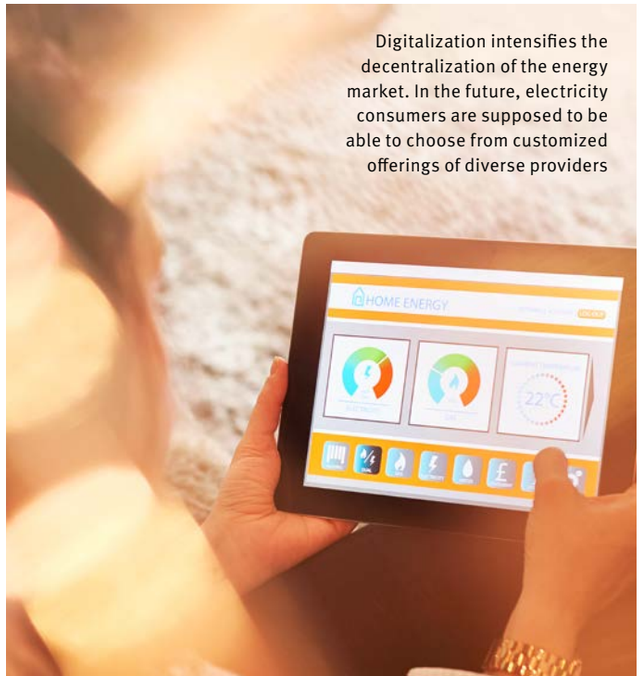
Competition threatens from yet another direction. Google, Apple and Amazon have already secured licenses to sell electricity in the United States. The internet corporations have everything it takes to successfully enter a market: millions of customer data points, digital know-how and an incredible amount of money. “If one of these IT corporations enters the market,” says Fritz, “change might be happening very fast.”

That’s why Agora CEO Graichen feels it’s naïve to dream of a world in which all of us would be able to cover our demand for kilowatt hours from a green source next door in the near future. “Size matters also in the new energy world because the profitability of this business increases in relation to the number of data points a company is able to collect.” Also, the electricity business, he adds, is an extremely regulated market in which supply and demand always have to be carefully balanced to keep the grids stable and prevent power outages. In Wildpoldsried, the local energy supplier, together with Siemens, established a self-sufficient electricity grid that remains stable without external interventions. In a big city, this would be a far more difficult undertaking. “Most app developers significantly underestimate this aspect,” says Graichen. “Plus, none of the currently available storage systems has the capacity to buffer a week without wind in winter.” Will decentralized supply of green energy work in spite of all this? Perhaps Copenhagen’s pioneering plan to generate its entire electricity consumption from local renewable sources by 2025 will shed some light on this question.

Still, the fact that even the new energy world will have to draw on conventional power plants for quite some time is undisputable. “We’re going to need reserve power plants until about 2040 or 2050,” says green electricity pioneer Kohler. But environmentally friendly fuels can be burned there as well, like hydrogen which has previously been separated from water in power-to-gas plants using excess wind and solar power, and subsequently admixed with fossil natural gas. Or that in another step, in methanation, has been transformed into a renewable gas which, by the way, is also suitable for use as a fuel for internal combustion engines. Locations that make particular sense for such power-to-gas plants are those where green electricity is generated in abundance – such as Wildpoldsried.

SMART GRID FOR MOBILITY OF TOMORROW

Schaeffler is following the digitalization of the energy market – like all areas along the energy chain from source to consumer – *with great interest as it yields new opportunities for mobility of tomorrow as well. Chief Technology Officer Peter Gutzmer: “Not only the powertrain concept of a vehicle is of crucial importance. Equally important is how the energy for the powertrain is generated and stored. Otherwise there’s a risk of simply shifting CO_2 emissions from one place to another. Smart grids are an important element of efficient energy utilization.” Sustainable mobility can only be achieved if the primary energy for locomotion is generated from renewable sources – wind power, solar power, hydropower or geothermal energy – and efficiently used by means of smart grids. Schaeffler makes contributions to the consistent expansion of these energy sources and supports renewable energy production with technology and know-how.*



Digitalization intensifies the decentralization of the energy market. In the future, electricity consumers are supposed to be able to choose from customized offerings of diverse providers

THE AUTHOR

Claus Gorgs *lives south of Hamburg, Germany, literally encircled by wind farms. Unfortunately, though, he can’t buy his electricity there directly. Until such time as decentralized energy supply becomes available everywhere he eases his environmental conscience by buying eggs and potatoes from the region and green electricity from the local public utility.*

HEADS UP! ELECTRIFYING EXCITEMENT!

Electric mobility is moving full speed ahead, increasing its presence both on the road and the race track. The success of the booming Formula E is electrifying. More and more manufacturers and more and more racing series are jumping on the electric bandwagon which Schaeffler has been helping to drive for a number of years now. Here's a look at the current state.

by Lukas Stelmaszyk

Events in major cities: Formula E delivers an emotive environment

A robot's arm pulls the bright-yellow satin cloth off the car, accompanied by a frenzy of flashing cameras and techno sound. There were numerous impressive presentations and innovations to be admired at the 2018 Geneva Motor Show, but for motorsport enthusiasts this one stood out from the crowd in a special way: The FIA unveiled the "Gen-2 car" for the 2018/2019 Formula E season. The new race car for the world's first fully electric racing series not only looks futuristic on the outside, but its inner values show the direction in which electric motor racing is developing as well. Power output has increased from 200 to 250 kW in qualifying and from 180 to 200 kW in the race, enabling top speeds of 280 km/h (174 mph). Thanks to a more powerful battery and enhanced efficiency, range has now doubled.

Due to its events being held in major cities around the globe, Formula E delivers significant additional value: an emotive environment. So, why is this important? "Because we need to engage everyone in this new and game-changing topic of electric mobility," says Professor Peter Gutzmer, Chief Technology Officer of the Schaeffler Group. "The technical products are engineered, in other words they're based on rational thinking. But this is not enough to make all their benefits understandable to external audiences. It takes marketing and emotionalization. After all, this has also been an original principle in automotive engineering where even in the early days the players would compare and pit themselves against each other in various competitions." Win on Sunday, sell on Monday – this piece of commonly known motorsport marketing wisdom is still valid in the electric age and, not least, the reason why more and more manufacturers are seeking to join Formula E.

Adapted Formula E technology: 1,200 electric horsepower in a notchback

According to Gutzmer, motorsport has yet another very important effect. The fierce competition with rivals requires expertise in taking technology to the limits. On all levels: in terms of function, weight and service life, and also in terms of thermodynamics. That's exactly why Schaeffler became involved in Formula E early on: in order to use the know-how gained on the race track for the development of electric powertrain systems in production.

In the Schaeffler 4ePerformance concept car, the automotive supplier showcases the technology that's already feasible today. The all-electric vehicle transforms and multiplies technology from the ABT Schaeffler FE01 Formula E car in a notchback sedan. The Schaeffler 4ePerformance is powered by four Formula E traction motors. They've been adopted from the race car and were used in the full second Formula E season. In the Schaeffler 4ePerformance concept, each motor is directly connected to a wheel via a spur gear, with two transmissions per axle sharing the same housing. The twin axle enables wheel-selective distribution of torque (aka torque vectoring). Powered by two traction batteries with a total capacity of 64 kWh, the vehicle develops output of 880 kW, equivalent to about 1,200 horsepower.

Formula 1 toys with the idea of electricity

But back to the race track. While many established racing series are struggling with declining popularity, Formula E is booming. The electrification of the powertrain is legitimizing top-caliber motor racing again, reason enough for traditionalists to take a close look at electrification as well – even in Formula 1. 2009 was the year in which KERS hybrid technology was introduced into motorsport's top category. The response, though, was not very encouraging: too little influence on lap times and essentially way too heavy. Many teams chose not to use the technology. 2014 produced the revolution: the new power unit, an IC engine with two energy recuperation systems, a turbocharger and an enormous battery. The KERS of the new V8 engines now had twice the output of its predecessors: 120 kilowatts, about 160 horsepower. Now that's something to write home about!

It's safe to assume that no changes will be made to this powertrain until 2020, but then? Head of Mercedes Motorsport Toto Wolff excludes the possibility of a return to conventional, aspirated engines: "Formula 1 is the world's fastest lab – we must be sure not to lose that." Drawing even more power from the hybrid engines would have to be the objective. To achieve it, Wolff can even imagine some drastic actions: "If this should mean

In Formula E, Schaeffler and Audi Sport are taking technologies to the limits

The fully electric Schaeffler 4ePerformance concept vehicle is based on technology from the Formula E car

that in ten or fifteen years from now our races will be one hundred percent electric, because those are the more powerful motors, then I can definitely imagine that we'll be heading in that direction."

Drifting with high voltage

10 or 15 years … Other racing series are clearly further ahead in their plans than Formula 1. Take rallycross for example, which is just one of four official FIA world championships. By introducing electric rallycross, the series intends to finally emerge from its niche existence. Due to a lack of media presence, only hardcore fans have been interested in this discipline so far, although the action-packed races featuring six cars with up to 600 horsepower pitted against each other on short tarmac-gravel tracks are highly spectacular – and with a race duration of just a few minutes perfectly suited for electric powertrains.

In 2020, electric rallycross is supposed to become reality. Eight manufacturers participating in the FIA's electric rallycross project team have already begun to work on the regulations. The technical and organizational boundary conditions are supposed to be finalized before the end of the year. "I think that with a dedicated electric racing series rallycross can turn into something really great," says Mattias Ekström. The two-time DTM Champion and 2016 World Rallycross Champion, who contests the series with his own team, EKS, adds: "As a complement to Formula E, rallycross might be playing a pioneering role in electric motorsport."

The plans of the FIA are for electric cars to use one electric motor with output of 250 kW per axle. The race cars, like the current ones with turbo IC engines, are supposed to tip the scales at 1,300 kilograms (2,866 lbs). The system output of 500 kW and the immediately available torque should make for rapid acceleration and spectacular driving maneuvers. Invitations for bids by battery suppliers for the years 2020 to 2023 have already been issued. Volkswagen is one of the eight manufacturers interested in rallycross. At the moment, the German automaker is supporting the reigning double World RX Champion, Team PSRX Volkswagen Sweden. If the planned electric series should become reality, a factory-backed commitment would be considered, according to Volkswagen.

Another project at Volkswagen has already been signed and sealed: Pikes Peak. In the tradition-steeped U.S. hill-climb race in Colorado, VW intends to storm up the mountain with an all-wheel drive race car and set a new track record in the category of electric prototypes. "For us, the Pikes Peak project means breaking new ground," says Head of Volkswagen Motorsport Sven Smeets, emphasizing the importance of the project. Volkswagen has developed a fully electric race car for the first time. "Pikes Peak is the perfect test for new technologies," confirms Frank Welsch, Member of the Volkswagen Board of Management for Technical Development. "Our electric race car will be equipped with innovative battery and powertrain technologies. The extreme demands at Pikes Peak are going to provide us with important findings for future developments."

Electric on two wheels as well: in 2019, the MotoE will be racing as part of the MotoGP

250 km/h on an electric motorcycle

The expectations pinned on the MotoE by the organizers of the MotoGP in the field of two-wheelers are similar. Starting in 2019, the World Motorcycle Championship will introduce electrification as well. A total of 18 motorcycles made by the Italian manufacturer Energica are planned to contest 20-minute races as part of the supporting programs at selected world championship rounds. "I tested this motorcycle for the first time in 2016 and immediately said to myself: "This is fantastic to ride," says three-time World Motorcycle Champion Loris Capirossi. The Energica Ego Corsa is said to accelerate from 0 to 100 km/h (62 mph) in three seconds and to achieve a top speed of about 250 km/h (155.3 mph). "We've been talking about the possibility of such a series for five or six years," says Carmelo Ezpeleta, CEO of MotoGP promoter Dorna. The Spaniard is sure that following the preparations in 2018 the series will become "a great success."

The officials of other electric racing series believe in success as well. In touring car racing, there are plans for the E-TCR to complement the newly incepted FIA World Touring Car Cup (WTCR) in which Seat's Cupra E-Racer is planned to be fielded. Powered by four electric traction motors installed in tandem arrangements on the rear wheels, the car with rear-wheel drive achieves permanent output of 300 kW and a peak of up to 500 kW. But touring car racing is not the only field in which things are moving forward. An electric GT series based on Tesla's Model S P100D is planned to launch before the year is out. The sedan that delivers some 550 kW has already successfully passed the required crash test.

Even 24-hours races to become electrified

Nicolas Perrin is still pursuing a long-held dream. The Frenchman would like to compete in the famous 24-hour race at Le Mans in an all-electric vehicle from the famous "Garage 56" for innovative vehicles. Electric vehicles fielded in the tradition-steeped race at La Sarthe might even motivate record winner Porsche, following its departure in 2017, to return to the FIA World Endurance Championship (WEC) to battle for the brand's 20th victory at Le Mans. If electric vehicles were to be raced at Le Mans this might be an option for Porsche, Oliver Blume emphasized at the end of last year. Porsche's CEO would give preference to a battery-electric powertrain like in Formula E.

FIA President Jean Todt tends to favor fuel cells in endurance racing. The principle is simple and basically not new. Instead of being supplied by a battery the electric energy is generated on board of the vehicle due to the combination of oxygen and hydrogen. "The fuel cell is probably the decisive technology," says Todt. "FCVs have a range of 600 kilometers and can be filled up to the brim within three minutes." The Frenchman intends to have fuel cells established in the WEC by 2021. Whether or not this will be feasible will also depend on cost-conscious regulations and the manufacturers involved. In any event, Todt has a clear vision: fuel cells in endurance racing, modern hybrid powertrains in Formula 1 and battery-electric systems in Formula E.

Todt's statements and extensive plans for the diverse other racing series underline the fact that the players in Formula E recognized the signs of the times early – just like pioneer Schaeffler. "We made a bold move when we decided to be part of the series from day one," says Professor Peter Gutzmer. "I was sure that this innovative series would become a success and find a prominent place in the motorsport scene. But that its place would become so prominent and emerge so fast … that's definitely remarkable."

AS OLD AS THE AUTOMOBILE ITSELF

Even though it may seem that way, *Formula E did not invent electric racing. Electric race cars existed as far back as in the automobile's infancy. The first car to have broken the 100 km/h (62 mph) mark was running on electric power. That was back in 1899. But just like electric road vehicles disappeared in the meantime, so did electric race cars. Formula E at least has a very large part in the power switch having been flipped again on the race tracks.*

METAMORPHOSIS ON THE RACE TRACK

Formula E Champion Lucas di Grassi about the transformation and future of motorsport.

by Lucas di Grassi

Race cars have been at the technological forefront of the automotive industry for more than 100 years now. Engineers in motorsport continue to drive developments forward. They design and build the fastest vehicles on wheels that can be moved by human hands. That makes this sport so incredibly fascinating. As drivers, in every qualifying, in every race, we have to tame an uncontrollable beast again and again while driving at the limit. It makes no difference whether the race car is powered by internal combustion, hybrid or electric technology. You just try to eke out the maximum from all the components, from the tires, from the engine. If you manage to do that, you've put a perfect lap on track. The second aspect of the fascination exuded by a race car is the sporting competition with your fellow race drivers. We all battle for who is best under very similar prerequisites in an identical environment and on an absolutely high level.

The basis is the same in any racing series: moving the car at the limit in competition. Obviously, though, there are some differences. In Formula 1, the quality of the race car, especially in terms of aerodynamics, plays a major role. If you're not sitting in one of the fastest cars you're not going to be in contention for victories no matter how good a driver you are. The philosophy in the endurance races in the WEC is a completely different one. Although the cars there have to be fast as well, they have to be equally reliable. A race strategy not only has to have an effect on a few laps but, as in the case of the 24 Hours of Le Mans, on a whole day. The drivers may be sitting in the car for three or four solid hours, even at night. That's an enormous challenge for the body and for the fitness of every individual. And, ultimately, for motivation and concentration, too. Formula E has caused an all-new aspect to emerge in motor racing: How can I manage to be fast while paying attention to the energy consumption of my electric race car in the process? For every racer, driving as efficiently as possible is the name of the game. This is a very complex subject that's added to the factors which are typical in motorsport. On top of that, Formula E exclusively races on city street circuits. So, there's practically no room for mistakes. If you make one, you'll end up in the wall in no time and your race weekend is over.

> ***» Automated driving might change our sport completely***
>
> Lucas di Grassi, Formula E Champion from Team Audi Sport ABT Schaeffler

Motorsport must be sure not to lose its character

Essentially, the idea of motorsport has not changed ever since its beginnings. You get into a car, hit the track and try to be as fast as possible. Today, though, efficiency plays a major role besides speed. We're right in the middle of a state of transformation in terms of the energy that powers the cars – from the IC engine to the electric motor. This is a path that must be pursued and will continue to be pursued. At the moment, the automotive industry is conducting research into another technology that might move into motorsport as well: automated driving. That might change our sport completely. Drivers would no longer need to know how to control their cars or, putting it in even more drastic terms, race drivers would no longer be needed at all. We'd lose any reference to what it means to move a car at the limit because we wouldn't understand the limit. That scares me a little. Motorsport must be sure not to lose its character. I wish for a competition in which the driver plays a greater role again than the technology. MotoGP is a good example. It goes without saying that the motorcycle is important too, but there the rider makes a really big difference. However, automated driving may be a great opportunity as well. Perhaps a way will be found to combine traditional racing and automated driving. In that case, we'd first have to understand how this new technology might actually enhance motorsport. It's important that the entertainment factor for the fan remains at least equally high. I could imagine, for example, that automated driving might have a part in the 24 Hours of Le Mans. The driver, for instance, might operate the vehicle for one half of the race while the car would drive itself for the other, always taking turns. As a result, only one instead of several drivers would be needed. It's just an idea, an example of the direction in which motorsport might develop. I believe that there are still a lot of other paths that we're not thinking about at all at the moment. I am, however, completely convinced that motorsport as such will continue to exist. For example, today nobody needs a horse anymore to get from A to B, like people perhaps used to a hundred years ago. But equestrian sports still exist, like show jumping or dressage riding. Motorsport in 50 years from now will have to face a similar question: Is it still necessary? Do will still need the drivers? And the answer will be: Yes, but in modified ways.

Schaeffler has been involved in the transformation of motorsport with innovative products for more than 100 years: from the early days like the Indianapolis 500 in 1911 to fully electric Formula E

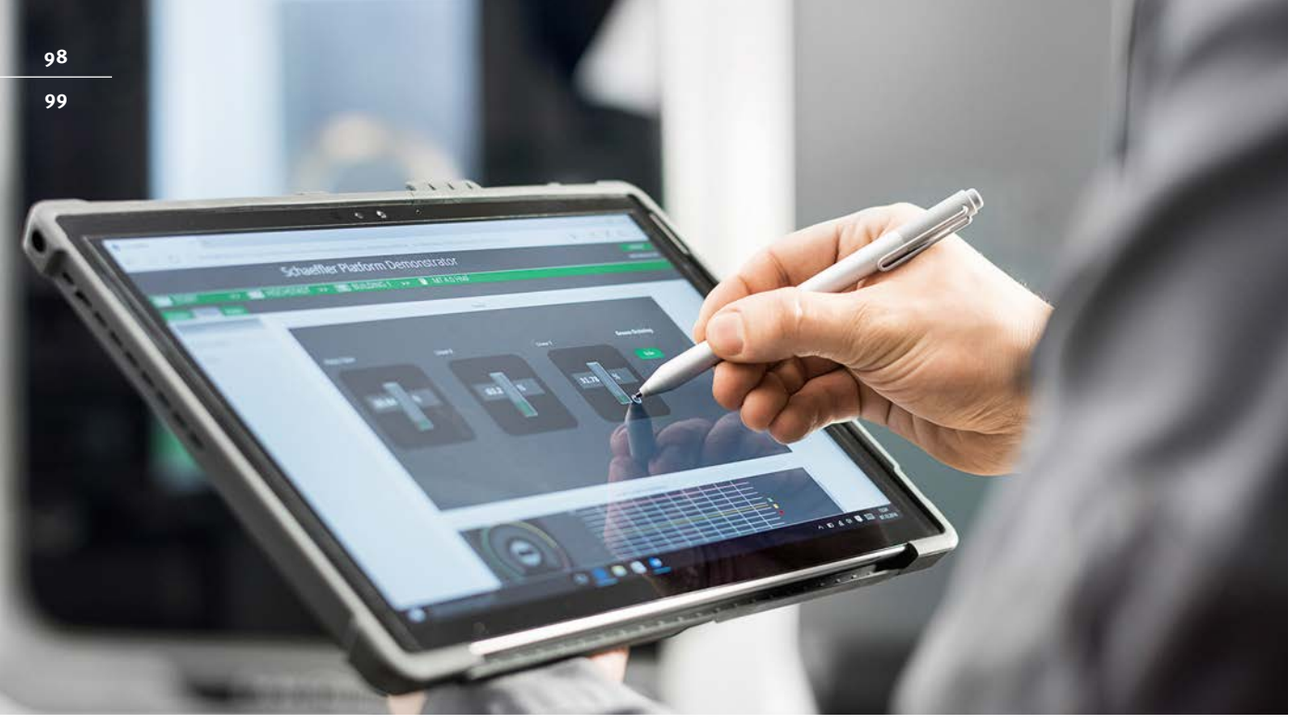
THE AUTHOR

*Formula E Champion and Schaeffler brand ambassador **Lucas di Grassi** is one of the co-founders and first ambassadors of the all-electric racing series. The former F1 campaigner enjoys technical gadgets, develops electric bicycles with a startup and is CEO of Roborace – a company dedicated to advancing the development of automated driving with a spectacular uncrewed vehicle.*

FULLY **DIGITAL,** OR WHAT?

Digitalization accelerates the transformation of nearly all spheres of life with massive momentum like no other technology before it. This yields opportunities for companies like Schaeffler and for each and every one of us.

by Carsten Paulun



New manufacturing lines and production worlds at Schaeffler are initially created in the digital world

Holger Meyer smiles mischievously: “Digitalization not only has something to do with data,” says the man who, of all people, was Google’s third-ever employee in Europe and established Google’s German headquarters in Hamburg in 2001. Google, the company that scoops up data in a way that has been likened to an octopus. “Especially today, digitalization also stands for transformation, a process that never ends. At the moment, it is digital experiences that shape us, that change our lives. Our ability to influence and to actually take advantage of it depends on how we incorporate this transformation, permit and even accelerate change,” explains Meyer who is currently working as CDO (Chief Digital Officer) for “Volksbank” in Itzehoe and provides consulting support to its sister banks throughout Germany. “Facebook and online banking are an initial step, but the digitalization journey requires an all-new corporate culture – not only in our sector, the banking business. It’s a prerequisite for successful transformation,” Meyer is convinced.

Technologization, internationalization and digitalization – success will only come to those who keep pace with the process of constant change and continually adapt. To some extent industrial companies, capturing billions of data points, have made greater strides in digital transformation than banks and other service providers at this juncture. But is the mere gathering of operational data enough? How does this create value? What’s the business case? Value only results from intelligent analysis, meaningful data mining and recommended actions derived from this process.

By 2020, 50 billion devices are expected to be connected

So, everything is being connected with everything else. Larger systems such as wind turbines and machine tools, as well as everyday things like cars, heaters or parcel deliveries. This gigantic network is also called the “internet of things.” American multinational Cisco Systems Inc. estimates that by 2020 there’ll be more than 50 billion connected devices. The objective: Real-world objects post their own condition information on the internet in order to create value that way. Examples include cars warning each other of hazards or wind turbines being serviced at times when there’s very little wind. As a result, all-new, data-based business models emerge in the automotive and general industrials sectors.

When data from research, development, manufacturing and operation of various products is used to add value, customers around the globe are willing to pay for the resulting benefits. Gerhard Baum, Chief Digital Officer of the Schaeffler Group, shares this view: “Due to increasing digitalization, we’re able to use data to the customer’s benefit. However, just providing customers with data is no value proposition. The valued-added lies in deriving recommended actions from data analysis and to thereby assist customers in creating value themselves.”

Schaeffler data analyst Dr. Pankaj Joshi is another expert who knows that data gathering is not an end in itself. If, for instance, the nexus between the design of a machine, the external conditions and the operating loads acting on it is known increasingly precise predictions of failure probability can be made by means of learning algorithms.

That’s the theory. In practice, however, experts like Dr. Joshi face many hurdles because data from the past is not always available in such a structured form that it can be processed by machines. “Not only the quantity but also the quality of data matters,” explains Joshi. In addition, close communication with teams in other functional areas is important to ensure the high quality and usability of data.

Dr. Pankaj Joshi is one of a total of 15 highly specialized experts working in the Advanced Analytics department. This team develops various prediction models which are used to optimize commercial and engineering processes and to predict the behavior of machines, equipment and products. Like many companies around the globe Schaeffler is expanding intelligent data analysis to more and more areas. To date, 150 of the Group’s production machines have been equipped with data acquisition sensors enabling preventive maintenance. Technology that today already works with manufacturing machines, wind turbines and trains will be used in automotive applications as soon as possible as well.

The working world is changing

At the end of a transformation process not only the contents of work but the entire working world will have changed. In conventional mechanical engineering,

2008
was the first year in which there were more **devices digitally communicating with each other via the internet** than people living on Earth.
Source: Cisco Systems

50 %
of the world population was **online in 2017.** 37 % used social media for communication, 22 % used the internet for shopping.
Source: “Digital in 2017” survey

2026
the first **artificial intelligence machine** might become part of a corporate board of directors.
Source: World Economic Forum

43 %
of employees in Germany say that their jobs have changed significantly or very significantly due to **digitalization.**
Source: IfD Allensbach

» Not only the quantity but also the quality of data matters

Dr. Pankai Joshi,
data analyst at Schaeffler

for instance, it's not possible to quickly make a physical prototype in order to try something new because the costs and work involved on the one hand and the risk of failure on the other are too high. In the digital world, engineers use real-world data for testing innovations in simulations before building the first prototype. Subsequently, the new products are efficiently designed according to specifications.

Here's an example of such an "agile" development method from the Schaeffler world: When it comes to reducing friction on rolling bearings, plain bearings and other mechanical components or, for example, avoiding corrosion digital methods are the key tool for further optimization. "We've developed an electrically conductive coating system for this purpose which allows information about loads and torques of a rolling bearing to be captured," says Dr. Joanna Procelewska from Schaeffler's Surface Technology Competence Center, adding that: "Due to this data and its analysis and the intelligent interpretation of the results, we enhance the energy efficiency of our components." Essential to this work

Information scientist Dennis Arnhold: "We digitally test how much space a machine needs in the real world."

is the virtual tribology lab in which Dr. Procelewska uses various computer programs to capture and analyze the friction of various surface materials and to make respective predictions. "Digital methods and autonomous processes can assist us in finding ways to solve problems of lesser complexity – such as increasing the quality of manufacturing processes," she explains. "This provides development and design engineers with greater scope to focus their resources on more complex issues." Humans, she's convinced, will not become redundant due to digitalization, but their workload will be eased.

The creativity and ideas of experts will continue to be in demand particularly in the case of highly specific customer requirements. "In the future, we'll verbally express our requirements and receive the recommended actions calculated by means of complex algorithms via chats," Dr. Procelewska predicts. The work of the engineers will be to control this process and to convert the answers into results – as simple as possible, but not any simpler.

> ***» Digital methods will provide greater scope for solving complex problems***
>
> Dr. Joanna Procelewska,
> Tribology specialist at Schaeffler

The digital world allows things to be tested

Data, however, not only plays an immensely important part in research and development. It's also indispensable in the smart Factory 4.0. "But thinking that all it takes is to put a few smart machines in a factory hall and everything else will then automatically organize itself is a fallacy," says Dr.-.Ing. Dennis Arnhold, an information scientist at Schaeffler. To increase flexibility in a manufacturing operation, the industrial revolution must be carefully planned. In a factory that operates according to Industry 4.0 standards, all the devices and processes must be represented in digital form as completely as possible. That's why experts have also dubbed this as a factory's "digital twin." If a factory or a new manufacturing segment is digitally planned in advance a meaningful utilization of the data stream in the subsequent operation becomes much easier.

"It won't be long before we're able to inspect any new factory with VR glasses even before the ground is broken, which makes a virtual pre-acceptance possible," says Arnhold. Today, 3D models are already promoting the discussion between planners, product developers and management. "In the digital world, we can test how much space we'll need for loading a particular machine, for example," Arnhold explains. In the former, analogous world, planners would allow for a little more space just to be on the safe side. In fact the amount of space gained by digital planning is remarkably large. Compared to an older line in the Schaeffler Group the space required for a new wheel bearing line in Kysucké Nové Mesto with comparable production output was reduced by 40 percent.

Here in Slovakia, transformation has fully arrived as well.

DIGITAL TRANSFORMATION – SCHAEFFLER THINKS AHEAD

While other companies are merely responding to digital transformation Schaeffler is thinking ahead with its "Digital Agenda" and actively involved in shaping the future in automotive and plant engineering. The resulting four-pillar model is an integral component of Schaeffler's strategy billed as "Mobility for tomorrow."

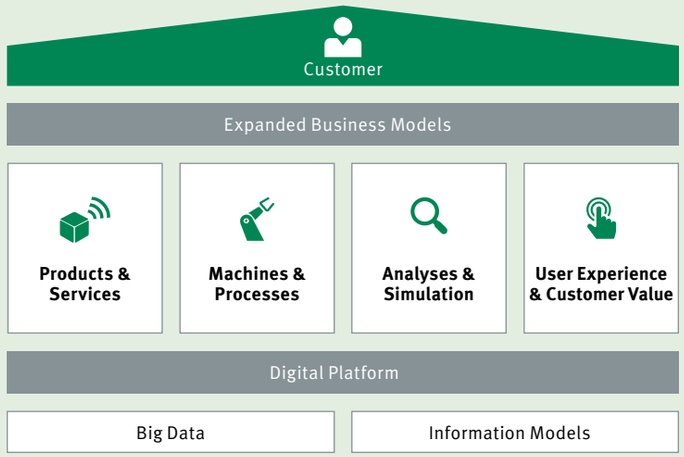
The first pillar, "Products & Services," is about data acquisition. Equipped with sensors, electronics and actuators, bearings and other drive system components from Schaeffler supply the data needed for Big Data analyses.

The second pillar, "Machines & Processes," is focused on digitizing the production equipment for Industry 4.0. Schaeffler equips smart factories and additionally places a focus on its own production operations.

The third pillar, "Analyses & Simulation," adds particular value in the context of product development. Schaeffler uses real-word operating data to subject innovations to thorough testing before the first prototype is built, which enables engineers to efficiently design new products according to specifications.

The fourth pillar, "User Experience & Customer Value," is dedicated, among other things, to the question of how data can be prepared for optimum consumption by the user – the starting point being intuitive user interfaces. The results are an enhanced user experience and higher customer value. A mobile end device provides users with full decision control of their processes anywhere anytime.

DIGITAL AGENDA OF THE SCHAEFFLER GROUP



A QUESTION OF HARDWARE

Will vehicles in the future be able to repair themselves, aerodynamically adapt to wind conditions or, if necessary, even mutate from a sporty two- into a family-friendly six-seater? How smart materials are going to shape the automobile of tomorrow.

by Oliver Jesgulke

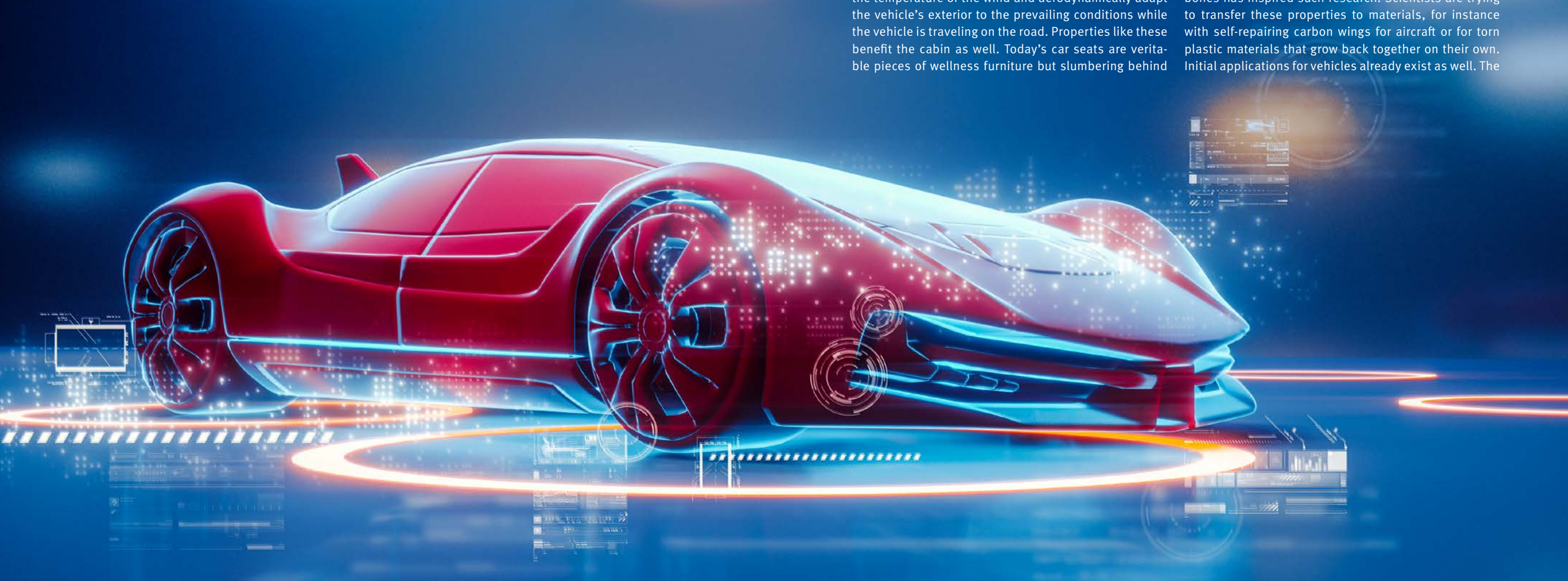
An SUV today, a station wagon tomorrow and a convertible day after tomorrow – a vehicle that, at the push of a button, will change its form and adapt to the needs of its owner at any time. Will in a few years from now the automotive future be such that we no longer have to choose a model at a car dealership but just take the entire model range home? Overshadowed by current discussions about connectivity, artificial intelligence and automated navigation for vehicles, designers, universities and research institutions have long begun to work on bold visions of making the automobile more flexible and autonomous by using smart materials. Many of these approaches are no doubt still in their infancy. Yet tongue twisters like magnetorheological elastomers, piezoelectric ceramics or electroactive polymers have one thing in common: this new generation of materials is able to set rigid vehicle components in motion.

The reason is that their properties are changed by electricity, magnetism, heat or light, which makes them ideally suited for use as actuators or sensors. Already known for a longer period of time, for example, have been metallic shape memory alloys which under the influence of heat change their shape and return to their original form as soon as the temperature drops again. In Alfa Romeo's Essence concept car, such alloys react to the temperature of the wind and aerodynamically adapt the vehicle's exterior to the prevailing conditions while the vehicle is traveling on the road. Properties like these benefit the cabin as well. Today's car seats are veritable pieces of wellness furniture but slumbering behind the leather is an array of electronics. Yet more purist approaches are possible as well. Materials with shape memory are being used in the "SensA-Chair" research project of Cologne University of Applied Sciences, adapting the seat to individual anatomical body contours – without requiring a lot of additional technology.

Safety features and self-healing forces

In the future, smart materials are also intended to enhance the safety of vehicle occupants and other traffic participants. The Max Planck Institute for Iron Research has been experimenting for some time with switchable particles for aluminum alloys and steel that can be deformed by magnetic or electrical impulses and, as a result, decisively change the properties of the whole material. The hardness of the vehicle's body, for instance, is supposed to be influenced this way in the event of an impact. In case of an impending collision with a pedestrian or cyclist, the front end will change and soften. If the car approaches an obstacle at high speed, the front will harden. After a crash, the material may be able to recover completely on its own.

Nature with its self-healing forces for skin and bones has inspired such research. Scientists are trying to transfer these properties to materials, for instance with self-repairing carbon wings for aircraft or for torn plastic materials that grow back together on their own. Initial applications for vehicles already exist as well. The



High-tech fabric instead of steel skin: the EDAG Light Cocoon (top) and BMW GINA concept cars

Leibniz Institute for New Materials is testing paint made of corn starch. Due to a pearl string structure, its molecules can flow together within a few days and, as a result, repeatedly seal cracks and tears.

Bye-bye steel!

While some scientists are working on the paint and crumple zones of the future, others are accelerating their demise. Automated driving with the vision of an era without accidents is promoting this development. Due to the quantum leaps in the world of materials, material-intensive designs will be replaced by skeleton-like ones in the near future, such as constructions made of metallic foams. So, with a flexible body shell the automobile would experience its emancipation from sheet metal after nearly 100 years. The EDAG Light Cocoon with an extremely lightweight shell made of a multi-layered polyester jersey fabric from a manufacturer of outdoor textiles, which is stretched over a 3D-printed skeleton, and BMW's GINA concept car provide an idea of what lies ahead. Due to the material's elasticity, a variable vehicle size with adjustable frame sections is conceivable as well, enabling the car to morph from a two- into a four-seater.

And what about tires? Manufacturer Continental is conducting research into "smart" tires which, thanks to tread-integrated micro compressors and rims growing in width, could adapt to the respective road conditions or demands of the driver. In addition, conductive rubber compounds help transmit data acquired by sensors in the tire into the car. This would make it possible to issue warnings when limits have been reached. Continental's competitor Goodyear showcased a "breathing tire" at the 2018 Geneva Motor Show that uses organic moss as a "smart material" in the sidewalls. The moss is supposed to absorb carbon dioxide and convert it into oxygen by photosynthesis. The tread is a self-supporting skeleton of recycled rubber powder that has been 3D-printed into shape. A little older is Goodyear's idea of a spherical tire using magnetic levitation technology for contactless integration into the car. The tread of this concept tire consists of elastic polymers that imitate the bionic structures of human skin. Located underneath is a foam-like material that's able to flexibly adjust to road surfaces and weather conditions.

Will the origami car become reality?

How far does the development of smart materials go? Scientists at the Massachusetts Institute of Technology are intensively conducting research into so-called self-assembly materials. The technology used is referred to as 4D printing. It involves 3D printing of a material that will subsequently transform into a different shape on its own. The vision: Objects like automobiles can be transported as flat components and autonomously unfold into a pre-defined, three-dimensional shape by a trigger. However, the future will not only produce innovations but also entail an increasing scarcity of resources. Perhaps manufacturing industries will have no choice but to radically part with the conventional use of materials. If that should be the case and we should desire the body styles of our vehicles to change as we'd like them to the solution might be a barebones skeleton enveloped by a holographically generated exterior that transforms itself as needed.

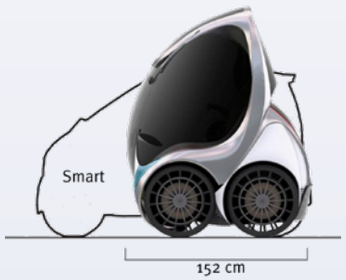
THE AUTHOR

Oliver Jesgulke *has been working as an author for newspapers, blogs and corporate magazines since 2007. He has reported about the latest developments in the automotive and mobility sectors for the Daimler Corporation, the German Association of the Automotive Industry, Toll Collect and others. Jesgulke studied business communication and lives in Berlin.*

MECHANICAL **TRANSFORMERS**

Toy manufacturer Hasbro in the 1980s conquered children's playrooms in western industrialized countries with vehicles that could be transformed into robots and vice versa with just a few flicks of the wrist – the "transformers." These toys also serve as inspiration for mobility of tomorrow.

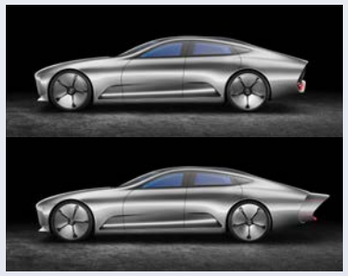
Airbus and the Volkswagen Group *at the 2017 and 2018 Geneva Motor Show presented a futuristic joint project: a flexibly usable passenger pod that can dock with car chassis, rail vehicles, drones and even the Hyperloop.*



South Korean researchers have developed the "Armadillo-T," *a concept car that can be folded in half by means of an app. This saves parking space. Measuring a mere 152 centimeters (about 60 inches) when folded, the tiny vehicle is more than a meter (about 40 inches) shorter than a first-generation Smart. In the "Hiriko," researchers at the Massachusetts Institute of Technology and in the "EO smart connecting car 2," the German Research Center for Artificial Intelligence have presented similar concepts.*

The idea of a floating car that resurges from time to time was given new buoyancy by Hyundai at the 2018 Geneva Motor Show. *The Koreans' idea is an electric buggy that's able to transform into a jet ski, also powered by electricity. Although clever but arguably not likely to be implemented, this is another concept that shows that transformation vehicles which can adapt to diverse uses are high on the list of projects being pursued by automakers.*

Mercedes applied the transformers idea to the "Intelligent Aerodynamic Automobile" concept in 2015. *Starting at a speed of 80 km/h (about 50 mph), the four-door coupe automatically switches from design to aerodynamic mode which causes numerous features to change their form and shape, trimming Cd to a possibly world record-breaking 0.19. For the transformation, which is still purely mechanical here, smart materials might also be used in the future.*



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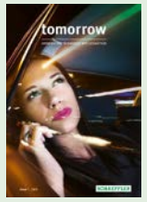
** The integrated torque converter (iTC) developed at Schaeffler's Wooster/Ohio location integrates the clutch function directly into the turbine of the torque converter. The new design has lower weight and minimizes the required assembly space.*

tomorrow All previous issues



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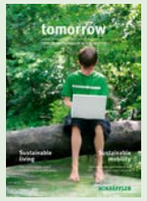

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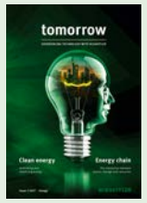

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